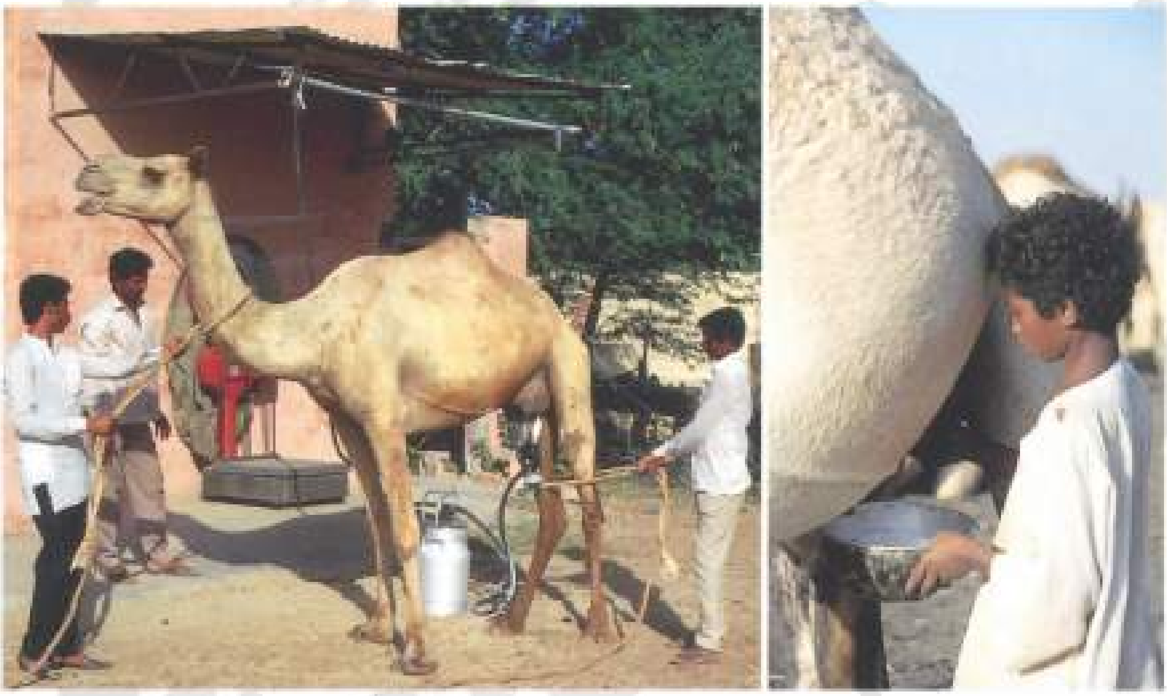
COLLOQUES

Dromadaires et chameaux, animaux laitiers

Dromedaries and camels, milking animals



UCEC ▮ Ministère français de la coopération
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Actes du colloque
24-26 octobre 1994
Nouakchott, Mauritanie

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Dromadaires et chameaux, animaux laitiers

Dromedaries and camels, milking animals

Pascal Bonnet
Editeur scientifique

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Séance d'ouverture
Opening session

Allocution de Monsieur le Chef de la Mission française de coopération et d'action culturelle à Nouakchott

Speech by the Head of MCAC, Nouakchott (French Ministry for Cooperation)

Messieurs les Ministres,

Messieurs les Ambassadeurs,

Messieurs les Représentants des organisations internationales,

Mesdames, Messieurs.

AU NOM DU MINISTRE DE LA COOPÉRATION, je remercie le Gouvernement mauritanien d'avoir accepté que se tienne à Nouakchott cette importante réunion de chercheurs des différents pays concernés par l'élevage des camélidés.

Ce colloque a été organisé par l'Unité de coordination pour l'élevage camelin du Cirad-emvt soutenu par le ministère français de la coopération et il a lieu dans votre pays, Messieurs les Ministres, pour lequel l'importance de l'élevage du dromadaire n'est plus à souligner.

Comme vous le savez, la France a marqué de longue date son intérêt pour les camélidés et les vétérinaires ont accumulé, longtemps avant les indépendances, de précieuses données pratiques sur l'alimentation et les soins à prodiguer aux dromadaires utilisés comme montures par les hommes des compagnies méharistes. A cette époque, l'intérêt économique représenté par le dromadaire, animal laitier, était quelque peu masqué par cette première utilisation.

Les connaissances sur la production de viande et la production laitière du dromadaire et du chameau ont été approfondies au cours des dernières décennies et l'occasion est donnée aujourd'hui aux chercheurs et spécialistes des camelins de faire le point sur leurs connaissances en matière de production laitière de ces animaux.

Les camélidés, et particulièrement le dromadaire, se sont en effet illustrés au cours des sécheresses successives, de 1968 à 1983, par leurs facultés à surmonter les difficultés d'abreuvement et d'alimentation.

Ce constat a d'ailleurs conduit la France à financer un « programme régional camelin » dont le coordonnateur anime aujourd'hui le présent colloque dont le déroulement dans votre pays confirme, comme je l'ai déjà évoqué, l'attachement qu'il porte, Messieurs les Ministres, à cet animal de production si rustique et polyvalent, merveilleusement adapté aux dures contraintes du désert.

Cet attachement, conjugué à une forte demande en lait de dromadaire des populations déplacées par la sécheresse, a conduit le Gouvernement à soumettre une requête au ministère français de la coopération. Elle a abouti, en 1990, à la naissance du projet intitulé « Développement de l'élevage dans la province du Trarza » d'un montant de 3,2 millions de francs (70 000 000 UM environ).

Très rapidement, le volet « Recherche-développement sur les camélidés dans les élevages périurbains » est apparu prioritaire. Il a conduit à la mise au point de systèmes de protection sanitaire, de conduite et d'alimentation des troupeaux périurbains permettant ainsi d'améliorer l'approvisionnement de Nouakchott en lait frais.

Parallèlement et de manière complémentaire, la Caisse française de développement participe au financement d'une laiterie privée que vous aurez d'ailleurs l'occasion de visiter au cours de cette réunion.

Nul doute que les ateliers de travail qui vont se dérouler dans les prochaines heures, permettront de renforcer les connaissances de chacun dans le domaine de la production laitière cameline, contribuant par là-même à l'amélioration de la production et de la commercialisation du lait de camélidés et de ses dérivés.

Je vous remercie.

Discours d'ouverture de Son Excellence Maître Sghair Ould M'Bareck

Opening speech by His Excellence Maître Sghair Ould M'Bareck

Ministre du développement rural et de l'environnement de Mauritanie

Minister of Rural Development and Environment of Mauritania

Excellences Messieurs les Ministres,
Excellences Messieurs les Ambassadeurs,
Monsieur le Directeur scientifique du Cirad-emvt,
Messieurs les Représentants des organisations scientifiques,
Honorables invités,
Mesdames, Messieurs.

L'HONNEUR M'ÉCHOIT DE PRÉSIDER AUJOURD'HUI la cérémonie d'ouverture du présent colloque qui débattra d'un thème ayant un écho particulier en Mauritanie : « Dromadaires et chameaux, animaux laitiers ».

Vous remarquerez sans nul doute les liens profonds qui ont toujours lié les fils du désert de ce pays à ce charmant animal qu'est le dromadaire. En effet, l'homme mauritanien qui a toujours vécu avec le dromadaire dans des conditions naturelles difficiles, a découvert en cet animal une capacité de résistance qu'on ne retrouve pas chez les autres mammifères.

C'est ainsi que le dromadaire n'a cessé d'assurer pour nos populations un rôle de premier plan dans la couverture des besoins alimentaires, mais aussi en matière de transport et d'exploitation des cuirs.

Mesdames, Messieurs,

les relations qui se sont tissées entre nos concitoyens et le dromadaire ont largement dépassé les fins purement économiques pour atteindre la vie culturelle et sociale.

Nombreuses étaient autrefois ces universités ambulantes qui sillonnaient le pays à dos de chameau pour propager le savoir ; combien de savants formés dans ces universités ont transmis leur message intellectuel au delà des frontières du pays, se déplaçant en dromadaire, seul moyen et seul compagnon de voyage ? Aussi est-il patent que pour le citoyen mauritanien, redonner de la considération au dromadaire répond à une double exigence, économique et sociale.

C'est d'ailleurs là que l'intérêt accordé par le président de la République, Son Excellence M. Maaouya Ould Sid'Ahmed Taya, à la redynamisation du secteur du bétail avec toutes ses composantes parmi lesquelles les camelins, trouve sa justification et sa signification profondes. C'est aussi pourquoi le gouvernement du Premier ministre, M. Sidi Mohamed Ould Boubacar, fonde un grand espoir dans les résultats de cette rencontre. Le Gouvernement, faut-il le rappeler, vient d'implanter dans notre pays les premières unités du continent dans le domaine de la fabrication du fromage à partir du lait de chamelle.

Mesdames, Messieurs,

le niveau scientifique élevé des participants à ce colloque et la qualité des communications qui y sont programmées, attestent, à notre grande satisfaction, de l'intérêt que porte la communauté scientifique internationale à ce remarquable animal. Nous aboutirons dans le futur, je l'espère, à l'harmonisation des démarches visant à l'accroissement de sa production laitière.

C'est sur ce ferme espoir et en souhaitant à tous un excellent séjour en Mauritanie, que je déclare ouvert le colloque « Dromadaires et chameaux, animaux laitiers ».

Je vous remercie.

Opening welcome by IFS

Discours d'accueil par l'IFS

Christina AROSENIUS

International Foundation for Science (IFS), Grev Turegatan 19, S-114 38 Stokholm, Sweden

Distinguished guests and colleagues,

Dear participants in this seminar,

Ladies and gentlemen.

AS REPRESENTATIVE OF THE INTERNATIONAL FOUNDATION FOR SCIENCE it is a great pleasure for me to welcome all of you during this opening ceremony of the seminar on "Dromedaries and camels, milking animals".

For those of you present who are not very familiar with the work of IFS I will now give a brief presentation.

IFS is an international, non-governmental organization which was founded in 1972 with the aim to counteract the "brain-drain" from developing countries and to stimulate the build-up of scientific competence in these countries. We are not a large organization, our annual budget is approximately 4 million US$ and the staff consists of 22 persons working in our office in Stockholm, Sweden. IFS has 92 Member Organizations consisting of scientific academies, research councils and in some cases universities, located in 78 countries.

IFS works in six scientific areas : aquatic resources, animal production, crop science, forestry/agroforestry, food science and natural products. Until 1993 IFS has supported more than 2,300 scientists in more than 90 countries in Africa, Asia, the Pacific and Latin America and the Caribbean.

The IFS grants are given to enable non-established, promising young scientists born in a developing country to do research in such countries. The upper limit of a research grants is at present 12,000 US$ for one research period. If the work goes well the grant can be renewed twice. This grant should be used to purchase equipment, expendable supplies and literature for the project. It cannot be used for salaries or honorarium for the grantee which means he/she must be employed by research institute or university in the home country, which can provide the salary and other basic facilities. In return for this support all equipment bought with the IFS funds will belong to the institute when the project is finished.

One of the main aims of IFS is to promote scientific contacts and create regional networks between our grantees and other scientists working in the same fields. To do this IFS can give its grantees travel grants to participate in scientific meetings and to a limited extend we can also arrange expert visits to the grantees in their home institutions. One of the most efficient ways to promote these kind of contacts, however, are the IFS workshops and seminars. They deal with specific topics and bring together grantees from one region as well as international experts in the same field. The possibility for our grantees to present their work, discuss their problems and make personal contacts with other researchers is considered to be an important part of their scientific training and we hope this will help them to enter the international scientific community.

IFS has to date organized approximately 100 seminars, workshops and training courses within our different research areas and out of these 22 have been on animal production topics. In December 1979 IFS in co-operation with the Sudan National Council of Research organized a workshop on camelids in Khartoum, Sudan. The meeting became a landmark and a starting point for new efforts in the previously largely disregarded research on these animals. The papers from that meeting were first published in a limited edition as an IFS report but following a heavy demand later on, a book was published by the Scandinavian Institute for African Studies. It was edited by Ross Cockrill and called "The Camelid - An all-purpose animal".

IFS has to date funded 23 projects dealing with research on camelids, both in Africa, Asia and Latin America within our individual grants programme. Cirad-emvt has however made a more concentrated effort in supporting a broad research programme following the growing interest in camelids in the context of rural development and environmentally friendly and sustainable animal production. It has created UCEC "Coordination Unit for Camel Production"; we are pleased to have a good co-operation with this network which gives our grantees a possibility to co-operate with fellow researchers. At the meeting in Paris 1990 on "Reproductive performance of the camel" IFS sponsored 4 grantees. At this meeting we are sponsoring 6 researchers and also sharing some of the costs of publishing.

Before I finish I would like to thank Cirad-emvt and specifically Dr. Pascal Bonnet for the efficient preparations and for offering IFS this opportunity to join in. I am sure this is going to be a good meeting and we are grateful to The Ministry of Rural Development and Environment of the Islamic Republic of Mauritania for hosting this event and giving us all a possibility to visit his interesting country.

Thank you.

Les filières laitières camelines, un pari sur la modernité et les techniques traditionnelles

The camel's milk commodity systems, how to lay a bet on modernity, and traditional techniques

Pascal Bonnet
CIRAD-EMVT, Unité de coordination pour l'élevage camelin (UCEC),
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La présentation d'un ouvrage sur la filière laitière cameline tel que celui ci, fût-il le résultat d'un atelier scientifique, ou d'un travail préparatoire au lancement de projets de développement dévolus à ce thème, est toujours un exercice difficile. La plupart des scientifiques et hommes de développement qui ont côtoyé l'espèce cameline n'en sont pas ressortis totalement indemnes — pour reprendre un terme propre à la terminologie vétérinaire. En effet, que ce soit le dromadaire (*Camelus dromedarius*), ou le chameau de Bactriane (*Camelus bactrianus*), ces espèces ont en commun de croiser les trajectoires de peuples et d'ethnies riches en histoire, en connaissances diverses, souvent symboles de maux historiques (razzias, guerres, conquêtes), mais aussi terriblement représentatifs des difficultés de la vie nomade ou transhumante, et des adaptations que l'homme et l'animal ont réussies ensemble. Cela est sans doute encore à l'origine des hésitations persistantes des décideurs en matière de développement à promouvoir des animaux assurément productifs : les dromadaires et les chameaux, qui n'en restent pas moins les animaux de la conquête écologique et de l'occupation des territoires arides, et les espèces qui ont permis la plupart des flux de commerce en Afrique, en Asie, et au Proche et au Moyen-Orient.

Le chameau, un animal de production à part entière

Aujourd'hui, après des années de productivisme agricole universel plus ou moins contrôlé, nous redécouvrons les vertus d'un environnement naturel protégé mais productif, apte à produire et ıeproduire une ressource alimentaire pérenne sans dégradation extrême de ses sources de production. Dans le cadre des environnements arides, qui mieux qu'une espèce animale domestique dont le processus d'adaptation a été amorcé depuis des millénaires, et dont le mode de vie est doublé d'un respect naturel pour son environnement (perceptible par exemple par ses capacités de piétinement et son comportement alimentaire), qui donc pourrait le mieux répondre au nouveau défi de la convention de Rio de 1992 sur l'environnement, tout en suivant la trace des révolutions vertes et autres défis alimentaires de ses zones de prédilection ?

Certains pays ont déjà relevé le défi consistant à fournir aux camélidés le statut d'animal de production à part entière, pièce importante de l'échiquier de leur économie de l'élevage. La plupart du temps cela fut initié par certains particuliers visionnaires, leaders en leur temps et qu'il faut saluer aujourd'hui. L'exemple des laiteries fondées ici ou là en est un exemple remarquable bien qu'encore isolé, et l'expérience de la Laitière de Mauritanie doit être soulignée. L'exemple des initiatives privées d'éleveurs, pour la vente de lait sur les zones de production ou sur les zones de consommations urbaines, est encore une fois un signe flagrant du dynamisme économique de ces opérateurs que l'on a trop souvent négligés. C'est aujourd'hui le cas dans de multiples sites d'élevage tels que le Sud marocain, de manière plus ancienne la Somalie, dans les fermes-ranchs du Nord-Kenya où les camelins ont été introduits aux côtés des bovins et zébus, pour ne reprendre que quelques exemples. D'autres fois, il s'est agi d'un engagement politique fort des responsables de l'économie agricole et de leurs structures d'application. Ce fut le cas en Asie centrale où des filières laitières camelines ont parfaitement rempli le rôle qu'on leur avait assigné pour nourrir dans certaines grandes villes des populations cibles particulières (pour les régimes diététiques ou thérapeutiques en hôpitaux) mais aussi les populations valides pour lesquelles les produits laitiers des camelins ont autant valeur de symboles que de simples aliments. C'est encore le cas aujourd'hui en Afrique et en particulier en Mauritanie, où les autorités ont justement compris le rôle multiple et productif que pouvait jouer cette espèce dans l'approvisionnement laitier des villes.

A parler de laiteries, on pourrait presque en oublier le rôle essentiel joué par le « chameau » (expression vernaculaire désignant à la fois les deux espèces), dans la vie pastorale quotidienne. Or les pasteurs utilisateurs de camelins sont actuellement, sous réserve de contraintes foncières normales, les meilleurs utilisateurs de l'espace pastoral dans le respect de l'environnement, par son utilisation optimale et le maintien de ses potentialités. Ils sont aussi à l'origine des systèmes laitiers camelins améliorés (périurbains), et leur rôle est essentiel par leur savoir-faire d'éleveur dans l'approvisionnement des systèmes modernes en animaux de qualité. Les diverses sécheresses survenues en Afrique dans un passé proche ont conduit certains éleveurs traditionnellement usagers des zébus à se doter de camelins. C'est le cas par exemple en Afrique de l'Est, chez les Boranas du Sud éthiopien et du Nord kenyan, pour qui le lait est traditionnellement un aliment de consommation et de commercialisation, transformé ou cru. Ces ethnies ont naturellement remplacé une partie de leur production laitière bovine par le lait de camelins sans rencontrer de difficultés majeures, en dehors du nécessaire temps d'adaptation à l'élevage de cette espèce. Au Kazakhstan, après l'abandon partiel des fermes d'Etat et la disparition de la chaîne étatique de transport et de transformation du lait camelin, ce sont des opérateurs privés (paysans, autres professionnels ou villageois dans le cadre de leur élevage de subsistance) qui ont repris l'élevage de l'espèce à des fins d'autoconsommation ou d'amélioration de leurs revenus par la commercialisation de ses produits. Le *shubat* est ainsi retrouvé au « Green Market » à Almaty, sur les bancs des vendeurs de produits laitiers qui le proposent à côté du *koumis* de jument.

La filière laitière cameline comme objet d'étude

Il ne faut pas oublier qu'en Europe et en particulier en France, terre de tradition des produits laitiers et de leur diversité, les filières laitières et fromagères ont été les dignes héritières des « fruitières » issues des communautés religieuses montagnardes du XIV[e] siècle, mais que leur industrialisation a moins de cent ans. Bien avant, les abbayes avaient été les seuls réels centres de recherche en fromagerie. Les premières traces d'élevage laitier qui remontent à 10 000 ans avant Jésus-Christ se situent au Moyen-Orient et concernent surtout les petits ruminants. Si les premiers fromages plus ou moins élaborés et connus naissent vers 5 000 avant Jésus-Christ, le beurre sumérien (3 500 av. J.-C.) puis celui d'Inde (1 100 av. J.-C.) sont plus récents, et le procédé des fromages à pâte pressée date des Romains et est contemporain de Jésus-Christ. Le *koumis* , lait de jument fermenté, est connu lors des découvertes des steppes mongoles vers le XII^e^ siècle, et le yoghourt turc est utilisé en Europe au XV^e^ siècle, bien que ses ancêtres fermentés soient plus anciens. Pour ce qui concerne les produits laitiers de camelins, l'histoire n'est pas précise mais il est bien connu que les voyageurs commerçants trans-africains utilisaient le lait de chamelle. Il fut utilisé très tôt en Mongolie pour produire une famille de produits issus de la transformation de ses protéines, de ses matières grasses, ou de sa fermentation, ou bien comme lait cru, ingrédient d'autres préparations culinaires. Il est à noter que le lait de chamelle Bactriane est rarement consommé tel quel, à la différence de son équivalent chez le dromadaire. Une partie de l'histoire de ce lait reste encore à écrire.

Les processus de développement de l'agriculture et de l'élevage ont une forte composante socio-culturelle qu'il est utile d'intégrer aux études restant à mener. Le processus d'accompagnement des filières vers une structuration forte et pérenne des échanges entre les partenaires économiques concernés, nécessite même pour des filières courtes (du milieu pastoral vers la ville pour le lait cru) de favoriser l'environnement desdites filières sur l'ensemble des maillons de la chaîne de production et de transformation. Dans ce cadre de nombreux essais ont tenté de dresser le canevas idéal d'un développement harmonieux et rentable de ces filières (voir les travaux de l'ILCA, International Livestock Centre for Africa, avec la collaboration du Cirad[1]), mais aucun n'a réellement et complètement intégré le rôle de l'élevage extensif pastoral des camélidés. La recherche a accompagné le développement de l'espèce depuis un passé récent, mais il reste encore beaucoup à faire pour rattraper le retard sur les autres filières. Cela est en partie dû à l'absence longtemps accusée de travaux fondamentaux de référence sur cette espèce absente des pays tempérés, qui sont en général de grands pourvoyeurs de résultats de recherche agricole. Cependant l'existence de structures de recherche nationales et de méthodologies éprouvées dans d'autres espèces peut permettre de rattraper ce retard dans le développement et la connaissance des secrets du lait de chamelle et de ses produits de transformation. De nombreux travaux ont abordé et comblé ce manque de connaissance et l'on trouve aujourd'hui des références significatives dans la littérature. Mais l'accompagnement de l'ensemble de la filière à tous ses étages, production, transformation, ou commercialisation, nécessite d'inclure les règles de décision de l'acheteur et du producteur de ce type de produit. Ce dernier point étant selon nous un nécessaire exercice de la recherche en vue d'actions opérationnelles, nous avons privilégié dans cet atelier une vision scientifique large recouvrant ces diverses images et des approches multidisciplinaires à différentes échelles de la filière cameline.

Au sein de la filière on peut organiser les unités d'étude significatives en « systèmes acteurs », mettant en œuvre des individus ou groupes humains et des procédés techniques, en présence d'informations diverses, et en interaction constante avec leur environnement. Ces approches incluent bien entendu, une connaissance de l'animal lui-même, une information sur le troupeau et sa gestion, un regard sur l'encadrement sanitaire et technique adéquat

1. Rey B., Thorpe W., Shapiro B., Smith J., Osuji P., Mullins G., Agyemang K., 1993. Improvement of Dairy Production to Satisfy the Growing Consumer Demand in SSA: A Conceptual Framework for Research. Addis Ababa, Ethiopia, ILCA, 16 p. (MOSD working paper 1)

Mullins G., Rey B., Nokoe S., Shapiro B., 1994. A research methodology for characterising dairy product consumption systems. Addis Ababa, Ethiopia, ILCA, 40 p. (MOSD working paper 2).

dans les zones d'élevage et de collecte, qui soient aptes à augmenter la production naturelle de base de l'espèce sans transformation exagérée des pratiques. L'appui sanitaire de qualité, une meilleure information sur le suivi des pâturages et leur amélioration, l'évaluation et l'usage d'une complémentation en sous-produits agricoles, en particulier dans les zones d'échanges où cela est possible, sont autant de thèmes de recherche devant aboutir à des recommandations du domaine technique.

Cadre juridique, commercial et politique de la filière

Il nous appartient dès maintenant de poser les bases d'un environnement juridique, commercial et politique de ce type de production. Il est par exemple nécessaire de participer, par la santé publique vétérinaire et par d'autres approches qualitatives, à la définition globale de la qualité des produits requise pour une promotion sur les marchés actuels mais aussi dans des marchés d'exportation en Afrique, au Moyen-Orient, ou même sur des segments de marché européens. A ce titre, il est important de noter que la réglementation de la Communauté européenne (CE) est dans un processus d'adaptation à ce type de produits. En effet, suite à des demandes d'exportation de la Mauritanie vers l'Union européenne (UE), les services de la législation vétérinaire et zootechnique de la Direction générale de l'agriculture de la Commission ont proposé au Conseil la modification de l'annexe II, chapitre 2 de la directive 92/118/CEE du 17 décembre 1992 dite directive « balai ». Ce fondement juridique en cours dans l'UE vise à l'établissement d'une base juridique pour la prise de décisions spécifiques ultérieures adaptées aux produits concernés. Ce projet n'est pas adopté à ce jour et est en cours de procédure. En absence de ces bases, aucun texte communautaire ne fixe de normes spécifiques pour les produits laitiers et laits de camelins, mais elles seront établies en dehors de toute référence aux normes des autres espèces, les camélidés n'étant pas couverts par la directive 92/46/CEE qui fixe ces normes, par exemple pour les bovins.

D'autre part la procédure d'établissement des normes bactériologiques CE va bientôt être revue pour être conforme aux normes internationales en ce domaine, basées en particulier sur la connaissance scientifique et sur les techniques d'évaluation des risques. Cela permet de penser que des autorisations seront accordées sous réserve de la garantie des conditions sanitaires requises de fabrication (statut des unités laitières), de production (statut des cheptels), et sous la condition que des recherches complémentaires soient conduites en matière de sécurité alimentaire ; dans le domaine de la santé publique vétérinaire, la salubrité des produits et la santé du cheptel de production en matière de tuberculose par exemple, doivent être étudiées. Les marchés traditionnels en zone islamique sont probablement les premiers visés sur ce segment exclusif, encore réservé aux producteurs des pays chauds. La consommation de produits alimentaires reflétant encore beaucoup les valeurs des diverses cultures et une éducation du goût qui est largement variable dans le monde, on peut s'attendre à un succès de certains produits laitiers encore nouveaux ou à venir sur les marchés urbains.

Dans ce cadre, des travaux mettant en jeu l'analyse sensorielle en milieu réel (futur marché cible) manquent encore à l'appel. Or on sait que le plus souvent le marché actuel du lait de chamelle est relativement bien segmenté et différencié du lait de bovin. De même, le rôle des politiques sectorielles est important pour accompagner l'émergence de telles filières et leur permettre d'acquérir une compétitivité économique et des segments de marché. La prise en main de ce secteur est donc nécessaire à tous les niveaux, et par tous les acteurs, publics ou privés. A ce niveau de connaissance, il n'est pas exclu que dans le cadre des évolutions sanitaires en Europe (BSE) ou dans le cadre de la globalisation des échanges commerciaux, des segments de marché pour le lait de camelin et ses produits laitiers soient ouverts en Europe — ou au moins sur le marché musulman. Cela pourrait contribuer à la création d'élevages laitiers sur le territoire européen dans le cadre de la diversification de l'agriculture, en particulier dans les zones méditerranéennes ; l'exemple récent des élevages d'autruches est à ce titre significatif. Cette éventualité placerait d'ailleurs cette espèce dans le cadre officiel des programmes de recherche nationaux et européens propres aux espèces animales élevées sur le territoire de l'UE.

De la recherche au développement

Pour ce qui concerne les produits laitiers fabriqués en milieu traditionnel, il est important de percevoir la demande et l'acceptation des innovations (comme les nouveaux produits de report) proposées en milieu pastoral, et de s'assurer de leur appropriation par certains acteurs de la vie nomade, les femmes par exemple. Dans tous les cas l'étude des systèmes d'élevage actuels a été menée suffisamment loin pour qu'on puisse établir, dans des environnements précis, les référentiels techniques des performances respectives de ces systèmes camelins. Les systèmes de gestion mis en œuvre participent à la fois à la maintenance d'une dynamique des troupeaux par un renouvellement par les jeunes protégés et nourris au lait maternel, et à la création d'un excédent nutritionnel pour les membres du noyau familial ou clanique.

Cette confrontation et cette mise en balance doivent être gardées à l'esprit quand on décide d'améliorer la production laitière d'une espèce cible par les pratiques, l'encadrement, la sélection. C'est l'ensemble du processus d'accompagnement qui doit être pris en compte par les projets, car les facteurs contribuant à l'élaboration ou à l'amélioration d'une performance de production, doivent conserver leurs rôles traditionnels au moins à leur niveau de départ. Des essais en station et en milieu paysan ont montré la forte sensibilité de la production laitière cameline à l'amélioration d'un facteur de production, par exemple l'action sur la contrainte sanitaire ou alimentaire. Dans tous les cas les progrès réalisés dans ces productions entraîneront une demande de recherche émergente qui n'est pas près d'être tarie, au vu de l'exemple des autres filières de ruminants.

Il est cependant nécessaire d'ajuster les résultats théoriques de la recherche aux logiques des éleveurs. L'exemple de l'amélioration de la reproduction peut ici être mis à contribution, car s'il est important de connaître les bases fondamentales et multidisciplinaires de la physiologie de la reproduction de la chamelle en ce domaine — les interactions alimentation-reproduction par exemple —, il est nécessaire de respecter l'équilibre global du système de production issu des rythmes naturels de mises bas dans les milieux pastoraux. La vitesse de reproduction, la diminution des pertes numéraires de jeunes sont autant de facteurs déterminants de l'équilibre du système pastoral mis en œuvre par l'éleveur. Il est probable que les améliorations les plus significatives mais les plus risquées en ce domaine seront à mettre en pratique dans les ranchs commerciaux ou les fermes améliorées, disposant d'une liberté de gestion foncière, et de l'encadrement général nécessaire. Les efforts visant à accroître la production laitière devront être accompagnés par un suivi des effets sur l'ensemble du système mis en œuvre et sur son environnement. L'introduction de techniques comme l'insémination artificielle (encore mal maîtrisée) peut être envisagée dans des systèmes bien contrôlés, en particulier pour accélérer la sélection des animaux.

Parmi les facteurs socio-économiques et techniques relevés dans une étude de l'ILCA[2] portant sur les déterminants du développement de la filière laitière en Afrique, on peut relever plusieurs facteurs qui semblent potentiellement importants pour la filière laitière cameline. Mais quelles que soient les conclusions tirées des diverses études sur d'autres espèces, il reste qu'une analyse systémique large du système particulier que constitue une filière, et de ses sous-systèmes (production, commerce,...), nécessite une planification stratégique nationale et internationale des activités de recherche sur toute la filière et à diverses échelles d'étude. Cela est nécessaire avant de parvenir à une connaissance suffisamment précise des déterminants des performances économiques ou sociales des systèmes mixtes et complexes mis en œuvre entre l'animal, l'homme, et l'environnement. C'est la condition qui doit permettre le transfert et l'acceptation de connaissances théoriques vers les acteurs pratiques de cette filière, sans risques majeurs de rejet ou d'échecs techniques.

Afin d'alimenter ce débat sur la recherche et le développement de la filière laitière cameline, nous avons souhaité réunir dans le cahier hors texte de ces actes, des documents illustrant des exemples d'amélioration et d'adaptation de procédés et de produits à l'intérieur des filières camelines ; le lecteur y trouvera un éclaircissement sur des thèmes cités dans les actes du colloque. Il pourra aussi se reporter aux lexiques français-anglais et anglais-français des termes usuels de la filière laitière, afin que lui soit facilitée la lecture de tous les articles. A titre d'illustration encore, des exemples de conditionnement publicitaire et diverses fiches techniques sont reproduits.

2. Rey B. *et al*, 1993, *op. cit.*

Présentation de l'élevage du dromadaire en Mauritanie

Introduction to dromedary's husbandry in Mauritania

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LA PLUS GRANDE PARTIE DU TERRITOIRE MAURITANIEN (superficie totale : 1 036 000 km²), est de type saharien. La superficie des terres cultivables (oasis inclues) atteint à peine 4 500 km². La pluviométrie ne dépasse 100 mm par an, qu'au sud d'une ligne reliant Nouakchott à Tidjika. Dans cette frange sud vivent 85 % des habitants du pays pour une population totale de 2 380 000 habitants en 1993 ; ils y exploitent 140 000 km² de potentialités sylvo-pastorales avec 1 100 000 bovins, 8 800 000 petits ruminants et 1 080 000 dromadaires.

L'élevage traditionnel des dromadaires

La Mauritanie est le « pays de la soif » ; le dromadaire est l'animal domestique qui lui convient le mieux. Les sécheresses successives, de 1968 à 1983, ont confirmé, s'il en était besoin, la supériorité des animaux à bosse sur les bêtes à cornes lors de dégradations des cycles climatiques.

Mode d'élevage

En Mauritanie, les déplacements de familles entières sont uniquement conditionnées par l'alimentation et l'abreuvement des dromadaires. Traditionnellement, les productions du troupeau sont particulièrement importantes pour les populations (notamment les populations sahariennes), qui en tirent l'essentiel de leur revenu et de leurs moyens de subsistance. A cet égard, le lait représente l'aliment de base, disponible tout au long de l'année, sauf en période de sécheresse. La consommation de viande est plutôt exceptionnelle chez les éleveurs, à l'occasion de fêtes ou de visites d'hôtes de marque.

La commercialisation des dromadaires approvisionne les boucheries de certaines villes du nord du pays, et il arrive que l'on sèche la viande (« *tichtar* ») d'un animal abattu pour la consommation familiale durant l'année. Les poils et les peaux des animaux sont utilisés pour la confection des objets et ustensiles artisanaux, notamment les tentes, résidences principales ou secondaires de la plupart des Mauritaniens. La vente ou le troc des animaux sur pied permettent de couvrir les autres besoins familiaux, surtout l'achat de céréales (sorgho) qui constitue la base du repas quotidien. Pour cela, il n'est pas exagéré de dire qu'en Mauritanie, l'homme et le dromadaire vivent en véritable symbiose.

Effectifs

Les effectifs camelins de Mauritanie sont donc estimés à un 1 080 000 têtes, et sont en croissance continue. La plupart des animaux se déplacent au nord de l'isohyète 400 mm et fréquentent peu les régions méridionales, par crainte de la trypanosomose. Les plus fortes densités se situent à l'ouest du pays dans les régions du Trarza et de l'Inchiri, du fait de l'existence sur la côte de pâturages salés très appréciés.

Production

Transport et biens d'équipement

Le dromadaire est utilisé traditionnellement pour le transport des hommes et des marchandises, ainsi que pour la confection des tentes évoquée plus haut ; ces apports en travail et en biens de consommation sont difficilement chiffrables mais d'une importance capitale.

Lait

Les femelles adultes représentent 40 % de l'effectif. Elles se reproduisent en moyenne une année sur deux, avec un taux de fécondité annuel de l'ordre de 60 % et une mortalité chez les jeunes se situant aux alentours de 15 %. La production de lait par femelle suitée est au minimum de 400 litres par an ; la production nationale de lait de dromadaire serait voisine de 40 millions de litres par an.

Viande

La production annuelle de viande cameline est de l'ordre de 17 100 tonnes par an (viande et abats confondus : 150 kg de carcasse et 30 kg d'abat par animal). Elle représente le quart du total des viandes produites en Mauritanie. Les exportations annuelles sont estimées à environ 32 000 têtes.

La filière lait de dromadaire à Nouakchott

Le phénomène récent d'urbanisation des populations nomades à la suite des sécheresses des deux dernières décennies (plus du quart de la population mauritanienne vit maintenant à Nouakchott) a contribué à accroître les effectifs des dromadaires aux abords de la capitale et des principaux centres urbains, le long des principaux axes routiers qui les approvisionnent. Le lait de chamelle, qui constituait hier encore la base de l'alimentation dans la campagne mauritanienne, est désormais aussi consommé en ville. Cette intégration du lait de camelin dans l'alimentation a donné naissance à un nouveau mode d'élevage de type semi-intensif, voir intensif, dont la finalité première est la vente de lait.

Les élevages laitiers consomment en totalité la paille de riz produite par les périmètres irrigués de la wilaya du Trarza et les farines basses de récupération. La demande des éleveurs péri-urbains dépasse l'offre, et les prix sont élevés. Le prix de vente du son de riz sorti d'usine est égal voire supérieur au prix d'achat du paddy chez le producteur, situation paradoxale dans laquelle l'élevage devient une sorte de « garant » de l'agriculture.

Une filière lait s'est ainsi organisée à Nouakchott et dans les principaux centres urbains. Elle concerne l'approvisionnement en aliments et la vente du lait : vente directe du producteur au consommateur de lait frais, ou vente indirecte de lait pasteurisé par l'intermédiaire de la laiterie de Nouakchott - dont l'unité de transformation, qui vient tout récemment de se doter d'une fromagerie, pourra être visitée par les participants au colloque.

La recherche mauritanienne

La recherche vétérinaire en Mauritanie est conduite par le Centre national d'élevage et de recherches vétérinaires de Nouakchott (CNERV). En matière d'élevage camelin, ce centre est appuyé depuis 1990 par un projet spécifique d'encadrement des éleveurs et de recherche-développement, intitulé « Développement de l'élevage dans la wilaya du Trarza ». Ce projet a été élaboré sur financement français pour un montant de 3 200 000 FF (80 millions d'UM). La composante recherche-développement du « projet Trarza », mise en œuvre essentiellement dans les élevages péri-urbains, a permis d'obtenir des informations sur :

– les affections dominantes à incidence économique et l'efficacité des traitements appliqués ;
– les performances zootechniques des femelles en lactation et de leurs chamelons ;
– l'économie des systèmes laitiers rencontrés dans ce type nouveau d'élevage ;
– les contraintes inhérentes au lancement d'une unité de transformation (collecte, purification, commercialisation, maintenance,...).

Ces travaux et leurs conclusions seront présentés en détail dans les discussions avec nos collaborateurs du CNERV et du projet Trarza.

Communications

Introduction aux communications

LES PREMIÈRES TENTATIVES D'ENCOURAGEMENT DES FILIÈRES CAMELINES, et de mise au point de produits laitiers à base de lait de chamelle, sont toujours un défi. Pour le relever, il est nécessaire de conjuguer les intérêts des opérateurs de la filière à un moment opportun, et d'obtenir une adhésion générale au lancement de projets de recherche dans ce domaine. Fort heureusement, nous sommes quelques-uns dans le milieu scientifique, à être persuadés qu'un animal comme le dromadaire ou le chameau, représentant la tradition pastorale et réparti sur tous les espaces pastoraux et périurbains arides, devrait être l'objet de beaucoup d'innovations. Ces dernières ne devraient pas être seulement destinées aux systèmes modernes d'exploitation (le secteur périurbain par exemple) mais aussi aux systèmes d'élevage traditionnels pastoraux.

C'est pourquoi je suis heureux de présenter les actes d'un atelier de recherche consacré à la filière laitière cameline.

Nous savons tous que l'impact de nos recherches doit mieux apparaître sur le terrain. C'est la raison pour laquelle certaines communications présentent des réalisations pratiques, tandis que d'autres sont volontairement réduites à des expériences de laboratoire. Les deux approches sont bien sûr utiles, et les éleveurs mauritaniens qui ont assisté à l'atelier de Nouakchott ont bien compris l'intérêt de nos résultats pour leurs activités.

Les actes du colloque sont organisés autour de trois grands thèmes intimement liés à la filière laitière :

- ❒ A : pratiques d'élevage ; pathologie ; génétique.
- ❒ B : composition du lait ; caractéristiques du lait ; technologie laitière ; produits laitiers.
- ❒ C : économie de la filière lait frais ; systèmes laitiers ; stratégies pour la transformation du lait[1].

Je remercie tous les participants pour leur contribution à ce travail.

Dr Pascal BONNET
Editeur scientifique

1. Ce thème comprend la visite d'une unité de transformation du lait et la présentation d'un ferment fromager spécifique (voir annexes, p. 285-288).

Introduction to the communications

First attempts in supporting camel commodity systems, and producing camels' milk products are always a challenge. It needs conjunction of interest, opportunities and an overall feeling of agreement to launch research projects in this topic. Fortunately some of us in the scientific sphere, are persuaded that an as traditional and well spread animal like camel should be the base of a lot of innovations. These innovations should not be directed and devoted only to modern farming systems using this species (peri urban subsector), but also to the traditional pastoral production systems.

Therefore I am really satisfied to present these proceedings devoted to the dairy subsector of camels.

We all know that the beneficial repercussions of our research have to become more apparent in the field. Consequently some papers are devoted to a presentation of the field while others are reducted to lab training. Both of them are usefull, and the herders who where present during the workshop in Nouakchott have well understood the output of the research for their activities.

The proceeding are published through 3 main topics linked to dairy subsector:

- ❒ *A: livestock farming practices; animal pathology; animal genetics.*
- ❒ *B: milk composition; milk characteristics and qualities; dairy technology; dairy products.*
- ❒ *C: dairy sector economics; milk production system; planning the cheese and milk production processes*[1]*.*

I thank all the participants for their active contribution to this work.

Dr. Pascal Bonnet
Editor

1. Including the visit of a milk processing unit and the demonstration of a specific cheese making starter (see annexes, p. 285-288).

Thème A/*Topic A*

Pratiques d'élevage/ *Livestock farming practices*

Pathologie/*Animal pathology*

Génétique/*Animal genetics*

Président/*Chairman*: M. FALL

Animateur/*Facilitator*: I.H. ABU-LEHIA

BONNET P. (éditeur), 1998.
Dromadaires et chameaux, animaux laitiers / *Dromedaries and camels, milking animals.*
Actes du colloque, 24-26 octobre 1994, Nouakchott, Mauritanie.
Montpellier, France, Cirad, 304 p. + X p. hors texte.
(collection Colloques)

Detection of subclinical mastitis in camels: relationship between udder infection and inflammatory indicators in milk

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Abstract. An analysis was made of 180 and 391 quarter milk samples from 7 Bactrian and 101 dromedary camels respectively to study the occurrence and cause of mastitis and to evaluate the value of California Mastitis Test (CMT), Somatic Cell Count (SCC) and adenosine triphosphate (ATP) in predicting udder infection in the camel. About 43% of the quarter milk samples from dromedary camels yielded pathogenic bacteria. *Streptococcus agalactiae*, other *Streptococcus* spp., *Staphylococcus aureus*, coagulase-negative *Staphylococcus* spp., and *Escherichia coli* were recovered. Bacteria were isolated from 23.3% of the 180 Bactrian's milk samples examined. *Staphylococcus aureus*, coagulase-negative *Staphylococcus* spp. and *Corynebacterium bovis* were isolated. Infected quarters had generally higher mean values for SCC and CMT than non-infected quarters. The presence of cell fragments in camel's milk makes cell count difficult. CMT was comparatively more accurate in predicting udder infection status than SCC.

Key words. Camel, *Camelus bactrianus,* Dromedary, *Camelus dromedarius,* milk, pathology, mastitis, pathogen, diagnosis, Sudan, Sweden.

Résumé. Une étude a été menée sur 180 et 391 quartiers mammaires échantillonnés à partir de 7 chameaux de Bactriane et 101 dromadaires respectivement, afin d'étudier l'incidence et l'origine bactérienne des mammites ainsi que pour évaluer la qualité des tests CMT (California Mastitis Test), SCC (Somatic Cell Count) et ATP (adénosine triphosphate) dans la prévention et la prédiction de l'infection mammaire chez les camelins. Environ 43 % des échantillons de lait provenant des dromadaires révèlent des bactéries pathogènes. *Streptococcus agalactiae*, d'autres *Streptococcus* spp., *Staphylococcus aureus*, *Staphylococcus* spp. à coagulase négative et *Escherichia coli* ont été isolés. Des bactéries ont été retrouvées sur 23,3 % des 180 échantillons de lait de chameaux de Bactriane examinés. *Staphylococcus aureus*, *Staphylococcus* spp. à coagulase négative et *Corynebacterium bovis* ont été isolés. Les tests SCC et CMT présentent en général des valeurs moyennes supérieures, pour les quartiers infectés, que pour les quartiers non infectés. La présence de nombreux fragments cellulaires dans le lait de camelin a rendu les dénombrements cellulaires difficiles. Comparativement, le CMT a été plus sensible pour prévoir l'infection de la mamelle que le SCC.

Mots clés. Chameau, *Camelus bactrianus,* dromadaire, *Camelus dromedarius,* lait, pathologie, mammite, agent pathogène, diagnostic, Soudan, Suède.

Introduction

Mastitis is a complex disease occurring worldwide among dairy animals, with heavy economic losses largely due to subclinical mastitis. There is extensive literature on bovine mastitis and to a lesser extent on ovine and caprine mastitis. Very little is known about mastitis in the camel. The disease was believed to be rare in the camel (LEESE, 1927). However, cases of mastitis in the camel have recently been reported from different countries, e.g. Egypt (MOSTAFA *et al.*, 1987); India (KAPUR *et al.*, 1982); Saudi Arabia (BARBOUR *et al.*, 1985; HAFEZ *et al.*, 1987); Somalia (ABDURAHMAN *et al.*, 1991; ARUSH *et al.*, 1984); Sudan (OBEID, 1983) and the United Arab Emirates (QUANDIL and OUDAR, 1984). Few available data also indicated a high prevalence of udder infection in the camel (BARBOUR *et al.*, 1985 ; MOSTAFA *et al.*, 1987).

Clinical mastitis in the camel can be detected by examination of the udder and/or of the milk. Detection of subclinical mastitis, on the other hand, is difficult and depends mainly on indirect procedures. Bacterial infections are considered the primary cause of mastitis in domestic animals. Camels under pastoral systems are usually kept in the far bush where laboratory facilities are scarce or unexisting. Hence bacteriological examination of milk presents considerable difficulties.

Normal mammary gland secretions from dairy ruminants contain leucocytes, mainly neutrophils, macrophages and lymphocytes, derived from the blood and epithelial cells from the glandular epithelia and lactiferous ducts of the mammary gland (SCHALM *et al.*, 1971). The proportion of each cell type varies, depending on the stage of lactation and on health status of the gland. Mastitis results in milk compositional changes such as increase in leucocyte count, leakage of plasma proteins into the milk, cell damage resulting in leakage of intracellular constituents into milk, change in ion composition; and also decrease in milk production. Many indirect tests based on these changes have been introduced for screening purposes. The merits of these tests in relation to various physiological and pathological states of the mammary gland have been extensively studied in cows (EMANUELSON *et al.*, 1987; KITCHEN, 1981), ewes (MAISI *et al.*, 1987) and goats (DULIN *et al.*, 1982), but are not described for the camels.

This communication presents findings on the morphology of cell fragments found in camel's milk and reports the occurrence and causes of mastitis in both zoo and traditionally managed camels. It also attempts to evaluate the value of indirect mastitis tests i.e California Mastitis Test (CMT), Somatic Cell Count (SCC) and the level of adenosine triphosphate (ATP) in predicting udder infections in the camel.

Materials and Methods

Animals

Seven Bactrian camels (*Camelus bactrianus*), at different lactation stages, kept at the zoological park of Kolmården, Sweden, and 101 dromedary camels (*Camelus dromedarius*) kept by nomadic pastoralists under traditional management in eastern Sudan were used. The camels were at varying age and lactation stages. Bactrian camels were free from clinical mastitis during the whole sampling period.

Sampling

Bactrian camels were sedated in a standing, slightly cataleptic state. The udder of each camel was examined for abnormalities and the secretion inspected. The teats were cleaned and about 8 ml of milk was collected. A total of 180 (repeated sampling during one year period) and 391 quarter milk samples from Bactrian and dromedary camels respectively were collected and transported to the laboratory or the nearest field camp. A portion of the dromedary's milk was transfered to a device specially designed for sampling and preserving milk for bacteriological and ATP analysis, MASTISTRIP (NILSSON, 1994). In order to get secretions from the non-lactating Bactrian camel's udders, about 40 ml of 0.01 M phosphate buffered saline, pH 7.2 (PBS) was infused into the udder. The udders were massaged and stripped.

Isolation of cells from mammary gland secretions

Milk was diluted in PBS and centrifuged for 20 min at 800 x g. The fat layer on top and cell-free milk were removed. The cell pellet was washed twice in PBS. The cells from the non-lactating udder secretions were concentrated by centrifugation.

Electron microscopy

Cells from milk and from udder washings were fixed in glutaraldehyde, processed and examined under a Philips TEM 420 electron microscope at 60 kV.

Bacteriological examination

The MASTISTRIP paper discs were cut in RPMI solution and the mixture or milk samples were cultured on bovine blood agar plates. Colonies were picked and identified according to a standard procedure (KALSTRUP, 1975).

Somatic Cell Count (SCC)

The SCC was done using the microscopic method according to PRESCOTT and BREED (1910).

California Mastitis Test (CMT)

The test was carried out as described by SCHALM and NOORLANDER (1957).

Adenosine triphosphate (ATP)

ATP was measured using the bioluminescence technique (Wallac/LKB) (OLSSON *et al.*,1986).

Results

Bactrian camels

Ultrastructural study revealed the presence of large numbers of cell fragments in camel's milk. The cell fragments were bounded by a plasma membrane, had no nuclei and contained mitochondria and abundant

rough endoplasmic reticulum (RER). Macrophages were the dominant cells recovered from milk and udder washings during the dry period. Neutrophils and lymphocytes were also present.
Intramammary infections were present in 42 (23.3%) quarter samples. These were represented from all seven animals. Coagulase-negative *Staphylococcus* spp. represented 64.3% of all the isolates. *Staphylococcus aureus* was the second most prevalent with 33.3%. *Corynebacterium bovis* was isolated only once (2.4%). Infected udder quarters had higher mean values for SCC and CMT than uninfected quarters. SCC showed significant correlation with the CMT scores.

Dromedary camels

One hundred and seventy (43.5%) of the quarter milk samples yielded pathogenic bacteria. *Streptococcus agalactiae*, other *Streptococcus* spp., *Staphylococcus aureus*, coagulase-negative *Staphylococcus* spp., and *Escherichia coli* were recovered. Thirty two (8.2%) of the quarter milk samples yielded mixed culture, while 189 (48.3%) yielded no growth.

The mean values for CMT, SCC and ATP were higher in quarters infected with major pathogens. However, there was a significant number of quarter milk samples which gave elevated values in these tests and from which no bacteria were isolated. The predictive ability of the tests increased slightly when two or three tests were combined.

Discussion

The microorganisms isolated in these studies are regarded as important mastitis pathogens in camels (BARBOUR *et al.*, 1985; MOSTAFA *et al.*, 1987), cows (SCHALM *et al.*, 1971), sheep (MAISI *et al.*, 1987) and goats (PETTERSON,1981).

The study demonstrates that cell fragments are the predominant and constant feature in camel's (*Camelus bactrianus*) milk. Their ultrastructure is similar to cytoplasmic fragments found in goat's milk (DULIN *et al.*, 1982). SCC in milk is widely used as an indicator of the degree of inflammation of the udder and to predict udder infection (POUTREL and RAINARD, 1982). It is also the basis of most indirect tests for subclinical mastitis. CMT is one of these indirect mastitis screening tests where the degree of gel formation is related with the number of cells in milk.

The finding of cell fragments in camel's milk have important practical implications. Since the cell fragments lack nucleus they do not react with reagents of some mastitis indicators like California Mastitis Test (SCHALM *et al.*, 1971). They might, however, be counted as cells when using direct microscopy for detection of subclinical inflammation. DULIN *et al.* (1982) suggested the use of methods employing specific dyes for DNA such as fossomatic counting. In this study the direct microscopic method was used. It is indeed difficult to differentiate proper cells from cell fragments when using the direct microscopic SCC method. It is possible that there has been an underestimation of cell counts when using the direct method in an attempt to avoid counting fragments which may constitute up to 95 % of the total particles in milk (ABDURAHMAN *et al.*, 1992 ; DULIN *et al.*, 1982).

KOSPAKOV (1976) reported a mean of 1.3 million cells in milk samples from uninfected Bactrian camels. BARBOUR *et al.* (1985) applied CMT on composite camel's milk samples and stated that the test was useful for screening subclinically infected udders. OBEID (1983) found a good correlation between milk leucocyte count and "Rapid Mastitis Test". In the present study, infected udder quarters had higher mean values for SCC and CMT than uninfected quarters. There is a trend for a positive relationship between high CMT score, elevated SCC and presence of bacteria in milk. CMT was found as the most suitable in detecting udder inflammation.

Acknowledgement

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Milk production potential of dairy camels in northern Saudi Arabia

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Abstract. Milk production potential of 4 Saudi camel colours or breeds was recorded during 3 consecutive lactations and daily milk yield of different camel breeds were compared. Malhah camel breed produced the highest daily milk yield: 9.33 kg/head, followed by Wadhah camel breed 8.94, Safrah camel breed 8.13 and Hamrah camel breed 6.83 kg/head. A maximum daily milk yield of 18.3 and 14 kg/head were observed for Malhah and Wadhah respectively. Raised under improved management system with a very low investment costs, selected camel breeds like Majaheem (Malhah camels) can be recommended for camel dairy farming.

Key words. Dromedary, *Camelus dromedarius,* milk production, breed, lactation, Saudi Arabia.

Résumé. Le potentiel de production laitière a été enregistré sur 4 phénotypes ou races de chamelles saoudiennes, pendant trois lactations consécutives, et les productions laitières journalières des différents types camelins ont été comparées. La race cameline Malhah a produit le rendement journalier le plus élevé : 9,33 kg par tête, suivie par la race cameline Wadhah (8,94), la race cameline Safrah (8,13) et la race cameline Hamrah (6,83 kg par tête). Un maximum de production laitière journalière de 18,3 et 14 kg par tête a été observé respectivement chez les races Malhah et Wadhah. Le choix de la race Majaheem (chamelles Malhah) peut être recommandé afin de relancer l'élevage laitier camelin, dans le cadre d'une gestion technique améliorée, à des coûts d'investissement faibles.

Mots clés. Dromadaire, *Camelus dromedarius,* production laitière, race, lactation, Arabie Saoudite.

Introduction

According to statistics of the MINISTRY OF AGRICULTURE AND WATER (1988), camel population of Saudi Arabia is estimated at 400,000 heads of Arabian camels or dromedaries (*Camelus dromedarius*). Camels are mainly raised under traditional pastoral system throughout the country. During the last survey carried out by the Range and Animal Development Research Centre, regarding geographical distribution of camel breeds, one shows the presence of 4 main local camel types or breeds indentified according to the colour of the body and to local Arabic names as follow:

- Breed n° 1: Malhah = Majaheem = Black colour;
- Breed n° 2: Wadhah = Maghateer = White colour;
- Breed n° 3: Safrah = Dark brown;
- Breed n° 4: Hamrah = Light brown-red.

Other camel colours were reported and classified as a result of cross breeding of the above 4 breeds.

Local camels are multipurpose animals; meat and milk production are the main objectives of camel farming. Camel's meat is consumed by a large number of Saudis, 25% of red meat consumption in the Kingdom was provided by slaughtering camels (MINISTRY OF FINANCE AND NATIONAL ECONOMY, 1987). Camel's milk is consumed in large quantities mainly during ceremonies and parties offered by Saudis officials, the market price of camel's milk is almost the double of the cow's milk price.

Considering the harsh climate of the Kingdom of Saudi Arabia, with very low annual rainfall and very hot climate during the 2/3 of the year, the economic importance of camel has been proved by its physiological and anatomical adaptation to such harsh conditions prevailing in the Arabian Peninsula.

Despite economic and social role of camels as a symbol of wealth and social prestige in the Kingdom, productive parameters of camels are poorly understood for an objective evaluation of its potential in supplying local market with meat and milk.

This paper describes the potential of milk production of 4 main camel breeds in the Kingdom based on experimental data collected during 1988-1990 production seasons at the Camel Research Station of the Range and Animal Development Research Centre based at Al-Jawf in northern Saudi Arabia.

Geography and climate of northern Saudi Arabia

The area covered by the research activities of the above Research Centre includes the northern part of the Kingdom (figure 1) limited at the north 28°N by the international borders with Jordan and Iraq and approximately laying from 38°E to 42°E. It included Al-Jawf, Gurayat and Ar' ar districts. Rangelands cover more than 90% of the area and have served as the major source of feed in the livestock production followed by local Bedouin tribes (BHATTACHARYA, 1988).

Figure 1. Map of the kingdom of Saudi Arabia.

An arid climate dominates the area, with a very hot summer where day temperature can exceed 40°C in July and August (figure 2*a*) and a cool winter. Rainfall is erratic with an average of 40-50 mm per year as recorded over a period of 10 years at Kuneitra Research Station (figure 2*b*). Winds are relatively strong in the winter as well as in summer, increasing the evaporation and desiccating sparse vegetation.

Soil resources vary according to the topography of the region. Deep sandy soils are found in the Great Nafud desert (sand). Best soils are found in the wadis and around oasis having good moisture storage capacity.

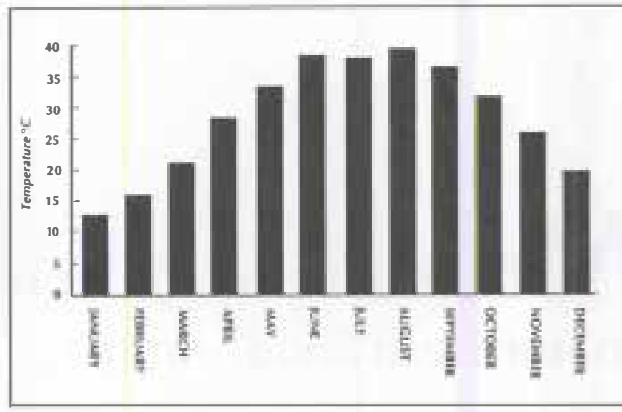

***Figure 2a.** Air temperature recorded at Kuneitra station during 1984-1990.*

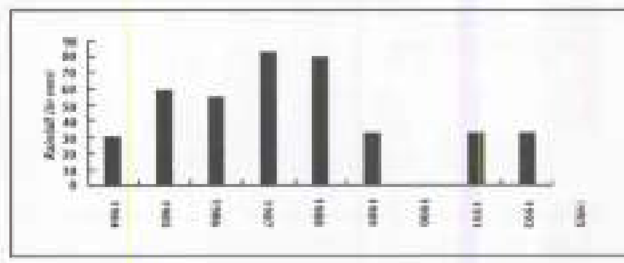

***Figure 2b.** Rainfall (in mm) at Kuneitra station, 1984-1993.*

The plateau of the Hammad and Al Harrah are characterized by limestone gravel plains with depressions and dark basaltic stones and loamy depressions and wadis.

The vegetation cover tends to be sparse in the desert area and confined to depressions and wadis with supplement water as a result of run off. Shrubs and annual forb are the main common component of the vegetation, grasses are less frequent.

Materials and Methods

Animal material

As it has been mentioned earlier, the camel herd of the Centre was used in this study to investigate production parameters of local Saudi camels under improved management system. The camel herd was purchased by the Centre in 1983 from Al-Jawf area, to be raised under intensive feeding management. Camels were housed in shade pens and fed with green fodder or alfalfa hay and concentrates. During the purchasing period all camels were clinically examined as free of diseases. Test for brucellosis was carried out before purchasing of each animal. Table I summarises the actual composition and relative importance of different camel colours or breeds.

Table I. Presence of different camel colours or breeds at the camel farm of the Centre.

Camel colours or breeds	Malhah	Wadhah	Safrah	Hamrah	Other colours	Total
Number of heads	14	25	22	12	8	81
Percentage	17.28	30.86	27.16	14.81	9.87	100

Housing management of the camel herd

The camel herd moved from the former camel farm based at Kuneitra station to the new constructed camel farm at the site of the Range and Animal Development Research Centre near Al-Jawf airport in october 1988. Four similar sheds were constructed to house a camel herd size of 200 to 300 heads of mature camels. Each shaded pen is divided into 4 breeding pens for housing lactating camels with their calves.

All pens were made with metal posts and shaded with galvanized aluminium sheets. Pens were provided with permanent feeding troughs made of concrete and running through the whole length of the pens. Mobile water troughs were supplied from the local market.

Herd management

Green alfalfa and green barley were cultivated and fed as fresh matter or ordinary cured hay. A feeding plan based on restricted feeding system (versus *ad libitum* feeding system) was used to meet the requirement of camels according to their production stages and to avoid any excess fat deposition in the hump. Feed requirements of lactating camels were calculated as a percentage of live body weight using previous results of feeding trials carried on lactating camels. During feeding time, camels were divided into two groups according to their milk production level. Good lactating camels were supplemented with concentrate.

Nutrient contents of the diet were estimated using the results of proximate analysis of feed ingredients as reported by KEARL (1982). Camel's calves were separated from mothers at 3 weeks old and allowed for suckling only during milking time to enhance milk release by the mother. Calves were given a good quality forage with concentrates.

To facilitate data collection, all camels were tagged at birth or at arrival to the farm if purchased. Lactating camels were milked twice a day at 6.00 am and 5.00 pm. After the first milking lactating camels were daily taken to the range for grazing and walking with their calves at least for two hours. When brought back to the farm, calves were separated until the evening milking time. Calves were fed concentrate and forage *ad libitum.*

Female camels were mated in November-December to calve in next December-January. The camel herd was housed in sheds exposed to natural environment and bedded with normal sand. A based alfalfa hay diet was offered with a concentrate mixture supplement. Fresh water was offered *ad libitum*. Salt and a standard mineral mixture block were provided for licking.

Live-weight changes of lactating camels and their calves were recorded on monthly and bi-weekly basis respectively for mother and calf.

Milk sampling

Potential milk yield of individual lactating camels is recorded on bi-weekly basis.

Milk sampling technique consists of recording the total milk yield produced by each lactating camel for 24 hours in two milking times. Females were prepared the day before samples after finishing the second milking time (6.00 pm) of that day, and the calf was separated over 12 hours. The next day morning (6.00 am), the right half of the udder will be milked and the quantity of milk is recorded as Q1, the other half is left for the calf which is separated 1 hour later for another 12 hours. At evening milking time, the left udder is milked and the quantity of milk is recorded as Q2. The total milk yield produced by each lactating camel during 24 hours is noted QT = (Q1 + Q2) x 2. This method was more accurate than using the milk off take for sale.

Statistical analysis

Differences between means of daily milk yield of different camel colours were performed using LSD test (Least Significant Difference) (STEEL and TORRIES,1960).

Results and Discussions

Incidence of deliveries

During 1988, 1989 and 1990 production seasons, 50 camel deliveries were recorded (figure 3*a*). The delivery season lasted for 6 months from November to April which corresponded to the mating season in camel. The peak of deliveries was observed in December and January which represented 70% of total deliveries recorded. This distribution of camel deliveries can explain the presence of 2 peaks of daily milk in lactating camels as shown in figure 3*b*.

The peak of milk yield observed for Malhah, Wadhah, Safrah and Hamrah camel colours during different production seasons were the results of the first and second peaks of deliveries. The first peak is the highest because it represents 70% of the lactating camels. This peak is observed from 2 to 3 months of lactation (March-April). The second peak is less pronounced because it represents only 30% of the lactating camels and it occured between 6 to 7 months of lactation.

Variation of milk of different camel colours or breeds

Recorded for 3 years consecutively, the results of average daily milk yield for 4 camels colours: Malhah, Wadhah, Safrah and Hamrah are reported in table II. Lactating camels of Malhah colour recorded the highest milk yield on daily and early basis. Average daily milk yields of 9.33, 8.94, 8.13 and 6.83 kg were reached by Malhah, Wadhah, Safrah and Hamrah respectively. At peak of lactation the average daily milk yield performed by different camel breeds was 13.7, 10.86, 8.71 and 7.91 kg for Malhah, Wadhah, Safrah and Hamrah respectively.

Malhah and Wadhah milk potential is significantly higher ($P < 0.05$) than Safrah and Hamrah (table II). The peak of lactation is reached between 2nd and 3rd month for Malhah, Wadhah, Safrah and later on for Hamrah camel breed. The peak of lactation reported here for Malhah, Wadhah, Safrah and Hamrah which occurred between 2 to 3 months of lactation is similar to the results reported by Richard in Ethiopia (1985), Hjort in Somalia (1993) where the lactation peak of local camel occurred between 1 to 3 months after deliveries.

Lactation curves of different camel colours are presented in figure 4. Lactation curves of the 4 camel colours show less pronounced variation of milk yield among lactation stages in each camel breed which result in a higher persistence level of daily milk yield.

Results of milk production potential of local Saudi camels are comparable to those obtained in other Asiatic camel breeds. In Pakistan Yasin and Wahid (1957), Rao (1974) and Knoess (1980), reported a daily milk yield of 9-13 kg/head, 6.9-18.2 kg/head and 15-35 kg/head respectively.

During the 3 lactation seasons 1988-1990, the average milk yield of the whole camel herd was higher in 1988, followed by 1990 and 1989 (figure 3*b*). The lactation curve of the whole lactating camels in each season shows two peaks of milk yield corresponding to two groups of lactating camels according to the delivery calender in the camel herd. Seventy percent of the lactating camels started milking in December-January reaching the first peak of lactation in March, the second group of lactating camels with late delivery in February-March reached the peak (the 2nd peak) of lactation in May-June. This waving model of the lactation curve is dictated by the calving calender of the camel herd in each season (figure 4).

Effect of camel colours or breeds

Like other mammals, milk production in camel is under control of camel genotype and environmental conditions. Under similar conditions of camel husbandry the difference in milk production potential between Malhah, Wadhah, Safrah and Hamrah was significant ($P < 0.05$) and confirms the previous observations of Al Mutairi

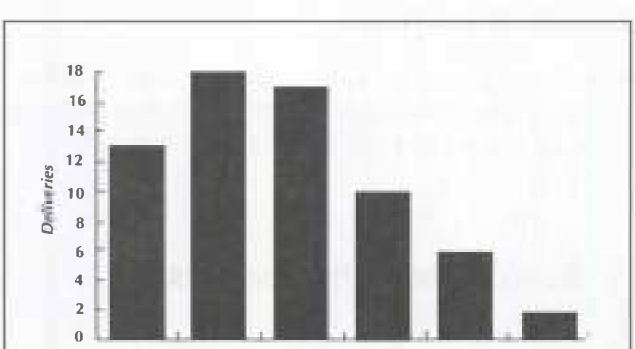

Figure 3a. *Incidence of deliveries in Saudi camels during three calving seasons.*

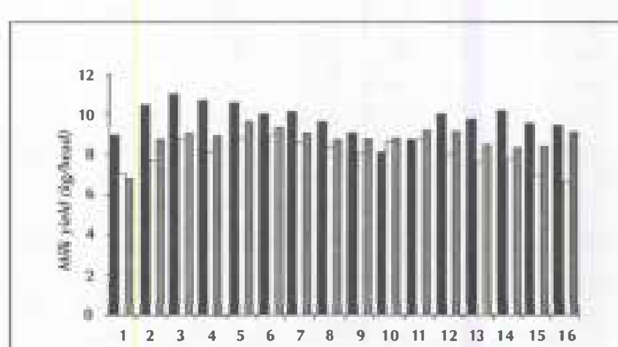

Figure 3b. *Variation of daily milk yield during different lactation seasons.*

Table II. Variation of daily milk yield of different colours or breeds (kg/head/day).

Camel colours	Lactation stages																Means
	1	2	4	5	6	7	8	9	10	11	14	15	16	17	18	19	20	
Malhah (black)	7.5	8.8	11.2	13.7	10.8	11.1	11.4	10.9	11.1	10.2	7.8	6.2	5.2	6.2				9.33a
Wadhah (white)	8.18	9.01	9.01	10.44	10.58	10.86	9.47	9.78	9.98	9.11	9.58	8.45	8.77	5.77	7.33	5.8		8.94ab
Safrah (brown)	7.07	7.64	8.52	7.82	7.82	8.71	8.17	8.35	8.36	8.2	7.9	8.04	7.6	7.6	6.73	7.8		7.95b
Hamrah (l. brown)	6.44	7.08	7.02	6.75	7.91	7.82	7.62	6.58	6.72	7.73	6.87	6.87	6.2	8.5	8.13	4.8	4	6.85c

a, b, c : means in the same row with different letters differ significantly at $P < 0.05$

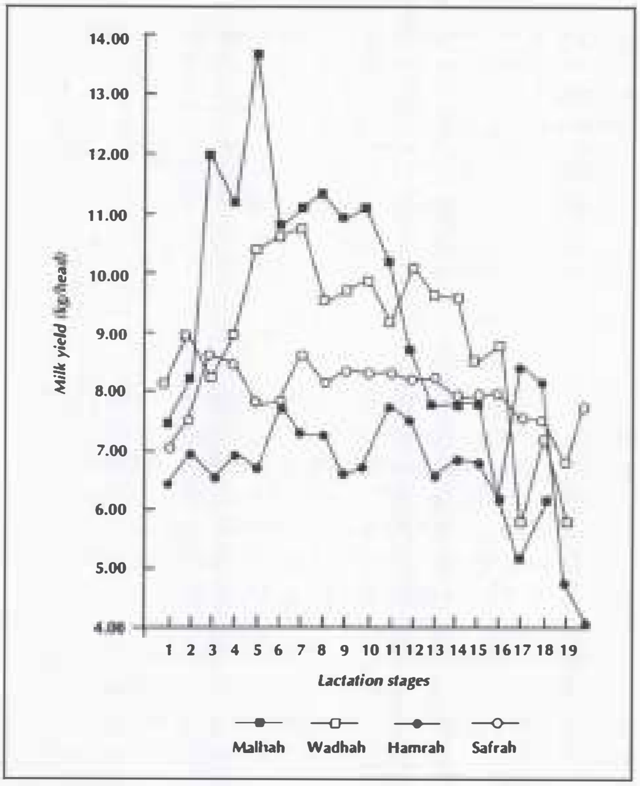

Figure 4. Variation of daily milk yield of 4 camel colours.

and Al Hashimi (1988), Ismail and Al Mutairi (1991) regarding to the classification of local camel breeds as dairy type animals and the relative importance of local camel breeds distribution in the Kingdom. Malhah camel breed was identified as the best milking camel and represented more than 50% of the camel population in some provinces of the Kingdom. A daily milk yield of 18.3 kg/head and 14 kg/head/day was recorded for Malhah and Wadhah camel breed in private farms during 1993 and 1994 seasons (Ismail, unpublished data).

Effect of the season and lactation stages

Despite the standard management plan of breeding and feeding adopted at the dairy camel farm of the Range and Animal Development Research Centre, a slight variation of milk yield of camel colours was observed when comparing the results of milk yield for the same breed during different calving seasons. The differences between camel colours were not significant but sources might be the variation of the lactating camel groups from one season to another. Lactating camels for the first season will be pregnant in the next season therefore lactating camels of paired and unpaired lactation seasons have to be compared. The milk yield recorded in this farm during 1988 and 1990 lactation seasons was almost the same for these two seasons. For 1989 lactation season the milk yield is lower because a second group of lactating camels was used and the proportion of Malhah, Wadhah, Safrah and Hamrah was different from the previous

Table III. Variation of daily milk yield (kg) during 1998-1990 lactation seasons.

Lactation seasons	Lactation stages											
	3	4	6	7	8	9	10	11	12	13	16	**Means**
1988	11.01	10.7	10.05	10.15	9.59	9.12	8.15	8.85	10.12	9.95	9.65	9.75
1989	8.68	8.09	8.96	8.6	8.43	8.15	8.64	8.75	8.12	7.9	6.84	8.28
1990	9.07	8.95	9.85	9.1	8.78	8.85	8.85	9.3	9.24	8.68	9.3	9.03

seasons (table III). Another source of variation is the increase of the number of new lactating camels which produce a lower daily milk yield than multiparous camels. The daily milk yield of lactating camels was improved from 1988 through 1990 (figure 4) due to the extension of lactation period which has been extended from 276.5 days per lactating camel during 1988 to 332 days during 1989, and 336 days during 1990 successively for Malhah, Wadhah, Safrah and Hamrah. The length of the lactation period can exceed 400 days per lactating camel for the majority of lactating camels but the authors have decided to dry the lactating camels between the 10th and the 11th month of lactation to prepare females for the next breeding season.

Conclusion

The results presented here seem very optimistic in identifying a good camel breed for milk production under arid environment using new management system of camel husbandry. The objective of this study is to develop the main guide lines of a national strategy to increase self sufficiency in dairy products based on promotion of indigenous animal species.

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Parasitisme et production laitière

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Résumé. Les auteurs présentent les mécanismes physiopathologiques entrant en jeu dans diverses parasitoses sanguines (trypanosomose) ou digestives (strongyloses gastro-intestinales) pouvant interférer sur la production laitière des ruminants et leur reproduction. Comparant les approches de mesure de ces effets élaborées chez d'autres ruminants, ils proposent le cadre d'études qui devraient être menées chez le dromadaire dans le but de quantifier ces interactions.

Mots clés. Dromadaire, *Camelus dromedarius,* ruminant, parasitose, production laitière, lactation, reproduction, Mauritanie.

Abstract. The diverse functional disorders caused either by blood parasitic infestation, or gastrointestinal parasitosis, and their connection to the reproduction and the milk production of the ruminants are discussed. Different approaches for the measurement of those interactions are proposed for the dromedary species, with reference to other ruminants bibliography.

Key words. Dromedary, *Camelus dromedarius,* ruminant, parasitic diseases, milk production, lactation, reproduction, Mauritania.

Introduction

Avec un cheptel camelin de 1 050 000 têtes (FAO, 1993), la République islamique de Mauritanie est le premier pays d'élevage camelin d'Afrique de l'Ouest. Parmi les productions camelines, le lait occupe une place essentielle, de telle sorte que, depuis quelques années, on assiste à un début de structuration de l'élevage péri-urbain et d'initiatives industrielles privées, toutes destinées à promouvoir cette filière.

Parallèlement à cela, la couverture sanitaire du cheptel camelin de Mauritanie est fragile en péri-urbain et inexistante à l'intérieur du pays.

Dans la pathologie du dromadaire, les parasitoses représentent une part importante. Elles peuvent sévir sous une forme clinique aiguë mais également d'une façon plus insidieuse sous une forme sub-clinique, sous-estimée par les éleveurs, mais qui peut être économiquement très dommageable (GIBBS, 1982 ; HAWKINS, 1993 ; HUNTER et MOORHOUSE, 1976 ; MARCHAND, 1984 ; YVORE et HOSTE, 1990).

Les travaux du service de Parasitologie du CNERV ont permis de déterminer les trois plus grandes parasitoses du dromadaire en Mauritanie :

- la trypanosomose à *T. evansi* (JACQUIET *et al.*, 1994*a*) ;
- les strongyloses gastro-intestinales et l'haemonchose en particulier (JACQUIET *et al.*, 1994*c* ; JACQUIET *et al.*, 1995) ;
- la gale à *Sarcoptes scabiei* var. *cameli*.

Les références concernant l'impact économique des parasitoses sur la production laitière cameline sont très peu nombreuses ; aussi, dans la suite de l'exposé, il sera surtout fait mention de travaux réalisés chez les bovins, buffles et petits ruminants. L'accent est mis sur les facteurs à prendre en compte dans ce genre d'études en vue de proposer des protocoles spécifiques à l'espèce cameline.

Parasitisme et production laitière : mécanismes physiopathologiques d'interférence

Dans les trypanosomoses en général et la trypanosomose à *T. evansi* en particulier, les mécanismes physiopathologiques impliqués sont l'hémolyse et la perturbation de l'érythropoïèse responsables d'anémie, les troubles circulatoires (thrombocytopénie et coagulation intravasculaire disséminée), les troubles liés aux complexes immuns, l'immunodépression, les actions toxiques (TNF, indole-éthanol, ...).

Les mécanismes physiopathologiques suivants incriminés dans les strongyloses gastro-intestinales en général et les haemonchoses en particulier sont nombreux :

Diminution de l'appétit

Elle est sensible dans les cas de strongyloses de la caillette et de l'intestin grêle (*Haemonchus* et *Trichostrongylus*) chez les ovins et les bovins, mais elle est compensée, quand les ressources fourragères le permettent, par un comportement de tri chez les animaux infestés : ils mangent moins mais mieux (VAN ADRICHEM et SHAW, 1977). Le déterminisme exact n'est pas connu avec précision, les douleurs abdominales provoquées par les vers et des modifications du taux d'hormones peptidiques ont été incriminées.

Perturbation de l'assimilation digestive

A ce niveau, interviendraient plusieurs phénomènes (HOSTE, 1994) :
– des modifications structurelles des muqueuses digestives avec destruction des cellules à pepsinogène et à HCl de la caillette, et abrasion des villosités intestinales ;
– une digestion enzymatique perturbée par manque de pepsine (le pepsinogène se transforme en pepsine active en milieu acide) dans la caillette et manque de peptidases, saccharidases et estérases dans l'intestin ;
– une accélération (parasites de la caillette) ou un ralentissement du transit digestif (parasites intestinaux) ;
– une malabsorption, notamment dans la portion parasitée du tube digestif, mais qui peut être compensée dans une portion saine du tube digestif ;
– une action sur les systèmes de régulation de la physiologie digestive, une infestation par *Haemonchus* sp. induisant une augmentation du taux de gastrine.

Conséquences sur la métabolisation des nutriments

Chez un animal sain non parasité, les synthèses protéiques sont dirigées principalement vers les fibres musculaires striées, les follicules pileux, ... Au contraire, chez l'animal parasité, ces tissus sont délaissés au profit du parenchyme hépatique, de la moelle osseuse, des épithéliums digestifs, ..., pour le maintien de l'homéostasie sanguine et des structures intestinales.

Un certain nombre de facteurs de modulation existent : espèce parasitaire en cause, charge parasitaire, infestation monospécifique ou multispécifique, qualité de la nutrition, âge et état immunitaire des animaux. En ce qui concerne la chamelle laitière dans le sahel mauritanien, un certain nombre de facteurs défavorables sont réunis : des espèces très pathogènes sont bien présentes (*T. evansi, Haemonchus longistipes*, ...), souvent en infestation forte ; dans les strongyloses gastro-intestinales, les infestations multispécifiques sont de règle, la qualité de l'alimentation en période de soudure est loin d'être optimale, enfin les animaux dépensent beaucoup d'énergie à la recherche d'eau et de pâturages.

Parasitisme et reproduction

Action sur le cycle œstral

Un arrêt du cycle ovarien et une perte de poids importante (8 à 21 % selon les animaux) ont été observés chez des zébus Boran après infection expérimentale par *Trypanosoma congolense* au Kenya (LLEWELYN *et al.*, 1988). Vingt-et-un à soixante-treize jours après traitement au Bérénil®, l'activité œstrale reprend, mais les premiers cycles sont plus courts et le taux de progestérone plus faible qu'avant inoculation ou en comparaison avec des animaux témoins. Au bout de quelques cycles, plus aucune différence n'est constatée entre animaux précédemment infectés et témoins. Des résultats similaires ont été obtenus sur des chèvres (LLEWELYN *et al.*, 1987).

Ce résultat est nuancé par une étude récente de PAYNE *et al.* (1993), où, sur 12 génisses Holstein inoculées avec une souche indonésienne de *T. evansi*, une seule a perdu du poids (– 16 %) et cessé toute activité œstrale. Il faut cependant souligner que *T. congolense* est beaucoup plus pathogène chez les bovins que ne l'est *T. evansi*.

Effet abortif

LÖHR *et al.* (1986) ont mis en évidence en milieu villageois thaïlandais une corrélation entre avortements dans les derniers mois de la gestation et mortinatalité chez des buffles infectés par *T. evansi*. Ces avortements n'étaient pas accompagnés d'autres symptômes. De même, dans le sud Trarza, nous avons pu observer que les commémoratifs d'avortements répétés chez des chamelles sont souvent associés à une sérologie *T. evansi*-positive, sans que l'on puisse déceler d'autres symptômes liés à l'infection trypanosomienne. Cependant, la trypanosomose n'étant pas la seule cause d'avortement chez la chamelle, il est bien souvent difficile de faire la part des choses.

Parasitisme et lactation

Action du parasitisme sur la quantité de lait produite

Les répercussions de l'infection trypanosomienne par *T. congolense* et *T. vivax* sur la production laitière des N'Dama ont fait l'objet d'un travail récent en Gambie (AGYEMANG *et al.*, 1990). Dans le groupe de N'Dama infectées, la quantité de lait produite dans le premier mois d'infection est inférieure de 25 % à celle du mois précédant l'infection. Sur un suivi de six mois, la quantité moyenne de lait produite dans le lot de 60 vaches infectées est inférieure de 26 % à celle produite par le lot de 50 vaches témoins élevées dans les mêmes conditions.

Une diminution aussi sensible de la production laitière est très rarement retrouvée dans la littérature abondante qui traite des répercussions économiques des strongyloses gastro-intestinales.

Pour aborder cette question, deux approches ont été tentées :
– l'infection expérimentale d'un premier groupe de femelles en lactation dont on compare la production laitière avec celle d'un lot témoin (BARGER et GIBBS, 1981 ; BLISS et TODD, 1977 ; HOSTE et CHARTIER, 1993 ; THOMAS et ALI, 1983) ;
– l'étude de l'effet d'un traitement anthelminthique sur la production laitière, par comparaison entre un lot traité et un lot témoin non traité (BISSET *et al.*, 1987*a* ; BISSET *et al.*, 1987*b* ; FARIZY, 1970 ; O'FARRELL *et al.*, 1986 ; PLOEGER *et al.*, 1989 ; THOMAS *et al.*, 1984).

Dans le premier cas, un certain nombre de facteurs interviennent :
– la dose infectante : importance, dose unique ou répétée (BARGER et GIBBS, 1981) ;
– le moment de l'infection : dans une étude menée sur bovins (BLISS et TODD, 1977) il a été montré que si l'infection par les strongles digestifs a lieu avant le 90e jour de lactation, les pertes en lait sont importantes (– 12 %), en revanche, si l'infection a lieu au-delà du 90e jour les pertes enregistrées sont mineures. Une autre étude réalisée sur ovins (THOMAS et ALI, 1983) met également l'accent sur le moment de l'infestation : les brebis sont très sensibles au début de la lactation ;
– la période de suivi de production laitière : c'est dans les semaines qui suivent l'infection (2 à 4 semaines) que les répercussions sur la production sont maximales. Par la suite, les courbes de production entre inoculées et témoins ont tendance à se rapprocher (CORBA *et al.*, 1980). Il en ressort que si le suivi de production est court, il aura tendance à surestimer les pertes encourues par parasitisme ;
– les facteurs individuels : une étude réalisée sur des chèvres laitières (HOSTE et CHARTIER, 1993) révèle que les effets d'un parasitisme sub-clinique par *Haemonchus contortus* et *Trichostrongylus colubriformis* sont bien plus importants chez les individus à fort potentiel laitier (– 18 %) que chez des individus à faible potentiel laitier (non significatif). Cette notion est importante car elle pourrait expliquer les grandes variations de réponses individuelles ;
– le nombre d'animaux utilisés : lors des expérimentations entreprises, le nombre d'animaux impliqués est souvent réduit, ce qui ne manque pas d'entraîner de grandes difficultés d'interprétation des résultats obtenus. De plus, comme les gains de production sont souvent assez limités (CHARTIER, 1994), le nombre théorique d'animaux nécessaires pour mettre en évidence une différence significative est élevé (plusieurs centaines dans chaque lot), ce qui n'est jamais réalisé dans les conditions expérimentales.

Dans les études réalisées avec un ou plusieurs traitements anthelminthiques, les résultats obtenus sont contradictoires :
– pour certains auteurs, il n'y a pas de différences significatives dans la quantité de lait produite avant et après traitement (FOX et JACOB, 1984 ; JACQUIET *et al.*, 1995 ; MICHEL *et al.*, 1982) ;
– pour d'autres, cette différence est significative mais rarement au delà du seuil de 5 % (BLISS *et al.*, 1982 ; GOUFFE *et al.*, 1984 ; SPENCE *et al.*, 1992 ; THOMAS *et al.*, 1984 ; VAN ADRICHEM et SHAW, 1977).

Là encore interviennent de nombreux facteurs (CHARTIER, 1994) :
– le type de parasitisme et son importance dans les différentes exploitations et entre les animaux d'une même exploitation ;
– le statut immunitaire des animaux : ainsi, un traitement anthelminthique au premier vêlage a un effet important sur la production laitière ; aux vêlages suivants cet effet s'estompe (THOMAS *et al.*, 1984). Ceci, cependant, n'est pas retrouvé à chaque fois (MICHEL *et al.*, 1982 ; O'FARRELL *et al.*, 1986) ;
– l'importance du niveau de production laitière : on retrouve ici les facteurs individuels et de conduite du troupeau (BISSET *et al.* ; 1987*a* ; PLOEGER *et al.*, 1989 ; THOMAS *et al.*, 1984) ; l'effet du traitement est meilleur dans les troupeaux à haut niveau de production laitière ;
– l'anthelminthique utilisé doit être actif sur les espèces et leurs formes les plus pathogènes ; il ne doit pas avoir d'effet par lui-même sur la production laitière (ce qui est vrai dans la plupart des cas), son activité doit pouvoir être mesurée par des indicateurs du parasitisme ; malheureusement, ceux-ci se révèlent souvent insuffisants (PLOEGER *et al.*, 1989 ; PLOEGER *et al.*, 1990).

Action du parasitisme sur la qualité du lait produit

A ce niveau, se dessine un consensus dans la littérature : le parasitisme sub-clinique par les strongles digestifs n'a pas de répercussions sur le taux protéique du lait (YVORE et HOSTE, 1990). Seuls certains auteurs (HOSTE et CHARTIER, 1993) relatent une baisse légère du taux butyreux. En revanche, l'effet est plus net dans les cas de fasciolose (KUMAR et PACHAURI, 1989 ; LOSI et CASTAGNETTI, 1984).

Conclusion

L'extrapolation au dromadaire de données obtenues sur bovins et petits ruminants a souvent réservé des surprises (JACQUIET *et al.*, 1994*b*). Aussi, il paraît indispensable aux auteurs d'engager des études spécifiques pour l'espèce cameline. Le service de Parasitologie du CNERV se propose d'étudier :

– dans un premier temps, les répercussions sur la reproduction et la production laitière dans les cas de trypanosomose, car celles-ci devraient être assez facilement mesurables ;

– dans un deuxième temps, l'effet des strongyloses gastro-intestinales (haemonchoses en particulier) et de la gale.

Dans chaque cas, il sera impératif de tenir compte des différents facteurs intervenant, dont la multiplicité rend délicate l'étude des répercussions du parasitisme sur la production laitière.

Ces études sont pourtant indispensables pour mieux cerner le rapport coûts/bénéfices d'éventuelles campagnes de lutte à grande échelle (THYS et VERCRUYSSE, 1990).

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Approche pratique des besoins énergétiques, azotés et hydriques des Negga (*Camelus dromedarius*) en lactation

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Résumé. L'auteur rapporte les résultats d'une expérimentation menée en Tunisie sur des chamelles *(Camelus dromedarius)*, en vue de fournir quelques recommandations sur les apports alimentaires azoté et énergétique ainsi que pour l'abreuvement. Les résultats apportent des indications en ce qui concerne les besoins de croissance, de gestation et de lactation.

Mots clés. Dromadaire Negga, *Camelus dromedarius*, nutrition animale, gestation, lactation, croissance, Tunisie.

Abstract. An experimental study has been carried out in Tunisia on dromedaries. It has been attempted to establish nutritional recommendations, for energetic and nitrogen supply as well as water supply, for she camels at different stages of life: pregnancy, during lactation and growing.

Key words. Negga dromedary, *Camelus dromedarius*, animal nutrition, pregnancy, lactation, growth, Tunisia.

Introduction

En Tunisie, les dromadaires de race Maghrabi, malgré une bonne aptitude laitière (KAMOUN, 1993), sont exploités pour la production extensive de viande, sur de vastes parcours où la période du pâturage est limitée par la sécheresse. En effet, les chamelages ont lieu en général de janvier à mai, et le pic de lactation est atteint au 3ᵉ mois (KAMOUN, 1990 ; KAMOUN et WILSON, 1991). Ainsi, la première partie de la lactation, où les besoins du couple mère-chamelon sont importants, a lieu durant la période sèche (mai-août) et la seconde partie, où les besoins sont relativement plus faibles, a lieu en automne. A l'échelle de l'année, les femelles dromadaires Negga sont donc sous-alimentées pendant la période estivale où elles perdent du poids. Mieux alimentées aux pâturages dès l'automne, elles récupèrent le poids perdu, mais malheureusement ces fluctuations compromettent la production de lait.

L'amélioration de la production de lait de dromadaire passe en premier lieu par la régularisation de l'apport alimentaire et son ajustement aux besoins (KAMOUN, 1993). La méconnaissance assez générale de la capacité d'ingestion de la Negga, de la variation des quantités ingérées selon l'ingestibilité de la ration et l'état physiologique (femelle tarie, gestante ou en lactation) et les rendements d'utilisation des rations a conduit l'auteur à entreprendre une série d'expérimentations à Mateur en Tunisie. On a trouvé que la capacité d'ingestion des dromadaires est faible ; les valeurs d'ingestion les plus élevées ont été observées à Mateur avec une ration mixte de foin d'avoine à volonté et de concentré alloué à raison de 1,5 kg pour 100 kg de PV dans un rapport 38/62 (foin/ concentré). L'ingestion était de 2,1 ± 0,1 kg de MS pour 100 kg de PV chez des Negga en lactation (3ᵉ, 4ᵉ et 5ᵉ mois). Pour l'ensemble des Negga en lactation, multipares et primipares, la matière sèche ingérée durant la phase de démarrage de la lactation représente 80 % du plafond et atteint 1,80 ± 0,22 kg pour 100 kg de PV. Les Negga primipares ont une capacité d'ingestion inférieure de 10 % environ à celle des multipares.

Ainsi, l'objectif de cette étude est de fournir des recommandations pour l'ajustement de l'apport azoté, énergétique et hydrique aux Negga primipares et aux Negga multipares, selon leur stade physiologique et dans la perspective d'une amélioration de la production de lait.

Matériel et Méthodes

L'étude s'est déroulée dans la ferme expérimentale de l'Ecole supérieure d'agriculture de Mateur, située au nord de la Tunisie, à environ 60 km au nord-ouest de Tunis. Bien que l'élevage camelin n'y soit pas pratiqué, un troupeau de dromadaires a été constitué en 1987, à partir d'animaux provenant d'élevages situés plus au sud du pays. Depuis, 37 mises bas ont été enregistrées, 12 sur primipares et 25 sur multipares. La durée moyenne de gestation est de 373 ± 11 jours. Les dromadaires sont de race Maghrabi, animaux musclés et trapus. Les femelles adultes mesurent au garrot entre 1,60 et 1,76 m. Le poids des animaux varie selon l'état physiologique et la saison. Dans l'ensemble, les adultes pèsent entre 450 et 650 kg. La robe est habituellement fauve ou claire, couleur café au lait.

L'expérience s'est déroulée en deux essais réalisés entre le 1er décembre 1989 et le 30 avril 1992 ; le premier avec des Negga multipares, dans le cadre du projet CEE TS2/0233/C "Studies on the energetic and proteic requirements of camel" et le second pour estimer les besoins de lactation des Negga primipares (tableau I).

Dans les deux essais, 12 Negga ont été suivies (6 multipares + 6 primipares), et 3 primipares ont été suivies en début et au milieu de la lactation.

L'alimentation a été composée d'un fourrage grossier (foin d'avoine récolté tardivement « F1 », ou paille de blé « F2 ») distribué à volonté pour des animaux entretenus en stabulation entravée, et de deux aliments concentrés (tableau II). Les régimes appliqués diffèrent par le type et la quantité du concentré alloué et le type de fourrage. Lors du démarrage d'un essai ou la modification d'un régime, une phase de 28 à 56 jours d'adaptation a été respectée. Les données relatives à cette phase ont été éliminées du calcul.

Les pesées des Negga sont hebdomadaires. Dans ces essais, l'abreuvement est quotidien, la matière sèche ingérée et l'eau consommée sont appréciées par des mesures quotidiennes et individuelles des quantités offertes et des quantités refusées. La température ambiante et les événements relatifs à la conduite des animaux ont fait l'objet d'un enregistrement quotidien.

Les Negga multipares en lactation sont traites trois fois par jour ; la quantité et la qualité du lait sont directement estimées (voir ce volume, p. 167-171). Chez les primipares, la traite complète n'est possible qu'à partir du second mois de lactation. En début de lactation, la production a été estimée par la différence du poids des jeunes avant et après tétées. Les jeunes ont été lâchés et pesés trois fois dans la journée, pendant une semaine, à heures fixes.

Mille deux cents séries de mesures du contrôle d'ingestion de matières sèches (MS), d'une ration de qualité connue, ont été retenues et mises en relation avec les performances. Les apports et les performances correspondantes ont été ramenés au pourcentage du poids vif, en prenant en considération les variations du poids des individus. L'estimation des besoins a été obtenue par la régression linéaire de la forme $y = ax + b$ entre les performances et l'apport quotidien de la ration en matière azotée totale (MAT) (g) et en énergie (kcal).

Les résultats relatifs à une Negga, à un stade physiologique, dans un essai, ont été individualisés, élaborés et traités statistiquement à l'aide du logiciel STATITCF.

Tableau I. Animaux et caractéristiques des essais sur les Negga adultes.

Negga n°	Poids (kg)	Age (mois)	Stade (mois) Gestation	Lactation	Concentré	Ration kg	Fourrage	Durée adaptation (jours)	Essai Nb mesures	n°
8211	566	> 84	–	9-11	C1	5	F1	56	91	1
8261	592	> 84	–	4-6	C1	5	F1	56	91	1
8341	520	> 84	–	1-3	C1	5	F1	56	91	1
8351	518	> 84	–	2-4	C1	5	F1	56	91	1
8381	452	> 84	–	5-6	C1	6	F2	28	63	1
8391	458	> 84	4-5	5-6	C1	6	F2	28	63	1
8713	388	46	–	1-2	C2	2,5	F2	–	63	2
8714	329	50	3-5	5-6	C2	6	F2	28	63	2
8743	525	48	–	1-2	C2	2,5	F2	–	63	2
8744	491	51	–	4-6	C2	6	F2	28	63	2
8772	396	50	–	1-2	C2	3	F2	–	63	2
8764	575	59	–	1-4	C2	5	F2	–	105	2
8844	469	50	–	1-2	C2	5	F2	–	63	2
8852	428	40	–	1-2	C2	3	F2	–	63	2
8853	407	45	1-4	6-9	C2	4	F2	28	63	2

Tableau II. Caractéristiques des aliments utilisés.

Aliment	MS (%)	Pourcentage de matières sèches (MS)				Energie / kg MS	
		MAT	CB	MM	MO	kcal	UFL
Fourrage 1 (F1)	88	5,5	41	8,5	91,5	935	0,55
Fourrage 2 (F2)	88	2,8	45	8,3	91,7	510	0,3
Concentré 1 (C1)	87	17,5	6,2	8,3	91,7	1 870	1,1
Concentré 2 (C2)	87	15,8	7,1	8,1	91,9	1 700	1

Résultats comparés et Discussion

Ingestion d'eau

L'eau ingérée est la somme de l'eau apportée par les aliments et de l'eau de boisson. Lors d'un abreuvement quotidien, une Negga tarie non gestante ou en début de gestation ingère entre 75 et 78 g/kg $p^{0,82}$ d'eau et une Negga produisant 6,65 kg de lait ingère 122 ± 51 g/kg $p^{0,82}$. Comparée aux Negga taries, cette dernière consomme un litre d'eau en plus par kilogramme de lait produit. Les quantités d'eau ingérées par kilogramme de lait produit augmentent quand la température ambiante maximale s'élève de 18 à 26 °C. Elles passent de 2,46 à 2,87 litres. Les quantités d'eau ingérées par les Negga en lactation sont apparemment faibles, car on ne tient pas compte d'importantes quantités d'eau métabolique libérées lors de l'utilisation des réserves corporelles (catabolisme) en début de lactation.

Estimation des besoins énergétiques et azotés

Les apports et les performances correspondantes sont présentés dans le tableau III pour 15 individus en lactation. Les besoins totaux de la Negga sont obtenus en faisant la somme de ses besoins partiels d'entretien, de gestation et de production de lait. Pour les Negga primipares, il a été tenu compte des besoins de croissance. Les besoins d'entretien, de croissance et de gestation ont été récemment estimés. Une Negga adulte a besoin en moyenne de 817 ± 105 kcal d'énergie nette et de 66,5 ± 9,1 g de MAT pour 100 kg de poids vif et par jour. Sont données dans les tableaux IV et V les recommandations pour les besoins de croissance et de gestation.

L'ingestion et les performances des 15 individus suivis en lactation sont résumées dans le tableau VI. Les Negga produisent 1,6 ± 0,3 litre par jour pour 100 kg de PV (de 0,93 à 2,38 l). Sous-alimentées en début de lactation, neuf d'entre elles perdent du poids, 89 g/j pour 100 kg de PV ; ainsi, elles puisent dans leur masse corporelle les éléments nutritifs qui leur permettent d'assurer une production de 7,6 litres de lait par jour. Cette situation est fréquente sur le parcours où le troupeau est nourri durant la période estivale en-dessous des apports théoriques nécessaires à un bilan alimentaire équilibré. Ensuite, avec les pluies d'automne qui coïncident avec la seconde moitié de la lactation, le parcours s'améliore et les Negga sont mieux alimentées, soit à un niveau supérieur à leurs besoins d'entretien et de lac-

Tableau III. Negga en lactation.

Negga n°	Apport MS (kg)	Apport Energie (kcal)	Apport Azote (g x 6,25)	Durée du suivi (jours)	Gestation Stade (mois)	Lactation Stade (mois)	Lactation Lait (kg/j)	Poids Initial (kg)	Poids Final (kg)	Poids Evolution (g/j)
Multipares										
8211	9,11	12750	1080	91	–	9-11	6,67	566	566	+000
8261	9,1	12733	1079	91	–	4-6	9,46	592	587	–055
8341	8,86	12002	1036	91	–	1-3	8,86	520	481	–428
8351	9,07	12699	1077	91	–	2-4	9,3	518	499	–208
8381	8,42	11390	1003	63	–	5-6	8,19	452	472	+317
8391	8,36	11356	1001	63	4-5	5-6	6,5	458	483	+397
Primipares										
8713	4,8	4998	438	63	–	1-2	7,4	388	353	–555
8714	7,58	9404	960	63	4-5	5-6	8	329	342	+206
8743	7,2	5219	448	63	–	1-2	7,2	525	480	–714
8744	8,54	10035	1006	63	–	5-6	8,8	491	496	+079
8772	8,07	8518	752	105	–	1-4	7,6	575	535	–381
8764	4,75	5259	516	63	–	1-2	5,4	396	368	–444
8844	8,18	9254	836	63	–	1-2	8,2	469	441	–444
8852	4,93	5351	521	63	–	1-2	5	428	403	–396
8853	6,86	7236	638	154	1-4	6-9	4	407	467	+389

tation. L'auteur a simulé cette situation par l'apport de 2 279 kcal et de 210 g de MAT pour 100 kg de PV et par jour. Les Negga gagnent du poids (54 g/j pour 100 kg de PV) et produisent 7,0 ± 1,5 litres de lait par jour.

Les dépenses des Negga sont très élevées, surtout en début de lactation. Dans une conduite traditionnelle, la production laitière est peu compromise car le pâturage d'automne permet une remise en état après la période estivale. Mais dans une perspective d'intensification de la production de lait, la conduite alimentaire est à réviser.

Les besoins de ces Negga en lactation sont la résultante des besoins d'entretien, de production laitière et des besoins liés à l'évolution du poids. Les besoins d'entretien et de prise de poids ont déjà été estimés, et des

Tableau IV. Apports alimentaires recommandés selon l'âge, et capacité d'ingestion de jeunes Negga en croissance.

Classe d'âge (année)	Poids vif (kg)	Gain poids vif (g/j)	Apports journaliers			Apports/kg MS	
			UFL*	MAT (g)	MS**	UFL*	MAT (g)
1-2	300	200	2,33	338	5,7	0,41	59
		300	2,57	377		0,45	66
		400	2,80	416		0,49	73
		500	3,04	455		0,53	80
	350	200	2,62	379	6,6	0,40	57
		300	2,86	418		0,43	63
		400	3,10	457		0,47	69
		500	3,33	496		0,50	75
	400	200	2,92	420	7,6	0,38	55
		300	3,15	459		0,41	60
		400	3,39	498		0,45	66
		500	3,63	537		0,48	71
3-4	400	200	3,06	456	7,2	0,43	63
		300	3,46	526		0,48	73
		400	3,85	596		0,53	82
		500	4,25	666		0,59	92
	450	200	3,32	493	8,1	0,41	61
		300	3,72	563		0,46	69
		400	4,12	633		0,51	78
		500	4,52	703		0,56	86
	500	200	3,59	529	9,0	0,40	59
		300	3,99	599		0,44	66
		400	4,38	669		0,49	74
		500	4,78	739		0,53	82

*1 UFL = 1 700 kcal d'énergie nette. ** Références établies à l'ESA Mateur.

Tableau V. Apports alimentaires recommandés et capacité d'ingestion de Negga en gestation (chamelon de 30 kg à la mise bas).

Negga	Stade de gestation (mois)	Apports quotidiens		Apport total		Capacité d'ingestion (kg MS*)
		UFL	MAT (g)	UFL	MAT (kg)	
Primipares de :						
450 kg	0-9	3,00	344	819	94	7,8
500 kg	9-12	3,48	792	316	72	6,8
450 kg	0-12	3,12	456	1 135	166	7,6
Multipares de :						
550 kg	0-9	3,06	388	848	106	9,9
550 kg	9-12	3,33	637	303	58	8,6
550 kg	0-12	3,13	450	1 139	164	9,6

* Référence : ration mixte foin d'avoine/concentré (38/62), ingérée à raison de 2,10 ± 0,1 kg de MS pour 100 kg de PV par une Negga multipare en pleine lactation.

Note : pour une variation de 5 kg en plus ou en moins du poids à la naissance, on augmentera ou on diminuera les besoins journaliers de 0,11 UFL et de 44 g de MAT en moyenne durant le dernier quart de la gestation.

Stade de lactation	Démarrage	Milieu	Moyenne
Nombre de Negga	9	6	15
Poids moyen (kg)	475 ± 66	458 ± 69	469 ± 68
Concentration par kg de MS :			
Energie (kcal)	1 183 ± 168	1 263 ± 120	1 215 ± 156
MAT (g)	105 ± 12	116 ± 10	109 ± 13
CB (g)	246 ± 17	220 ± 23	235 ± 23
Apport de la ration (p. 100 kg de PV) :			
Matières sèches (g)	1 445 ± 262	1 802 ± 220	1 588 ± 302
Energie (kcal)	1 742 ± 520	2 279 ± 353	1 957 ± 530
MAT (g)	154 ± 41	210 ± 40	176 ± 49
Performances (p. 100 kg de PV) :			
Evolution du poids (g)	– 89 ± 42	54 ± 34	de – 146 à 91
Lait produit (kg/j)	1,60 ± 0,24	1,57 ± 0,47	1,59 ± 0,35

Tableau VI.
Ingestion et performances des Negga en lactation.

liaisons entre l'apport total et l'évolution négative du poids ont été établies.

Pour chaque individu, les excès ont été évalués selon l'évolution du poids, et l'apport a été corrigé et ramené aux justes besoins de production de lait, qui correspondent aux besoins de production d'une Negga non gestante, de poids stable en lactation. C'est l'apport corrigé pour la production de lait.

En partant de l'hypothèse que la production de lait est nulle pour un apport nul, les régressions linéaires suivantes ont été établies entre l'apport corrigé en énergie (kcal) ou en grammes de MAT pour 100 kg de PV (Y) et le lait produit (l/j) pour 100 kg de PV (X) :

❒ pour l'énergie (kcal) = lait (litres) x 821,69 – 116,19 (avec $R \geq 0,78$, ETR = 7,2 % et $P < 0,001$, n = 16)

❒ pour les MAT (g) = lait (litres) x 85,92 – 12,08 (avec $R \geq 0,90$, ETR = 4,9 % et $P < 0,001$, n = 16)

Les résultats individuels — besoins mesurés, besoins calculés à partir des régressions et composition chimique du lait produit — sont réunis dans le tableau VII.

Les besoins mesurés et calculés sont respectivement 730 ± 162 et 744 ± 18 kcal pour l'énergie et 76,5 ± 12,1 et 77,9 ± 1,9 g pour les MAT. On constate toutefois des différences entre individus. Ces différences seraient liées à la teneur en matières grasses du lait qui est mieux corrélée aux besoins de production (r = 0,66) que les MAT (r = 0,30).

Les besoins de la Negga en lactation sont directement associés aux besoins d'entretien et aux besoins de lactation estimés à 744 kcal (0,44 UFL) et 77,9 g de MAT par kilogramme de lait produit à 33,5 g de matières grasses. De plus, les primipares doivent encore effectuer durant leur lactation une croissance d'environ 25 kg, soit 100 g par jour. Pour couvrir ses besoins, la Negga devrait donc consommer une grande quantité de matières sèches. Or, l'appétit de cet animal est limité et ne dépasse guère 2,1 kg de MS pour 100 kg de PV. De plus, les quantités de matières sèches (MS) ingérées après la mise bas ne sont que de 80 % des valeurs maximales atteintes vers le 3e mois de lactation, et les primipares ont une capacité d'ingestion inférieure de 10 % à celle des multipares. A partir de ces informations, ont été calculées et réunies dans le tableau VIII, les estimations des besoins des Negga en lactation, et la concentration minimale de la ration à distribuer à ces animaux selon le niveau de production, le rang de lactation et le stade de production.

Conclusion et Recommandations

Pour satisfaire ses besoins, la Negga doit pouvoir consommer suffisamment de fourrage, de qualité moyenne à médiocre. Or, on constate que la capacité d'ingestion de cet animal est limitée. Les quantités d'aliments ingérées sont minimales avant et après la mise bas. Elles représentent environ 80 % du plafond atteint vers le 3e mois de lactation. Les Negga primipares ont une capacité d'ingestion inférieure de 10 % environ à celle des multipares. Ces caractéristiques, associées à un appétit faible (seuil maximal à 2,1 ± 0,1 kg de MS pour 100 kg de PV), accroissent encore les risques de déficit en nutriments dans un système traditionnel de conduite alimentaire.

D'après le tableau V, les besoins totaux d'ingestion d'une Negga qui donne naissance à un chamelon de 30 kg de poids vif, sont en moyenne de 215 UFL pour l'énergie et de 38 kg de MAT, soit l'équivalent des besoins pour produire 490 et 456 kg de lait respectivement.

En effet, pour produire un litre de lait à 33,5 g de matières grasses et à 28,5 g de matières protéiques, les besoins de lactation sont de 744 ± 18 kcal (0,437 UFL)

Tableau VII. Besoins de production d'un litre de lait : valeurs mesurées et valeurs estimées par les régressions.

Negga n°	Apport par litre de lait Energie (kcal) Mesurée	Estimée	MAT (g) Mesurée	Estimée	Teneur en lait (g/l) MG	MAT	EST
8211	912,8	723,1	78,1	75,6	41 ± 4	33 ± 2	118 ± 7
8261	872,3	749,6	77,4	78,4	34 ± 2	24 ± 1	101 ± 9
8341	972,9	757,3	96,6	79,2	35 ± 4	32 ± 2	114 ± 6
8351	968,4	758,7	96,6	79,2	34 ± 3	29 ± 1	111 ± 7
8381	706,2	756,4	65,1	79,4	39 ± 5	38 ± 5	128 ± 6
8391	823,3	738,5	76,0	77,2	32 ± 3	34 ± 2	118 ± 6
8713	747,3	762,0	80,7	79,7	32 ± 4	31 ± 1	114 ± 2
8714	688,9	772,9	77,9	80,8	50 ± 2	30 ± 1	136 ± 1
8743	819,9	740,7	90,6	77,5	33 ± 2	28 ± 1	107 ± 4
8744	636,7	755,7	72,1	79,1	29 ± 1	23 ± 1	109 ± 2
8764	611,0	737,7	68,8	77,2	33 ± 1	26 ± 1	115 ± 3
8772	505,1	739,3	75,5	77,3	29 ± 2	23 ± 1	109 ± 2
8844	747,3	756,5	82,9	79,1	33 ± 5	25 ± 4	107 ± 3
8852	488,3	722,7	74,5	75,6	25 ± 1	26 ± 1	104 ± 4
8853	459,3	696,7	42,4	72,9	23 ± 1	20 ± 2	101 ± 4
Moyennes	730	744	76,5	77,9	33,5	28,5	112,8
Ecarts types	162	18	12,1	1,9	6,9	5,0	10,5

et 77,9 ± 1,9 g de MAT au-dessus des besoins d'entretien.

Chez une Negga produisant 2 400-2 500 kg de lait en une lactation de 240 jours (Kamoun, 1995), les besoins vont varier de façon rapide entre la mise bas et le tarissement, puisque la production passe de 7,4 litres la 2e semaine à 11,9 litres vers la 10e semaine pour retrouver un niveau plus bas à la fin.

Pour l'établissement de rations types, on cherchera pour des raisons économiques à faire consommer aux Negga un maximum de fourrages, et dans la mesure du possible on comblera le déficit par l'apport de son de blé (0,83 UFL et 170 g de MAT/kg de MS), d'orge (1,1 UFL et 120 g de MAT/kg de MS) et de féverole (1,1 UFL et 260 g de MAT/kg de MS), séparés ou mélangés. Dans cette approche, on se basera sur le tableau IX qui résume le niveau d'ingestion de rations couramment utilisées en Afrique du Nord par des Negga qui ont été contrôlées à Pise et à Mateur (3e rapport annuel du projet STD DG12 TS2/0233/C). On a porté sur ce même tableau les quantités de lait permises par ces rations.

Distribués seuls, le foin d'avoine récolté tardivement et la paille de blé sont ingérés en faible quantité, leur apport est en deçà des besoins d'entretien aussi bien chez les multipares que chez les primipares. Le foin de bersim et le parcours de printemps sont relativement bien équilibrés, les écarts entre les apports énergétique et azoté sont faibles. L'apport en UFL et en MAT de ces rations de base couvre respectivement une production de 5 et 5,8 kg de lait par jour avec le bersim et de 3,8 et 3,6 kg de lait par jour sur le parcours de printemps chez les Negga multipares. Chez les primipares, ces rations couvrent 2,4 kg de lait en moins par jour. Les foins de prairie naturelle et le foin d'avoine de bonne qualité sont déficitaires en MAT, l'écart équivalent à la production permise est compris entre 2 et 3,5 kg de lait chez les multipares, mais chez les primipares, il est souvent bien en deçà des besoins.

Pour préserver le potentiel laitier de ces Negga qui produisent entre 2 000 et 3 500 kg de lait par lactation, on distribue un complément de concentré. L'aliment concentré ne se substitue pas ou peu aux rations de base étudiées mais, au contraire, améliore l'ingestibilité de celles qui ont une qualité médiocre. Ainsi, les fourrages qui permettent un niveau de production proche pour l'azote et l'énergie seront complémentés avec un aliment concentré équilibré (MAT/UFL = 77,9/0,44 = 178), en l'occurrence un mélange (50/50) d'orge et de féverole distribué à raison de 1 kg par tranche de 2,2 kg de lait au-dessus du niveau permis par la ration de base. Dans le cas où les apports en MAT de la ration de base ne permettent pas la même production de lait que les apports en UFL, soit on composera un nouvel aliment concentré, soit on utilisera le même concentré, mais en compensant les écarts par l'addition de l'orge et du son ou de la féverole, selon le type de déficit.

Ainsi, pour une production de 2 400 kg de lait en 240 jours, une Negga multipare conduite en stabulation comblerait son déficit respectivement au début, en milieu et durant la seconde moitié de lactation, par un apport quotidien de 2,5 kg de concentré (50/50, orge/son de blé), de 4,5 kg d'orge et de 2,5 kg d'orge en association avec le foin de bersim ; ou bien de 5,5, 6 et 4,5 kg de son de blé, en association avec un bon foin d'avoine ou un foin de prairie naturelle. Mais, pour des multipares qui produisent plus de 10 litres par jour (de 3 000 à 3 500 kg de lait par lactation), et des pri-

Tableau VIII. Apports alimentaires recommandés selon le niveau de production et la capacité d'ingestion des Negga multipares et primipares en lactation.

Production (l/j)	Stade de lactation (mois)	Apports quotidiens		Apport total		Ingestion	Apports de kg de MS	
		UFL*	MAT (g)	UFL	MAT (kg)	Max/Min (kg MS)**	UFL	MAT (g)
Primipares poids : 450 kg								
8	0-2	6,43	1 047	386	63	6,8	0,95	154
10	2-4	7,30	1 202	438	72	8,5	0,86	141
7	4-8	5,99	969	719	116	8,1	0,74	120
8	0-8	6,43	1 047	1 543	251	7,9	0,81	132
10	0-2	7,30	1 202	438	72	6,8	1,07	177
12	2-4	8,18	1 358	491	82	8,5	0,96	160
9	4-8	6,87	1 125	824	135	8,1	0,85	139
10	0-8	7,30	1 202	1 753	289	7,9	0,92	152
Multipares poids :500 kg								
8	0-2	5,76	933	346	56	8,4	0,68	111
10	2-4	6,64	1 089	398	65	10,5	0,63	104
7	4-8	5,33	855	640	103	9,6	0,56	89
8	0-8	5,76	941	1 384	224	9,5	0,61	98
10	0-2	6,64	1 089	398	65	8,4	0,79	130
12	2-4	7,52	1 245	451	75	10,5	0,72	119
9	4-8	6,20	1 011	744	121	9,6	0,65	113
10	0-8	6,64	1 089	1 593	261	9,5	0,70	114
12	0-2	7,52	1 245	451	75	8,4	0,79	130
16	2-4	9,27	1 556	556	93	10,5	0,88	148
10	4-8	6,64	1 089	797	130	9,6	0,69	113
12	0-8	7,52	1 245	1 804	299	9,5	0,79	131

* 1 UFL = 1 700 kcal d'énergie nette. ** Références établies à l'ESA Mateur.

Tableau IX. Niveau d'ingestion et quantités de lait permises par des rations types.

	Valeur/kg de MS			Multipares 500 kg			Primipares 450 kg		
	UFL	MAT	MSI (p. 100 kg PV)	MSI (kg)	Lait permis* (kg) UFL	Lait permis* (kg) MAT	MSI (kg)	Lait permis* (kg) UFL	Lait permis* (kg) MAT
Foin seul :									
Bersim	0,69	119	1,29	6,5	5,0	5,8	5,8	2,5	3,4
Prairie 1	0,77	73	1,16	5,8	5,0	1,5	5,2	2,5	0,0
Prairie 2 (FP)	0,70	73	0,92	4,6	2,2	0,3	4,1	0,0	0,0
Avoine 1 (A1)	0,67	72	0,98	4,9	2,3	0,5	4,4	0,0	0,0
Avoine 2 (A2)	0,55	55	0,81	4,1	0,0	0,0	3,6	0,0	0,0
Paille 1 (P1)	0,54	35	0,62	3,3	0,0	0,0	2,9	0,0	0,0
Paille 2 (P2)	0,30	28	0,98	3,5	0,0	0,0	3,1	0,0	0,0
FP/P1 (70/30)	0,66	62	0,90	4,5	1,6	0,0	4,0	0,0	0,0
Parcours :									
Printemps	0,65	98	1,21	6,1	3,8	3,6	5,5	1,4	1,4
Été	0,54	77	0,97	4,9	0,8	0,8	4,4	0,0	0,0
Ration mixte :									
P2/concentré (38/62)	0,70	120	1,84	9,2	9,6	10,2	8,3	6,6	7,4
A2/concentré (49/51)	0,72	116	1,66	8,3	8,5	8,4	7,5	5,7	5,8
A1/concentré (38/62)	0,94	151	2,10	10,5	17,3	16,3	9,4	13,5	12,8

* Lait permis (kg) : quantité de lait théorique permise par l'apport en UFL, ou en MAT.

mipares, il est difficile d'obtenir l'équilibre entre les apports nutritifs et les besoins des Negga, en raison d'un appétit faible et d'une évolution divergente entre les besoins et la capacité d'ingestion. Elles sont obligées, pour combler le déficit, de mobiliser leurs réserves dès la mise bas. Elles perdent donc du poids, et la reconstitution des réserves commence dès le milieu de la lactation. De ce fait, les Negga primipares produisant 10 litres de lait par jour, et conduites en stabulation, ont besoin d'une ration plus concentrée. Le complément sera composé d'orge et de féverole (50/50). Ces primipares recevront 1 kg de plus que les multipares, avec la ration à base d'un bon foin d'avoine ou d'un foin de prairie naturelle. Mais le foin de bersim sera distribué en quantité limitée, soit 2, 2,5 et 7 kg avec un apport de 6, 7 et 3,5 kg d'aliments concentrés, respectivement, au début, en milieu et durant la seconde moitié de lactation.

Conduites sur un parcours de zone méditerranéenne composé à 52,6 % de graminées, à 19 % de composées et à 25 % d'acacia, les Negga multipares peuvent combler le déficit durant la première moitié de lactation par la distribution d'un mélange de féverole et d'orge (50/50), soit 3 et 4 kg au démarrage, majorés de 1 kg dès le 3[e] mois de lactation lorsque le chamelage a eu lieu l'hiver ou à la fin du printemps. Mais avec l'évolution du parcours durant la seconde moitié de lactation, le déficit est comblé par l'apport de respectivement 5 et 3,5 kg d'un mélange orge/son de blé (50/50). Les primipares recevront 1 kg de concentré de plus que les multipares.

Les Negga en gestation sont moins exigeantes que celles en lactation :

– sur parcours et en dehors de la période estivale, les besoins des neuf premiers mois sont largement satisfaits. Toutefois, durant la période estivale, l'apport énergétique du parcours est faible, le déficit énergétique peut être comblé par la distribution de 0,5 à 1 kg d'orge par jour. Durant les trois derniers mois de la gestation, les besoins azotés augmentent plus rapidement que les besoins énergétiques, le déficit est comblé par la distribution respective aux multipares et aux primipares, de 0,2 et 1,2 kg de féverole en dehors de la période estivale, et 1,6 et 2,0 kg de féverole durant la période estivale ;

– en stabulation, les Negga en gestation valorisent bien les foins de prairie et d'avoine, mais ces rations de base doivent être équilibrées par l'addition d'environ 300 à 500 g de foin de bersim ou son équivalent en son de blé en début de gestation, et par l'apport de 1,2 à 2,1 kg de féverole ou son équivalent en son de blé en fin de gestation.

On constate donc qu'avec l'intensification, les Negga produisent plus de lait, l'intervalle entre mises bas est plus court, il y a recouvrement entre lactation et gestation, entraînant une mise bas ayant lieu en plein été (Kamoun, 1990). De plus, les femelles entrent de plus en plus jeunes en production (Kamoun et Wilson, 1991 ; Kamoun *et al.*, 1993), et l'on peut se retrouver dans une nouvelle situation zootechnique, en face d'animaux à faible capacité d'ingestion, plus exigeants et plus difficiles à conduire.

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The dairy characteristics of the Kenyan camel

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Abstract. Milk production potential of the Kenya Somali camel was determined from six lactation camels that were fed on natural browse. All the milk was hand milked from the whole udder, measured, and daily records kept over a period of 10 to 12 months. The calf was bucket fed with measured quantities of milk. Two thousands and eighty five records were obtained and subjected to statistical analysis. The total lactation yields ranged from 1,614 to 2,151 kg with a mean of 1,876 kg for the herd. The average daily milk production varied with month of lactation being high in the first 7 months of lactation and declining during the last 3 months of lactation. The highest daily yield was obtained of 10.50 kg which was ever higher than some of the daily yields of milk obtained from dairy animals under small scale sector management. This high yield was maintained over a period of two weeks during the 5th month of lactation by one of the camels in the herd. The other camels had peak lactation yields of 8.5 to 9.5 kg during 2nd to 5th lactation months. The potential of the camel to produce milk at the level of 8 to 10 kg from the natural vegetation and under simple management interventions is demonstrated. The lactation curve of the camels herd was similar in all characteristics to that of a dairy cow. The camel was able to maintain a milk production level that was between 6 and 8 kg for the first 7 months of lactation. With improved nutrition it would be possible to raise the amount of milk produced from the camel. In comparison to the dairy cow, the dairy cow dependent on forage from natural pastures is able to yield 5 to 6 kg of milk per day. This has demonstrated that the camels production from natural forage can even be higher than that of a dairy cow under similar feed conditions. The quality of camel's milk is similar in all aspects to that of a dairy cow. In fact, the camel's milk has the advantage of having a higher vitamin C content than the cow's milk due to the camel's feeding habits. The butter fat content as well as the protein content of the camel's milk does not differ substantially from that in cow's milk.The information obtained from this camel herd in terms of lactation yields, persistence of lactation, lactation curve and the quality of milk indicates that the Kenya Somali camel is more of a dairy camel than a meat camel. This gives hope to the pastoralists in the arid environments that with the improvement of the nutritional status of the camel, the camel they already have has the potential to become the best dairy animal for their arid environments.

Key words. Dromedary, *Camelus dromedarius,* Dairy cow, Milk production, lactation, milking, animal nutrition, pastoralism, Kenya.

Résumé. Le potentiel de production laitière de chamelles de race Somali a été étudié au Kenya, sur six chamelles nourries en parcours naturels. Le lait a été trait manuellement de tous les quartiers de la mamelle, puis mesuré, et les enregistrements quotidiens conservés sur une période de dix à douze mois. Le chamelon a été nourri au seau avec des quantités contrôlées de lait. Deux mille quatre-vingt-cinq enregistrements ont été obtenus et soumis à une analyse statistique. Les niveaux de production totale au cours d'une lactation varient de 1 614 à 2 151 kg, avec une moyenne de 1 876 kg pour le troupeau. La production moyenne journalière de lait varie selon le mois de lactation : elle reste élevée pendant les sept premiers mois de lactation et diminue pendant ses trois derniers mois. La production quotidienne la plus élevée a été de 10,50 kg, ce qui était comparativement plus élevé que des productions journalières de lait issues d'animaux laitiers exploités dans un système fermier plus intensif. Cette production élevée a été maintenue sur une période de deux semaines et pendant le cinquième mois de lactation par une des chamelles du troupeau. Les autres chamelles ont eu des pics de lactation variant de 8,5 à 9,5 kg pendant les deuxième et cinquième mois de lactation. Les capacités de la chamelle à produire du lait régulièrement à des niveaux de 8 à 10 kg par jour, à partir d'une alimenation basée sur la végétation naturelle et à l'aide de simples interventions de gestion sont ainsi démontrées. Les courbes de lactation des chamelles ont été similaires sur tous les plans à celles de la vache laitière. La chamelle a été capable de maintenir un niveau de production laitière entre 6 et 8 kg par jour pendant les sept premiers mois de lactation. Avec un apport de nourriture supplémentaire, il serait possible d'augmenter le niveau de production de lait produit par la chamelle. Si l'on compare ces données avec celles obtenues avec des bovins, la vache laitière élevée sur pâturages naturels est capable de produire 5 à 6 kg de lait par jour. Ceci démontre que la production des chamelles utilisant du fourrage naturel peut même être supérieure à celle de la vache laitière nourrie dans les mêmes conditions. La qualité globale du lait de chamelle est identique sous tous ses aspects à celle du lait de vache laitière. En fait, le lait de chamelle a l'avantage de contenir plus de vitamine C que celui de vache laitière, ceci étant dû aux habitudes alimentaires des chamelles. Les matières grasses, tout comme les protéines contenues dans le lait de chamelle, ne diffèrent pas de celles du lait de vache laitière. Les informations obtenues en termes de niveau et de durée de lactation, de forme des courbes de lactation, et de qualité du lait, indiquent que la chamelle Somali du Kenya est davantage une laitière qu'une productrice de viande. Les éleveurs pastoralistes des zones arides peuvent ainsi penser que, avec une amélioration de l'apport nutritionnel, les camelins resteront les animaux laitiers privilégiés de cet environnement.

Mots clés. Dromadaire, *Camelus dromedarius*, vache laitière, production laitière, lactation, traite, nutrition animale, pastoralisme, Kenya.

Introduction

There are two types of camels in the world: the one humped camel (*Camelus dromedarius*) and the Bactrian two humped camel (*Camelus bactrianus*). The dromedary camel is the most dominant and is widely distributed in the tropics and the sub-tropics of the African and the Asian continents. The Bactrian camel is mainly found in the temperate regions of the european-russian continent and only accounts for 5% of the world camel population.

The dromedary camel has an estimated population of 18.5 million. They occupy some of the arid environments of the African and Asian continents. The dromedary is the main source of livelihood in these areas, supplying milk for pastoral food needs, meat for ceremonial cultural activities and transport for migration, fetching water or loading supplies from the market centres.

In some cases, the dromedary is the only means of the subsistence economy of the nomad. It is therefore important that the milk production, which is the main source of food for the nomad communities, will be improved so that the survival patterns of these communities can be enhanced.

In Africa, the dromedary population of about 15 million accounts for 74% of the world population. Of this 60% of the population of camels is found in the Eastern Africa countries of Somalia (6.2 million), Sudan (2.8 million), Ethiopia (1.7 million) and Kenya (0.9 million). This accounts for 11.6 million camels. It is therefore important that the countries involved should determine the contribution of this resource to the national food security systems within their national plans.

In Kenya (table I) there are 903,000 dromedaries supporting a population of 1,583,000 people. These animals are located in the arid and very arid environments of Kenya. The loading districts are Isiolo (424,000), Marsabit (227,000), Wajir (153,000), Garissa (61,000), Samburu (14,000), Mandera (12,000), Turkana (10,000), Baringo (1,000) and West Poko (1,000). The dromedary is the main source of milk and camel rearing is the main economic activity of the four first most arid districts of Isiolo, Marsabit, Wajir and Garissa.

There are three types of dromedaries that are found in Kenya. These are named after the communities that keep them. The Somali camel is mainly kept by the Kenyan Somali community. It is large, white, and has a short-haired coat. The Rendille camel is mainly kept by the Rendille and Gabbra communities in Marsabit district. It is a medium sized animal with a short-haired sandy coat. The Turkana camel is mainly kept by the Turkana community. It has a smaller body size than the Rendille camel, has a short haired light-brown to light-grey coat, and is fine boned. The objective was to study the milk production parameters of the Kenyan Somali camel. The study would cover the various dairy characteristic indicators in the camel. They will be determined like the lenght of the lactation period, the shape of the lactation curve, the persistence of milk production, the quantity of milk produced, as well as the nutritional value of the camel's milk.

Table I. Camel distribution in Kenya.

	Camels (x 1,000)	People (x 1,000)
Marsabit	227	125
Isiolo	424	70
Turkana	10	179
Samburu	14	114
Mandera	12	123
Wajir	153	125
Garissa	61	124
Baringo	1	286
West Poko	1	231
Total	903	1,583

Materials and Methods

Twelve camel heifers plus two young bulls were purchased from Wajir for the study. They were approximately 3 to 4 years of age. They were trekked to Isiolo holding ground which was the first project site and were kept there for a period of two years.

After stabilisation, the herd was moved to Bombing range ranch in Machakos district where the vegetation was assessed as comparable to that in Isiolo.

The camels were allowed to feed during the day on the natural vegetation. They were provided with mineral licks in the evening in the "Boma". The herd was housed every night for security reasons and to protect it from theft and wild animals.

When the camels calved they were trained for milking, with the calf by the side of the dam. Milking was done at the Boma in the morning and in the evening. The milk was measured and the calf was fed sufficient milk from a bucket. The analysis of data was done with use of SPSS Software programme for levels of milk production, milking frequency and for differences between individual performances.

Results

The results on the association between the frequency of milking and the total daily yields are presented in table II for 5 lactating camels. The thrice a day milking was done during the second, third and fourth month of lactation; whereas the twice a day milking was done during the 5th to 7th month of lactation. For camel A8, the daily milk yields were 7.132 and 6.950 kg during thrice a day milking regime. The daily yields for camel A8 during a twice a day milking regime were 6.986 and 7.025 kg. These milk yields were not significantly different. Similar comparisons between the other 4 camel's milk yields according to milking regime confirmed that there was no difference in total milk yields whether the camel was milked twice or thrice a day.

The study indicated the herd had a tendency to produce 50% of the daily milk in the morning and the other 50% in the evening (table III). In thrice a day milking regime, 50% of the daily total production was in the morning. While the rest was distributed between midday milking and evening milking. The camels D4 and P4 had interesting distribution which differed from the other camels: D4 has a distribution of 40:30:30 and P4 had a distribution of 35:35:30 for the morning, midday and evening milk yields. These are special characteristics that indicate with improved nutrition these two camels could probably produce higher amounts of milk if milked more frequently. However even for these two, the distribution of milk during the twice a day milking regime remained at 50:50.

The daily milk yields are presented in table IV. Recording was maintained from the first month of lactation to the 12th month of lactation where this was applicable. Recording was done for five days in each week and the mean production for week calculated. The total production during the month was determined and the average daily production for the month calculated. Milk production varied from one camel to another with D1 and A8 having the highest values. Camel D1 was able to maintain its milk production at between 6 and 10 kg per day for the first 7 months of lactation. The highest mean daily yield was recorded during the 4th month of lactation of 9.36 kg. Camel A8 was able to maintain its milk production yields at 6 to 9 kg per day during the first 7 months of lactation. The highest daily production

Table II.
Daily yield of milk of camels milked twice or three times a day (kg).

Animal		Daily yield of milk (3 times/day)	Standard deviation	Daily yield of milk (2 times/day)	Standard deviation
A8	(19)[1]	7.132	.783	6.986	.760
	(16)	6.950	.271	7.025	.648
B5	(19)	6.331	.766	6.361	.595
	(16)	8.438	.642	6.050	1.189
D1	(19)	7.040	.723	8.125	.865
	(16)	8.350	.900	7.283	1.239
D4	(18)	6.309	.912	7.292	.386
	(18)	7.033	.589	7.042	.602
P4	(19)	6.553	1.558	7.224	.820
	(18)	6.781	1.080	7.184	.606

1. Number of days recorded in a month.

Table III.
Effects of milking frequency on distribution of milk, percentages of total yield.

Animal	Thrice a day milking			Twice a day milking	
	Morning	Midday	Evening	Morning	Evening
A8	50	20	30	53	47
B5	45	30	25	50	50
D4	40	30	30	50	50
D1	45	30	25	50	50
P4	35	35	30	50	50

Table IV. Daily mean milk yields for camels in Kenya (in kg/day).

Lactation month	Camel					
	A8	B5	B8	D1	D4	P4
1	7.70	6.00	6.50	6.00	5.70	5.80
2	8.25	6.62	7.44	7.00	6.31	6.26
3	7.66	5.77	7.72	8.35	7.03	6.67
4	7.13	6.26	7.47	9.36	7.29	7.16
5	6.95	6.27	6.07	8.50	7.04	7.18
6	6.99	6.42	6.14	7.93	6.50	6.22
7	7.03	6.39	6.64	7.02	6.04	5.38
8	5.96	5.61	5.93	6.43	5.67	4.25
9	5.35	4.58	4.09	5.08	4.14	2.33
10	4.20	3.71	3.73	3.48	3.43	1.93
11	2.32	2.48	Rested	Rested	Rested	Rested
12	1.35	2.48	Rested	Rested	Rested	Rested

was recorded during the second month of 8.25 kg per day. Similar performances of the other camels are reflected in table IV. The best lactation phase for the herd was between the 1st and the 7th month of lactation.

The total lactation yields for the six camels is given in table V. The yields varied from 1,614 kg per lactation to 2,151 kg with a mean yield of 1,876 kg for the herd. This yield compares well with the national dairy cattle lactation yield of 2,000 kg per cow. The lactation curve for the camels was based on the mean daily yields for each month. The yields varied from 6.28 to 7.45 kg during the 4th month, then declined to 3.41 kg during the 10th month of lactation. The curve is similar to the curve obtained from the dairy breeds of cattle. This indicates that the Kenyan Somali camel is more of a dairy animal rather than a meat animal (figure 1).

Table V. Milk lactation yields.

Animal	Lactation length (in months)	Lactation yield (kg)
A8	12	2,151
B5	12	1,895
B8	10	1,778
D4	10	1,797
D1	10	2,100
P4	10	1,614
Mean	10.2	1,876

The quality of milk from camels was determined using the standard procedures that are used for milk analysis. The total solids for the whole milk ranged from 10.64 to 14.14 with a mean of 12.14. The solids non fat was determined as 8.40%, the butter fat as 3.74% and the protein had a mean of 3.42% (table VI). The major component of milk protein was casein which accounted for 77% of the protein component. Overall the composition of the camel's milk was similar to that of the cow's milk. The colostrum during the first three days of lactation had higher components of protein, ranging from 12.52 in the first day to 9.75% in the third day of lactation (table VII). This high protein component has usually made it difficult to offer colostrum to newly born calves without further dilution.

Table VI. Composition of whole milk.

Component	Kenya camel (%)	Friesian cow (%)
Water	87.86	87.85
Total solid	12.14	12.15
Solids non fat (SNF)	8.40	8.85
Fat	5.60	3.50
Protein	3.42	3.50
Lactose	3.65	4.60
Ash	0.86	N/A

Casein content in the colostrum protein accounted for 44% indicating that other proteins were forming a higher proportion of the colostrum proteins. Lactose component in the colostrum was slightly higher than that in the whole milk and so was the free fatty acids (FFA). The biggest difference was noted as that between the protein component (CP) in the colostrum and the protein in the whole milk where the colostrum contained about three times as much protein as for the whole milk and the colostrum protein having a higher component of other proteins (non casein) than in the whole milk.

The lactose component of the whole milk was 3.65% and was not different from that of the cow's milk. Mineral component was determined as total ash and was within the values accepted for normal milk from dairy breeds. These values of camel's milk composition are similar in all aspects to the values reported for cow's milk in the literature.

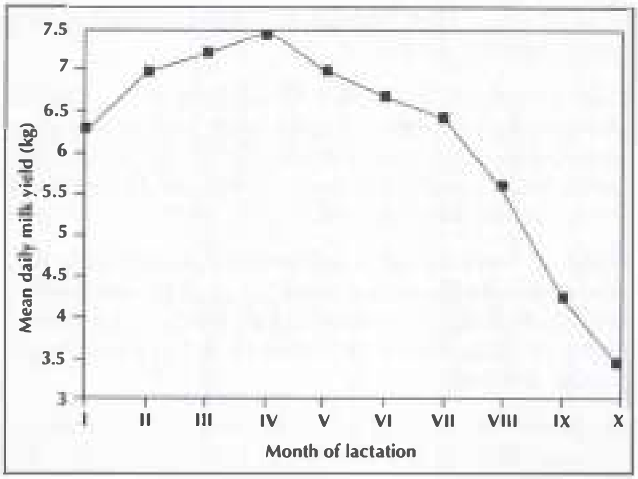

***Figure 1.** Second lactation.*

Table VII. Composition of colostrum.

Colostrum	CP (%)	Fat (%)	Casein	FFA	Lactose
Day 1	12.52	4.5	4.34	1.38	4.19
Day 2	11.98	4.6	6.34	1.51	4.33
Day 3	9.75	4.4	4.28	1.39	4.71
Whole milk (fresh 7 samples)	3.42	3.74	2.64	1.03	3.65

CP: protein component; FFA: free fatty acids.

Discussion

The dromedary camel is located in the Sahel region and some of the driest parts of the continent of Africa. In Kenya, the dromedary are concentrated in the regions north of the equator in areas that are classified as arid and very arid. These areas are frequently affected by drought and the camel has become the only animal that has survived and continued to provide milk for the subsistence needs of the 1.5 million inhabitants of this arid land. In some districts like Wajir, Mandera, Garissa and Isiolo, over 30% of the population depends on the camel for their food needs and also for their family income. Camels have been reported to withstand drought better than cattle on small stock. GAUTHIER-PILTERS and DAGG (1981) reported that in the Sahel region nearly 100% cattle died, but the records indicated that only 20 to 30% of the camels were lost. This hardiness of the camel is one of the characteristics that have enabled the animal to inhabit, colonise and continue to support the human population that occupies the arid and semi-arid areas of the tropics.

Information on the milk production of the camels in the tropics is scanty. Lactation yields have normally been estimated from observations made from short durations of experimentation or from questionnaires based on local knowledge. Such data is usually suspect as to its accuracy. BREMAUD (1969) from a yield visit to Northern Kenya gave daily yield of 9 to 12 kg. In Laïkipia district, EVANS and POWYS (1984) estimated the average daily yield of Kenyan camels to vary from 5.9 to 6.9 kg. These camels were milked twice a day, FIELD (1984) in Marsabit district determined the average daily yield of camels to be 4.87 kg. The current studies have indicated that the potential milk production of the Kenyan camel of the Somali breed vary between 3.4 kg per day and up to 7.45 kg per day with an overall mean of 6.15 kg for the 10 months lactation period. This is in agreement with the values reported by EVANS and POWYS and FIELD as referenced above.

The total lactation yields varied from 1,614 to 2,151 kg for individual animals with an overall mean of 1,876 kg for a lactation period of 10 months. These values are within what had been reported by FIELD (1984) for Kenyan camels and KNOESS (1976) for Afar camels in Ethiopia.

A study of milking frequency showed that there was no advantage in the three times a day milking over the twice a day milking as this did not increase the total daily milk production. EVANS and POWYS (1984) reported that when camels were milked twice a day compared to milking 4 times a day, there was an increase in milk yield from 5.9 to 6.9 kg. This was not confirmed in this study and more studies may need to be carried out to determine whether increased milking frequency actually increases total milk yield from the dam.

Milk production of the herd is affected by many factors. The first most important factor is the changing nutritional status of the dam. For such animals that are wholly dependent on natural vegetation, the milk production is easily influenced by the availability of the forage and its quality.

Forage availability is affected by the incidence of the dry season when leaf drop and drying of grass reduces the quantity and quality of feed available to the lactative animal. There was always a positive response to increased milk production with the outset of the rainy season when lush green forage was available. The dry spell of August to October 1986 was noted to have affected the smoothness of the lactation curve of this herd.

The state of health is important for the lactative camel. The six camels were kept under close control, so that any that developed signs of swollen due to incidence of mastitis might be quickly treated. It was observed that the lactative camel is prone to infection by the bacteria *Streptococcus* sp. which were the cause of mastitis even in dairy cows.

Availability of water is important for lactating animals. During this study the camels were provided with water freely. In addition mineral licks were provided *ad libitum* in form of salt blocks.

Camel's milk is white, odourless and had a sweet taste.

The specific gravity of the camel's milk was determined with a densitometer at 20°C from six samples at 1.0% for the normal whole milk. This is in agreement with the value reported by SHALASH (1984).

The total solids and butter fat content of the camel's milk was similar to that of a dairy cow. There was in fact no difference between the chemical composition of the camel's milk and that of a Friesian cow. Earbei work had reported that the camel's milk has a higher vitamin C content than the cow's milk at the level of 5 mg per 100 ml (MUKASA-MUGERWA, 1981). Also it has been reported that camel's milk had higher levels of some minerals like iron, copper, manganese, carotene and vitamin E than milk from a dairy cow (MUKASA-MUGERWA, 1981).

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La production laitière du dromadaire en Tunisie

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Résumé. Un contrôle laitier de quatorze chamelles suitées de race Maghrebi, élevées sur parcours naturels, a permis de comparer la production sur trois rangs de lactation et pendant huit mois. Trois femelles sur quatorze ont été complémentées chaque soir après le retour du pâturage, avec 2 kg de grignon d'olive et 1 kg d'orge concassée par tête, pour voir l'effet de la complémentation sur la production laitière. La moyenne de la production journalière a été de 1,22 à 2,02 kg de lait selon le rang de lactation, pour les dromadaires élevés sans complémentation, tandis que celle des femelles recevant la complémentation a été de 2,03 à 4,13 kg de lait. Le pic de lactation est atteint au 3^{e} mois pour la totalité des femelles. La descente de la courbe de lactation a commencé à partir du 4^{e} mois pour le troupeau privé sans complémentation, et à partir du 6^{e} mois pour le troupeau recevant une complémentation. Le coefficient de persistance fut très élevé et il était supérieur à 80 % pour la plupart des dromadaires contrôlés entre les mois 4-6 et 1-3, à l'exception des trois dromadaires en 3^{e} lactation du troupeau sans complémentation où ce coefficient était de 67 %. En comparaison des productions observées lors de contrôles ponctuels effectués sur des chamelles dans certains pays du Maghreb, on remarque que la moyenne de la production laitière du dromadaire de race Maghrebi élevé sur parcours naturels se situe entre 2 et 5 litres par jour. Toutefois, cette production pourrait être supérieure avec l'amélioration des conditions alimentaires.

Mots clés. Dromadaire Maghrebi, *Camelus dromedarius*, production laitière, lactation, nutrition animale, parcours, Tunisie.

Abstract. A milk recording of fourteen she-camels with young at heel, and reared in natural grazing conditions, has been carried out to compare the milk production of three lactation ranks during eight months. Three of the fourteen animals have been supplemented each day, after coming back from grazing area, with 2 kg of olive's cake and 1 kg of barley per capita, in order to observe the effect of supplemental feeding on milk production. The daily mean production of the unsupplemented animals ranged from 1.22 to 2.02 kg of milk, in accordance with the lactation rank. The daily mean production of the supplemented animals ranged from 2.03 to 4.13 kg. The maximum of the lactation curve is reached at the third month for all she-camels. The lactation curve decreases slightly from the fourth month in the case of unsupplemented herd, while it drops steadily from the sixth month in the case of the supplemented herd. The persistence's coefficient is higher than 80% (eighty percent) for the main part of the animal's batch, with an exception for the three unsupplemented animals at third rank of lactation for which it was 67% (sixty seven percent). It is possible to compare the production yield observed in different areas of Maghreb. It is noticed that the mean production of Maghrebi breed, in natural extensive environment, yields between 2 and 5 litres per day. However, this yield could be rised by improving the feeding conditions.

Key words. Maghrebi dromedary, *Camelus dromedarius*, milk production, lactation, animal nutrition, rangeland, Tunisia.

Introduction

En Tunisie, et principalement dans les zones arides, la présence du dromadaire reste capitale, vu sa formidable capacité à transformer des ressources alimentaires médiocres et souvent inexploitables par d'autres espèces animales (notamment des plantes halophytes et épineuses) en produits consommables (lait, viande). De plus, cet animal tolère de longues périodes sans accès à l'eau. Ainsi, son adaptation au milieu aride et aux conditions difficiles du désert représente un atout remarquable pour renforcer la présence de l'homme dans ce milieu par l'amélioration de ses conditions d'élevage.

Suite à l'éloignement des troupeaux camelins des marchés urbains, du fait de la distribution des effectifs sur de vastes étendues et de l'absence d'une infrastructure adéquate pour la collecte, le lait de dromadaire n'est plus commercialisé. Il constitue aujourd'hui l'alimentation de base pour le chamelier et ses visiteurs. En cela, l'étude du potentiel laitier et de ses possibilités d'amélioration n'est plus dans cette zone un objectif prioritaire pour l'éleveur puisqu'il n'en tire plus profit.

Matériels et Méthodes

Localisation de l'étude

Cette étude a été effectuée sur des femelles appartenant à deux troupeaux différents du sud-est de la Tunisie (figure 1) :
– un premier troupeau privé, élevé dans la zone de Tataouine ;
– un second troupeau appartenant à l'Institut des régions arides (IRA), élevé dans la zone de Médenine, aux alentours du siège de l'établissement.

Le pâturage du premier troupeau est essentiellement à dominantes de *Rhantherium suaveolens, Aristida pungens* et *Arthrophytum shmittianum.* C'est uniquement pendant les mois de mars et avril que l'on trouve les herbacées et les plantes annuelles (*acheb*).

La fréquence d'abreuvement des animaux varie d'une saison à une autre, et elle est de cinq à dix jours.

Le pâturage du troupeau de l'Institut des régions arides est constitué principalement de plantes halophytes des genres *Limoniastrum, Arthrocnemum, Suaeda.* L'eau d'abreuvement est relativement abondante, du fait de la présence des abreuvoirs collectifs sur le site où le campement est établi.

Les animaux

Quatorze femelles suitées de race Maghrebi font l'objet de cette étude : onze femelles appartenant à un éleveur

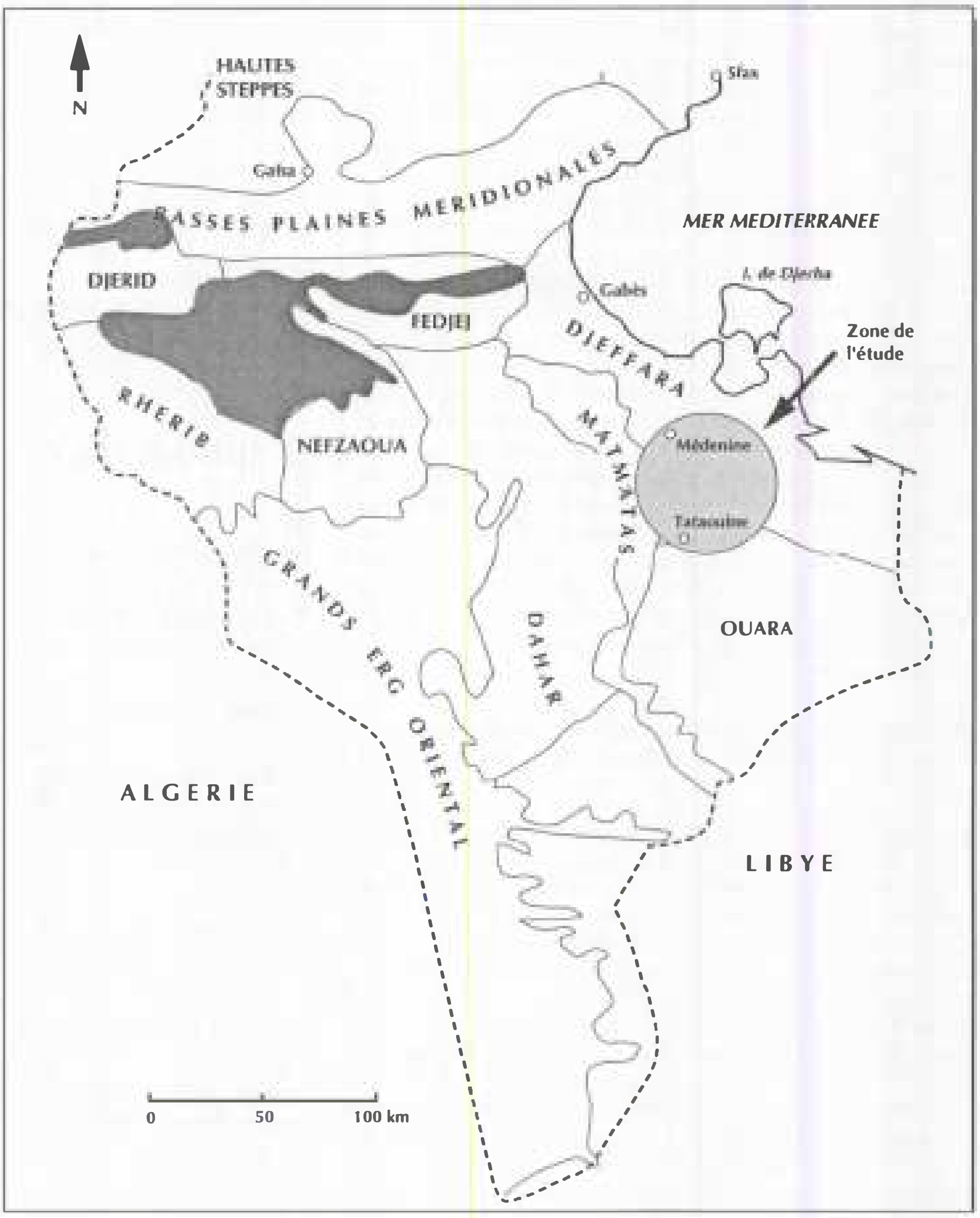

Figure 1.
Zone de l'étude parmi les régions naturelles du Sud tunisien.

privé de la région de Tataouine et trois femelles appartenant à l'Institut des régions arides (IRA).

Les femelles allaitantes ont des rangs de lactation différents :
- dans le troupeau privé, on trouve quatre chamelles primipares, quatre chamelles en 2ᵉ lactation et trois en 3ᵉ lactation ;
- dans le troupeau de l'IRA, on trouve une chamelle primipare, une en 2ᵉ lactation et une en 3ᵉ lactation.

Conduite du troupeau

Les femelles du troupeau privé restent toute l'année dans un troupeau collectif de 90 têtes environ. Leur alimentation est basée sur les parcours naturels sans complémentation. C'est un troupeau mobile effectuant de nombreux déplacements pour rechercher des végétaux. Le troupeau est gardé pendant toute l'année par un chamelier spécialiste de l'élevage camelin et de la zone concernée.

Le troupeau de l'Institut des régions arides pâture pendant toute l'année dans le même endroit, à proximité du siège de l'établissement à raison de 8 heures par jour sur un parcours à dominante de plantes salées. Le soir, de retour au campement, le troupeau reçoit une complémentation de 2 kg de grignon d'olive et de 1 kg d'orge concassée par tête.

Du fait des difficultés de déplacement, le contrôle laitier sur les chamelles du troupeau privé n'a été suivi que pendant 7 mois, tandis que le contrôle sur les femelles du troupeau de l'IRA a été suivi jusqu'à 8 mois, soit de début avril à fin novembre.

Contrôle laitier

Pendant le premier mois de lactation, la totalité de la production laitière est réservée à l'alimentation du produit. Le contrôle laitier commence à partir de la 5ᵉ ou de la 6ᵉ semaine suivant la mise bas, à raison d'un contrôle tous les 15 jours.

Pour empêcher le jeune de téter sa mère, le chamelier protège les mamelles avec des cache-mamelles, confectionnés spécialement pour cette raison avec la laine et le poil du dromadaire.

La traite complète est faite uniquement sur deux quartiers (un antérieur et un postérieur), et la quantité recueillie est pesée et multipliée par deux. Les deux autres quartiers sont réservés au chamelon, pour stimuler la descente du lait. La production moyenne journalière pour chaque mois est établie par la moyenne des contrôles à 15 jours, alors que la production moyenne journalière pour toute la période de lactation est calculée par la moyenne des contrôles mensuels.

Résultats

Les résultats individuels de la production laitière sont indiqués dans le tableau I.

La production laitière moyenne par jour des femelles recevant une complémentation est supérieure à celle des femelles pâturant seulement sur les parcours naturels, et ce pour tous les rangs de lactation. L'effet de la complémentation sur l'amélioration de la production est de l'ordre de 60 % pour la première et la 3ᵉ lactation et de 39 % pour la 2ᵉ lactation. Ceci témoigne du bon potentiel laitier de la chamelle, qui pourrait toujours être utilisé avec l'amélioration des conditions alimentaires.

La production laitière de la chamelle multipare est plus élevée que celle de la chamelle primipare, et ce pour les deux modes d'élevage.

Le pic de lactation se situe au cours du 3ᵉ mois pour la totalité des femelles ; la descente de la courbe de

Propriétaire	**Nombre de dromadaires**	**Rang de lactation**	**Production moy./j** (kg)	**Production totale** (kg)	**Coefficient de persistance 4-6/1-3*** (%)
IRA avec complémentation	1	1	2,03	497,15	85,5
	1	2	4,13	1 009,55	100,77
	1	3	3,4	828,7	100
	Moyenne		3,15		95,4
Troupeau sans complémentation	4	1	1,22	259,2	92,35
	4	2	1,62	346,1	80,63
	3	3	2,02	430,5	67,11
	Moyenne		1,62		80,03

* Le coefficient de persistance a été calculé sur la base de mesures entre le 1ᵉʳ et le 3ᵉ mois, puis du 4ᵉ au 6ᵉ mois.

Tableau I. Evolution de la production laitière.

lactation commence à partir du 4e mois pour le troupeau privé sans complémentation, et à partir du 6e mois pour le troupeau recevant une complémentation (figure 2).

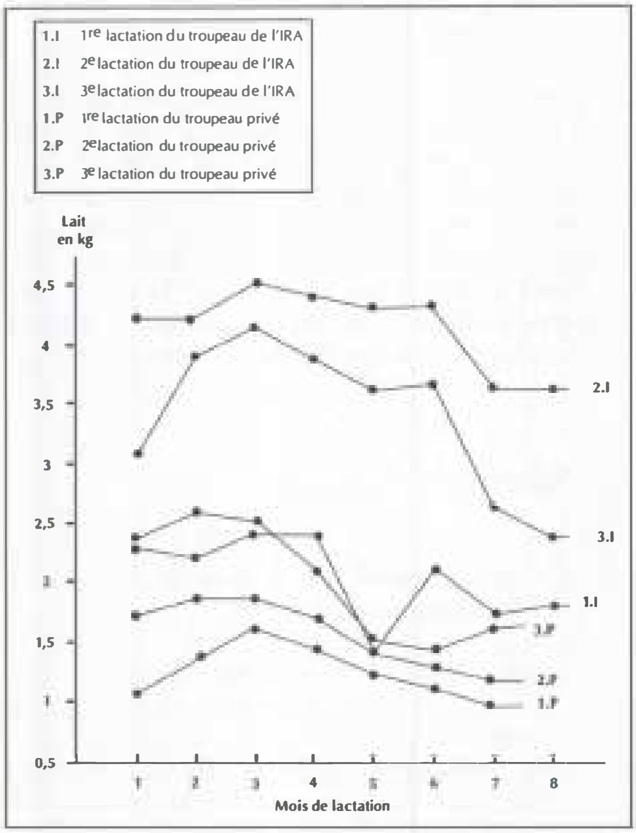

Figure 2. *Courbes de la production laitière (en kilogrammes par tête et par jour).*

Le coefficient de persistance est très élevé, surtout pour les femelles de l'IRA recevant une complémentation où il est en moyenne de 95,4 %. Pour les dromadaires du troupeau privé ne recevant pas de complémentation, il est en moyenne de 80 % avec un coefficient plus élevé en faveur des femelles de première lactation (92,35 %) par rapport aux femelles de troisième lactation (67,11 %).

Discussion

Il paraît un peu difficile de comparer les résultats du présent protocole avec des chiffres résultant d'un contrôle laitier régulier sur les dromadaires élevés en mode extensif en Tunisie et sans complémentation. Les quelques chiffres indiqués sur la production laitière des femelles élevées sur les parcours naturels, faisaient suite à des contrôles ponctuels, sans indiquer le numéro et le mois de lactation, ni l'état du parcours et la composition de sa végétation.

En Tunisie, les seuls résultats du contrôle laitier connus sont ceux de Kamoun et Bergaoui (1989). Leur étude s'est faite sur cinq chamelles dont une en première lactation et quatre en deuxième lactation, recevant une complémentation de 4 kg de son de blé par tête et par jour, en plus du foin d'avoine *ad libitum* et du temps de pâturage pendant la journée. Le régime était donc plus consistant que celui des femelles suivies dans notre étude. Cependant, en comparant les résultats observés sur les dromadaires recevant une complémentation avec ceux obtenus par Kamoun et Bergaoui (1989), l'effet du régime est remarquable, nos résultats de production laitière se situant entre 2 et 4 kg de lait par jour selon le rang de lactation, alors que ces auteurs indiquent des résultats de 3 à 11 litres par jour avec une moyenne de 6,1 ± 2,8 litres pendant la même période de 8 mois. Burgmeister (1975) signale une production journalière de 4 litres sur des dromadaires élevés dans la région de Gabès dans le Sud tunisien.

En outre, en comparant les résultats de la présente étude avec ceux indiqués par d'autres auteurs dans certains pays du Maghreb, on remarque que la production laitière journalière est presque identique dans tous ces pays. En Mauritanie, Martinez (1989) indique une production journalière de 3,8 litres de lait entre le troisième et le huitième mois de lactation. En Algérie, Gast *et al.* cités par Richard (1985), signalent une production journalière de 2 à 5 litres. En Libye, Karam et Al-Ansari, cités par Richard (1985), indiquent une production quotidienne de 2,26 ± 1,0 litres sur une durée de lactation de 12 à 18 mois.

D'après les courbes de production laitière observées dans cette étude, on remarque très bien que le pic de lactation est obtenu au 3e mois pour la totalité des femelles, avec et sans complémentation. Alors que la descente de cette courbe n'est pas identique pour les deux troupeaux, elle l'est, dans les deux groupes, à partir du 4e mois pour les femelles du troupeau privé sans complémentation, et à partir du 6e mois pour les femelles du troupeau de l'Institut recevant une complémentation. Ceci explique que pendant cette période, entre le 3e et le 6e mois, l'alimentation ait été un facteur limitant aussi bien sur la production laitière que sur la persistance de la courbe de lactation.

Toutefois, cette étude ne permet pas de juger le vrai potentiel laitier de cette race Maghrebi, étant donné que les deux troupeaux n'étaient pas placés dans les mêmes conditions d'élevage (différence de la qualité de la végétation du parcours, fréquence d'abreuvement et habileté du chamelier). Donc, si on veut exprimer le potentiel laitier de cette race, il faudra prendre en considération tous ces facteurs et jouer sur une seule variable : la complémentation.

Conclusion

La production laitière communément retenue chez la race Maghrebi est de 2 à 5 litres par jour sur une période de 8 à 12 mois de lactation. Mais l'amélioration des conditions alimentaires peut prolonger la période de lactation et augmenter la production, voire même la doubler. Ce qui montre que malgré l'utilisation du même matériel génétique, le dromadaire de race Maghrebi a un bon potentiel laitier et qu'il mérite d'être étudié davantage.

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Traditional camel management methods in Kenya with special reference to milk production

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Abstract. Camel management strategies amongst the northern tribes of Kenya are described. Herd size, herd composition and daily management are related to the major uses and offtake requirements of the owners, and the historical association between the owners and the herd. Tribes who have owned camels for generations tend to have larger herd sizes. Milking practices and milk yields vary considerably between tribes. Differences between yields are caused by a number of both intrinsic and extrinsic factors, some of the most important are food intake, breed, calf survival and milking frequency, water availability, milking efficiency, health and reproductive status. There is considerable scope for improving milk yields through simple improvements in management and breeding.

Key words. Dromedary, *Camelus dromedarius*, animal husbandry method, milk production, milking, animal nutrition, breed, animal health, reproduction, Kenya.

Résumé. Les méthodes de gestion et d'exploitation des troupeaux camelins sont décrites parmi les tribus du Nord-Kenya. La taille du troupeau, la composition du troupeau et la gestion quotidienne des animaux dépendent des utilisations et des besoins financiers des propriétaires et du type d'association existant entre les propriétaires et le troupeau. Les tribus qui sont propriétaires de camelins depuis des générations ont tendance à avoir des troupeaux de taille importante. Les pratiques de la traite et les productions laitières varient considérablement entre les ethnies. Les différences entre les productions sont dues à la fois à des facteurs intrinsèques et extrinsèques, les plus importants étant la consommation de nourriture, la race, le taux de survie des jeunes, la fréquence de la qualité de traite, ainsi que la disponibilité en eau, les performances de reproduction et la santé. Il existe des possibilités considérables d'augmentation de la production laitière à travers de simples améliorations de gestion et de sélection.

Mots clés. Dromadaire, *Camelus dromedarius*, méthode d'élevage, production laitière, traite, nutrition animale, race, santé animale, reproduction, Kenya.

Preamble

Research on traditional camel management practices is a component of the PhD thesis of the author investigating the effects of breed and management on camel milk production. Data on present and traditional management strategies are being collected by the use of questionnaires amongst the major camel keeping cultures in Kenya. A lot of data have already been collected from Samburu camel owners, but surveys of Rendille, Gabbra and Turkana camel management are ongoing. Data on Somali management has yet to be collected.

Questionnaire data will complement ongoing field trials comparing milk yields from 44 Somali and 20 Turkana breed primiparous camels; and calf separation trials on a further 50 multiparous Somali breed camel's batch.

Introduction

The last aerial livestock survey carried out in the northern rangelands of Kenya was carried out by Kenya Rangeland Monitoring Unit (KREMU) in 1988, and recorded a population of 585,913 ± 82,704 camels (EATH, 1993). The camels are largely owned by the 7 tribes who live in the more arid northern districts of the country. Based on the KREMU data HEATH (1993) gives a breakdown of camel ownership by tribe in columns 2 and 3 of table I. The remaining columns are adapted

Table I. Camel numbers, uses and ownership in Kenya (adapted from HEATH, 1993, and FIELD, 1993).

Ethnic group	Number of camels owned	% of national camel herd	Livestock kept in order of importance	Purpose or use	Land use strategy
Somali	371,135	63.56	Camels Smallstock Cattle Donkeys	F, D, T F, T T, F D	Nomadic
Rendille	51,268	8.78	Camels Smallstock Cattle Donkeys	F, D F, T T, F D	Semi-nomadic
Gabbra	46,012	7.88	Camels Smallstock Cattle Donkeys	F, T F, T T, F D	Nomadic
Turkana	102,360	17.53	Smallstock Cattle Donkeys Camels	F, T F, T T, S F	Transhumant and semi-nomadic
Samburu	13,138	2.25	Cattle Smallstock Donkeys Camels	F, T F, T T F	Transhumant and sedentary
Pokot	3,000	0.5	Smallstock Cattle Donkeys Camels	F, T F, T T F	Transhumant and sedentary
Boran and Sakuye			Cattle Smallstock Donkeys Camels	F, T F, T D F, T	Transhumant and sedentary

F = Food/subsistence; D = Draft; T = Trade.

from FIELD (1993), ranking the livestock species by importance to each tribe, and the uses of each species.

It can be seen from the table that the people who rank the camel as the most important livestock species live in the more arid areas, and by circumstance have to live a nomadic or semi-nomadic existence, relying on the camel for subsistence food production (milk, meat and blood) as well as for transport and trade.

Milk is probably the most important camel's product for most camel owners in Kenya. There is however considerable variation between camel breeds and in the manner in which camel owners manage their milk animals, which in turn leads to differences in production. The different breeds and management systems are correlated to the different ethnic groups that keep camels, and at this point it is worth looking at each group, their historical association with camels, and their management activities in closer detail.

Major camel owning groups in Kenya

Somali

Most of north-eastern province of Kenya is occupied or inhabited by Somali people, and it is the Somali people that own the majority (over 370,000) of camels in Kenya, and have had the longest association with camels in eastern Africa (BULLIET, 1975). Somali are commonly acknowledged as being the most able and experienced camel handlers or owners. Daily management and herd size vary within the tribe depending on clan and individual preference. Management also varies with season and pasture availability.

The Somali inhabit districts with an aridity index between 5-7, and hence have to be nomadic, in order to ensure best utilisation of the forage resources. The camel herd is often split into two groups: animals that are lactating, which remain at the main camp with their calves to provide food for the owner's family, and the dry stock (including males and immatures) which are sent off in highly mobile camps.

Stock ownership varies considerably by clan, and from individual to individual. A household survey by MERRYMAN (1987) of pastoral and settled Somali farmers in Garissa district found a livestock breakdown per household as reported on table II.

Table II. Variations in livestock holding by the Somali people (from MERRYMAN, 1987).

Stockholding	Pastoral Somali		Settled Somali farmers	
	1963	1980	1963	1980
Camels	12.4	5.3	20.4	1.1
Cattle	86.3	74.4	69.6	9.0
Sheep/goats	161.4	117.5	179.5	41.0
Livestock units per household	129.1	99.9	127.1	16.9
Livestock units per capita	11.2	8.6	17.8	2.7

These figures seem remarkably low, but it is likely that if MERRYMAN was surveying settled farmers who indulge in cultivation, they are unlikely to be typical of the majority of camel owning Somalis.

Camels are released to graze at 8.00 a.m. and do not return to the pen until well after dark (8.00 p.m.-11.00 p.m.). They are watered between 7-10 days in the dry season. When there is little risk of predation the camels can be left to graze for a large part of the night. Herding is carried out by young men.

Camels are important as transport animals, 2-3 male camels being required to move one household (HEATH, 1993).

Rendille

After the Somali, the Rendille have probably been camel keepers longer than any other tribe in Kenya. Camels are not only important to the Rendille for subsistence, but religiously and sociologically they play a major role as well. Camels are referred to as the "other half of God", and the whole ageset structure of the tribe is based on the generation time of the camel. They are used in payment of blood money and bridal gift.

Camels play a vital role in carrying water from the wells to the homesteads, without which the Rendille would be unable to survive in such hostile conditions.

Results of a surveys sampling the whole Rendille population in 1980's (FIELD and SIMPKIN, 1985) found the average family size to be 7-8 people owning on average 12 camels, 11 cattle and 101 smallstock. A survey of camel owning households found the average camel herd size to be 15 camels (SIMPKIN, 1985*b*).

Camels are herded by boys, young men or ritually cleansed adult men. Most of the camels are kept at mobile grazing camps ("*fora*"), whilst the lactating females are rotated between *fora* and homestead.

Camels are milked after all the other livestock, and are released to graze between 8.30 a.m.-9.00 a.m., and are returned between 7.00-8.00 p.m. In dry periods they water every 10-14 days (average 11 days).

Gabbra

Gabbra live in a very arid environment, and started camel husbandry in the 19th century (ROBINSON, 1985). Most camels remain at the homestead instead of mobile grazing camps (*fora*), but are very mobile moving 15 or more times per year.

A survey by O'LEARY (1984) found an average household size of 4.7 people, with access to an average of 23.4 camels. TORRY (1973) estimated total Gabbra camel population in 1973 to be 52,000, with household herd sizes averaging 43-50 camels, 150-200 cattle, and 300-400 smallstock.

A survey of 120 Gabbra households carried out by this author in 1992, found an average of 18 camels, 19 cattle and 330 smallstock per household. The average household size was 2 adults and 4 children.

Despite predominantly being kept for their milk and meat, camels are the main beast of burden for the Gabbra, and by carrying water and the household materials and possessions, make it possible for the people to utilise these rangelands.

Gabbra take camels to graze at 9.00 a.m. and return them back to the pen at sunset. Watering occurs every 8-12 days in the dry season.

Turkana

The Turkana, like the Pokot, have only acquired camels over the last 200-300 years, largely by raiding from the Gabbra and Rendille. Despite their relative short period of camel husbandry they now have a large number of camels. They keep camels for milk, meat and blood, but never use them for transport or draft.

In Turkana district the camels are often left to graze freely, and are not actively herded, but any herding done is usually by young boys or women. Camels are released between 8.00 a.m.-9.00 a.m. and return at 5.00 p.m.-6.00 p.m., females may return to the pen during the day to be milked and suckled by the calf, which is normally tethered at the homestead.

A good distribution of surface water in Turkana means that many camels drink freely, but in the dry season watering intervals are 3-4 days.

In Turkana district average herd size is 15-20 animals; a survey of 50 Turkana camel owners living in Samburu district showed an average herd size of 19 camels (Simpkin, unpublished).

Breeding control is basic, rutting bulls wander at will, and many owners do not own a stud bull, but rely on these stray bulls to impregnate the females.

Pokot

The Pokot are relatively new to camel management, with a small camel population, however some family names incorporate the vernacular name for camels, which indicates that they may have owned camels before coming to the present area 150 years ago.

There are only about 250 camel owning Pokot families, the average herd size being about 10 animals; the mode is more likely to be around 3-4 camels.

Camels are released at 8.00 a.m.-9.00 a.m. and returned at 7.00 p.m.. Most camels are home based and are kept under less nomadic conditions than some of the other tribes. The Pokot do not use camels as burden animals.

Samburu

The Samburu people are an offshoot of the Maasai, and similarly to the Maasai they are pastoralists who largely depended on cattle and mixed herds of sheep and goats for their survival. In recent years however, a number of Samburu have started keeping camels. In a survey carried out in six selected communities in Baragoi division, between 15-84% of heads of household owned camels. Overall, 39% of Samburu households and 28% of Turkana households possessed camels (Iles, 1990).

The Samburu have been in contact with camels for a long time, especially those neighbouring the Rendille or Turkana. Camels became more common in Samburu district following the first recorded migration of Turkana into Baragoi division in 1915. Numbers increased in the 1950's but it was only in the 1960's that a large number of Samburu people started buying camels from the Turkana at Baragoi. Further peaks in purchasing of camels by the Samburu occurred in 1971 and 1985, years following drought periods. In a recent survey of 261 Samburu camel owners, 63% had obtained their camels within the last 15 years while only 7% of families had owned camels since 1950. Table III shows where they had obtained their camels.

Table III. Origin of the Samburu's camels.

Origin	Percentage
Bought from Turkana	59
Bought from Pokot	3
Bought from Rendille	8
Bought from Somali	12
Bought from other Samburu	8
Inherited	5
Received as dowry	5

Bridewealth is becoming an increasingly important means of obtaining camels. Average household size in Samburu is between 7.9 people (Iles, 1990) to 3 adults and 6 children.

The breakdown of livestock ownership of Samburu camel owning households is presented in table IV.

Table IV. Ownership of different types of livestock by the Samburu people.

Species	Mean	Median	Range
Camels	14	11	1-115
Cattle	50	33	0-400
Smallstock	144	100	2-2,2000

The Samburu are much less nomadic than their neighbours, and therefore their camels tend to be herded in a similar manner to their cattle. Many owners state that they obtained camels to provide milk for the family, enabling them to release their cattle from the homestead and go to satellite grazing camps earlier in the dry season. In effect the camels are kept in a sedentary manner in order for the cattle herd to be more mobile —a bit of an anachronism since camels are better adapted than cattle to be mobile in an arid environment.

Since Samburu have only recently obtained camels there are no hard and fast rules about management. Some owners are interested in training camels for draft work, but the majority only use camels for meat and milk production.

Camel herds are released at about 8.00 a.m. and are returned to the pen at about 6.30 p.m. - 7.00 p.m. Herding is usually done by young boys or girls, or by the owner's wife.

Some Samburu camels are allowed free access to water, many are watered at weekly intervals, others may only be watered at fortnightly intervals. The main constraint appears to be water availability rather than actual need by the camel.

Commercial ranchers

A number of commercial beef ranchers of European origin have also integrated camels into their beef ranches. They follow traditional management to some extent. Camel pens are moved around the ranch as in rotational grazing, but the moves are cyclical depending on forage, climate, and disease outbreaks.

The camels are primarily kept for their milk production capabilities. The employed herdsmen, instead of milking the beef cattle, drink camel's milk, thereby the cattle calves have faster growth rates as they receive all their mothers milk.

Camels on ranches control bush encroachment and their feeding habits complement those of cattle. Some ranchers also use camel for transport, ploughing, desilting dams, etc., and for diversification into tourism.

Most camels on the ranches are originally of Somali or Turkana stock, with a large number of crossbred offspring. Recently, camels have been imported from Pakistan in an attempt to improve milk production.

Boran and Sakuye

The Boran and Sakuye people of northern Kenya own camels. They are mainly a cattle people, but have camels primarily as transport animals, as well as some for milking.

Maasai

Since 1989, the Maasai people of southern Kenya have begun to show a desire to keep camels. To date they own less than 500 camels, but more Maasai are interested in obtaining camels, primarily as milking animals.

Table V summarises all reports found in the literature, on camel herd structure for the different tribes.

Milking and calf management

Milking management varies from tribe to tribe; in general, camels are milked before going to graze in the morning, and on their return from grazing in the evening. The calf is normally allowed to suckle to stimulate milk letdown, for without this stimulation the camel cannot be milked. Milking is carried out in the standing position, and the milk pot can be balanced on the upper part of the leg to allow milking with two hands. Less competent milkers hold the milk pot with one hand, and milk with the other hand. Two people are normally required if all four teats are to be milked.

Somali

Somalis allow calves to accompany their mothers, and to suckle freely during the day, so the calf is only separated for a short period at night. They do restrict colostrum intake by the calf. To stop the calf suckling all the milk during the day, and to conserve milk for human consumption, the teats may often be tied with string made from *Acacia* spp. *"bark"*.

Camels are milked early in the morning and late at night, at least two hours after returning to the pen (MARES, 1954). Normally, only two teats are milked, whilst the calf suckles two other teats. All milking is done by men, and they often milk the camels whilst at pasture during the day. Under good conditions, Somali camels can average 3 litres of milk per day for human consumption (SIMPKIN, unpublished).

Rendille

Rendille only milk camels twice a day, at about 8.00 a.m. and 9.00 p.m. If yields are high e.g. early in lactation camels may be milked 3-4 times per day. Only uncircumcised boys and ritually cleansed man may milk. Calves are separated from their mothers when only 2-4 weeks old, and are penned separately night and day. Calves are only allowed to suckle after all four teats have been milked, as a result there is a high calf mortality.

Table V. A review of camel herd composition (%) in Kenya.

Tribe	Adult males	Castrate males	Adult females	Immature males	Immature females	Male calves	Female calves	Source
Rendille	5	14	61		11		9	Schwartz (1980)
Rendille	8	12	46		17		17	Field (1982)
Rendille	7	9	67			17		Fratkin (1976)
Rendille	3.3	14.5	61.5		9.5		11.1	Sato (1976)
Rendille	–	–	40-50					Spencer (1973)
Rendille	5	15	38	13	11	8	10	Simpkin (1985)
Rendille		14.4	36.5	13.9	18.4	7.5	9.4	Heath (1993)
Turkana		8.7	41.1	13.5	19.5	7.6	8.6	Heath (1993)
Turkana	2.5	12.2	46.9	8.4	10.2	9.5	10.8	Simpkin (unpublished)
Turkana	0.8	7.7	49.8			41.7		Bremaud (1969)
Somali	7	0	62.4			30.5		Bremaud (1969)
Somali		16.2	37.9	9.5	19.4	7.1	10	Heath (1993)
Gabbra	3.4	22.2	40.6			34.1		Bremaud (1969)
Gabbra	–	–	40	–	–	–	–	Torry (1973)
Gabbra		25.1	30.2	11.1	13.7	9.6	10.4	Heath (1993)
Gabbra	10.1	24.5	36.6	8.4	11.6	7.1	6.9	Simpkin (unpublished)
Samburu		12.2	42.4	12.1	16.2	8.7	8.4	Heath (1993)
Samburu	5	12	40		26		18	Simpkin (in prep.)
Pokot			40					McGovern (in prep.)

Mean yields are 2-3 l/day over a lactation of 41-57 weeks. If calves survive daily yields reach 3-3.5 l/day. The maximum recorded yield was 17 litres. Calves are weaned at 8-12 months (Simpkin, 1985*a*).

Both Rendille and Gabbra do not take calves less than 2 months to water.

Gabbra

Gabbra milk camels at about 9.00 a.m. and again at 9.00 p.m.-10.00 p.m. Calves are only allowed to suckle for 4-5 hours during the night and are separated again at 2.00-3.00 a.m. Young calves are kept in the pen all day, but join a nursery herd at 3 months.

The calf suckles two teats whilst two teats are milked. Peak yields are 10 litres per day, but the mean is 0.5-2.0 litres per day in dry seasons.

Pokot

Pokot milking is done by both men and women, only one hand is used to milk the animals. In times of high yield camels can be milked up to 4 times a day (morning, noon, evening and night), but in very dry times they are only milked at night.

Calves remain behind in a pen during the day, and browse is cut for them. At night, calves sleep in the same pen as their mothers.

Mean milk yield to the family is about 2 litres per day.

Turkana

In Turkana all the milking is done by women. Calf and mother are separated just a few weeks after calving, and the calf is only permitted to suckle whilst the mother is milked and for a short time afterwards. Camels are often milked four times a day, but may be milked up to seven times a day during the rainy season. Generally only two teats are milked on each occasion, but it depends on food requirements, all four teats can be milked if necessary.

Mean daily yields are about two litres of milk in a lactation 16-18 months long.

Samburu

Samburu camels are milked 3-4 times per day. It is the women who milk the camels. Milking imitates the style favored by the Turkana—the camel has one side of the udder milked whilst the calf suckles the other two teats. This is the same manner in which the Samburu milk their cattle, they milk with one hand and hold the milk container with the other hand. This relatively slow and inefficient method of milking probably results in a lower milk output to the people, and enables the calf to obtain a better proportion of the yield, subsequently there are lower calf mortality rates recorded in Samburu herds when compared to Rendille herds.

Young calves are often separated from their mothers during the day, but the practice varies from place to place, and since camel husbandry is still new to them there are no hard and fast rules.

Table VI summarises the various milking methods utilised by the different tribes in Kenya. It only includes the factors that may have an effect on milk yields.

Milk production

Many of the reports in the literature comment on the high milk yields obtained from camels and compare them to yields from other livestock. Spencer (1973) claims that camels yield more than 4 times as much as cattle in the Samburu and Rendille areas, whilst STILES (1983) claims the figure to be between 5 and 10 times more.

There is a considerable range in actual mean yields for camels which can be put down to many factors, but one of the major reasons is that many of the reported yields are only based on short-term observations and are estimates rather than accurately and routinely collated milk records.

Furthermore, many of the authors do not state whether the yields are those obtained by the herdsmen, and represent the milk available for human consumption, or whether the figures include estimates of the volume consumed by the calf.

It should be noted that the duration of lactation is of equal importance to the pastoralist as the actual mean daily yield. This is because all the other livestock have relatively short lactations, and in the long dry season it is often only camels that are able to produce milk.

Table VII summarises documented and published milk yields for camels in Kenya.

Camel milk yields in Kenya tend to be lower than yields quoted in the literature for dromedaries in other parts of the world. The reasons for this include:
- camels in Kenya are kept in the marginal areas and receive no food supplement;
- management levels are primitive;
- there is little or no disease control;
- camels have been kept for subsistence rather than commercial purposes, hence there has been little quality control because quantity rather than quality of animal was important.

Factors affecting yields

The variables that affect milk production are the same for all ruminants, but some of the effects are more obvious in camels due to the more extreme conditions and management methods that they have to endure.

The major factors that affect camel's milk yields include:
- forage (quantity and quality);
- watering frequency;
- climate;
- breed;
- age and parity;
- milking frequency;
- calf survival and presence of the calf;
- milking method (hand or machine milking);
- speed of milking;
- health status;
- reproductive status;
- individual potential.

Since this paper is intended to concentrate on the different milking management methods, some of the other factors are only discussed briefly despite the fact that they may have a more noticeable effect on yields than the actual milking methods adopted by the different pastoral groups.

Many of the factors are interdependant as for example climate which affects both forage availability and quality, water availability, and indirectly the reproductive status.

Table VI. Milking management techniques in Kenya.

Management	Somali	Gabbra	Rendille	Samburu	Turkana	Pokot	Ranch
Management system	nomadic	nomadic	nomadic	semi-nomadic/ sedentary	sedentary	sedentary/ semi-nomadic	rotational
Watering frequency	7 days	7-10 days	10-14 days	2-7 days	free access	free access	free access
Calf access	free	restricted	restricted	restricted	restricted	restricted	free
Number of teats milked	2	2	4	2 or 4	2 or 4	2	2
Who milks	men	men	boys/men	men/women	women	men/boys	men/women
Number of hands used to milk	2	2	2	1	1	1	varies

Table VII. Camel's milk yield in Kenya.

Location	Tribe	Mean daily yield (kg)	Maximum daily yield (kg)	Total lactation (kg)	Duration of lactation (months)	Calculated 365 days yield (kg)	Source
Not stated	Not stated	5.2-10.3		1,905-3,744		(1,898-3,760)	Mukasa-Mugerwa (1979)
Not stated	Not stated	4.0-10.0				(1,460-3,650)	Farah *et al.* (1990)
Not stated	Not stated	4.5		2,500	11-16	1,643	Farah (in publ.)
North	Not stated	2.2		1,897	11-16	(803)	Field (1979)
North	Not stated	4	12		12	(1,460)	Hartley (1984)
North	Rendille breed	3				(1,095)	Bachmann and Schulthess (1987)
North	Somali breed	4.5				(1,643)	Bachmann and Schulthess (1987)
North	Boran	4	12		18	(1,460)	Dahl and Hjort (1976)
North	Somali	5.0-6.0		3,500	15-16	(1,825-2,190)	Schwartz (1992)
Mandera	Somali		9		10-24		Bremaud (1969)
Wajir	Somali		9		10-24		Bremaud (1969)
Marsabit	Not stated	2.7-4		1,019-1,975	13	(986-1,460)	Field (1980)
Marsabit	Gabra		10		10-24		Bremaud (1969)
Marsabit	Gabra		11				Torry (1973)
Marsabit	Rendille	2.6			20	(949)	Sato (1976)
Marsabit	Rendille	4.5		1,660	12	(1,643)	Spencer (1973)
Marsabit	Rendille-Treatment	2.84		1,146	13.1	(1,036)	Simpkin (1985)
Marsabit	Rendille-Traditional	2.37		687	9.4	(865)	Simpkin (1985)
Laikipia	Ranch	5.5-7.5				(2,008-2,738)	Evans and Powys (1984)[1]
Laikipia	Ol Maisor Ranch	2.83		1,033	12	(1,032)	Simpkin (1985)
Laikipia	Ol Maisor Ranch	1.23[2]				(448)	Atkins (unpublished)
Laikipia	Ol Maisor Ranch	1.38[2]				(504)	Evans and Atkins (1987)
Laikipia	Ol Maisor Ranch Somali breed	5.0-6.0			15-18	(1,825-2,190)	Atkins (pers. comm.)
Laikipia	Ol Maisor Ranch Turkana breed	2.0-2.5			15-18	(730-913)	Atkins (pers. comm.)
Tana River	Galana Ranch	5.33		1,945	12	(1945)	Simpkin (1985)

1. Only measured over 30 days, and depended on milking frequency per day—some milked 2x and some 4x.
2. Daily milk in bucket yield. ( ) = calculated from daily yield.

Forage

Both the quantity and quality of forage are important. The majority of camels in Kenya are managed in a nomadic or semi-nomadic manner, in order to make optimum use of the available forage. There are however, still periods when forage is in short supply and milk yields decrease.

There appear to be two peaks in the lactation curve: the first is very marked and occurs in the first few weeks of lactation; the second corresponds to the following wet season when forage is again plentiful.

It is interesting that even on ranches where the forage is often more plentiful than in the northern grazing lands, camel herds are still rotated around the ranch to make more even use of the vegetation—a small scale equivalent to nomadism.

A feeding trial where lactating camels received a fodder supplement of poor quality millet and sorghum, showed that there was no statistically significant increase in milk yield. The camels' anatomical and physiological adaptations to the arid environment enable it to fill a feeding niche that would make apparently supplementary feeding or zero grazing economically viable in only a few situations. It would only be worth implementing in the more arid areas, using high producing animals, in locations where supplementary fodder is locally available, and where there is a local market for the milk.

Watering frequency

During dry seasons in the arid rangelands, camels may be watered at intervals of up to 2 weeks. Water intake effects milk yields in most ruminants, although camels can suffer 7 days of dehydration without any effect on milk yield (Yagil, 1982). However 10 days dehydration did significantly decrease milk yield in camels in Marsabit district (Simpkins, 1985*a*). Water deprivation over the long term may adversely affect yields, since dehydrated camels stop feeding and seek shade earlier in the day, thus limiting food intake.

Climate

Climate, primarily rainfall and temperature, affects productivity in many ways since it correlates with forage availability and quality, water availability and intake, ambient temperature and reproductive status.

Breed

Camels in Kenya are normally classified into 3 classes or breeds: Somali, Rendille/Gabbra, and Turkana. The names used for this classification are primarily based on the ethnic group and distribution of the camels, however some distinguishing anatomical and physiological differences are apparent and are summarised in table VIII. The Somali pastoralists recognise different characteristics within camels of the Somali breed and 3 or 4 types or races are described.

It is widely recognised that the 3 different breeds have different milk producing capabilities. The only documented results of studies to determine their relative productivities are from the feeding trials on Ol Maisor Ranch and are reported in table IX.

Somali breed camels had significantly higher weekly yields than other breeds in the feed group.

As in other livestock, there are also considerable differences in milking potential between individuals.

Table VIII. Breed characteristics (compiled from Mares, 1954, Wardeh *et al*., 1991, Dioli, unpublished, Simpkin and Guturo, unpublished).

Breed	Race/ type	Shoulder height (metres)	Adult male live-weight (kg)	Adult female live-weight (kg)	Birth weight (kg)	Daily milk yield (litres)	Duration lactation (months)	Total yield (litres)	Description
Somali		1.8-2.2	550-600	600-700	30-35				
	Siftarr					6	12	1,500	Tall, heavy, light colour
	Horr					7-8	8-16	2,050	Shorter, broad, black drooping lips, full bellied, some lack hair
	Aidimmo						6-10	1,000	Tall, heavy, light colour
	Gelab								Medium, grey
Rendille/ Gabbra		1.7-1.9	350-450	400-500	30	3-4	12	1,000	Grey, fawn, red/brown
Turkana		1.7-1.87	350	400-450	25	2-3	9-10	700-1,000	Small, dark, hairy

Table IX. Mean weekly yield per camel during pre-trial and trial periods according to different camel types (kg).

Camel type	Feed group		Control group	
	Pre-trial	Trial	Pre-trial	Trial
Somali	10.4[1]	9.9[1]	6.6	6.3
Turkana	6.8	6.3	6.1	5.7
Cross-breed	5.8	5.5	5.6	6.0

1. Significant at P = 0.01.

Parity

There has been no specific research on how parity effects milk yields in camels in Kenya. It is likely that the same trends that occur in other ruminants also apply to camels. Observations indicate that first parity lactations are much smaller than subsequent lactations. Work reported by MARTINEZ (1989) in Mauritania shows differences in yield between age and parity, but it is not certain if there are significant differences.

Milking frequency

The size and anatomy of the camel udder limits milk secretion rates. Unlike the cow there are no large storage cisterns or sinuses in the camel udder. This is likely to lead to a build up in intra-mammary pressure and a reduction in secretion rate. Frequency of milking or suckling is therefore likely to have a considerable effect on milk production.

SHALASH (1984) reports a 10-12% increase in yield if milking is done 3-4 times per day instead of twice. EVANS and POWYS (1984) have shown that increasing milking frequency increases milk yields. Over a one month period camels that were milked 4 times per day averaged 6-7.5 litres per day compared to 5.5-6.5 litres for camels milked twice a day.

Table VI shows that some tribes allow the calf free access to suckle, whilst other severely restrict suckling to morning and evening only. Some of the tribes that restrict calf access do milk the camel more often, whereas others only milk the camel the usual two times per day.

The effects of these different milking regimes on milk production are presently being investigated in order to determine which method proves to be the most suitable in ensuring sufficient milk offtake for human consumption, whilst not jeopardizing the survival chances of the calf. In this experiment there are two milking management systems:

Controlled herd

Calves run with their mothers during the day, but are separated at night—similar to the traditional Somali style of management.

Separated herd

Calves are separated from their mothers day and night, and only suckle morning and evening, similar to the Rendille and Gabbra management system.

The results are presented in table X.

Table X. Milk yiels of camels: comparison of two strategies.

	Mean "in-bucket" yield		Estimated total yield	
	Controlled	Separated	Controlled	Separated
Mean annual yield (litres)	820	1,154	2,394	2,498
Mean daily yield over 12 months (litres)	2.2	3.1	6.6	6.8
Mean 305 days total yield (litres)	746	1,066	2,202	2,314
Mean daily yield over 305 days (litres)	2.4	3.5	7.2	7.6

Preliminary results show that in-bucket yields were affected, but estimated 24 hour total milk yields and milk secretion rates were unchanged. Calf growth was unaffected.

Calf survival and presence of the calf

The importance of the presence of the calf on milk letdown is well understood by camel owners, and in most circumstances the calves are always present to initiate milk letdown before the camels are milked.

Camels whose calves survived past weaning had mean daily yields 65% higher than camels whose calves died before weaning. Mean lactational yields were 2.9 times higher (SIMPKIN, 1985*a*). These considerable differences are no doubt due to increased suckling frequency in camels with surviving calves, and the action of suckling releases the hormones responsible for milk ejection which may also have an effect on milk secretion.

Milking method

All camels in Kenya are milked by hand. Machine milking of camels in Russia obtained higher yields in a shorter milking time than hand milking (MUSAEV, 1982).

Skill and speed of milking

The experience of the milker has an important effect on yields. In the absence of the calf the strength of the milk letdown reflex depends on the skill of the milker, and if only poor milk letdown is achieved the amount of milk obtained at milking will be reduced. If the udder is not emptied completely it can have a negative effect on secretion rates.

Speed of milking increases milk output.

In table VI, the tribes that allowed calves to suckle two teats whilst the herder milks two teats are likely to achieve better letdown, a higher degree of milking out, and proportionally a higher yield of milk than tribes who allow the calf to initiate milk letdown but then restrain the calf from suckling and milk all four teats by hand.

Similarly, the tribes that balance the milking bowl on their leg and milk using both hands are likely to achieve a better milking rate than those who hold the bowl in one hand and milk with the other hand.

Health status

Camels suffer from a number of diseases, all of which affect production in different ways. In Kenya, trypanosomosis, internal helminths, external parasites (ticks and mange mites) are some of the most common diseases that affect production. The effects can be direct, such as mortality (both adult and calf), morbidity and general unthriftiness; or indirect, such as abortion and loss of feeding opportunities.

A study carried out in Marsabit district comparing the milk production from traditionally managed camels with a herd receiving routine veterinary input showed that veterinary input significantly increased mean daily milk yield by 463 ml, and total lactational yield by 66.7% (SIMPKIN, 1985*a*).

A cost benefit analysis proved that the use of veterinary drugs was economic in its effect of increasing both milk production, meat production and calf survival.

Reproductive status

FIELD (1979) records that lactation declines after a successful mating occurs, and ceases altogether about 6 weeks later. He also noted that in dry years when the breeding pattern is interrupted and camels do not become pregnant, the lactation can continue for up to 2 years.

Conclusion

There are a number of different customs regarding camel management, all of which have some effect on milk production. These customs have been built up over centuries of camel keeping and are a result of the aims of the owners and the environmental conditions in each area. Many of these customs appear to be retrogressive and to the scientific mind might actually reduce production levels. One tends to find however that there are real reasons for these customs to have developed and it is often dangerous to come up with new camel management proposals before sufficient research and investigation is undertaken. The practice of calf separation for example, may appears to be detrimental to the calf's wellbeing, but is in fact maintained in order to reduce stress on the lactating female.

Trying to change centuries of tradition and lore is very difficult, especially with pastoralists. Research results should however help recent and future camel owners to benefit more from their stock. Practical research of this nature should not simply end in scientific reports, but should be incorporated into extension and information packages that can benefit the camel owners themselves.

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Science and camel's milk production
(some keys for nutrition and marketing)

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Abstract. Camels can lactate even under severe drought conditions. This communication describes how the camel is able to retain lactation even when dehydrated and when other milk-bearing animals perish. Not only is lactation preserved but the quality of the milk under drought conditions is admirably suited to human requirements. The mechanisms governing milk production are described. Besides milk production of amounts up to 20 litres a day or more, other aspects which make the milk special are discussed. These aspects are: the logistic problems associated with camel's milk production; the requirements for maximal milk production; the uses of camel's milk besides for drinking; the need for pasteurization of camel's milk; the medicinal properties of camel's milk; if camel's milk is a usable product, why then are the production systems of the nomads considered as primitive? The scientific input in answering all of these questions is important and will help in elevating the status of camel herders in all arid lands. It is concluded that the inherent ability to provide milk in times of drought, can be utilized to provide much needed food for children who would otherwise succumb to malnutrition and even to food aid which is not suitable for them. The years of misconception that camel herders are "primitive" have worked against the acceptance of camel's milk as a suitable source of nutrition, but that is all changing in the present climate of seeking ways to make people self-sufficient in food production.

Key words. Dromedary, *Camelus dromedarius,* lactation, milk product, colostrum, human feeding, child feeding, therapy, Israel.

Résumé. Les chameaux peuvent produire du lait même sous de sévères conditions de sécheresse. Cette communication décrit l'aptitude du chameau à assurer une lactation complète même en état de déshydratation, quand d'autres mammifères (pourvoyeurs de lait) périssent. Non seulement la lactation est préservée, mais la qualité intrinsèque du lait, même sous ces conditions de sécheresse, reste conforme aux exigences humaines. Les mécanismes en œuvre dans la production de lait sont décrits. Outre la production de lait qui peut s'élever jusqu'à 20 litres par jour ou plus, d'autres aspects qui rendent cette filière si spéciale sont discutés. Ces aspects sont : les problèmes logistiques associés à la production de lait de chamelle ; la demande pour une forte production de lait ; les usages du lait de chamelle autrement qu'en boisson ; la demande de lait de chamelle pour la pasteurisation ; les propriétés médicinales du lait de chamelle ; enfin, si le lait de chamelle est un produit de consommation, pourquoi les systèmes de production nomades sont-ils considérés comme primitifs ? Une réponse scientifique à toutes ces questions est importante et aidera à promouvoir le statut des chameliers dans toutes les zones arides. On en conclut que la capacité inhérente du dromadaire à produire du lait en période de sécheresse peut être utilisée pour fournir plus de protéines et de matières grasses aux enfants qui souffriraient de malnutrition, et pour l'aide alimentaire en général. Les malentendus historiques ayant abouti à la mise à l'écart des systèmes camelins hors des projets de développement ont fait que la prise en compte du lait de chamelle, en tant que source alimentaire, a été retardée. Mais cette contrainte s'amenuise aujourd'hui dans un environnement qui cherche à favoriser et à valoriser avant tout la sécurité alimentaire des populations.

Mots clés. Dromadaire, *Camelus dromedarius,* lactation, produit laitier, colostrum, alimentation humaine, alimentation de l'enfant, thérapeutique, Israël.

Introduction

The most frequently asked question is "how much milk does a camel give, compared with a cow ?". The answer is not always easy if one is not familiar with all the animals concerned, and misleading information in the past has often led to the conclusion that the camel has no role to play in modern farming. When writing about camel's milk it is imperative to stress that the most important point is that "the camel is not a cow" and should not be compared with a cow. This communication concerns the one-humped camel, the dromedary (*Camelus dromedarius*) and not the two-humped camel, the Bactrian (*Camelus bactrianus*). Although they are both camels, the physiological adaptation is entirely different: dromedaries are adapted to hot arid lands, camels are adapted to cold, arid lands. The difference in environment affects the type of milk produced. It is important to ensure that the questioner understands that the milk production of a camel—the one-humped desert species—takes on special significance in the drought-stricken, famine-rife areas of the world, where cows have difficulty in surviving, and camels let alone for producing milk (YAGIL,1984). In consequence, often even meager amounts of camel's milk can make the difference between life and death.

Camels were first domesticated some 3,000 years ago for their milk (EPSTEIN,1971), and for use as pack animals. However, their use as pack animals was discontinued after the end of the First World War when armies became mechanized, and pack animals fell into disrepute. Camels were then relegated to being "animals of primitive societies". Publications by KNOESS (1977) and YAGIL (1982) were not convincing enough to warrant large scale acceptance of the camel as a farm animal. The main reason for this was that the experts in large governmental organizations are more familiar with cows and find it difficult to accept that a "primitive" animal like the camel, can be a good producer of milk, even better than cows and goats. This means that virtually nothing was done to utilize the milk production of camels, especially in the drought-stricken lands where the milk could have played an important role in feeding children. So the "Great Drought of Africa" (1984) and the "Long Drought of Africa" (1990-1993) were palliatively handled by the industrialized countries by flying, or shipping, food which was often foreign to the palates of the local population and indigestible, by the children (YUVAL, 1992). Camels, which are tylopodes and not ruminants, were virtually unaffected by drought. The only problems encountered by the camels were caused by a lack of salt and by intestinal parasite infestation (personal observations).

At an international conference of the Physiological Society held in Budapest in 1980, a paper was presented describing the scientific rational of the camel as a farm animal (YAGIL and ETZION, 1980). The presentation was well accepted by the scientific community but still did not activate development of camel farms by the agricultural community. Slowly this has changed as more and more information has become available. The importance of this symposium in Mauritania will be to gather all available data on milk production of camels to formulate a multi-national approach for disseminating the data.

This present communication will present scientific data showing the importance of camel's milk in arid lands especially in times of drought when other ruminants cannot survive. The communication stresses the need for academic involvement in camel farming.

In orders to convince policy makers of the agricultural benefits of camels the following information is necessary:
- Does the camel maintain lactation in times of drought?
- Are there logistic problems associated with camel's milk production?
- What is required for maximal milk production?
- What are the uses of camel's milk?
- If camel's milk is a usable product in modern society, why are nomads considered primitive?

Materials and Methods, Results, Discussion

Camel lactation in times of drought

In drought-stricken areas ruminants are inferior to camels because of their physiological dependence on large amounts of water for metabolism and cooling (YAGIL, 1984). In these areas they are also negatively affected by other circumstances such as: extreme heat in the day, cold at night; extreme solar radiation; brackish surface water due to evaporation; poor quality and sparse vegetation. Under these circumstances, sheep, goats and cattle stop lactating and eventually die if shade, fresh water and good fodder are not available. In Wajir, in the north-eastern area of Kenya, over 85% of the ruminant population perished in the drought of 1990-1992.

Water deprivation and milk production

Six camels belonging to a Bedouin were milked three times a day and the amounts of milk recorded. The camels were in their third month of lactation.

RESULTS

The average volume of milk was 9.2 ± 0.6 liters per day, evenly divided between milkings. It must be noted that the let-down is for a limited period and an inexperienced milker will have difficulty getting out milk in this period. During the day the calves had free access to the udder and were observed drinking every few hours throughout the day.

Calf requirements

Six female camels in the fourth month of lactation were studied. The amount of milk drunk by a calf was estimated using methods used for determining milk volumes of animals which are difficult to handle, like primates, based on the dilution of blood by milk (water). Calves were injected with tritiated water and blood samples were taken each day. The natural decay of tritium in blood was previously determined. The studies were carried out when drinking water was readily available and following 7 days of dehydration.

RESULTS

The four-month old calves drank an average of 6 liters per day. When adding the amount of milk consumed by the calf to the amount milked, the daily milk production reached approximately 15 liters a day.

Water deprivation and milk quality

The lactating camels were subjected to 7 days periods without drinking water. At the end of these periods they were allowed free access to water for 2 hours after which the water deprivation began again.

Water, salt, vitamin C, pH and fat content of the milk was examined by standard laboratory procedures.

RESULTS

The most striking finding was that the milk became more diluted due to the dehydration, over 90% water with low fat, about 1%. The salt (NaCl) content of the milk was significantly ($P < 0.001$) elevated from 10 ± 0.4 to 23 ± 2.6 meq/l. Vitamin C content was 28 ± 3 mg/l. The pH was low (6.3 ± 0.4) and virtually unchanged during water deprivation.

DISCUSSION

Camels continue lactating during times of drought because water is not absorbed from the mammary gland in order to conserve body water. In fact the milk becomes more diluted, a phenomenon which is hormonally controlled (YAGIL, 1988). The lack of drinking water increases the secretion of aldosterone and vasopressin, the hormones governing salt and water metabolism, leading to the conservation of water and salt. This occurs when these hormones regulate homeostasis but when they regulate homeothermia, water is lost from the skin for evaporative cooling. As the mammary glands have the same ontogeny as sweat glands, the effect of vasopressin also causes water secretion from the mammary glands, hence diluted milk. This phenomenon was also found in rats exposed to heat and treated with vasopressin; instead of milk being concentrated it became diluted (ETZION and YAGIL,1981). In addition, vasopressin in large concentrations acts on the kidneys and mammary glands as oxytocin and vice versa (YAGIL, 1985). Therefore, dehydration in fact leads to added water secretion and hence protects milk volume while diluting milk. This is also the reason why attempting to stop lactation by restricting drinking water in women or dogs fails—lactation is retained or even enhanced. This hypothesis was further reinforced by the finding that diluted milk in cows was caused by increased vasopressin concentrations when the animals were allowed only a fraction of the daily water requirements (YAGIL *et al.*, 1986). Dehydration in camels led to an increase in salt content, thereby providing the calves with essential salt for their metabolism.

These facts are important when considering using camel's milk for various products as the state of hydration will affect the composition of the milk and, hence, the product itself.

KNOESS *et al.* (1986), showed that camel were producing milk volumes ranging from 17 to 26 litres per day and that after one year these volumes were often unchanged or only slightly lowered (11 to 26 litres). Lactating camels still maintained lactation capabilities after one-and-a-half years in spite of participating in various research projects (YAGIL, personal observation). These projects demanded the insertion of bladder catheters, veinous punctures to be carried out many times a day and also periods when the camels were subjected to water deprivation for 14 days a time.

The low pH of camel's milk appears to be correlated with the high vitamin C content, giving the milk its sweet taste, which can be masked if the animal eats salty or bitter vegetation. The pH is much lower than for cows (6.8) or women (7.6).

The stories of desert travelers taking a milk camel with them are, therefore, based on the fact that the amounts of milk are virtually unchanged during a long, stressful march. In fact the milk is diluted, making it a good source of nutrition for the travelers. This is in striking contrast to the ruminants, sheep, goats and cattle, where the lack of drinking water leads directly, and quickly to a decline in milk production (KONAR and THOMAS, 1970).

The rapid let-down of milk in camels has been recognized by pastoralists who normally milk with two people simultaneously, one on each side.

CONCLUSION

The physiological or evolutionary adaptation of she-camels to aridity allows them to continue providing milk while the quality changes in order to guarantee life for their young, but is also admirably suited for human consumption. The camel can produce high volumes of milk and so should be selected for milk production.

All of these scientific data confirm the words of the Koran that when people were suffering in the hot climate God save them :
"...the she-camel to drink of its milk" (KHAN, 1974).

Colostrum

It is necessary to provide some information about camel's colostrum. In some parts of Africa, colostrum is not drunk by the calves as the pastoralists believe that it contains poison (SAIDI, 1992). This prevents calves from acquiring basic antibodies which are essential for their well-being and would account for calf deaths. It appears that when a Chief drank the milk directly after the she-camel gave birth he was struck with severe stomach cramps and, hence, its relegation to being spoilt on the ground as being unfit for even the calf. Camel's colostrum is not yellowish to reddish color as in cattle but white directly after partus, as normal milk, with low fat, high protein and high ash content. It is highly cathartic, which brings the calf's alimentary tract into physiological activity. Over 200 camels were examined and the colostrum described by OHRI and JOSHI (1961) as being yellowish-white with abnormal odor were never seen. ABU-LEHIA *et al.* (1989) in their studies of colostrum do not mention the color or smell.

Logistics associated with milk production

It has become clear that camels can provide milk in times of drought when it is often the only food available, especially for children. As an example of the importance of camel's milk let us consider the area of Wajir in north-eastern Kenya bordering on Somalia and Ethiopia. In this area alone there are 120,000 camels (CHEGE, personal communication). If half are females and they would provide only 5 litres of milk a day this would mean a daily production of 300,000 litres. If 1 litre per day would be given to every starving child, then 300,000 children could be kept alive. A theoretical, highly imaginative idea or a practical proposal?

At a camel forum held together with the camel pastoralists in this area in June 1993 (SPAETH, 1993) it was clear that they were only providing milk for home consumption. After learning of the monetary compensation that could be derived from selling their milk, they asked for information on ways of improving lactation of their animals in order to provide more milk and thereby increase their income. This could be achieved by improving milking practices and treating animals for internal and external parasites. However, the logistics of getting fresh milk to the market must be solved, as well as possible friction caused by competition between herders for sales. The authors' idea was to set up a marketing office in the framework of a "Camel Centre". The "centre" would handle the sale of milk and meat while also providing a place for purchase of medications and experts to advise the herders on keeping their camels in the best condition. The camel centre would also provide a mobile extension service as well as top grade males for serving local females, show ways to plant fodder crops and find solutions for problems which would depress milk productivity.

What is required for maximal milk production?

Genetic make-up

The genetic potential of camels can be improved by selection, artificial insemination (using good bulls) and even embryo transfers using the best females as donors and the poor milkers as surrogates (YAGIL and VAN CREVELD, 1993).

Healthy animals

Healthy animals will provide maximum milk yields. As little is known about treatment of camels, the choice of drugs and dosages are normally based on treatment regimens of cattle and horses. Treatment of sick camels with drugs developed for ruminants or horses does not always give the desired result because of the camel's physiological ability to conserve water by radical changes in body water distribution (YAGIL, 1985). Therefore, intramuscular injection of some drugs does not heal the camel as the drug remains in the periphery (BEN-ZVI *et al.*, 1994 ; YAGIL *et al.*, 1994 ; ZIV *et al.*, 1994). Intravenous injections can also have unexpected results due to the decline in both renal (YAGIL, 1993) and hepatic (BEN-ZVI *et al.*, 1989) function, the two paths of drug elimination from the body. Less destruction of a drug will increase its activity time in the body and further injections will elevate the concentrations to lethal levels.

The best way to treat a sick camel is to give from 50 to 100 litres of 3% salt solution by gavage directly into the rumen before treatment. The choice of drugs should then be based on the probable cause of the infection and drug availability. Long-acting oxytetracyclines have been shown to remain active for 5 days after a single intramuscular injection, a period which normally suffices to get the camel "on its feet" and two further injections every 3-5 days are enough to cure the animal (YAGIL *et al.*,1994). If possible milk from the treated animals should not be used for human consumption for 5 days after the last treatment.

Milking machines

In general, it is difficult to visualize milking machines for camels because of the great variability in shape and size of udders and teats. However, if milking machines are introduced this will give impetus for the camel herders to breed towards standard sized udders and teats. Over 100 camels belonging to the Abu-Rabiya tribe in the Negev have udders and teats which are well-formed for milking machines. In other countries there certainly are those who could conform to standards that can be set and used as demonstration material. In Kazakhstan, although milk production is not only lower than dromedaries but only persists for 5 months (BORODIN, personal communication) milking machines have been used in the past. Milking machines will not only guarantee higher milk productions and better milk quality but also improve the social status of camel farmers.

Uses of camel's milk

The main use of camel's milk will, of course, be for drinking. However, as soon as production is higher than consumption, other ways of preserving and marketing camel's milk products must be found. Soured milk products are the most common milk products of all mammals.

Pasteurization or not?

One of the questions about camel's milk is whether it should be pasteurized or not. Often unfounded statements are made that pasteurization is a "must" for camel's milk, probably based on the fact that camels are normally dusty and their environment dirty-looking. However, the literature does not reveal milk-borne diseases among camel-milk-drinkers while many stories have been told about the medicinal properties. It was, therefore, decided to examine camel's milk in the same way that cow's milk is checked.

MATERIALS AND METHODS

Udders were cleaned with soap and water after which the teats and udders were wiped with an iodine solution. Hands were cleaned with alcohol and sterile gloves were used. Milking was done into sterile containers and immediately cooled. Samples were frozen until examination.

Bacteria content of the milk samples was examined in the Microbiology Department of the Veterinary Institute, Bet Dagan, using standard laboratory techniques. Specific tests for *Staphylococcus* spp. and *Streptococcus* spp. were used: Pladebact *Staphylococcus* test and Pladebact *Streptococcus* test (Karo Bio Diagnostik, A.B. Huddinge, Sweden).

RESULTS

Besides bacteria normally found in the mouths of calves no pathogenic bacteria were found in any of the samples. Fecal cocci appeared in the milk only once, coming from the hands of a camel herder who helped in the milking.

DISCUSSION

One particular problem associated with camel's milk marketing is the question: "Is there a need for pasteurization"? The answer seems fairly simple but in fact has given rise to much controversy. It must be considered that pasteurization was initiated to rid milk of harmful pathogens, especially tuberculosis. Besides the fact that camel's milk has been used to treat tuberculosis (DONCHENKO *et al.*, 1975), all camels that are milked are checked for tuberculosis which can easily be done in every country. Other pathogens like brucella, pasteurella, etc., can be checked, in the same way as for tuberculosis, before marketing the milk. If all camels are healthy there is no need for pasteurization. Mare's milk from Kazakhstan is exported to West Europe without pasteurization in order not to destroy special qualities of the milk (DUISEMBAEV, personal communication) as the mares have been examined and found to be free of diseases which could be spread by milk. Although camels have been proven to be free of pathogenic infection there is still a resistance to drinking unpasteurized milk. The resistance is normally based on the (mis)conception that camels are dirty animals and, therefore, must harbor diseases. However, it must be noted that camel udders are not normally cleaned before milking and the hygiene of the milkers is such that there is always a chance of bacteria from their hands entering the milk. So when considering the marketing of camel's milk basic hygiene practices must be introduced, although this applies to all products marketed by farmers in the developing countries. Milking machines would improve the hygiene of milking practices.

Cream and cheeses

The Jewish Talmud states that if a religious person wants to purchase milk he must make sure that it isn't camel's milk which is not kosher but he does not have to check when buying cheese or butter because they cannot be made from camel's milk. Modern technology has allowed these products to be made, and in Paris at the Conference on Reproduction of Camels in 1990, camel's cheese was brought from Tunisia. The main problem in making cheeses is the fact that a coagulum is only poorly formed when camel's milk comes in contact with acid or pepsin. The fat composition of camel's milk differs greatly from that of cow's milk fat (ABU-LEHIA *et al.*, 1989; FARAH, 1993).

Separation of cream requires 5-6 days under refrigeration and must be repeated to obtain a good yield (WANGOH,1993) compared with several hours for cow's milk (ABU-LEHIA,1989).

Using modern techniques, cheese can be prepared and there is even a cheese-making kit available. It should be noted that as far back as 1985 a Swiss lady, Ms Gower, successfully made cheese from camel's milk in Kenya.

Medicinal Purposes

There are many folklore stories told by camel herders describing the use of camel's milk for medicinal purposes or as a health food (YAGIL, 1982). In many cases research carried out in the former Soviet Union showed that camel's milk was superior to mare's milk which in turn was superior to milk of other animals. Mare's milk is being exploited at present in Germany for medicinal purposes (DUISEMBAEV, personal communication). It has been shown that camel's milk has antibacterial and antiviral properties (EL-AGAMY *et al.*, 1992) which conform with previous data that camel's milk destroys *Mycobacterium tuberculosis* (DONCHENKO *et al.*, 1975). The laboratory of the authors has begun checking the scientific validity of the stories.

DIABETES

The authors personally have heard from Bedouin that they treat their diabetes by drinking camel's milk. There were even cases of juvenile diabetes being stabilized on camel's milk when insulin treatment had failed (LIBERMAN, personal communication). It was found that one of the camel's milk proteins is similar to insulin (BEG *et al.*, 1986).

The authors used a specific antibody to insulin in a RIA test for insulin (Coat-A-Count, Diagnostic Products Corp., Los Angeles, USA) in camel's milk and discovered large concentrations of insulin: 40 units/l.

Most skeptics to the anti-diabetes activity of camel's milk maintain that as insulin is a protein it will be destroyed by acid in the stomach especially as milk forms a coagulum in the stomach, allowing acid and pepsin to break down proteins over a period of time. However, the "disadvantage" of camel's milk is that it does not form a coagulum with acid (ABU-LEHIA, 1989) and is difficult to coagulate with rennet (WANGOH, 1993) and so cheese making is difficult. This lack of coagulum formation allows the camel's milk to pass rapidly through the stomach, together with the insulin. Even if some insulin will be destroyed enough will be available for absorption.

Another study was carried out on rabbits fasted and water-restricted for 24 hours. These rabbits showed a decline in blood sugar after camel's milk administration, suggesting that insulin activity was the cause. Although Bedouin are known to treat their diabetes by drinking camel's milk, more research is required before a final conclusion can be reached or before human studies can be carried out.

LIVER PROBLEMS

In Asia, it was shown that camel's milk had a beneficial action on chronic liver patients (SHARMANOV *et al.*, 1978). Based on this fact, camel's milk was given to a young child with biliary atresia (lack of tube carrying bile from liver to gall bladder) whose diet consisted only of cow's milk and whose condition was rapidly deteriorating. The deterioration was diminished and the child remained in good condition until a liver transplant was performed. It is quite possible that the relatively high concentrations of vitamin C in camel's milk, as also described by FARAH *et al.* (1992), aids in the improved liver function.

SUPPLEMENT FOR BREAST FEEDING

It is estimated that world wide there are 145 million malnourished children and from 4 to 5 million deaths due to diarrhea each year (UNICEF, 1992). Over 80% of these deaths occur in children under 2 years of age. Research is underway to examine the use of camel's milk as a supplement to mother's milk or as an alternative to formula in order to provide a nutritious fresh milk in areas prone to diarrhea due to bad hygienic conditions.

GENERAL FATIGUE

An adult man requested camel's milk from the authors to relieve his chronic fatigue as he had not worked more than 2 hours a day for the past 2 years. He had tried all kinds of treatment but nothing worked and medical checks could not find what was ailing him. After drinking camel's milk he immediately felt well and for a period of 6 months (to date) he drinks milk every few days and now works a minimum of 8 hours a day. The authors have considered that they were seeing a psychosomatic reaction. However, this man told of the "filling effect" ot the milk i.e., a feeling of satiation lasting up to 10 hours after drinking the milk, a phenomenon often described by the Bedouin. He aslo "complained" about added sexual prowess, another side-effect of camel's milk known to the Bedouin but not beforehand to this milk drinker. This person can also feel the differences in the effect of fresh milk and frozen milk.

Why are camel herders considered primitive?

This observation is true for herders all over the world. The main reason for downplaying the role of camels is the fact that they are mobile and present a (so-called) security risk for the host country. The mobile homes and lack of property also relegate the people to being "primitive". In fact society envisions town-dwellers as being the most advanced, then descending via cattle, then sheep and goat herders to the lowest, and hence "primitive", the nomads. It is true that camel herders lack formal education but they are far from being "primitive". They live in harmony with their environment and have a rich culture which also includes aspects of "alternative medicine".

Conclusion

It does not require a scientist to discover that pastoralists in drought-stricken areas are receiving milk from their camels when other food providers have succumbed to the environmental stresses. Nevertheless, the role of camels as food providers has been neglected because of the common misunderstanding of comparing camel production to cow production in the temperate climates. Even then the production of camels can be formidable. There are, however, many camels with low milk production because of bad selection practices over many decades which have increased the genes for poor milkers—bad milkers were mated more often than good milkers, increasing the numbers of bad producers. However, even poor milkers producing up to 5 litres of milk can still provide sustenance for 10 children because of the "filling effect" of the milk. The scientist can provide facts and figures which verify the ability of the camel to sustain milk production. Research has shown that the one limiting factor in camel health is salt (YAGIL, 1985). The physiological integrity of camels in drought is dependent on salt intake. Sometimes the soil lacks enough salt and if brackish water is not available, camels will resort to eating ant hills in their endeavor to find salt (YAGIL, personal observation). The role of science in camel's milk farming is one of problem solving. It is necessary to carry out research in those areas of milk production which are problematical as well as to upgrade milk production (by technology, drug treatment and milking machines). The years of misconception that camel herders are "primitive" have worked against the acceptance of camel's milk as a suitable source of nutrition, but that is changing in the present climate of seeking ways to make people self-sufficient in food production.

To quote the nomadic tribe of Ahaggar in the Sahara: *"Water is the soul. Milk is life."*

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Approche quantitative de la production laitière destinée à la consommation humaine, répercussion sur la croissance du chamelon

Etude réalisée en milieu traditionnel sahélien

M. SALEY, P. STEINMETZ
Projet camelin, B.P. 622, Zinder, Niger.

Résumé. Les auteurs rapportent les résultats d'un suivi laitier initié en janvier 1994 dans la zone pastorale des arrondissements de Gouré et Tanout (département de Zinder) au Niger. Ce suivi intéresse dix chamelles appartenant à quatre éleveurs (un Touareg et trois Toubous) sur six à huit mois, incluses dans le suivi zootechnique mis en place par le projet. Cette étude vise à apprécier la quantité de lait prélevée sur deux quartiers pour la consommation humaine. Parallèlement, un suivi pondéral mensuel des produits des chamelles en lactation est mené. Les premiers résultats font ressortir : une quantité moyenne quotidienne prélevée de 2,4 ± 1,1 litres par jour, ce qui correspondrait à une lactation annuelle de 1 760 litres ; un gain moyen quotidien (GMQ) des chamelons sur la même période de 319,0 ± 60,6 grammes par jour. L'importance de la quan6ité prélevée est fonction du milieu (saison), de l'animal (rang de lactation, race) et de l'éleveur (nombre de traites, priorité). Le passage d'une à deux traites par jour permet d'augmenter la quantité prélevée de 50 % sans minorer le GMQ du chamelon. La répartition des naissances au cours de l'année permet à l'éleveur de disposer de lait tous les mois. Ce suivi laitier se poursuivra afin de couvrir la durée totale de la lactation et s'étendra à de nouvelles chamelles entrant en lactation.

Mots clés. Dromadaire, *Camelus dromedarius*, production laitière, lactation, traite, croissance, nomadisme, Niger, Sahel.

Abstract. The authors report the results of a milk recording project carried out in the pastoral area of Goure and Tanout districts in Niger, from January to August 1994. The study monitored the performance of 10 female-camels belonging to four nomadic stock owners. This study aims to measure the quantity of hand-milked milk devoted for human consumption. At the same time monitoring of calf growth was carried out. The preliminary results indicate an average daily consumption of 2.4 ± 1.1 l/day. The average annual milk yield was estimated to be approximately 1,760 l. The Average Daily Weight Gains for their calves during the same period were 319.0 ± 60.6 g/day. The quantity of milk used for human consumption depends on the season, on the lactation rank, on the breed, and on the stock owners' practices. Milking twice a day increases the milk yield up to 50%, without any important consequences for calf growth. The distribution of births during the year provides an adequate supply of milk year-round in this area. Milk yield follow up will continue in order to monitor a full lactation period for females already in the scheme, and will also include new she-camels.

Keywords. Dromedary, *Camelus dromedarius*, milk production, lactation, milking, growth, nomadism, Niger, Sahel.

Introduction

La plupart des pays situés en zone aride et semi-aride connaissent un déficit en protéines d'origine animale, notamment en lait. Cet aliment est irremplaçable pour certaines catégories de la population et est fortement prisé. Dans les systèmes pastoraux traditionnels, il est bien difficile d'élaborer des méthodes de collecte de données afin de cerner cette production. Au Niger, dans le cadre des enquêtes menées sur les productions camelines par le Projet d'élevage Niger Centre-Est (PENCE) en 1984 (PLANCHENAULT, 1984), une ébauche d'étude avait porté sur deux femelles, mais la traite n'était pas complète. La plupart des études effectuées sur la production laitière du dromadaire ne précisent pas les conditions dans lesquelles elles se sont déroulées, la part de lait réservée au chamelon ni celle utilisée par l'éleveur pour ses propres besoins. DIAGANA (1976-1977) estime la quantité traite à 40 % de la production totale alors que pour FIELD (1980), 75 % de la production est utilisée par l'éleveur. Partant de ces considérations et constatant que les seules destinations du lait de dromadaire étaient l'alimentation du jeune et la traite (il n'y a pas de commercialisation ni de transformation), le projet camelin de Zinder (convention FAC 257/C.D./89) a initié un suivi laitier de mères suitées corrélé à un suivi pondéral de leur produit. Le but recherché est une approche quantitative de la traite et son éventuelle répercussion sur la croissance du chamelon, ceci afin de compléter la liste des indicateurs de productivité des troupeaux de dromadaires au Niger, dressée grâce au suivi individuel. Le propos du présent exposé, plus que les résultats partiels énoncés, s'attache à la méthodologie d'approche quantitative de la production laitière.

Matériel et Méthode

Le milieu

La zone d'intervention du projet (figure 1) est comprise entre 7° 40' et 11° 40' de longitude est, 14° 20' et 15° 40' de latitude nord. Elle reçoit en moyenne 100 à 150 mm de pluie par an. La végétation est composée d'arbres et arbustes (*Acacia seyal, Salvadora persica, Boscia senegalensis, Commiphora africana, Balanitex aegyptica, Ziziphus mauritiana, Leptadenia pyrotechnica, Calotropis procera, ...*), d'herbacées (*Cenchrus biflorus, Eragrostis tremula, Citrus lanata, Cyperus conglomeratus, Schoenfeldia gracilis, ...*).

Cette zone est équipée de six centres pastoraux, véritables pôles d'attraction et de services pour les éleveurs (santé humaine et animale, enseignement, boutique d'approvisionnement) mais également relais d'appui indispensables pour les actions de développement. Une esquisse d'organisation du monde pastoral est représentée par les groupements mutualistes pastoraux (GMP) comptant une trentaine d'éleveurs.

Les hommes

La zone pastorale du département de Zinder est occupée de façon permanente par des éleveurs en majorité touaregs (80 %), puis toubous et arabes. Leurs déplacements sont imposés par la disponibilité des pâturages mais restreints dans l'espace (rayon de 50 km) et varient d'un éleveur à un autre. Ils pratiquent l'élevage de dromadaires et de petits ruminants (troupeaux mixtes). Des Peuls traversent la zone avec leurs bovins ; après avoir essayé, sans succès, une reconversion dans l'élevage du dromadaire durant les périodes de sécheresse, ils sont revenus à leurs spéculations premières dès que les conditions le leur ont permis.

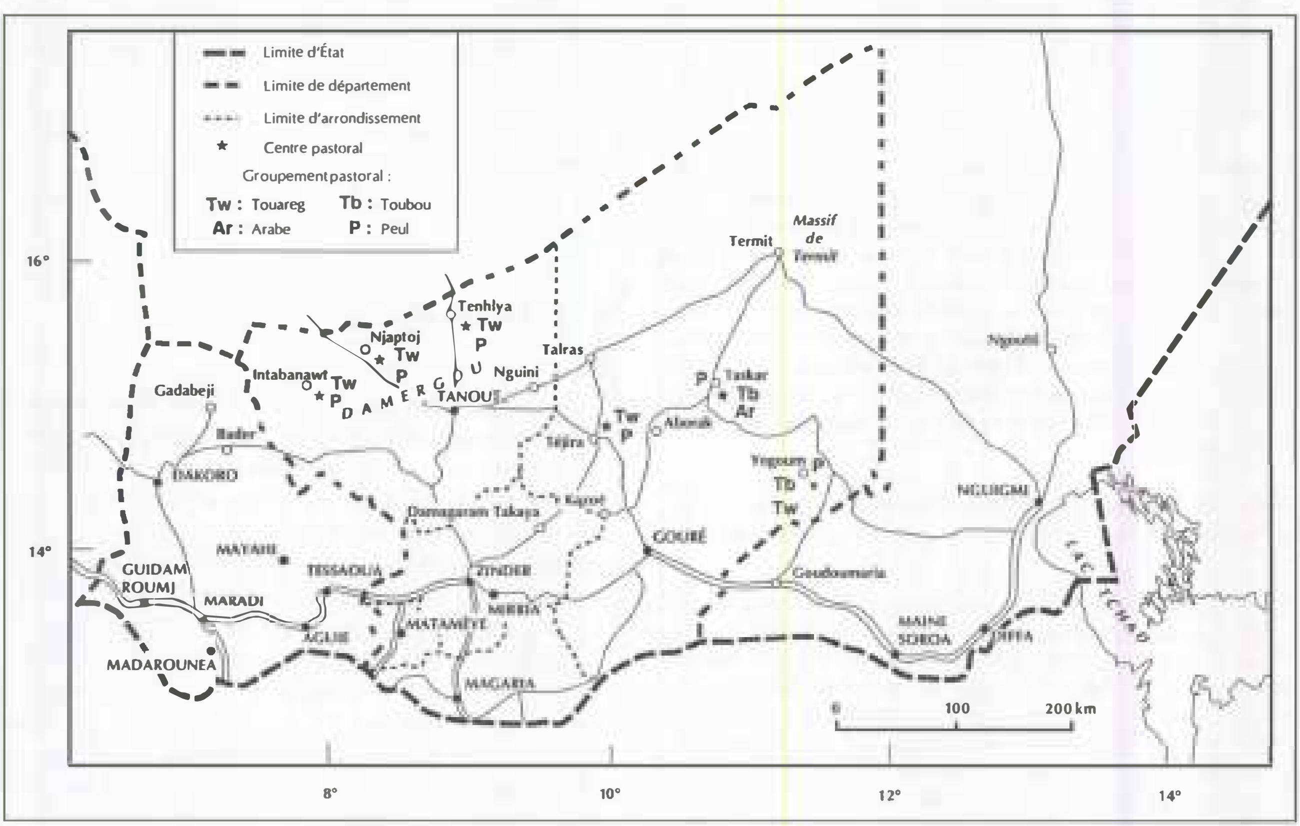

Figure 1. Aire d'intervention du projet : département de Zinder.

L'activité principale est l'élevage extensif. Le commerce basé sur les caravanes s'est considérablement réduit ces dernières années, se limitant au sel (natron) et aux dattes ramenés des oasis de Fachi et Bilma au nord (départements d'Agadez et de Diffa).

Le lait est destiné à la consommation humaine et à la croissance du chamelon. Les centres urbains du Sud sont occupés en majorité par des Haoussas ne consommant pas le lait de dromadaire.

Les chamelles suivies et suitées

Initié en janvier 1994, le suivi laitier devait porter sur un nombre important de chamelles en lactation. Proposé à l'ensemble des vingt-cinq éleveurs du suivi zootechnique, il n'a été réalisé de façon constante et sérieuse que chez quatre d'entre eux. Les chamelles sont en lactation, leur carrière de reproductrices est connue (tableau I) et elles n'ont pas bénéficié de traitement spécial (supplémentation, déparasitage systématique). Elles ont mis bas entre le 18 août 1993 et le 21 février 1994 et ne sont donc pas toutes au même stade de lactation.

Ces animaux font partie d'un suivi zootechnique et sanitaire portant sur 1 300 animaux, mis en place en avril 1992. Leur identification est faite par injection d'un transpondeur sous-cutané (tableau II). Les races retenues sont « Azargaf » pour les Touaregs et « Roux de Gouré » ou « Manga » pour les Toubous et les Arabes.

Le choix d'un système d'identification (tatouage, bouclage, identification par puce électronique) est fonction :
– des moyens disponibles ;
– de la population à identifier ;
– de la durée du suivi envisagé (renouvellement du troupeau).

Les perspectives envisageables sur le système choisi seraient la possibilité d'écrire (graver) le transpondeur, et l'utilisation d'un petit émetteur permettant la lecture à distance.

Tableau II. Avantages et inconvénients du marquage par implantation de transpondeur (type Indexel[ND]- Rhône-Mérieux, France).

Avantages	Inconvénients
• Pose rapide, indolore et sans réaction locale	• Disponibilité du lecteur
• Adhésion des éleveurs (nouveau, invisible)	• Autonomie du lecteur
• Pérennité	• Coût de la puce (30 FF)
• Fiabilité	• Coût du lecteur (5 000 FF)
• Identification de l'animal dès les premiers jours	• Numéros gravés à 10 chiffres et lettres
	• Environnement limité
	• Pas de lisibilité
	• Non-réversibilité du système
	• Hygiène de l'implantation

Les chamelons

Dans les jours suivant la naissance, les chamelons issus des mères incluses dans le suivi zootechnique sont identifiés et font l'objet d'un suivi pondéral et de la stature durant la première année. Le but initial de cette étude est la mise au point d'abaques. La répartition des naissances au cours de l'année (figure 2) montre une prédominance de la période suivant l'installation des pluies et précédant les grosses chaleurs. Avec des lactations supérieures à une année, les éleveurs peuvent ainsi espérer ne pas connaître de pénurie. Les chamelles du

Tableau I. Croissance des chamelons et production laitière des mères.

N° mère	N° produit	Ethnie	Mois de mesure	Quantité traite (l/j)	Production mensuelle (l)	GMQ sur la période (g/j)	l/kg PV pris
15	8168	Tw	8	392	49,0	338	13,0
18	2430	Tw	8	652	81,5	235	11,9
97	9800	Tb	6	273	45,5	278	6,9
93	6208	Tb	6	306	51,0	283	7,4
109	4075	Tb	6	263	43,8	237	8,0
575	621	Tb	6	394	65,7	390	6,4
3701	4047	Tb	6	396	66,0	320	6,1
274	8801	Tb	6	603	100,5	410	9,1
278	8399	Tb	6	581	96,8	368	13,5
280	7664	Tb	6	639	106,5	333	9,1
Moyenne				2,4 ± 1,1	70,63	319,0 ± 60,6	9,1 ± 2,7

Tw : Touareg ; Tb : Toubou ; PV : poids vif ; GMQ : gain moyen quotidien.

suivi montrent, pour les plus précoces, un intervalle vêlage-vêlage de deux ans.

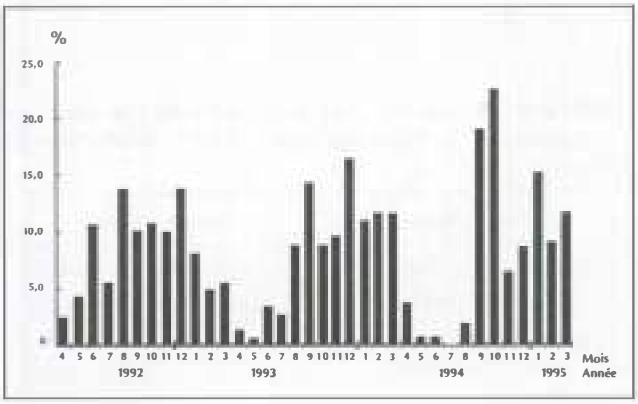

Figure 2. Répartition des naissances au cours des mois (% mensuel dans l'année de reproduction d'avril 1992 à mars 1995).

Mesures quantitatives

La famille de l'éleveur engagé dans le suivi laitier comporte un membre alphabétisé formé pour les mesures et le remplissage des fiches de collecte. La traite se fait dans des récipients en bois (*Balanitex aegyptica*) d'une contenance de 3 litres. Le contenu est ensuite versé dans des pots en plastique de 1 litre gradués de dix millilitres en dix millilitres. Le volume total de chaque traite est consigné sur des fiches de collecte, relevées tous les mois par l'équipe du projet qui assiste, à cette occasion, à la traite.

La pesée des chamelons se fait grâce à une balance sur portique démontable. Le recours à un palan est nécessaire pour hisser des animaux dépassant 150 kg.

Mesures qualitatives

Rythme de l'abreuvement

Bien connu des éleveurs pour sa répercussion sur la production laitière, le rythme de l'abreuvement est le même pour tous les éleveurs : d'un jour sur trois en saison sèche chaude (au puits), il passe à une fois par semaine en début de saison des pluies pour ne plus requérir la présence de l'éleveur en plein hivernage (mares temporaires).

L'abreuvement ne pourra pas être invoqué pour expliquer les variations de production d'un troupeau à l'autre.

Rythme des traites

Les femelles suitées sont gardées à pâturer aux abords du campement et rassemblées le soir avec leur petit dans le campement. Un climat d'insécurité s'est installé sur la zone pastorale (avec notamment les vols d'animaux) qui incite les bergers à regrouper leurs dromadaires pour la nuit. Dans ces conditions, deux traites peuvent être réalisées : une le matin avant le départ pour le parcours et une après le retour. Cependant, les éleveurs ne réalisent souvent qu'une seule traite quotidienne le soir. Elle a lieu en présence du chamelon (déclenchement et entretien de la sécrétion) et ne concerne que deux quartiers. Elle est effectuée par une ou deux personnes. Les deux quartiers ne sont pas traits complètement.

Conduite du sevrage du jeune

Le chamelon est sevré entre 12 et 14 mois, au plus tard 3 mois après la nouvelle saillie fécondante. La mamelle est enveloppée et soustraite au jeune. Dans de rares cas, on implante deux épines d'*Acacia* sur les naseaux du chamelon afin de provoquer une réaction de rejet de la part de la mère. L'influence bénéfique d'un sevrage artificiel (donc d'un tarissement effectif de la mère) sur la lactation suivante n'est pas évoquée par les éleveurs.

Alimentation

Elle est à base de pâturage herbacé et surtout aérien. La complémentation se limite à la distribution de natron en de rares occasions (approvisionnement rare, coût).

Résultats

Les figures 3 à 10 mettent en parallèle les quantités de lait prélevées pour la consommation humaine et la courbe de croissance du jeune. La traite quotidienne moyenne est de 2,4 ± 1,1 litres avec des extrêmes allant de 0,5 à 4,7 litres par jour. L'éleveur se livrant à deux traites par jour prélève ainsi 50 % de plus que ceux ne faisant qu'une seule traite (600 litres contre 400 sur six mois de mesure). Sur la même période, les chamelons expriment un GMQ de 319,0 ± 60,6 grammes par jour.

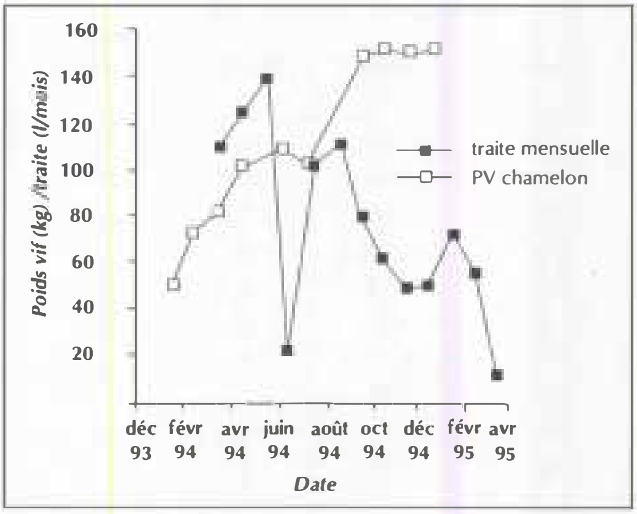

Figure 3. Evolution de la traite de la chamelle n° 274 et de la croissance du chamelon n° 8801.

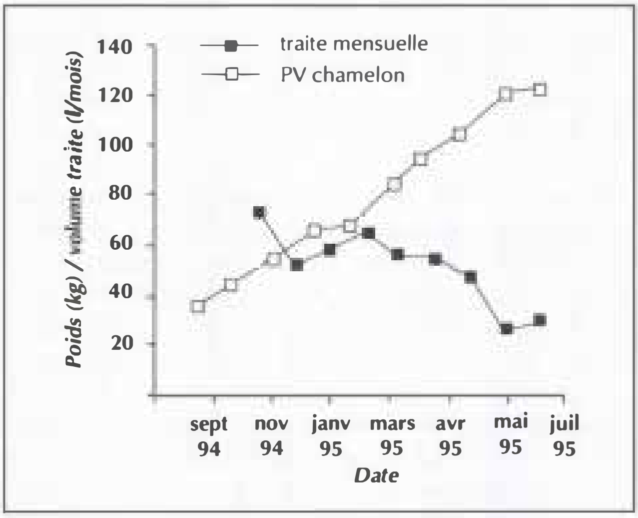

Figure 4. Evolution de la traite de la chamelle n° 185 et de la croissance du chamelon n° 7224.

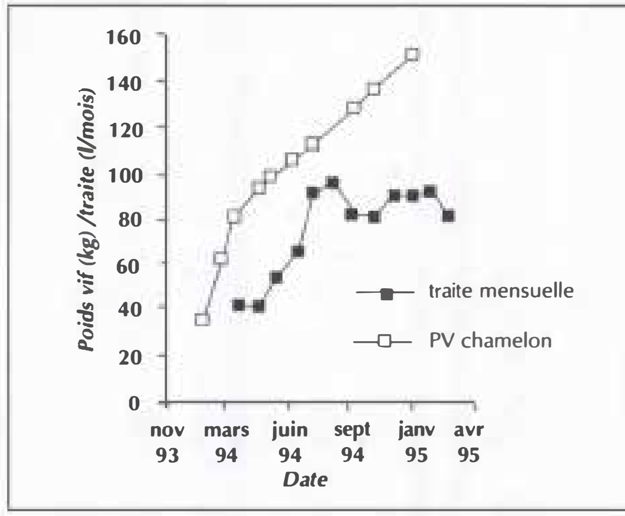

Figure 7. Evolution de la traite de la chamelle n° 575 et de la croissance du chamelon n° 621.

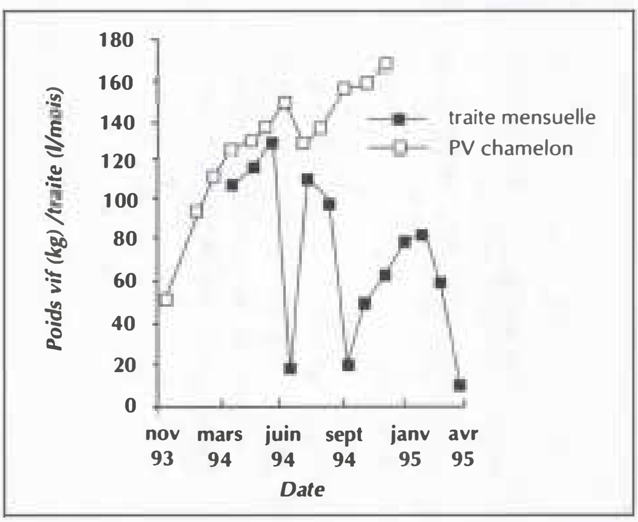

Figure 5. Evolution de la traite de la chamelle n° 278 et de la croissance du chamelon n° 8399.

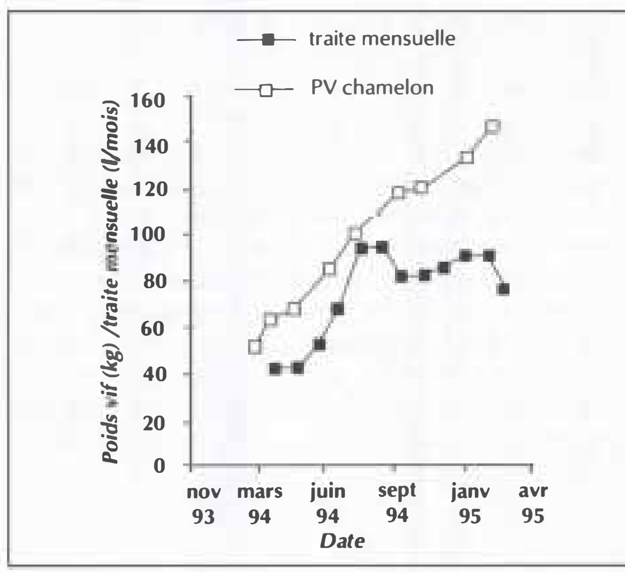

Figure 8. Evolution de la traite de la chamelle n° 3701 et de la croissance du chamelon n° 4047.

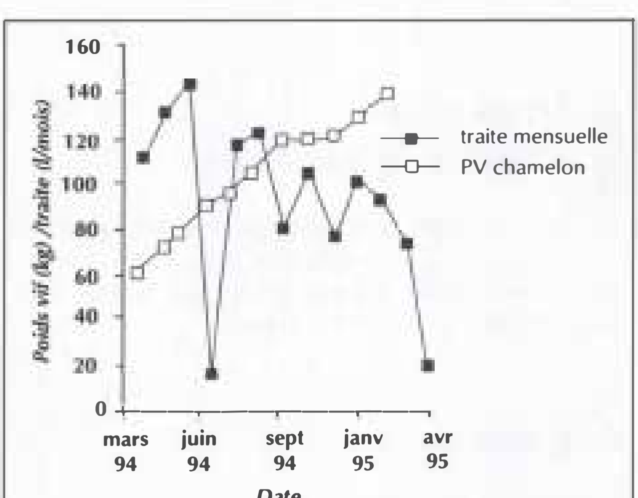

Figure 6. Evolution de la traite de la chamelle n° 280 et de la croissance du chamelon n° 7664.

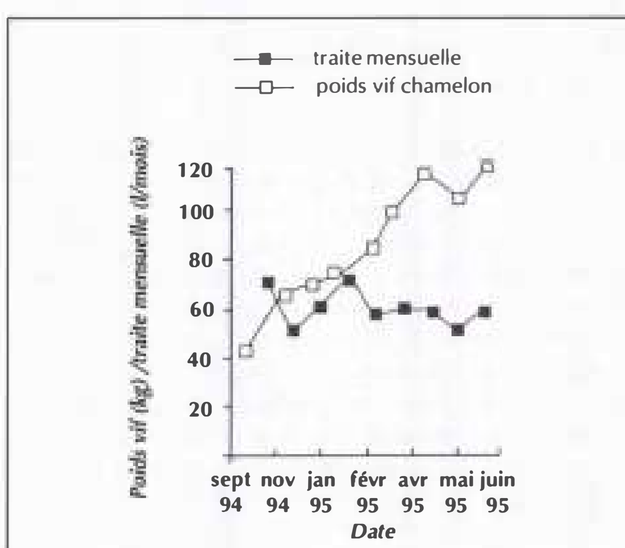

Figure 9. Evolution de la traite de la chamelle n° 193 et de la croissance du chamelon n° 2557.

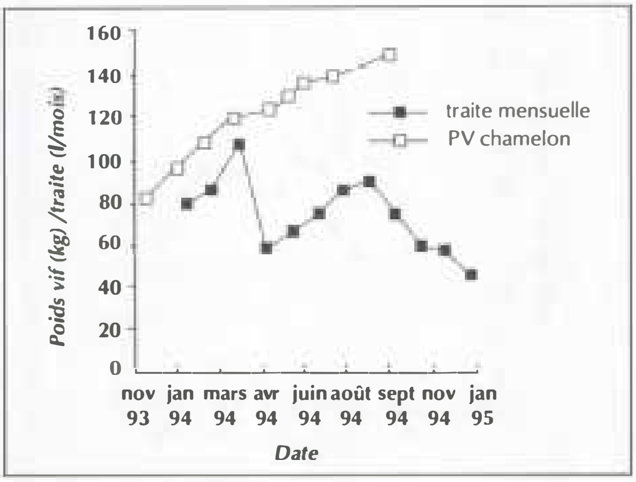

Figure 10. Evolution de la traite de la chamelle n° 18 et de la croissance du chamelon n° 2430.

De l'examen de ces courbes, on retiendra :
– la disparité des quantités prélevées d'un animal à l'autre, et ce, au sein du même troupeau, imputable à une différence de stade de lactation ;
– une tendance à l'inflexion de la courbe de croissance lorsque le prélèvement augmente, pouvant traduire une concurrence entre l'homme et le chamelon ;
– une diminution sensible des quantités prélevées en saison sèche chaude, laissant la priorité au chamelon. Un éleveur continue cependant à traire des volumes constants en une seule traite quelle que soit la saison : la conduite du troupeau peut être évoquée, cet éleveur se déplaçant sans cesse à la recherche de nouveaux pâturages alors que d'autres ne s'éloignent pas de leur zone d'attache.

Discussion

Cette mesure sur six et huit mois permet d'estimer une traite annuelle de 880 litres, soit une production laitière moyenne de 1 760 litres par an. Cette estimation peut être revue à la hausse si l'on considère que le chamelon dispose des deux quartiers non traits et de l'ensemble de la mamelle durant la nuit. Ceci peut se confirmer si l'on ramène la consommation journalière du chamelon (2,5 litres) à son poids de naissance (environ 35 kg) : 7 % alors que selon Granier (1991), il faut compter chez les bovins, une consommation du huitième du poids du veau à la naissance. Au rythme de deux traites par jour, cette production peut être amenée à 2 400 litres. Cet excédent prélevé ne semble pas affecter la croissance du chamelon. Le niveau atteint par cette production est voisin de ceux ramenés sur un an, avancés par Buron et Saint-Martin (1988) au Tchad et Knoess (1977) en Ethiopie mais supérieur à celui trouvé par Richard et Gerard (1989) en Ethiopie. Le potentiel laitier des chamelles au Niger est intéressant. Toutefois, les mesures se poursuivant, il convient d'attendre la fin du suivi pour juger de la persistance de la lactation : la chamelle ayant mis bas en août 1993 a déjà une production en nette diminution.

L'examen de ces différentes courbes devrait permettre de dégager des stratégies de production axées sur le maintien de la croissance du chamelon ou sur le maintien du volume trait. Les variations imputables à l'ethnie de l'éleveur, à la race de la chamelle, à son rang de mise bas, seront clarifiées. A partir d'une courbe de lactation moyenne, de la composition des troupeaux, de la répartition des naissances dans l'année, il sera possible d'estimer la production d'un troupeau (stock de lait disponible ou ressource). Ceci saura particulièrement intéresser qui se trouvera confronté à des impératifs d'approvisionnement, dans le cadre d'une collecte organisée par exemple. La figure 11 résume la confrontation des courbes d'offre et de demande de lait au sein d'un campement.

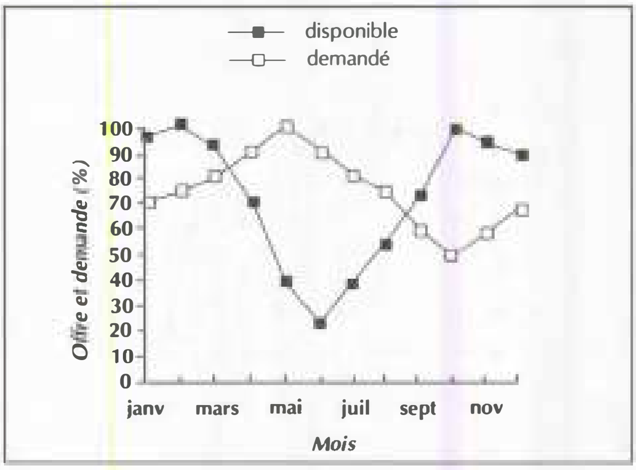

Figure 11. Schématisation de l'évolution annuelle de l'offre et de la demande en lait au sein d'un campement de pasteurs (l'échelle des ordonnées a pris pour référence 100 % le mois de l'année où la production laitière est maximale).

Dromadaire et aptitude à la traite

Les aptitudes laitières de la chamelle ayant été démontrées, il a paru intéressant aux auteurs de s'attacher à l'examen de la mamelle sous l'angle de la traite, en particulier la traite mécanique.

Propédeutique

Contention de l'animal

Dans les conditions naturelles, la traite de la chamelle ne nécessite aucune préparation particulière. En revanche, l'examen clinique ne pouvant se faire sur un animal baraqué, une contention est nécessaire : une personne maintient un des jarrets et la queue, une deuxième se tient à la tête ; on peut recommander de replier un membre antérieur. Cette immobilisation s'est avérée nécessaire dans le cas de l'examen d'un organe douloureux ou lors d'essais d'injections intra-mammaires.

Examen

La mamelle de la chamelle est semblable, dans sa position, à celle de la jument. Sa conformation extérieure est identique à celle de la vache : elle est composée de quatre quartiers ne communiquant pas, réunis deux à deux latéralement et pourvue de quatre trayons. La symétrie de part et d'autre d'un raphé médian doit être vérifiée. Les trayons sont plus courts que ceux de la vache et percés de deux canaux. L'ensemble est recouvert d'une peau épaisse et plissée, souvent lieu d'implantations de nombreuses tiques.

La palpation renseigne sur la présence d'indurations localisées ou généralisées à plusieurs quartiers. La douleur peut être provoquée lors de cet examen. Les trayons sont également palpés sur leur trajet.

L'élimination des premiers jets renseigne sur la qualité du lait et sur l'état des trayons. Les tests de dépistage de mammite peuvent être employés.

Biométrie

Le tableau III rassemble quelques données relatives aux mensurations de l'organe. Le nombre d'individus étudiés est faible, et les valeurs moyennes rapportées le sont à titre indicatif. Les mamelles ont été prélevées sur des animaux pesés la veille de leur abattage. La peau et le ganglion supra-mammaire sont laissés avec la mamelle. Le tout est pesé et ramené au poids vif de l'animal. Le volume a été apprécié par injection d'eau par les canaux de chaque quartier jusqu'à ce que la mamelle regorge. Un quartier a reçu du bleu de méthylène puis a été congelé : des coupes ont permis de juger de la diffusion du produit et du cloisonnement de la mamelle.

La taille et les espacements des trayons peuvent permettre la pose de godets trayeurs (traite mécanique), ce qui a déjà été réalisé expérimentalement (en Inde), ou en routine (au Kazakhstan).

Quelques données relatives à la conduite de la traite

Les données issues d'entretiens avec des éleveurs confirment la grande variabilité des pratiques de traite (tableau IV).

A des fins de traite mécanique, il faudrait savoir si la présence du chamelon est indispensable. A titre d'illustration, dans les conditions de routine existantes en Asie centrale, il est pratiqué le plus souvent une injection préalable et systématique d'ocytocine avant la traite, et les jeunes ne sont pas présents.

Pathologie de la mamelle

Les auteurs rapportent ici quelques rares cas cliniques rencontrés lors des visites mensuelles organisées par l'équipe du projet sur les animaux du suivi zootechnique.

Les trayons

IMPERFORATIONS

Evoquées par les éleveurs ayant des difficultés à traire, les imperforations sont soignées par l'introduction d'une

Tableau III. Biométrie de la mamelle de dromadaire.

	PV	Poids mamelle	Poids mamelle	Hauteur trayon avant	Hauteur trayon arrière	L	l	Volume
Unité	kg	g	g/100 kg PV	cm	cm	cm	cm	cc
Tarie	305	980	321	3,0	3,5	5,0	9,0	2 960
Tarie	◄—	Animal vivant	—►	2,5	3,0	4,0	9,0	560
Lactat.	376	1 320	351	3,0	3,0	6,0	9,0	3 660
Jeune	305	560	184	2,5	2,5	4,0	7,5	460
Jeune	365	780	214	2,5	2,5	5,0	8,5	560
Tarie	310	750	242	3,5	3,5	6,0	10,0	3 520
Tarie	260	520	200	3,0	2,5	5,0	7,5	4 260
Moyenne			252 ± 68	2,9 ± 0,4	2,9 ± 0,4	5,0 ± 0,8	8,6 ± 0,9	2 283 ± 1 686

PV : poids vif ; L : distance entre trayons latéraux ; l : distance entre trayons gauches et droits.

Tableau IV. Données issues d'entretiens avec des éleveurs.

Questions	Réponses
❒ Début de la traite après la naissance	■ 8 à 30 jours
❒ Nombre de traites par jour	■ 1 à 3
❒ Nombre de quartiers traits	■ 2 à 4
❒ Durée d'une traite	■ 3 à 10 minutes
❒ Durée d'une lactation	■ 12 à 24 mois
❒ Volume de la traite	■ 300 à 2 000 ml
❒ Age au sevrage	■ 2 à 3 mois après la nouvelle saillie fécondante
❒ Techniques du sevrage	■ Protection de la mamelle ou du jeune
❒ Persistance de la lactation après mort du chamelon	■ 3 jours si pas d'adoption
❒ Hygiène de la traite	■ Lavage de la mamelle dans de rares cas

sonde à trayon. L'utilisation d'épines est un recours traditionnel fréquent.

INDURATIONS

Elles peuvent faire suite aux traumatismes ou aux tiques.

TRAUMATISMES

Ils sont beaucoup plus rares que chez les bovins : les traumatismes occasionnés par piétinement lors du couchage sont limités par la taille, la position de la mamelle et l'attitude spécifique de la chamelle baraquée. Les sutures pouvant être employées sont comparables à celles utilisées chez les bovins.

Les quartiers

CONGESTION

Elle peut faire suite à la mort du chamelon : durant les trois jours suivant la disparition, la traite ne sera pas possible et la mamelle s'engorgera. Tout rentre dans l'ordre en cas de nouvelle adoption ou après application de cataplasme traditionnel à base de beurre et de terre rouge.

MAMMITE

Aucun cas n'a été rencontré. A titre d'essai, les injecteurs intramammaires commercialisées pour les bovins (type Mastijet[ND]) ont été employées sans difficultés. L'efficacité n'a pu être jugée.

Conclusion

En milieu traditionnel, une part importante de la production laitière de la chamelle devra être réservée à son chamelon pour en assurer la croissance. Toute amélioration de la production entraînera un excédent pour la consommation humaine ou la commercialisation. Aussi, il nous a paru intéressant de retenir une méthodologie reposant sur la quantité traite, laquelle est mesurable sans entraver les habitudes de l'éleveur, en parallèle avec un contrôle de croissance du chamelon, les deux mesures permettant d'approcher l'estimation du potentiel laitier.

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The camel as a milk animal: an Indian experience

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Abstract. This communication is a review of published work and data collected at the National Research Centre on Camel, Bikaner on the indian camel's milk. India has an estimated 1.5 million camel population which is the third highest in the world. Camels in this country are mostly used for draught purposes but camel's milk is also utilised. Data on the milk production potential, biochemical composition of milk from indian sources are reported. The milk production estimates at Bikaner revealed 1,655 litres in 305 days with an average of 5.5 kg/day yield. Milk production from the rear teats was 23.4 to 35.4% higher than from the front teats. Variation in the milk fat, protein and SNF at different stages of lactation were monitored. Information on the molecular structure of the milk fat and milk proteins and the results of the electrophoretic study of milk proteins are presented. The sialic acid content of indian camel casein was similar to that of cows although electrophoretic mobility was slower. The starch gel electrophoresis revealed no polymorphism in α-lactoalbumin and β-lactoglobulins. The biological value of milk protein consumption for growth in rats is presented. Observations on the effect of dry matter intake, crude proteins and metaboliz-able energy in different nutritional regimes on milk yield are presented. The weight loss in the lactating animals varied from 433 ± 82.9 g/day to 8 04 ± 39.2 g/day when she-camels were kept on different metabolizable energy (ME) and crude protein levels (CP) at different stages of lactation. Results on mineral absorption in the dry and lactating female camels indicated daily secretion of 7.03 g Na, 4.39 g Ca and 190.27 g fat. The efficiency of utilization of absorbed K, P, Mg, Fe, Zn and Mn was 14.74, 52.05, 3.79, 22.0, 4.55 and 0.58% respectively. Observations on biochemical composition of indian camel colostrum are also presented.

Key words. Dromedary, *Camelus dromedarius*, milk, colostrum, chemical composition, milk production, milking, animal nutrition, body weight, India.

Résumé. Cette communication est une revue des travaux publiés et des données collectées au Centre national de recherche cameline à Bikaner sur le lait camelin indien. L'Inde estime à 1,5 million de têtes sa population cameline, ce qui fait de ce pays le troisième en importance dans ce domaine. Dans ce pays, le chameau est surtout utilisé pour l'exhaure, mais le lait de chamelle est également consommé. Des données sur la composition et la production du lait sont fournies. Les estimations de la production laitière à Bikaner montrent un rendement de 1 655 litres en 305 jours avec une moyenne de rendement de 5,5 kg par jour. La production laitière des mamelles postérieures était de 23,4 à 35,4 % supérieure à celle des inguinales. Les variations de composition en matières grasses, en protéines et en SNF à différentes étapes de la lactation ont été enregistrées. Les informations concernant la structure moléculaire des matières grasses et des protéines du lait et les résultats de l'étude électrophorétique des protéines du lait sont décrits. La présence d'acide sialique dans la caséine était identique à celle de la vache, bien que la mobilité électrophorétique ait été plus lente. Le gel d'amidon de l'électrophorèse ne démontre aucun polymorphisme dans l'α-lactoalbumine et la β-lactoglobuline. Les résultats de la valeur biologique des protéines de lait pour la consommation et la croissance des rats sont décrits. Les observations de l'effet des niveaux de consommation de matières sèches, de protéines brutes et d'énergie métabolisable dans différents régimes nutritionnels sur les niveaux de production de lait sont présentées. Les pertes de poids chez les animaux en lactation varient de 433 ± 82,9 g/jour à 804 ± 39,2 g/jour quand les chamelles étaient maintenues à différents niveaux d'énergie métabolisable et de protéines brutes à différentes étapes de la lactation. Les résultats de l'absorption minérale chez les chamelles allaitantes et taries révèlent des sécrétions journalières de 7,03 g de sodium, 4,39 g de calcium et 190,27 g de matières grasses. L'efficacité de l'utilisation du K, du P, du Mg, du Fe, du Zn et du Mn absorbés était respectivement de 14,74; 52,05; 3,79; 22,0; 4,55 et 0,58 %. Des observations sur la composition biochimique du colostrum de la chamelle indienne sont également présentées.

Mots clés. Dromadaire, *Camelus dromedarius*, lait, colostrum, composition chimique, production laitière, traite, nutrition animale, poids corporel, Inde.

Introduction

The camels in India are mostly used for draught purpose. However, good genetic potential to produce milk exists (KHANNA and RAI, 1993). The milk production in India during 1991-1992 was estimated at 56 million tonnes (m. tonnes). The annual milk demand at the current rate is estimated by 2000 A.D. to more than 91 m. tonnes. FAO's provisional estimate in 1993 put world input of milk at 518 m. tonnes, 1.0% lower than previous year (FAO, 1993). India has estimated 1.5 m. camels out of world population 17.02 m., which is third highest in the world (FAO, 1992). It is therefore obvious that camels are important domestic livestock resource for supplementing milk production capability in the country. The present paper presents review on reports and observations published on indian camel's milk.

Milk production potential

The data on milk production potential of camels world over have very wide variation due to lack of uniform method of estimation (Wilson, 1984; Yagil, 1982). Rao (1974) estimated that indian camels can produce 3,105-8,190 kg milk per lactation with average of 2,519 kg/365 days under good conditions and 2,430-4,914 kg per lactation with average of 2,482 kg/365 days under poor conditions. Sharma and Bhargava (1963) reported 1,135-1,560 kg per lactation with 4.5 kg daily yield. An estimate by COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH, New Delhi (1960) put camel's milk at 10.8 kg per day with 3,294 kg in 305 days. Rathore (1984) reported that indian camel could produce 2.0 to 5.0 kg milk per day with 1,300-3,600 kg per lactation. On average the lactation period in indian camels could last from 12 to 18 months depending on weaning of the calf. Investigations on milk production potential of indian camels at NRCC, Bikaner revealed 1,655 litres in 305 days with average yield of 5.5 litres/day (Sahani et al., in press). These workers had observed that the milk yield from rear teats was 23.4 to 35.4% higher than front teats at different stages of lactation (table I). When we consider amount of milk needed to sustain body weight and average growth rate of approximately 700 g/day during the first 90 days after birth of a calf, i.e. when it is fully dependent on dam's milk, the milk requirement is much higher than what is generally recorded through hand milking (National Research Center on Camel, 1990-1991). Lower milk yield when hand milked could be explained on the basis of dams not letting down milk due to neuro-hormonal reasons based on camel psychology. This observation points towards higher milk production potential in the camels. Kohli et al. (1988) reported that agalactia is common in indian camels after parturition. Treatment with Leptaden (Alarsin, Bombay) stimulated lactation satisfactorily after 10 days.

In India, it is common relief that the camel's milk has some positive therapeutic effect on some chronic diseases (AGARWAL, 1977; DUTT, 1983; KHANNA and RAI, 1993). There is account in memoire of Emperor Jahangir (1579-1627 A.D.) that when sick he consumed camel's milk for some period and found it very useful and acceptable (ROGERS, 1989). Biological value of camel's milk protein consumption and digestibility in rats was reported to be 81.5 and 83.0 at 5% feed level, 71.3 and 83.4 at 10% and 58.8 and 76.2 at 15% level respectively. It was observed that the feeding of camel's milk protein above 10% supplementation were adequate for growth and development of skeletal muscles (GUPTA and APPANNA, 1967; KHAN, 1966).

Milk composition

OHRI and JOSHI (1961*a*) reported milk composition of indian camels. These workers observed specific gravity ranging from 1.026 to 1.035, specific heat 0.9465, refractive index 1.3195, boiling point 212°C, pH 6.88, titratable acidity 0.03 after 2 hours and 0.149 after 6 hours, water 86.6%, total solids 13.57%, fat 3.78%, total proteins 3.95%, milk sugar 4.88% and minerals 0.95%. KHAN and APPANNA (1964) reported fat 3.08%, solid not fat 9.92%, protein 3.76%, lactose

Table I. Month wide average milk production (litres) and average body weights (kg) of Bikaneri camels*.

Month	Front teats	Rear teats	Average per day	Range	Average body weight
February	2.317 ± 0.147	3.114 ± 0.324	5.420 ± 0.380	4.100-6.299	572.28 ± 21.97 (6)
March	2.200 ± 0.150	2.710 ± 0.200	4.910 ± 0.340	3.300-5.680	550.00 ± 15.34 (6)
April	2.636 ± 0.295	3.528 ± 0.302	6.160 ± 0.570	4.365-8.043	532.50 ± 14.68 (6)
May	2.758 ± 0.153	3.837 ± 0.205	6.590 ± 0.340	5.901-7.849	528.75 ± 14.88 (6)
June	2.369 ± 0.175	3.013 ± 0.612	5.381 ± 0.407	3.799-6.426	520.25 ± 16.82 (6)
July	2.437 ± 0.249	3.473 ± 0.294	7.045 ± 0.527	4.768-8.254	514.50 ± 15.34 (6)
August	2.892 ± 0.497	3.175 ± 0.338	6.067 ± 0.804	4.137-8.555	498.25 ± 18.30 (6)
September	2.075 ± 0.170	2.777 ± 0.203	4.852 ± 0.342	3.366-5.750	480.14 ± 21.85 (6)
October	1.781 ± 0.156	2.412 ± 0.220	4.192 ± 0.375	3.365-5.846	488.00 ± 18.75 (6)
November	1.729 ± 0.131	2.254 ± 0.125	3.993 ± 0.246	3.064-4.964	493.42 ± 14.19 (6)

* Cited from SAHANI *et al.*, in press.

5.43%, ash 0.73% and density 1.0374. Camel's milk composition of almost comparable ranges was reported by DESAI *et al.*, 1982. The milk composition significantly varies according to the stage of lactation, as revealed by experiments carried out at the National Research Centre on Camel, Bikaner. The fat content varied 2-4% with average 2.8%, total protein 2.06 to 3.24% with average 2.68%, lactose 4.3 to 5.6% with average 4.99% (NATIONAL RESEARCH CENTER ON CAMEL, 1989-1990). DHINGRA (1934) reported that the milk fat in the indian camels has low Reichert-value of 16.4. The other characteristics of fat were Polenske value 1.6, Kirschner value 14.2, iodine value 40.9, saponification value 210, saponification equivalent 259.0, Butyro refracto meter reading at 40°C, 44.4, free fatty acid 0.2% as oleic acid (DHINGRA, 1934). Detailed fatty acid composition of camel fat was reported in table II.

Table II. Fatty acid composition of camel's milk fat.

Acid	Molar percentage
Butyric	5.9
Caproic	1.9
Caprylic	1.1
Capric	2.1
Lauric	5.7
Myristic	7.9
Palmitic	28.3
Stearic	9.7
Oleic	34.1
Linoleic	3.3

The glyceride structure of camel's milk fat revealed fully saturated glyceride 25.6%, mono oleo di saturated glyceride 36.0%, di oleo mono saturated 37.8% (DHINGRA, 1933).

The collaborative studies on camel's milk between National Research Center on Camel, Bikaner and National Dairy Research Institute, Karnal revealed fat melting point 39.9 to 42.8°C (higher than bovines), BR reading 43.6 - 47.8 (also higher than bovine), iodine value 35.5 to 43.0, and saponification value 209 to 213 (lower than bovines). RM value 0.7- 2.1, Polenske values (0.7-1.0) confirmed that C4-C10 are much less in indian camel's milk fat than cattle and buffaloes (NATIONAL RESEARCH CENTER ON CAMEL, 1989-1990). Fatty acid profile indicated that camel's milk fat was devoid of butyric (C4.01) acid, other short chain fatty acids C6 to C10 were less as compared to cattle and buffaloes. However, significantly high levels of mystic (C14.0) palmitoleic (C16.1) and other long chain fatty acid were more less occurred in the same quantities as are present in bovine milk fat (NATIONAL RESEARCH CENTER ON CAMEL, 1989-1990). SAHANI *et al.* (in press) observed that camel's milk fat percent varied in morning and evening milking. It ranged from 1.68 to 2.80 at 9 a.m. milking and 2.91 to 4.18% at 5 p.m. milking. The dry matter, fat and SNF varied from 9.8 to 10.01, 2.34 to 3.81 and 7.22 to 7.86 respectively, in different stages of lactation up to 10 months.

Colostrum

Biochemical analysis of colostrum from indian camels was reported by Ohri and Joshi (1961*b*). The range and average values from eleven samples collected from parturition to 168 hours thereafter are presented in table III. In India, colostrum is generally fed in limited quantity to the calves managed under traditional management system. The excess colostrum is generally drained off. The physical properties of camel's colostrum are colour, yellowish white, viscosity at 80°F, 1.72 times water, boiling point 210°F, clot on boiling forms up to 86 hours, pH 5.9.

Table III. Chemical composition of colostrum from Indian camel*.

	Average	Range
Specific gravity	-	1.031-1.079
Fat %	0.45	0.10-0.40
Protein %	17.78	15.79-17.52
Lactose %	4.25	3.98-5.13
Ash %	2.60	1.44-2.80
Acidity	-	0.14-0.38

* Cited from OHRI and JOSHI, 1961*b*.

Mineral contents

KHAN and APPANNA (1964) analysed mineral constituents of indian camel's milk and observed calcium 127.53 ± 2.14 mg per 100 ml of milk (mg %), phosphorus 97.4 ± 1.90 mg %, magnesium 18.05 ± 0.99 mg % and iron 0.32 ± 1.80 mg %. These workers further reported 97.41 mg phosphorus which constituted 76.3 ± 1.3 mg acid soluble (ortho-phosphate and pyrophosphate) the remainder being organic forms lipid, 3.7 ± 1.3 mg and from casein, 17.0 ± 1.0 mg. NAGPAL *et al.* (in press) investigated mineral absorption in dry and lactating camels. The lactating camels were observed to daily secrete 7.03 g Na, 4.39 g Ca and 190.27 g fat. The efficiency of utilization of absorbed mineral K, P, Mg, Fe, Zn and Mn was 14.74, 52.05, 3.79, 0.20, 4.55 and 0.58% respectively.

Milk proteins

PANT and CHANDRA (1980) reported chemical composition of indian camel's milk proteins. The results are summarised in table IV. The essential amino acid content in camel casein and whey proteins are presented in table V. The camel's milk casein and their fractions are good source of protein. The whey proteins possess relatively higher nitrogen percentage. The essential amino acids were comparable to that of cow's milk proteins.

Whey from camel's milk and colostrum were fractionned on sephadex 0-75 and four fractions were obtained. The lactoferrins, a bacteriostatic protein, was present in the first fraction in quantities much higher than in cow's milk (SINGH, personal communication). The crystals produced from purified camel lactoferrins are being analysed for molecular structure, iron biding capacity and bacteriostatic qualities.

In protein studies on Bikaner, camel's milk revealed that caseins pellated at 10,000 rpm for 15 minutes and suggested larger micells size. The sialic acid content of indian camel's casein was similar to that of a cow, though electrophoretic mobility was comparatively slower (NATIONAL RESEARCH CENTER ON CAMEL, 1989-1990). The milk protein polymorphism studies on starch gel electrophoresis revealed no polymorphism *in facto* albumin, β-lacto-globulins, α-casein, β-casein and κ-casein. The κ-casein exhibited two bands while other proteins exhibited single band (NATIONAL RESEARCH CENTER ON CAMEL, 1990-1991).

Nutritional studies

During the course of 10 months study on 3 dry and 6 lactating camels maintained on *Phaseolus aconitifolius* dry fodder fed *ad-lib*, ones revealed that dry camels gained 14.63% body weights while lactating cows lost 23.64% body weight. During mid lactation (fifth month), the nutrient intake of lactating cows were 83.4 g DM, 4.2 g DCP and 0.723 MJME/kg$^{0.75}$ and were higher than dry camels by 36.5, 44.8 and 42.4% respectively. The average camel's milk yield l/kg DMI increased from 0.57 in first month to 0.80 in 6th month and then gradually declined to 0.47 in 10th month. The details are presented in table VI (NAGPAL *et al.*, in press). The results indicated need for higher energy supplementation in the ration.

In other study of camel's milk, the effect of dry matter (DM), crude protein (CP) and metabolizable energy (ME) intake on milk yield of lactating females were investigated. The results are presented in table VII. The results revealed continuous loss in body weights when kept on different regimen rations. The relationship between milk yield and daily intake of ME and CP is presented in table VIII. The data suggested that a multi factor regression is possible to predict milk yield based on intake data (NATIONAL RESEARCH CENTRE ON CAMEL, 1990-1991).

Table IV. Chemical analysis of camel's milk caseins and their fractions (g/100 g protein)*.

Constituents	Whole casein	∝-casein	ß-casein	∝-lacto albumin	ß-lacto globulin
Crude protein	70.18	71.76	70.81	77.83	78.11
Ash	3.83	3.90	3.85	3.40	3.25
Calcium	0.60	0.62	0.58	0.04	0.05
Phosphorous	0.72	0.73	0.69	0.10	0.20
Sulphur	0.84	0.86	0.83	1.32	0.86

* Cited from PANT and CHANDRA, 1980.

Table V. Essential amino acid content in casein and whey proteins (g/100 g protein)*.

Constituents	Whole casein	∝-casein	ß-casein	∝-lacto albumin	ß-lacto globulin
Arginine	3.09	3.92	3.81	3.20	2.80
Histidine	1.33	1.81	1.13	1.90	1.50
Lysine	6.86	7.45	6.54	10.80	11.20
Threonine	3.49	4.12	3.47	6.10	5.20
Tryptophan	0.77	1.00	0.56	1.20	1.00
Valine	6.61	7.25	6.77	5.60	8.00
Phenyl alanine	6.50	7.25	5.25	3.50	2.80
Methionine	3.06	3.42	3.06	2.80	3.10
Leucine-isoleucine	12.62	13.50	10.94	13.52	15.20

* Cited from PANT and CHANDRA, 1980.

Table VI. Monthly variation in average body weights, daily DM and water intake, daily milk yield and efficiency in dry and lactating camels*.

Month	Dry camels (n = 3)			Lactating camels (n = 6)				
	Body weight (kg)	**DMI** (kg/day)	**Water intake** (l/day)	**Body weight** (kg)	**DMI** (kg/day)	**Water intake** (l/day)	**Milk yield** (l/day)	**Milk yield** l/kg DMI
First	417.33 ± 30.38	5.78 ± 0.24	19.43 ± 1.59	572.28 ± 21.97	9.88 ± 6.37	20.99 ± 2.86	5.42 ± 0.38	0.57
Second	428.00 ± 32.19	7.34 ± 0.34	20.33 ± 1.20	550.00 ± 15.34	9.28 ± 0.28	28.23 ± 1.91	4.91 ± 0.34	0.53
Third	483.33 ± 25.75	7.67 ± 0.35	23.80 ± 2.50	532.50 ± 14.68	10.94 ± 0.23	30.08 ± 2.28	6.16 ± 0.56	0.61
Fourth	468.67 ± 33.79	6.85 ± 0.13	24.50 ± 0.79	528.75 ± 14.68	8.97 ± 0.15	29.00 ± 1.80	6.59 ± 0.34	0.74
Fifth	459.33 ± 30.33	6.58 ± 0.33	32.70 ± 2.30	520.25 ± 15.82	8.99 ± 0.15	36.70 ± 3.70	5.38 ± 0.40	0.60
Sixth	460.00 ± 26.83	6.77 ± 0.33	31.10 ± 1.50	514.50 ± 15.34	8.81 ± 0.17	37.50 ± 2.40	7.04 ± 0.52	0.80
Seventh	462.67 ± 26.43	6.31 ± 0.62	23.20 ± 1.60	498.25 ± 18.30	8.89 ± 0.23	26.60 ± 1.70	6.06 ± 0.80	0.66
Eight	460.00 ± 25.08	6.25 ± 0.23	25.60 ± 1.00	480.14 ± 21.85	8.27 ± 0.10	22.00 ± 0.60	4.85 ± 0.34	0.59
Ninth	459.00 ± 26.16	6.60 ± 0.06	27.60 ± 1.25	486.00 ± 18.76	8.62 ± 0.20	23.00 ± 0.56	4.19 ± 0.37	0.49
Tenth	478.00 ± 28.59	6.85 ± 0.15	21.30 ± 1.13	493.42 ± 14.19	8.52 ± 0.22	18.19 ± 1.03	3.99 ± 0.24	0.47

* Cited from NAGPAL *et al.*, in press.

Table VII. Studies on camel's milk: effect of intake of dry matter, crude protein and metabolizable energy on milk yield*.

	Ration**			
	R	**RG**	**RC**	**RCG**
Intake (kg/day)				
Dry matter (DM)	8.230 ± 0.111	15.160 ± 0.103	15.230 ± 0.048	18.150 ± 0.119
Crude protein (CP)	0.733 ± 0.009	1.470 ± 0.009	1.800 ± 0.004	2.170 ± 0.012
Metabolizable energy (ME) (Mcal)	16.110 ± 0.205	30.570 ± 0.200	31.420 ± 0.036	37.940 ± 0.233
DM (kg/100 kg weight)	1.420 ± 0.048	2.250 ± 0.061	2.340 ± 0.045	2.740 ± 0.040
Milk yield (kg/day)				
Observed	4.750 ± 0.410	5.740 ± 0.430	6.190 ± 0.170	7.260 ± 0.800
Estimated***	11.150	12.140	12.000	16.240
Body weight (w) (kg)				
Initial	580.000 ± 20.740	676.300 ± 15.290	853.000 ± 12.390	662.500 ± 14.510
Final	560.000 ± 20.350	662.500 ± 14.510	635.500 ± 14.430	653.000 ± 12.400
Loss in body weight (kg/day)	0.667 ± 0.225	0.458 ± 0.115	0.583 ± 0.070	0.317 ± 0.109

* Cited from NATIONAL RESEARCH CENTRE ON CAMEL, 1990-1991.

** R: Roughage *(ad lib.)* – RG: Roughage *ad lib.* + green 3 kg DM/head/day – RC: Roughage *ad lib.* + concentrate 4,0 kg DM/head/day – RCG: Green (3 kg DM) + concentrate (4.0 kg DM) + roughage.

*** On the basis of calculated values for mild yield assumed to be suckled by calves in addition to what was observed.

Table VIII. Studies on lactating camels: relationship between milk yield and daily intakes of ME and CP*.

Y	X	Regression	r
Milk yield (kg/day)	DM intake (kg/day)	5,97 ± 0,487x	0.548
Milk yield (kg/day)	CP intake (kg/day)	8,87 ± 2,619x	0.469
Milk yield (kg/day)	ME intake (kg/day)	6,71 ± 0,212x	0.537
Milk yield (kg/day)	ME intake over maintenance	6,65 ± 3,509x	0.515
Milk yield (g/kg $W^{0.75}$)	ME intake (kcal/kg $W^{0.75}$)	77,37 ± 0,110x	0.414
Milk yield (g/kg $W^{0.75}$)	CP intake (g/kg $W^{0.75}$)	66,12 ± 2,770x	0.483
Milk yield (g/kg $W^{0.75}$)	DM intake (g/kg $W^{0.75}$)	40,91 ± 0,530x	0.558

* Cited from NATIONAL RESEARCH CENTRE ON CAMEL, 1990-1991.

CP: crude protein; DM: dry matter; ME: metabolizable energy.

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Milk production of Chinese Bactrian camel (*Camelus bactrianus*)

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Abstract. The Bactrian camel has milk of special quality and long period of production. One especially important feature is the high content of vitamin C, which will supply camel keepers for that vitamin during seasons when vegetables are not available. However, the overall milk production takes place only occasionally and mainly in areas distant from the concentrations of population and thus only consumed by the keepers. Therefore, it does not entirely benefit to the camel keepers themselves in the Chinese condition of marketing. The author stresses the importance of further research in camel's milk production and milk marketing system which will be able to plan for a secure economic future for the camel's milk producers.

Key words. Camel, *Camelus bactrianus,* milk production, China.

Résumé. La chamelle de Bactriane produit un lait aux qualités reconnues, et ce, pendant de longues périodes de lactation. Une de ces qualités particulièrement importantes est la richesse en vitamine C, qui permet de couvrir les besoins des chameliers durant les saisons où les légumes sont introuvables. Cependant, la production laitière cameline en Chine est seulement possible occasionnellement, et surtout dans des zones éloignées du milieu urbain. Le lait est donc consommé par les gardiens, et ne profite pas totalement aux chameliers dans les conditions actuelles du marché chinois. L'auteur insiste sur l'importance de nombreuses recherches nécessaires sur la production laitière cameline et le système de commercialisation du lait qui devraient permettre de planifier un avenir économique plus sûr pour les producteurs de lait de chamelle.

Mots clés. Chameau, *Camelus bactrianus,* production laitière, Chine.

Introduction

The Bactrian camel (*Camelus bactrianus*), (about 500,000 in China), is esteemed as the "ship of the desert" for its capacity to travel and carry heavy loads in arid deserts. In addition, the animal is an economic actor which can uniquely survive in the desert or semi-desert areas as a producer of wool, hair, meat, milk and other by-products from natural resources which might otherwise be unusable. Therefore, it is of great importance to the people who inhabit the arid regions. However, many people who have managed their herds extensively on ranges have kept camels mainly for wool and for sale, and have bred them for the same purpose. Milk is not the most important economic product of the Bactrian camel, compared to its wool, meat and work productivity, but is a valuable food source in the arid environment of certain areas. The camel produces milk for a longer period of time than other indigenous domesticated animals in absolute terms, especially in the same environments. The Bactrian camel in China is traditionally not used as a milk supplier, especially in small holdings and in semi-arid areas. It is occasionally used to get milk for human consumption or for the needs of babies in extremely harsh zones where no other animal can produce milk, and where people may be fully dependent on the camel for their survival. The production efficiency is low and little research has been done about. Most people do not even consider the Bactrian camel as a dairy animal. Some brief observation on the milk production of Bactrian camel is reported herein as an introduction to this animal and the characteristics of its milk.

The mammary glands

The udder of the Bactrian camel has four quarters, the front two quarters are separated more distinctly from each other by the laminal midline than they are from the two smaller rear ones. Each quarter has one teat with two lactiferous sinus and two small orifices. The udder is covered by a thin dark skin and supported by the suspensory ligaments and lateral ligaments of the breast and the muscle retractor. In the Bactrian camel, the milk is generally only letdown if the calf is also present and the udder size varies greatly with the stage of lactation.

Lactation period and milk yield

The lactation period in the Bactrian camel is estimated between 14 and 18 months. The calvings are relatively concentrated on March and April, then the females begin to produce milk until they become pregnant in the next breeding season and the milk becomes less and less.

The total lactation yield estimates are between 500 to 1,254 kg. The results of one study of 15 months of lactation (ZHANG *et al.*, 1986) are shown in table I.

It is showed from the table I that Bactrian camel can produce 757.7 kg of milk in a 15 month lactation, thus the daily yield is about 1.68 kg, and the milk fat is 5.17%. The mean month yield increases from the 1st month to the 4th month, the maximum being 87.0 kg on this 4th month, then the yield decreases up to 28.7 kg on 14th month. The milk fat is high in the first few months then decreases with the increment of milk yield, and finally increases with the decrease of milk yield.

The overall milk yield is low in the Bactrian camel compared with that in the dromedary, although the yields obviously depends on the number of times an animal is milked daily and on the climate and vegetation. The results from some reports in dromedary and Bactrian camels are showed in table II.

Daily yields of 5 kg or less are most likely the common range of the milk production performance of the Bactrian camel. Such a yield does not sound very much impressive when compared to milk yield obtained from the cattle kept in the intensive conditions. Considering the local food base in semi-arid areas which is frequently inadequate to secure the mere survival of dairy animals, and beside the absolute quality of milk production, it is the persistance itself of pastoral population which is at stake. The camel provides staple food throughout the year and especially during the drought period, when milk production from cattle and goat almost stops. However, milking the camel takes place only occasionally and mainly in areas distant from the concentration of population and thus consumed by the camel keepers, and therefore does not benefit economically to the keepers.

Table I. Milk yield of Bactrian camel in 15 months of lactation.

Lactation month	Monthly milk yield (kg)	Daily milk yield (kg)	Milk Fat (%)
1	66.0	2.2 ± 0.73	6.9 ± 1.98
2	68.9	2.3 ± 0.52	5.93 ± 1.33
3	83.8	2.79 ± 0.66	4.44 ± 1.14
4	87.0	2.9 ± 0.81	5.12 ± 1.19
5	71.8	2.39 ± 0.46	4.14 ± 0.96
6	64.5	2.15 ± 0.44	4.3 ± 0.74
7	57.4	1.91 ± 0.93	4.62 ± 0.95
8	39.8	1.33 ± 0.35	5.19 ± 0.74
9	29.4	0.98 ± 0.33	5.22 ± 0.78
10	32.8	1.09 ± 0.32	5.48 ± 0.97
11	30.6	1.02 ± 0.31	5.02 ± 0.82
12	34.3	1.14 ± 0.33	4.7 ± 0.92
13	29.7	0.99 ± 0.24	5.25 ± 0.72
14	28.7	0.95 ± 0.21	6.1 ± 0.88
15	33.0	1.1 ± 0.26	5.19 ± 0.65
Total	757.7	1.68 ± 0.63	5.17 ± 0.98

Table II. Data milk production in the camelids.

Camel	Country	Mean daily yield (kg)	Lactation length (days)	Lactation yield (kg)	References
Bactrian	China	5	420-520	1,254	YANG, 1990
	China	1.68	450	757.7	ZHANG *et al.*, 1986
	China	1-2	420-480		RUI and XU, 1984
	Mongolia		480	700-800	CHAPMAN, 1985
Dromedary	Pakistan	6.6-10.0	270-540	2,700-3,600	LEUPOLD, 1986
	India	4.5-1.8	213-547	958-985	SHARMA and BHARGAVA, 1963
	Russia	7.0-9.1		750-5,000	WILSON, 1984
	Kenya	4.5		1,660	SPENCER, 1973
	Ethiopia	6.7	365	2,442	KNOESS, 1977

Composition

There are various reports on the composition of camel's milk as well as on total milk yield. In general terms, camel's milk contains much higher vitamin C level than other milks, at the amount of 5.7-9.8 mg/ml (RUI and XU, 1984), which is important to the people who live in the arid areas where the food of plant origin is rare. The vitamin C content increases with the lactation month. Vitamin B2 varies between 2.3 and 3.9 µg/ml; and vitamin A is 7.57 µg/ml, as the carotene is 9.4 µg/ml (RUI and XU, 1984).

The gross composition of Bactrian camel's milk and various animal species (RUI and XU, 1984; WILSON, 1984) are showed in table III and table IV respectively.

The moisture of Bactrian camel's milk varies with the water intake. When the camel drinks *ad libitum*, the moisture is about 86% and being 91% if the camels are restrained to drink once per week.

The protein content of the milk is about 3-5% and similar to that of the cow. Casein is 0.89%, albumin 0.97%, both of them are lower than in dromedary (2.7 and 8.8% in dromedary respectively [YANG, 1990]).

The content of the amino-acids in the milk of Bactrian camel decreases with the increase of milk yields. The contents in the Bactrian camel's milk and the comparison with some other animals are showed in table V.

Table III. Composition of Bactrian camel's milk.

	X	Ranges	CV	Sx
Specific gravity	1.037	1.035 - 1.104	0.03	0.001
Moisture (%)	85.32	82.83 - 87.04	0.02	0.56
Solid (%)	14.68	12.96 - 17.17	0.10	0.60
Fat (%)	5.5	3.98 - 7.60	0.23	0.40
Protein (%)	3.87	3.71 - 4.12	0.04	0.06
Lactose (%)	4.34	3.13 - 5.18	0.16	0.26
Ash (%)	0.97	0.95 - 0.98	0.02	0.01
Ca (%)	0.106	0.10 - 0.11	0.30	0.001
P (%)	0.090	0.008 - 0.10	0.08	0.003

Milk production efficiency of the Bactrian camel

The comparative advantage of the camel as a dairy producer over the other domesticated species, and under the influence of the same environmental factors, are difficult to quantify. Both the specific productivity indicators and the weighted contribution of any species to human support have to be discussed.

It is generally recognized that Bactrian camel has a long period of lactation. Assuming an average daily yield of 2-3 kg and a lactation period of 13 months, the milk output per lactation per unit of body weight from a 400 kg breeding female would be over 2 kg.

Table IV. Milk composition from different animal species (%).

Species	Moisture	Solid	Percentage		Composition			
			Protein	Fat	Lactose	Ash	Ca	P
Bactrian								
(Camelus bactrianus)								
Milk	83.9	16.08	4.08	5.54	5.5	0.91	0.29	0.12
Colostrum	74.93	25.07	18.93	0.35	4.51	1.28	0.33	0.26
Dromedary								
(Camelus dromederius)								
Milk	86.3-87.6	7.0-10.7	3.0-3.9	2.9-5.4	3.3-5.8	0.6-0.8		
Cow *(Bos taurus)*								
Milk	86.2-87.6	8.7- 9.4	3.2-3.8	3.7-4.4	4.8-4.9	0.7		
Cow *(Bos indicus)*								
Milk	86.1	8.5	3.2	5.4	4.6	0.7		
Buffalo-Milk	83.1	9.0-10.5	3.8	7.4-15.0	4.9	0.8		
Sheep-Milk	79.5-82.0	11.6-12.0	5.6-6.7	6.9-8.5	4.3-4.7	0.9-1.0		
Goat-Milk	87.1-88.2	7.8-8.8	2.9-3.7	4.0-4.5	3.6-4.2	0.8		
Horse-Milk	90.1-90.2	8.6-8.9	2.0-2.7	1.0-1.2	6.3-6.9	0.3-0.4		
Pig-Milk	82.8	12.1	7.1-7.3	5.1-6.7	3.7	1.0-1.1		
Human-Milk	88.0-88.4	8.3-8.9	1.1-1.3	3.3-4.7	6.8-6.9	0.2-0.3		

Table V. Amino-acid composition of Bactrian camel's milk and some domestic animals.

Amino-acid	*C. dromedarius* (g/16 g N)	Cow	Goat	*C. bactrianus*
Alanine	3.1 - 3.4	3.5 - 4.8	3.6	3.05
Arginine	3.2 - 4.6	2.9 - 4.2	2.1	3.5
Aspartic acid	6.2 - 7.7	6.2 - 7.8	7.4	7.65
Glutamic acid	15.4 - 23.5	15.8 - 23.2	20.3	23.4
Glycine	0.6 - 1.6	0.8 - 2.1	2.1	1.57
Histidine	2.5	3.0	5.0	2.5
Isoleucine				6.4
Leucine	18.0 - 21.0	8.1 - 17.4	14.4	10.4
Lysine	7.6	8.1	8.2	7.6
Methionine	3.5	3.2	3.5	3.5
Phenylalanine	5.7	5.4	6.0	5.7
Proline	13.3	10.1 - 11.8	14.6	13.3
Serine	5.9	6.6	5.2	6.9
Threonine	6.3	4.3	5.7	6.3
Tyrosine	5.8	5.8	4.8	5.8
Valine	7.4	7.5	5.7	7.4

Among the other biological factors, the reproductive performance affects with a major influence the productivity of the milk animal. Apparently, it seems that the various reproductive traits of Bactrian camel (later maturity, long calving interval, long gestation, induced ovulation and restricted breeding season, etc.) put the camel in a poor economic position. Although different techniques have made the improvement of reproduction performance possible, the arbitration between calf production and milk production, and the reproduction management pratices is devoted to extension of the lactation period in order to rear the calf even though this will have negative implications for the reproductive performance.

It is clear that milk productivity is determined by such factors as the environment, feed/water inputs, herd fertility, longevity, disease incidence and the method of management. However, in desert environment, other factors such as drought resistance, continuity of supply accross season, and "effective" yield referring to the accessibility of milk to the "needy" populations, affect the dairying efficiency.

Perspectives

Camels have an unique potential for milk production and exploit efficiently fragile habitats. It is the main milk supplier of not only nomadic herders, but also of the other rural population living in remote dry lands where there is in general inadequate supply of dairy products. The efficiency of camel's milk production can not only be evaluated in terms of total yields or specific productivity parameters but also within the context of its superb adaptation to harsh environments, and sustainability in marginal lands.

When considering the role of the camel in the pastoral food chain, the virtues of the different species often kept in mixture (in terms of drought resistance, productivity cycles, required resource including spectrum of vegetation utilized, water budget, labour requirement, etc.) are exploited in a strategic optimal manner. The camel is an integral component of that production strategy and its biological and socio-economic efficiency have to be weighted accordingly. To cite an example, if the camel is drought-resistant and will continue producing milk in the dry conditions when the survival of other species is in doubt, the small-stock on the other hand provides for a variety of different obligation, including petty cash to batter for gain. This will influence the extent of human subsistence on camel's milk and in turn the camel calf viability. In other words, the complimentary relative "utility values" of different species and their interacting reciprocal influences determine the nature of the pastoral food stability.

Although many camel keepers of China have managed their animals for wool, meat, work and for sales, there is still presumably a potential to increase the milk production capacity by scientific breeding and improved management in certain suitable areas around towns and other urban centers when the demand for milk is high. Camel dairy farm and dairies could be thus set up. More further research on the productivity, carefully designed breeding, selection system and milk marketing system are absolutely necessary for the camel as a dairy animal.

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Milk production potential of camels in Punjab (Pakistan)

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Abstract. One hundred and sixteen female camels were used in an experiment to study the milk production as well as milk composition from different parts of the Punjab province in Pakistan. Animals were grouped according to the availability of feed to these animals in different areas. The milk yield was highest in animals that were reared on green fodder. A significant high protein percent in milk of group II camels (fed on non-irrigated lands and deserts) reflect a dietary difference. Likewise, lactose was much lower in group II as compared to other groups.

Key words. Dromedary, *Camelus dromedarius,* milk production, chemical composition, animal nutrition, Pakistan.

Résumé. Cent seize chamelles ont été utilisées pour une expérimentation visant à étudier la production laitière et la composition du lait de chamelles provenant de différentes zones de la province du Punjab au Pakistan. Les animaux ont été regroupés selon leur zone d'origine et leurs potentiels nutritionnels. Le rendement laitier était plus élevé chez les animaux qui étaient menés sur du fourrage vert. Un fort pourcentage de protéine dans le lait du groupe II (animaux évoluant dans des zones non irriguées et désertiques) reflète un régime alimentaire différent. Aussi, le taux de lactose était beaucoup plus bas dans ce groupe que dans les autres.

Mots clés. Dromadaire, *Camelus dromedarius,* production laitière, composition chimique, nutrition animale, Pakistan.

Introduction

Developing countries have 98.47% of the world camel population whilst the developed countries possess only 1.53%. Pakistan as a whole and its province of Punjab have a considerable number of camels (1 million) that are being used as multipurpose animals. In modern times, ignored species like camel deserve to be taken in consideration in research and development in search for sources of food, particularly animal proteins in order to exploit the milk and meat production of the "Ship of the desert". Peak milk yields of 20 l to 40 l per day (KHANNA and RAI, 1993; KNOESS, 1980; QURESHI, 1986) have been recorded for the camel. In area of drought, where cattle can hardly survive, and where other sources of animal protein are unavailable, the camel could be of vital importance (YAGIL, 1982). Camel's milk is used by herders as food and water. In order to establish a clear picture of the milk yield of camel in the province of Punjab, a study was initiated to record the milk yield and its constituents, with regard to its rearing areas.

Materials and Methods

To establish a clear picture of the milk yields of camels an experiment was initiated in many districts in the Punjab province. Milk production was recorded from multipare camels at each milking. The a.m. and p.m. records were then averaged by week to give milk production. The a.m. and p.m. milk samples were analyzed once weekly for milk fat, protein SNF, and lactose concentration using the standard procedure of AOAC (ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS, 1980). These animals were divided into three main groups based on the diet that was fed to these animals in each district.

Results and Discussion

The lactation response of camels in each group have been shown in table I. The udder and teats of these camels are usually big and are in different variety of shapes. It is evident from the present data that milk yield of camel in the area of irrigated land (group I) is much higher as compared to group II and III. Acidity in milk mainly reflects temperature of milk after collection, husbandry techniques and marketing practices. No significant difference was noted between three groups (table II). RODRIGUEZ *et al.* (1985) reported acidity value of 0.14 and 0.15 for Jersey and Holsteins cow's milk that have been reported respectively; SAWAYA *et al.* (1984) however, found acidity of camel's milk was lower as compared to cows.

Water contents ranged from 85 to 89% of the total milk. These values are within range as reported by other workers (EL-AMIN, 1980; MUKASA-MUGERWA, 1981). High temperature and water restriction increased the water content in camel's milk and reduces its fat percentages. Present study have indicated variation in fat percentage between groups and it was lowest in animals of group II that were raised in the desert. It has been demonstrated that average fat percentage does not depend on the state of lactation but more likely on the climate and probably on the air temperature. Camel's milk had the smallest average fat globule size ranging between 2.31 and 3.93 µm in diameter as compared to other milking animals.

Milk protein contents are within the normal ranges as been reported by other workers (GHOSAL *et al.*, 1973; SAWAYA *et al.*, 1984). A significant high protein level in group II might reflect dietary differences. This difference appears to be related to the variations of camel's milk composition (MEHAIA, 1992; MEHAIA *et al.*, 1988; MEHAIA and AL-KANHAL, 1989), which are mainly affected by the feeding and drought conditions (YAGIL, 1987; YAGIL and ETZION, 1980).

Lactose in the present study was much lower in group II as compared to groups I and III. Taste of the camel's milk depends largely on the area where these animals were fed. If the animal took green fodder as in group I, the milk has high lactose and sweat in taste. Salty taste in group II might have been due to certain shrubs and herbs the animal took from the desert.

Table I. Description of animal, their diet and milk production in various district of Punjab, Pakistan.

Groups	District	Number of camels	Fed on	Average of body weight (kg)	Milk production (kg/day)
I	Jhang Faisalabad Sargodha	45	Irrigated land (fed on green pasture)	680 ± 40.11	7-12
II	Bahawalpur Dera Ghazi Khan, Bukhar	41	Non-irrigated and no rain (desert)	587 ± 23.0	4-7
III	Rawalpindi Chakwal Khushab Mianwali	30	Non-irrigated but rain fed grazing area	630 ± 39.0	5-10

Table II. pH and chemical composition of milk of various groups in the Punjab province, Pakistan.

Parameters	Group I	Group II	Group III
pH	6.6	6.3	6.5
Acidity	0.14 ± 0.08	0.13 ± 0.04	0.15 ± 0.03
Taste (%)	Sweat	Salty	Sweat/salty
Water	85.60 ± 0.83[a]	88.90 ± 0.54[b]	86.66 ± 1.41
Fat	5.22 ± 0.38[a]	3.50 ± 0.40[b]	4.50 ± 0.81[a]
Protein	2.68 ± 0.07[a]	4.0 ± 0.10[b]	3.0 ± 0.4[a]
Lactose	4.30 ± 0.50	3.26 ± 0.33	4.10 ± 0.09
Total solid	10.40	13.30	11.10
Ash	0.73 ± 0.02[a]	0.83 ± 0.04[b]	0.78 ± 0.03[a]

Same alphabets in row are not significantly different from each other.

Conclusion

It was not possible to judge the influence of different feeding regime on milk production. There is evidence that dairy type camel found in various district of Punjab has a unique potential for milk yield. This study also point out that if these animals are fed well or balanced feed, they have the genetic potential to higher milk yield. Also, lactation in dromedaries does not decline as in cattle or buffalo, but can be maintained for longer period until new pregnancy. Therefore, management systems for those animals have to be evolved, while increasing production also fit into the economic system to raise the standard of living of herder.

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The effect of milk recording method and calf separation on determining milk yield in the camel (*Camelus dromedarius*)

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Abstract. In 1991, a study was conducted in Kenya to determine the effects of calf presence and milking method on the milk yield of camels. Camels were divided equally into four different treatment groups: Camels in treatment A were accompanied by their calves during the day, two teats were milked after a 3 hour separation in the evening; all other treatments separated the calves from their dams and had either two teats milked (treatment B), all four teats milked (treatment C), or all four teats milked and the udder emptied by i.v. injection with 10 IU oxytocin (Oxytocyne Leo, Leo Laboratories Ltd) (treatment D—milk oxytocin technique). The calf suckling technique proved inaccurate and impractical under these conditions. Oxytocin was injected on 126 milking occasions yielding an average of 2.6 kg at each milking, 37% of which was obtained after the administration of oxytocin. Mean time to letdown was 35 seconds. Lowest "in-bucket" milk yields were obtained from camels that were accompanied by their calves (A), and highest from camels that were injected with oxytocin (D) (P = 0.05). However, milk secretion rates and estimated 24 hour total yields were significantly (P = 0.05) higher in treatment A than all other treatments. There were significant (P = 0.001) differences between night-time and day-time secretion rates. The presence of the calf with the dam during the day increased milk yields to such an extent that in-bucket yields were comparable to those that had been separated all day and had a longer separation time. It was not possible to determine in this experiment if the use of oxytocin actually increased milk yields, but exogenous oxytocin elicited a stronger letdown reflex which is important when milking camels. Calf management and the method used to determine milk yield both influence estimates of milk yield and actual milk secretion rates.

Key words. Dromedary, *Camelus dromedarius*, milk production, milking, measuring, animal husbandry method, Kenya.

Résumé. En 1991, une étude a été menée au Kenya afin de déterminer les effets de la présence du chamelon ainsi que des méthodes de traite sur la production laitière des chamelles. Le lot de chamelles a été divisé en quatre groupes égaux. Le groupe A était accompagné des chamelons pendant la journée, et 2 quartiers étaient traits dans la soirée après 3 heures de séparation. Toutes les autres méthodes (groupes B, C, D) séparaient les chamelons de leurs mères, et la traite était assurée sur 2 trayons (méthode B), ou sur les 4 (méthode C), ou bien les animaux avaient 4 quartiers traits et la mamelle vidée par une injection I.V. de 10 UI d'ocytocine (Oxytocyne Leo, Laboratoire Leo) (méthode D – technique à l'ocytocine). La technique de pesée des chamelons avant et après la traite s'est avérée impraticable dans ces conditions. L'ocytocine a été injectée à l'occasion de 126 traites produisant une moyenne de 2,6 kg de lait à chaque traite, dont 37 % du volume a été obtenu après l'administration de l'ocytocine. Le temps moyen pour une traite était de 35 secondes. Les productions laitières des collectes les plus faibles provenaient des chamelles qui étaient accompagnées de leurs chamelons (A), et les plus élevées des chamelles qui avaient subi l'injection de l'ocytocine (D) (P = 0,05). Cependant, les taux horaires de sécrétion lactée et les productions totales estimées sur 24 heures étaient significativement plus élevés (P = 0,05) dans la méthode A que dans toutes les autres méthodes. Il existe une différence significative (P = 0,001) entre les taux de sécrétion de la nuit et de la journée. La présence des chamelons avec leurs mères pendant le jour accroît le volume collecté de lait à un tel niveau que les productions collectées étaient comparables à celles rencontrées lors d'une séparation de la journée ou lors d'un temps de séparation supérieur. Il n'a pas été possible de déterminer dans cette expérience si l'utilisation de l'ocytocine accroît véritablement la production laitière, mais l'ocytocine permet un réflexe d'éjection plus intense, ce qui est important lors de la traite de chamelles. Le mode d'exploitation des chamelons et la méthode utilisée afin de déterminer la production laitière influencent à la fois la production laitière et les niveaux des taux horaires de sécrétion lactée.

Mots clés. Dromadaire, *Camelus dromedarius*, production laitière, traite, méthode de mesure, méthode d'élevage, Kenya.

Aims and Objectives

The aim of the experiment was to compare the different methods of estimating total milk yields, and to determine which method was most accurate and practical under the field conditions where camels are most commonly found in Kenya.

The four milk yield estimation methods to be used were:
- hand milking of two teats whilst the calf suckled two teats;
- hand milking of all four teats after initiation of letdown by the calf;
- calf suckling technique;
- milk oxytocin technique.

Soon after the start of the experiment it was apparent that the equipment used for the calf suckling technique was not sufficiently accurate to produce results, and the design of the experiment was altered to compare yields from hand milking with yields obtained using the milk oxytocin technique, at the same time as comparing the presence and absence of the calf, and thereby suckling frequency, on milk secretion rate.

The results of this experiment were to resolve which method of milk yield determination should be used in a long-term study of lactation and performance of camels kept under traditional nomadic management, noting the milk requirements of both the calf and the camel owner.

The different methods of recording milk yields were selected from scientifically proven methods reported in the literature. The calf separation times, and number of teats suckled/milked were based upon traditional camel/calf management techniques used by camel owners in Kenya.

Due to the remote area and lack of facilities all milking was done by hand. A lack of electricity meant that machine milking and calf body water turnover methods of determining milk yields were not practical.

Materials and Methods

Fourteen multiparous, lactating Somali breed camels in the 5-8th month of lactation were selected on the basis of their temperament and their milk yields over the preceeding month. A further two camels were included to balance the numbers (No. 161—a multiparous camel in second month of lactation, and No. 46—a primiparous camel in eigth month of lactation).

The camels were randomly allocated to four different milking treatments.

Treatment A. Calves accompanied their mothers during the day and suckled freely. On their return to the pen each evening the calves were allowed to suckle, and the udder was then stripped by hand (but the volume was not recorded). After a separation period of 3-4 hours, the calves were released to suckle two teats only, the remaining two teats were milked and the volume recorded. The calves were then separated overnight, and only able to suckle 2 teats in the morning, whilst the other two teats were milked and the volume recorded.

Treatment B. Calves were separated from their mothers both day and night, and were only allowed to suckle two teats at each of the morning and evening milkings. The remaining two teats were milked and the volume recorded.

Treatment C. Calves were separated from their mothers both day and night and were only released to stimulate milk letdown. After letdown, the calves were separated and all four teats milked.

Treatment D. Calves were separated as per treatment C. All four teats were milked until no more milk could be obtained, and the volume recorded. The camels were then injected intravenously with 1 ml 10 IU Oxytocyne (Leo Laboratories). After injection the time taken to letdown was recorded, and all four teats were again milked until empty and the volume recorded.

With the exception of milking management, the daily herd management remained the same over the whole period. All camels were penned at night, and released between 8:00-9:00 a.m. to browse on the natural forage, returning to the pen between 6:00-7:00 p.m.

Camels were milked once in the morning, and once in the evening (excepting treatments A and D) giving a milking interval of approximately 12 hours. All milking was carried out by hand. In treatments where only 2 teats were milked (A and B) alternate left and right sides of the udder were milked.

Each treatment was carried out over a period of four days.

The dose rate of oxytocin used in this experiment was determined following a survey of the literature, and discussions with the manufacturers. One camel (not in the experimental group) was repeatedly dosed with oxytocin before the experiment, and it was shown that 10 IU oxytocin injected intravenously were sufficient to empty the udder. The dose rate was again tested at the end of the experiment, and it was proven that

10 IU oxytocin was sufficient to empty the udder even after a prolonged period of usage.

Results were analysed using analyses of variance and the Student's t-test.

Literature review

Background

In recent years there have been a number of publications on camel's milk production, but very few make any reference to the method used to determine the yield. Research on other domestic livestock, notably cattle and goats, show considerable differences in yield depending on the method used to determine the yield, but in camels there is a lack of knowledge on the effect of different milking methods or strategies.

Subsequently, this review includes data from all over the world with information on Bactrian camels (*Camelus bactrianus*) as well as dromedaries (*Camelus dromedarius*). On particular topics where there is a lot of existing information, the review concentrates on work carried out on dromedaries, selecting the reports most applicable to Kenya and neighbouring countries in the African region.

Methods used for estimating milk yields

Methods commonly used to determine milk yields in cattle, sheep, goats and pigs include:
– hand milking;
– machine milking;
– calf suckling technique (weighing calves [and/or adults] before and after suckling);
– milk oxytocin technique (injection with oxytocin before or after milking or suckling);
– measuring the calf body water turnover;
– measuring the calf growth rate (ADG).

Each method has its advantages and disadvantages, and some are not practicable in typical camel keeping areas which are characterised by semi-nomadic management in remote arid regions.

Hand milking

Most camels are milked by hand. The milker stands to milk the camel, and if experienced milks with both hands (HARTLEY, 1984). Two people are normally required if all four teats are to be milked.

The presence of the calf is important in ensuring satisfactory milk letdown (BELOKOBYLENKO, 1978). Many of the estimates of yield are based on the yield from two quarters whilst the calf suckles the other two quarters, a widely acceptable method in cattle (GIFFORD, 1949; GIFFORD, 1953; TOTUSEK *et al.*, 1973), and more recently used on camels by BACHMANN and SCHULTHESS (1987) and KNOESS (1977). YAGIL (1987) suggests that the yield obtained from the two teats suckled by the calf is greater than that obtained by handmilking, and subsequently this method is likely to underestimate total milk yield, a theory supported by other work carried out on other livestock (SOMERVILLE, 1977).

TOTUSEK *et al.* (1973) found more oxytocin was released when cow's calves suckled two teats than when all four teats were milked by hand. He found also that allowing the calf to suckle all four teats increased oxytocin release, resulting in a stronger milk ejection reflex, and increased yields.

YAGIL (1987) notes that an experienced milker can milk faster than a milking machine.

Machine milking

Machine milking of camels has been carried out in Russia (BELOKOBYLENKO, 1978; MUSAEV, 1982), Saudi Arabia, Egypt and Libya (SHAREHA, 1987). The calf is still used to initiate letdown, but exogenous oxytocin has also been used. A conditioned milk letdown reflex can be established over time (BELOKOBYLENKO, 1978) but there is no record as to its effect on milk yield. MUSAEV (1982) found the letdown period and milking time was shorter in machine milked camels than hand milked camels, and the yields obtained were higher.

Possibe drawbacks of this method are a weak letdown response (SOMERVILLE, 1977), a higher risk of mastitis infection (SOMERVILLE, 1977), and DORMAN (1984) notes that machine milking has not always been successful in camels but gives no specific reason.

The calf suckling technique (weighing calves before and after suckling)

This system is widely used for determining yields in beef cattle, but there are no records of its use in camels. Calves are initially separated from the mothers, then weighed before and after suckling. Suckling should be 2-3 times in a 24 hour period.

This technique measures calf appetite rather than actual yield, and in high yielding animals, or during stages of lactation when yields are likely to exceed calf appetite it underestimates yields (DONEY *et al.*, 1979).

Other sources of error for this method include:

– frequency of suckling (naturally calves suckle more often than 2-3 times per day, and measurements would not be able to be taken at each suckling);
– longer intervals between suckling increase intra-mammary pressure and reduce secretion rates (DREWRY *et al.*, 1959; GIFFORD, 1949), and less frequent suckling reduces oxytocin secretion, subsequently reducing yields (BENSON and FOLLEY, 1957) ;
– Interrupted grazing pattern reduces yields (TOTUSEK *et al.*, 1973);
– it is tedious and time consuming, and can cause stress to the females which affects milk letdown (SWENDSON, 1974);
– lower yields and higher calf body weights later in lactation lead to increased errors of accuracy;
– weight loss due to urination and defecation can occur.

Milk oxytocin technique (injection with exogenous oxytocin)

The only published results of the use of this technique being used in camels are from Russia (DUYSEMBIN, 1972; DUYSEMBIN and RAKHIMBERDIEV, 1975). The usual technique is to separate cow and calf, inject oxytocin and milk the animal. After a further 6-12 hour separation the procedure is repeated and the yield obtained represents the volume of milk secreted over the period of separation. Milk removal is by either hand or machine milking, or the insertion of catheters (LAMOND *et al.*, 1969; SOMERVILLE, 1977).

Sources of error include :
– oxytocin itself may affect the rate of milk secretion;
– not all animals respond to exogenous oxytocin to the same degree (SCHWULST *et al.*, 1966).

Calf body water turnover

A radio active marker (tritiated water or deuterium oxide) is injected into the calf, and blood samples taken at known intervals. The dilution rate of tritium can then be used to estimate water or milk intake (SOMERVILLE, 1977).

YAGIL and ETZION (1979) have successfully used this method in Israel. The major advantage is that it does not interfere with the mother infant relationship (SOMERVILLE, 1977). The disadvantages are that it is only a measure of calf appetite and not milk yield, and can only be used if the mother's milk is the sole source of nutrients and water, which may be the case early in lactation, but cannot be used once the calf starts browsing or drinking.

Estimation of yield from calf growth rate

This method compares growth rates of calves compared to the actual milk yield recorded using one of the above methods (TOTUSEK *et al.*, 1973). It is only once this relationship is established that milk yields can be estimated from growth rate. In arid tropical extensive management systems the seasonal and extrinsic variables are likely to make this method very unreliable. To the authors' knowledge this relationship has not been established for camels.

Results

At the start of the experiment it was apparent that the platform weighscale was not sufficiently accurate to obtain the necessary data using the calf suckling technique (weighing the calf before and after suckling). The decision to change treatment C was made after a number of considerations were taken into account:
– although the weighscale was able to weigh to within 100 g, there was a variation of 2 kg from one end of the platform to the other;
– pre-trial observations showed that the calves, when left with their mothers over a 24 hour period, were suckling between 5-10 times; since it would only have been practicle to weigh the calves a maximum of three times in any one 24 hour period, one could expect a significant change in secretion rate;
– it was observed that the mean daily milk yield in the week prior to experimentation, was 5.3 litres (range 1.4-8.2 litres). The average calf liveweight was 160 kg. These large calf bodyweights, combined with the relatively small milk yields at each milking, suggested that reliable results would be difficult to obtain.

Treatment C was therefore changed to complete hand-milking of all four teats at morning and evening milkings, with the calves separated from their mothers for 24 hours each day for the full four days of treatment.

Determination of correct dose of oxytocin injection

The results of a test to prove whether the recommended dose for cattle (10 IU oxytocin injected intravenously) was also applicable to camels, are given in table I.

Average time taken from injection to milk letdown was 35 seconds. On the two occasions where milk letdown took longer than 2 minutes, a note was made of the milk yields in case it should prove necessary to omit them from the data analyses.

Injection with oxytocin was used at 126 milkings, giving a mean yield of 2.3 kg at each milking, of which 37% (0.86 kg) was obtained following the administration of 10 IU exogenous oxytocin.

Table I. Effect of higher doses of oxytocin (yields in kg).

Camel No.	Milk yield			Number of days* from start of oxytocin
	1st milking (no oxytocin)	2nd milking (after 10 IU)	3rd milking (after 30 IU)	
245	2.0	0.5	0.1	12
253	0.7	0.25	0.05	11
136	1.5	1.0	0.075	4
257	2.4	0.4	0.05	4
266	1.4	0.55	0.025	4
194	1.3	0.8	0.025	4

* At the time of testing the camels had been injected twice daily with 10 IU oxytocin for 12, 11 and 4 days respectively.

It is interesting to note that some camels became conditioned to the injection as a stimulus for milk letdown. The camels that were repeatedly injected with oxytocin, let down their milk when the needle was inserted into the jugular, but before the oxytocin was actually injected into the vein.

Milk yield

The analyses of variance shows no significant difference between actual "milk in bucket" yields of treatments A and B.

Apparent milk secretion rate

The milk secretion rate was calculated by dividing the milk yield at each milking by the number of hours since the last milking. The yield in treatments A and B were doubled to give the estimated total four teat yield. Rates are given as grams per hour and presented in table IV.

Morning (a.m.) rates represent secretion during the night from approximately 8:00 p.m. to 6:00 a.m. Evening (p.m.) rates represent day-time secretion from 6:00 a.m. to 8:00 p.m.

There was a negative correlation (– 0.261) between apparent milk secretion rate and milking interval.

There were significant differences (P = 0.001) between morning and evening secretion rates for all treatments. Overnight secretion rates were significantly higher in all treatments except treatment A.

Within treatment variation and carry-over effect

Analyses of the apparent milk secretion rates between Day 1 and Day 4 within treatments showed little variation. There were only significant variations within treatment A where Day 1 day-time (p.m.) apparent secretion rate was significantly higher than subsequent day-time rates within the period. Due to the short time duration for each treatment it was not possible to determine whether there were any significant carry-over effects.

Discussion

Despite the differences in parity, the milk secretion rates for camel No. 46 (first parity) were not significantly different from other camels in the group during most treatments. Camel No. 161 (in the second month of lactation) had significantly higher milk secretion rates than the other camels in the group. After carrying out analyses of variance including and excluding data from this camel, it was decided to include the data in later analyses, as removing the data increased error mean square.

To calculate the apparent milk secretion rates, the yields in treatments A and B were doubled to make them comparable to treatments C and D. The assumption was made that the yield obtained from the two teats milked by hand is equal to the amount suckled by the calf from the other two teats. There have been no specific experiments carried out on camels to determine the validity of this assumption, although it has been used in estimating camel yields (BACHMANN and SCHULTHESS, 1987). In cattle it has been found that the amount of milk suckled by the calf is generally higher than that obtained by hand milking (SOMERVILLE, 1977). This is also likely to be true for camels (YAGIL, 1987), in which case the results for treatments A and B will under-estimate rather than over-estimate milk secretion rates and estimated total yields.

Considering the extensive management system adopted by camel owners in traditional pastoral systems, this method of doubling the two teats yields to estimate total 4 teats yields, and taking into consideration the duration of separation, has so far proven to be the only practical solution for estimating total milk yields.

Determination of dose rate for oxytocin injection

Table I clearly shows that 10 IU oxytocin injected intravenously, is sufficient to effectively empty the udder. Further injections with 30 IU oxytocin only yielded very low volumes of milk. It is of course possible however that the reason 30 IU oxytocin did not release further milk is because there were still high levels of the enzyme oxytocinase in the blood and the oxytocin was being denatured before it could have full effect. Similar experiments with sheep (Dorman, 1984) showed that a further lower dose of oxytocin only yielded up to 5% of the original milk volume, which compares with this experiment where a second injection of higher dose only yielded 1-5% of the original milk volume.

The only other record of the milk oxytocin test being carried out on camels, was reported by Dyusembin (1972), where 10 Bactrian camels in the 4-5th month of lactation were injected intramuscularly with 5-10 IU oxytocin, and milking carried out 2 minutes later. He found the residual milk comprised 11.6 % of total yield. During the experiment he injected the camels before milking and the residual amount was taken to be the volume of milk obtained after a second injection with oxytocin; whereas in this experiment the calf was used to initiate milk letdown, and the residual milk is considered as being the milk obtained following the injection of oxytocin after the udder had been milked by hand. One can infer from the two experiments that the use of 5-10 IU oxytocin (i.m.) initiated a stronger letdown response than the use of calves to stimulate natural letdown. However since there were differences in breed, milking frequency and other management parameters, any closer comparisons between the two experiments cannot be made.

It was noticed that a conditioned milk letdown response occurs in camels. It was especially noticeable in older camels, or in camels late in lactation, and where milking is undertaken by the same person, in the same environment, following a set routine.

Actual milk yields

Differences in yields

Tables II and III of actual "milk in bucket" yields for each treatment are as one might expect, the differences primarily being due to the number of hours over which they were recorded, and the number of teats milked for each treatment. An analyse of variance shows no statistical difference between treatments A and B despite yields in treatment A being the result of only 12 hours of secretion, and treatment B representing a full 24 hours.

If treatment B is doubled to give an estimated 4 teat 24 hour total yield (3.6 kg), statistically there is no significant difference to treatment C.

Quadrupling treatment A to give an estimated 4 teat 24 hour total yield (5.6 kg) becomes significantly (P = 0.05) higher than all other treatment yields.

In table II D(exc) represents the yield obtained in treatment D, excluding the volume of milk obtained following injection with oxytocin. A Student's t-test carried out between treatment C and D(exc) shows significance at the P = 0.001 level. Since the only

Table II. Milk obtained by handmilking for each treatment (kg).

Treatment	Mean "in-bucket"	S.E.	n	Number of teats	Number of hours	Estimated 24 hour and 4 teat yield
A	1.4c	0.4	60	2	12	5.6a
B	1.8c	0.4	61	2	24	3.6c
C	3.4b	0.8	56	4	24	3.4c
D	4.6a	0.7	64	4	24	4.6b
D(exc)	2.9	0.7	64	4	24	2.9

a, b, c denotes significance at P = 0.05.

Table III. ANOVA table of milk yields.

Source	DF	Sum squares	Error mean square	p. value	
Treatments	3	104,953	34,984	9.23	—
Between squares	3	2,959	986	2.60	
Camels within squares	12	925	160	0.42	NS
Period within squares	12	896	75	0.20	NS
Error	32	12,125	379		
Total	62	122,858			

ANOVA: analysis of variance; DF: degrees of freedom; NS: non significant.

differences between treatment C and D(exc) is the use of exogenous oxytocin, the decrease in alveolar yield must be due to the effect of the oxytocin itself. The explanations fo this are discussed further.

Yields of residual milk

The residual milk (37%) obtained by the use of oxytocin was found to be much higher in this experiment than any other reports in the literature. Experiments carried out on Bactrian camels in Russia show that residual milk can comprise 8-14% (MUSAEV, 1982), 9-13% (BELOKOBYLENKO, 1978) and 12-20% (DYUSEMBIN, 1972) of total milk yield at each milking. BELOKOBYLENKO (1982) gives a correlation of 0.16 between residual milk and total yield.

Milk secretion rate

Table IV shows that day-time (p.m.) milk secretion rates in treatments B, C, and D were between 20-46% lower than night-time (a.m.) milk secretion rates (P = 0.001).

Table IV. Apparent milk secretion rate (g/hour).

Treatment	Mean a.m. rate	Mean p.m. rate	Mean daily rate
A	196 ab	346 a	271 a
B	187 bc	128 c	157 c
C	170 c	118 c	144 c
D	213 a	178 b	196 b
D(exc)	138 d	109 c	123 d
[LSD (P = 0.05)	26	45	35]

a, b, c, d denotes significance at P = 0.05; LSD: least square difference.

Differences between day-time (p.m.) milk secretion rates for each treatment were due to calf access and frequency of suckling/milking, and are discussed below.

The higher night-time milk secretion rates, when compared to daytime milk secretion rates, found in treatments B, C and D, suggest that physiologically camels secrete more milk at night than during the day. There were however differences in the milking intervals when these rates were recorded. Day-time rates were recorded after a milking interval of 13 hours, compared to night-time rates recorded over an interval of 10 hours. Other factors that may have had an effect on the differences in secretion rate are discussed below:

❑ At night, the calves were visible to, and in closer proximity to their mothers, only separated by a few metres, compared to the day-time when they were separated into two herds and grazed out of audio or visual contact. This may have led to different levels of stress on the females, which in turn may have effected secretion rate.

❑ At night, the camels were resting and ruminating. During the day-time the camels were walking and feeding with more energy involved in metabolism than milk production.

❑ Ambient air temperatures were lower at night than during the day.

The significant differences of night-time secretion rates between treatments are less, and are due to the reasons listed below :

❑ Treatment A rates are higher than B and C, because camels in treatment A were milked 3 hours later each evening, giving a milking interval of 3.5 hours compared to 13 hours. The increased milk secretion rate during the day, due to the presence of their calves, may have carried over into the night-time hours.

❑ Treatment D rates are higher than B and C, possibly due to the stimulating effect of oxytocin, but more likely due to the effects discussed above.

❑ B and C are not significantly different to each other as calf access and frequency of milking/suckling are the same for both treatments.

Effect of calf presence or absence on milk secretion rates

The results in table IV clearly show that the presence of the calf with the mother during the day (treatment A) increases milk secretion rate. In all other treatments where calves were separated from their mothers, the mean daily milk secretion rate was significantly lower (P = 0.05).

The importance of the presence of the calf on lactation is well documented for cattle and other domestic stock (SOMERVILLE, 1977). For camels, the only other work done on the subject was published from Libya (SHAREHA, 1987) which states that the separation of calves from their mothers results in a breakdown in lactation. Similarly, camels whose calves died early in lactation had significantly lower milk yields (SIMPKIN, 1985).

The calves in treatment A of this experiment, were observed to suckle between 3-5 times whilst with their mothers during the day-time, and it is this offtake or frequency of suckling that is likely to be the cause of increased milk secretion rates. The physiological explanations for this include:

❑ Increased suckling frequency or shortened milking interval, reduces the build up of internal pressure within the alveoli. In cattle if the interval between milking or suckling is large, the pressure within the alveoli increases resulting in a decrease in the milk secretion rate.

A higher frequency of suckling or milk offtake (milking) results in less milk in the udder, lower internal pressure and less interuption of the rate of galactopoiesis.

The negative correlation between milk secretion rate and the number of hours between milking confirms that the same trend may occur in camels.

❑ The suckling stimulus causes the release of oxytocin from the hypophysis (posterior pituitary). Oxytocin is not only responsible for milk ejection, but also increases the permeability of the cell membranes, thereby increasing the uptake of nutrients by the alveolar cells (MORAG, 1968).

❑ The suckling stimulus also stimulates the release of prolactin, corticosteroids, and possibly growth hormone, all of which may have a role in maintaining milk secretion. The actual role of these hormones in maintaining ruminant lactation is not fully understood.

The effect of oxytocin on milk secretion rates

At first glance the use of oxytocin in treatment D appeared to increase milk secretion rates, however on closer analysis this may not be the true situation.

Camels are known to have only small teat cisterns or sinuses, the bulk of the milk obtained at each milking is alveolar milk that has been stored in the lumen or ducts. Unlike the majority of other domestic ruminants, that have cisterns either in the gland itself, and/or in the teats, the milk ejection reflex must take place in the camel in order to get any milk at all (BELOKOBYLENKO, 1978).

The fact that the milk secretion rate for treatment D excluding the residual milk obtained after injection, is significantly lower than all the other rates, does suggest that a large proportion of the camel's milk is stored in the alveoli and not in any cisterns. It is therefore important to obtain satisfactory milk letdown in order for the camel owners to obtain sufficient milk for their own dietary needs.

The effect of exogenous oxytocin may have been to eject all the residual milk from the cytoplasm within the alveoli, which may not have been ejected in other treatments where only natural levels of oxytocin were released in response to the stimuli of the calves suckling. Since the calves were only allowed to suckle briefly to elicit the letdown response in all treatments, the use of further (and possibly a higher dose of) exogenous oxytocin resulted in a higher yield being obtained at each milking. The milk secretion rate calculations were based on the volume of milk obtained at each milking (as a factor of time), and subsequently appear higher, although true secretion rates were unlikely to have been effected.

The fact that treatment D(exc) yields and secretion rates are significantly lower than treatment C yields and secretion rates, where the only difference between treatments is the use of oxytocin, suggests that oxytocin may have actually decreased secretion rates. A possible explanation to this is that figures for treatments C and D(exc) only represent milk ejected from the teat cisterns and lumina. If this is the case it could be hypothesised that milk from D(exc) is significantly lower because the use of exogenous oxytocin has caused the myo-epithelial cells to constrict to such an extent that milk from within the alveoli cells has been ejected, and on subsequent milking (before the use of further exogenous oxytocin) the alveolar cells have to return to equilibrium before any milk is naturally secreted into the lumina, sinuses or ducts. Alternatively, there may be an inhibition of response to handmilking without the use of exogenous oxytocin.

In the discussion above it has been noted that it is important to obtain a good letdown response before any milk can be obtained from the camel. It could be argued that the estimated total daily yield and apparent milk secretion rates in tables II and IV reflect the intensity of the letdown stimulus in each treatment. The lowest yields and secretion rates occurred in treatments C and D(exc) where the stimulus would have been weakest. In these two treatments, the calves were only allowed to suckle briefly to initiate letdown, and then were kept away from the udder whilst all four quarters were milked. In treatments A and B the calf continuously suckled two teats whilst milk was obtained by hand from the other two teats. The continual suckling and butting of the udder by the calf would comprise a strong natural stimulus for milk letdown. In treatment D where exogenous oxytocin was injected, the yields and milk secretion rates were again very high, reflecting the strong letdown reaction in response to the artificially induced stimuli (i.e. high amounts of oxytocin in the blood).

Within treatment variation

Within treatment variation was only observed in treatment A. The variation in treatment A occurred on Day 1, where evening milk secretion rates and relative yields were significantly higher than all other rates. This was due to all the camels, with the exception of Group 1 camels, being separated from their calves for a period ranging from 4-12 days prior to the start of treatment A. It appears that once camels were reunited with their calves, milk secretion rates increased significantly, but then levelled off.

Longterm effect of oxytocin on milk secretion rates

There is a suggestion from some studies that the prolonged use of oxytocin may increase milk secretion rates in ruminants (ELLIOT, 1959), and the initial results appear to show that this could be the case with camels; further analyses of the data however, show that this cannot be confirmed in this instance (see above).

If frequency of milking and suckling, and the strength of the milk ejection reflex, and the degree to which the udder is emptied, all reduce internal pressures and promote milk secretion, then it is fair to hypothesise that the prolonged use of oxytocin will increase milk secretion rates in camels over the longterm. This experiment however was too short to determine whether this was the case in these camels.

Conclusion

Comparison of milking methods to determine daily milk yields

The aims and objectives of the experiment were accomplished despite the failure of the weighscale. The results show that different methods of obtaining estimates of milk yields, actually influence milk secretion rates and hence the yields themselves.

The most accurate method of determining daily yields was the use of the milk oxytocin test; there were however some sources of error even when using this method:
– exogenous oxytocin may increase milk secretion rates over the longterm;
– despite the camel having a large jugular vein, it is possible to miss the vein when injecting, and there would be a delay in letdown;
– young camels are often nervous, and the action of catching, restraining and injecting them may cause stress and the release of adrenalin, sufficient to affect the milk secretion and letdown reflex;
– the cost of the drug limits the extent of its use and hence sample sizes.

In this experiment, it was found that the calf suckling technique would have been inaccurate, due to the small quantities of milk and the relatively large bodyweights of the calves, especially towards the end of lactation. It requires very accurate measuring equipment that is both mobile and robust, and subsequently expensive.

Machine milking and the use of radio-active labelled water (tritium or deuterium) are impractible in these field conditions due to the lack of basic resources of electricity.

Hand milking at different time intervals and using different numbers of teats provides an insight into daily yields, but can have an effect on milk secretion rate. Some of the techniques used in this experiment did have significantly different results to each other as well as to the actual yield as determined by the milk oxytocin test.

Effect of milking strategies on milk secretion rates

As mentioned above, different milking strategies did influence milk secretion rates. Camels that grazed with calves at foot, had significantly higher milk secretion rates than camels that were separated from their calves.

The use of oxytocin over the short duration of the experiment did not appear to increase milk secretion rates, but prolonged use might affect total lactation yields.

Recommended milking strategy to maximise milk production

In order to maximise milk production, and enable sufficient offtake for human consumption without effecting calf growth, the Somali style of management, where calves accompany the mother day and night and are only separated for a few hours morning and evening is recommended for camels kept under these conditions. The presence of the calf stimulates milk production to such a degree that yields per milking were equivalent to yields from camels that had been separated from their calves all day. It is suggested that instead of only milking two teats at each milking, all four teats could be milked.

Unfortunately, during this experiment the volume of milk yielded when camels returned from grazing but before they were separated for a few hours, was not recorded. If it had been, the authors believe that treatment A "daily in-bucket" yields would have equalled or even exceeded treatment B yields, and if doubled would have been equivalent to treatment C yields where all four teats were milked without allowing the calf access.

In this experiment, calves were separated from their mothers during the night. If they had been allowed to suckle during the night, it is possible that milk secretion rate may have increased further, as they did in treatment A following access of the calves to the dam during the day.

At this preliminary stage, the recommended milking strategy is:
– allow all calves to accompany their mothers during the day and suckle freely;
– on returning to their pens at night, calves should be allowed to suckle two teats, whilst the other two teats are milked for human consumption;
– after the evening milking, the calves should be separated until 10-11 p.m. (or 3-4 hours), and then all four teats milked;
– calves should be allowed to sleep alongside their mothers at night and again allowed to suckle at 5-6 a.m.;
– at 8-9 a.m. all four teats should be milked, and the camels and calves released to graze.

This strategy should increase yields obtained by herdsmen on a daily basis, as well as prolonging duration of lactation. This recommendation however does not take into account the stress that might be put on the lactating camel, but daily condition observations on both camel and calf, would further determine whether this level of milk offtake could be maintained over the whole lactation.

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Studies on mastitis in lactating one-humped camels (*Camelus dromedarius*) in Iraq

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Abstract. The causes of mastitis were studied in 50 milk samples randomly collected from three herds of camels near Baghdad. The most predominant bacterial isolate from chronic mastitis was *Staphylococcus aureus* whereas the main bacterial isolates from subclinical mastitis were *Streptococcus* spp., *Staphylococcus epidermides, Pasteurella haemolytica, E. coli* and *Micrococcus* spp. A significant correlation has been found between milk cell counts and California Mastitis Test ($P < 0.05$). Also, the results indicated that most of the isolated bacteria were sensitive to the most readily available antimicrobial drugs.

Key words. Dromedary, *Camelus dromedarius,* mastitis, mammary glands, Iraq.

Résumé. Les causes de mammite ont été étudiées sur 50 échantillons de lait sélectionnés au hasard dans trois troupeaux camelins près de Bagdad. La bactérie dominante, isolée des mammites chroniques, était *Staphylococcus aureus* alors que les principales bactéries isolées des mammites cliniques et subcliniques étaient *Streptococcus* spp., *Staphylococcus epidermides, Pasteurella haemolytica, E. coli* et *Micrococcus* spp. Une relation significative a été constatée entre les numérations cellulaires et le résultat du test CMT ($P < 0,05$). De plus, les résultats démontrent que la plupart des bactéries isolées étaient sensibles à la majorité des médicaments antibiotiques disponibles.

Mots clés. Dromadaire, *Camelus dromedarius,* mammite, glande mammaire, Iraq.

Introduction

Camels are reared for meat, milk and wool production. The total camel population in Iraq in 1986 was reported to be 60,000 (AL-ANI *et al.*, 1990). The greatest proportion of this population is present in the middle and south parts of the country. Since milk production is a particularly critical time in the production process in dairy animals, mastitis has been regarded as one of the major reasons for early culling of lactating camels (AL-ANI *et al.*, 1990).

Micrococcus spp., *Staphylococcus aureus, Streptococcus* spp., *Corynebacterium* spp. and other organisms have been implicated as causes of mastitis in camels in different parts of the world (BARBOUR *et al.*, 1985; HAFEZ *et al.*, 1987; HASSANEIN *et al.*, 1984; KAPUR *et al.*, 1982; MOSTAFA *et al.*, 1987; QUANDIL and QUADAR, 1984; RAMADAN *et al.*, 1986). Yet, in Iraq no report on the causes of mastitis has been found in the available literature. Also, systemic investigation in the pathological aspects of the udder of camels are sparse (BARBOUR *et al.*, 1985). Therefore, the aims of the present study were:
- identification of the causative bacteria and fungi;
- detection of bacterial sensitivity to antibiotics;
- to describe the gross and microscopic features of the lesions.

Materials and Methods

Animals

Fifty lactating camels were examined during a 6 month period. The camels represent three different herds of camels in Iraq. All udders were subjected to careful clinical examinations by visual observation and palpation. Collected milk was also observed for the presence of blood clots or abnormal colour. The animals were divided into three different groups according to the clinical examination of the udder, California Mastitis Test (CMT) and bacteriological isolation. Group 1 involved eight lactating camels with clinical signs of mastitis. All were conditionally slaughtered at Najif abattoir. The mammary glands were collected and examined in detail. In each case, the mammary gland was opened from the teat orifice up through the mammary tissue and then to the suspensory ligament. Tissue specimens were obtained from the gross lesions.

Group 2 involved eleven camels with udder palpated normal but from which there were bacterial isolation and high milk cell counts. Three of them were conditionally slaughtered and processed as in group 1. Group 3 involved 31 lactating camels without clinical signs of mastitis and bacteriologically negative to serve as control.

Sampling

Before slaughtering the whole udder was washed with water and dried, and the end of the teat was disinfected with a swab of alcohol. The first two streams of milk were discarded and then 10 ml of milk was milked directly from teat into sterile bottle. California Mastitis Test was carried out using the method described by SCHALM *et al.* (1971). Somatic Cell Counts (SCC) was performed using the method of COLES (1981). For bacteriological isolation one loopful of milk was spread on 5% blood agar and McConky agar and incubated aerobically at 37°C for 24 to 72 hours. The isolates were characterized according to the method of CARTER (1984). Mueller-Hinton agar was applied for susceptibility testing of the isolated bacteria by the disc diffusion method using the following antibiotics: ampicillin (AM, 10 mg); gentamycin (GM, 10 mg); penicillin (P, 10 IU); streptomycin (S, 10 mg); and tetracyclin (Te, 30 mg). Also, a loop of milk was streaked on Sabouraud dextrose agar plates containing chloramphenicol. One plate was incubated at 37°C and the other at 25°C for 6 weeks for the growth of the fungi (PARKER, 1983).

Histopathological examination

Specimens of mammary tissues were fixed in 10% neutral buffered formalin and paraffin sections 6 mm thickness were prepared by standard methods and stained by haematoxyin and eosin (H & E) as described by LUNA (1968).

Statistical analysis

Analysis of variance, Student's t-test and correlation coefficient (r) were performed (SNEDECOR and COCHRAM, 1980). Differences and correlations were considered significant at $P < 0.05$.

Results

Of the 50 milk samples examined, 38% showed positive bacterial isolation during the single sampling (table I). Of the cases in group 1 with chronic mastitis, *Staphylococcus aureus* was isolated from a total of 7 glands and *Corynebacterium pyogenes* was isolated from 1 gland. Milk cell counts were ranged between 800,000 to 1,600,000 cells (table I). All gave positive CMT (grade five). Clinically affected udders were swollen, hard and painful to the animal by palpation (figure 1). One udder had an area of necrosis and abscess formation discharging greenish type pus mixed with milk. Histologically, the affected parts showed destruction of the epithelial lining of the acini together with granulation tissue proliferation around the interlobular and intralabular ducts. In some glands, epithelial hyperplasia were noticed. There were severe infiltration of neutrophils, mononuclear cells and occasional mast cells.

Table I. Results of a microbiological examination of milk from 50 lactating camels.

Organism isolated	Type of mastitis	No. of isolates	Frequency of isolating (%)
Staphylococcus aureus	chronic	7	36.84
Corynebacterium pyogenes	chronic	1	5.26
Streptococcus spp.	subclinical	4	21.06
Staphylococcus epidermides	subclinical	3	15.79
Pasteurella haemolytica	subclinical	2	10.53
E. coli	subclinical	1	5.26
Micrococcus spp.	subclinical	1	5.26
Total		19	100

In group 2, *Streptococcus* spp. was isolated from 4 glands, *Staphylococcus epidermides* from 3 glands, *Pasteurella haemolytica* from 2 glands, *E. coli* from 1 gland and *Micrococcus* spp. from 1 gland (table I). The udders appeared normal. Milk cell counts ranged between 600,000 to 1,300,000 cells/µl and all gave CMT of 2 to 3 scores. A significant correlation has been found between milk cell count and CMT ($P < 0.05$, $r = 0.78$). As milk cell counts in the milk rise, there also reflect positive CMT (table II).

Table II. Relationship between Somatic Cell Counts (SCC) and California Mastitis Test (CMT).

	Thousands				
Somatic Cell Counts	400	600	800	1,300	1,600
California Mastitis Test	1	2	3	4	5

$P < 0.05$; $r = 0.78$

In group 3, the milk appeared normal and no bacteria were isolated. Milk cell counts were less than 400,000 cells/µl. Sensitivity test of the isolated bacteria are shown in table III. It seems that the isolated bacteria were sensitive to most available antimicrobial drugs (table III).

Table III. Antibiotic sensitivity to antimicrobial agents.

Bacterial species	**Strains sensitivity to antimicrobial agents** (%)					
	AM	CL	GM	P	S	Te
Staphylococcus aureus (n = 7)	100	69	100	100	48	100
Staphylococcus epidermides (n = 3)	100	50	100	100	75	100
Corynebacterium pyogenes (n = 1)	100	100	100	100	100	100
Streptococcus spp. (n = 4)	100	75	100	100	50	75
Pasteurella haemolytica (n = 2)	100	100	100	50	50	100
E. coli (n = 1)	100	100	100	0.0	100	100
Micrococcus spp. (n = 1)	100	0.0	100	100	0.0	100

AM: ampicillin; CL: chloramphenicol; GM: gentamycin; P: penicillin; S: streptomycin; Te: tetracyclin.

Figure 1. *Clinically affected udders are swollen, hard and painfull.*

Discussion

Mastitis in camel is not common. However, clinical cases are occasionally seen by veterinarians, but the majority are uneconomic to treat and do not receive veterinary attention. It has been noticed in the slaughter house that early culling of female camel in Iraq is owing to chronic mastitis and infertility (AL-ANI *et al.*, 1990). The predisposing factors to clinical mastitis in camels are poorly understood. The authors believed that physiological act of suckling by the newborn calf is partly responsible for the occurence of mastitis when lactating camels are kept as suckling camels to the calf for 6-8 months.

This result showed that *Staphylococcus aureus* was the main causes of chronic mastitis in camels in Iraq. Such finding correspond to the finding of BARBOUR *et al.* (1985) and RAMADAN *et al.* (1986) who have reported mastitis due to *Staphylococcus aureus* on a number of occasions in Saudi Arabia. In another study in United Arab Emirates with 94 lactating dromedaries, 23 had mastitis. The common bacteria were *Streptococcus uberis, Strepagalactia, Diplococcus pneumoniae, Staphylococcus aureus, E. coli* and *Bacillus cereus* (QUANDIL and QUADAR, 1984). The common bacteria were : *Streptococcus* spp., *Staphylococcus epidermides, Pasteurella haemolytica, E. coli* and *Micrococcus* spp. Such results were in correspondence with the finding of MUSTAFA *et al.* (1987) in Egypt. The incidence of mastitis in camels under extensive condition of husbandry in Saudi Arabia has been reported by BARBOUR *et al.* (1985). They reported 55.7% incidence of mastitis in camels. This survey was based on examination of 205 milk samples in the central province of Saudi Arabia.

The role of fungi as a cause of mastitis in camels has been highlighted. The authors failed to isolate any fungi from 50 milk samples examined. QUANDIL and QUADAR (1984) were abled to isolate *Candida albicans* from a milk sample collected from camels with subclinical mastitis.

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Dairy camel breeds in the Arab Countries

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Abstract. Camel's milk is the staple food for prolonged periods of the year in many pastoral societies in Asia and Africa. Camels are being utilized as a mean of capital, for food (milk and meat) production, burden, transport, and for pleasure as sport animals in pastoral and agro-pastoral areas. A new system has been suggested for the classification of the dromedary camels into dairy, meat, dual-purpose and race camels. Dairy camel breed include Fakhreya and Sirtawi in Libya, Oulad Sidi Al-Sheikh in Algeria, and Shallageea in Sudan. This paper presents a brief description of the major dairy breeds or breed types in Arab Countries, and lays out a foundation for a basis for a classification system of the dromedary camels according to their production potentialities within the different pastoral and agro-pastoral systems.

Key words. Dromedary, *Camelus dromedarius,* milk yielding animals, breed, classification, Algeria, Libya, Sudan.

Résumé. Le lait de chamelle est un aliment de base pour les sociétés pastorales d'Afrique et d'Asie. Les dromadaires y sont utilisés comme source de capital, de production alimentaire (lait, viande), comme moyen de transport et de trait, et comme animaux de course. Une typologie des dromadaires est donc possible selon leur usage : animaux laitiers, à viande, mixtes et animaux de course. Les types laitiers comprennent les races Fakhreya et Sirtawi en Libye, Oulad Sidi Al-Sheikh en Algérie et Shallageea au Soudan. Cet article propose une description des principaux types laitiers des pays arabes, et pose des bases pour une classification des races selon leurs potentiels de production dans les différents systèmes pastoraux et agro-pastoraux.

Mots clés. Dromadaire, *Camelus dromedarius,* animal laitier, race, classification, Algérie, Libye, Soudan.

Introduction

The habitat of the dromedary is the dry hot zones of North Africa, Ethiopia, the Near East and West Central Asia (WILSON, 1984). It is believed that the dromedary camel was first domesticated in Southern Arabia (ZEUNER, 1963) or in the Northern steppe and deserts of Arabia (BULLIET, 1975; MIKESELL, 1955). KHANNA (1990) reported that the dromedary camels might have been separately domesticated in India.

The camel plays vital socio-economic roles and supports for the survival of millions of people in the semi-dry and arid zones of Asia and Africa. Camel's milk is the sole nourishment for the pastoralists for prolonged periods each year. The camel proved it is the most fit domestic animal during severe drought periods. The camel not only survived during such droughts, but continued producing and reproducing (WARDEH, 1989*a*).

From about 18 million camels world wide (FAO, 1992) the dromedary accounts for 95%. The Near East, North Africa and the Sahel region have about 70% (12 million) of the world's dromedary population. Somalia and the Sudan together own more than half of this figure. Camels contribute more than 29% of the animal biomass in Mauritania, 54% in Somalia and 58% in the United Arab Emirates. In the former two countries, camels have retained their important socio-economic role and constitute a large share of animal exports. In the latter, camels have become insignificant when compared with the oil sector, but remain prominent in social terms. Camels comprise 18% of the animal biomass in the Sudan, 15% in the Kingdom of Saudi Arabia, and 15% in Tunisia. The biomass of the camel in the other countries is below 10%, nevertheless it plays a considerable role in the provision of subsistence, transport and draught power.

Camels in the Arab Countries annually provide about 3,218, 358, 95 and 14 thousand tons of milk, meat, hides and fibers, respectively.

The camel possesses unique qualities which make it superior to other domesticated animals in the hot and arid desert ecosystems. These attributes of the camel are reinforced by its ability to traverse considerable distances with much less effort than other species, moving from one patch of short-lived vegetation to another.

The future role of camels will lie in their capacity to produce milk and meat and, to a lesser extent in the provision of draught power and transport. If the camel is to retain its unique position, then its capacity to utilize low quality feed resources and convert them into animal protein, power and other products, must not be lost. Its physiology and special features are therefore not only of scientific interest, but are the basic sustenance for people who live in marginal dryland areas.

A new system for classification of camels

The dromedary camels adapted themselves to the ecosystems of dry and arid zones where they are subject to harsh conditions in addition to the severe fluctuations in the nutritional status which in turn affect their performance in general. Moreover, the dromedary camels were not subject to modern studies and improvement.

Selection to perform certain physiological functions such as milk or meat production was not practiced on camels. They were selected to perform certain types of work and burden, and were classified into two basic classes (WILSON, 1984). The two classes were the ride and the pack camels. The ride camels were subdivided into ride and race camels, while the pack camels were subdivided into plain and hill camels (LEESE, 1927). Moreover camels were named after tribal or territorial names (HARTLEY, 1984; WARDEH, 1988*a*; WARDEH, 1989*a*).

The new classification system takes aim at establishing the foundation for selection of camels on the basis of their performance as meat, dairy, dual purpose and race animals. Such system of classification will fit the requirements for the development of camel production and the improvement of the standard of their owners.

Dairy camels

Dairy camels are camel breeds or breed types that are characterized by high milk production which is not less than 2,500 kg under natural grazing conditions (WARDEH *et al.*, 1990), the development of the udder and milk veins, small hump, less beefy body conformation and relatively big abdomen. The following are some examples.

Rashaida. They are found in the Kasala area of Eastern Sudan and raised by the well known Rashaida tribe. They are medium sized camels, hardy, red coloured and produce sufficient amounts of milk (2,000-3,000 kg) annually (KOHLER-ROLLEFSON *et al.*, 1990; WARDEH, 1989*a*).

Shallageea. The Shallageea or coast camels are found at the coastal strip of the Red Sea in North-East Sudan. They are sturdy and mainly browse on the salty *"adlib" Suaeda fruticosa* and the similar but smaller *"hadmal"*, supplemented with the leaves and fruits of mangrove. The Shallageea are very skillful at walking into the sea and nipping the lemon-like fruits from the mangrove stands (HJORT and DAHL, 1991). Frequently, they wade so deeply that only the head and hump are visible above water.

The Shallageea are very good milkers, especially during the 3 one-months periods, roughly November, March and July, when the *adlib* is in fruit. At the early night milking one camel may give up to 6 kg. Three hours later, it may give another 3.5 kg. The morning milk could then amount to 6-7 kg (HJORT and DAHL, 1991). With three milking per day each animal gives a daily yield of 15-18 kg. During good rains and excellent pasture on the *adlib* side, an animal gives about 18-21 kg of milk daily.

Sirtawi. It is found mainly in Sirt area in the middle coastal zone in Libya (WARDEH, 1989*b*). They vary in colour from light or dark brown, are medium in size, and their hump is not well developed, and udder is fairly developed. Selected females in certain private farms and herds respond to feeding by producing high amounts of milk (3,000-4,000 kg/305 days).

Ould Sidi Al-Sheikh. It is found in Ain Safra area among the north-eastern boarders of Mauritania, the south-eastern boarders of Morocco and south-western boarders of Algeria. They are light in colour, well built with good body conformation measuring 180 cm at the elbow. They have fairly developed udder and are well bred by the tribe of the same name. They produce about 2,000 kg per year under natural range condition and respond well to feeding in the breeding station for camel husbandry in the same area. Milk production might go up to 3,500 kg/305 days under good feeding conditions.

Fakhreya. They are well known for their milk production (3,500 kg/year) under natural grazing conditions in the southern and western areas from Benghazi in Libya (WARDEH *et al.*, 1991).

Dual purpose camels

Dual-purpose camels are breeds or breed types that are characterized by medium body size, average milk production (1,000-1,500 kg/year), relatively high rate of gain when feed is available and medium hump (WARDEH, 1988 *a*; 1988*b*). Most of the pack and riding camels may fit into this category (WARDEH *et al.*, 1990). The following are some examples.

Hoor Camels. They are the most numerous and widely distributed in Boucle, Herein, Galgadud, Metage, Middle Shabbily and some parts of Gedo regions of Somalia (HUSSEIN, 1987). They are characterized by their small size, short legs, and white colour.

Hoor camels are adapted to the more arid regions of Somalia. They mature between 3-5 years of age, but practically breed at 5-6. They loose weight during the dry season but have fast compensatory growth and are very susceptible to biting flies. The average daily milk production is 7-8 kg (2-20 kg). Milk production is about 2,050 kg (800-2,800 kg) during a period of 8 to 16 months.

Sifdar. It is found in lower Shabbily river belt in Somalia. They are tall, light, and grey to reddish in colour. They reach maturity at 5-6 years but breed at 6-7. They slowly loose weight during the dry season and are relatively resistant to biting flies (HUSSEIN, 1987). Sifdar camels produce about 4 kg milk daily (2-6 kg) and about 1,000 kg during 6-10 months.

Maghrebi. It is found in most coastal zones of the North African territories that extend from Egypt to Morocco. The Maghrebi is a camel of several strains that vary in size, body conformation and colour. It is believed to be a mixture of the Sudani, Egyptian, Libyan and Tunisian camels (WARDEH, 1989*a*; WILSON, 1984).

The Maghrebi camel is medium in size with small but pointed hump. Besides pack use, the Maghrebi camel is used for all kinds of agricultural, industrial and draft purposes. A number of types are locally developed to serve certain functions. The Maghrebi camel generally responds to feeding and might gain about 700-1,000 grams per day during the first year and under intensive conditions.

Aririt. It is found in the vast western plateau of the Red Sea hills of Aulib in Sudan. Their main advantage is their endurance as transport animals, they can cover long distances at a steady pace without water. The Aririt are also fair milk producers. Well kept animals give 2.5-5 kg milk at the midday and evening milking, and 3.5-5 kg in the morning (HJORT and DAHL, 1991). The volume of milk production depends heavily on the quality of pasture.

Al Majaheem. They are found in Najd and Al Dawaser valley in North and North East Saudi Arabia. They are big, rigid and black in colour. They are known to be good dairy animals under range conditions. However, they respond to better feeding and management practices where they produce an average of 3,550 kg of consumable milk annually (AL-MOTAIRY and HASHIMI, 1988). Al Majaheem are also fast growing camels. The average birth weight is 42 kg. They reach 300 kg at 1 year of age and about 750 kg when 5 years old (WARDEH, 1989*a*).

Lourak. They are found in most parts in Arabia, but there are two distinctive breed types within this group of camels that breed alike:

❒ *Al Maghateer* (Al Wadh or Al Beedh). They are found mainly in North Saudi Arabia but they could be found in Syria, Iraq, Jordan and Kuwait. They are medium to large animals and have pure white colour (WARDEH, 1989*a*). Al Maghateer are known to be good dairy camels and people liked them and have been proud of owing them through history. They produce about 3,500 kg of consumable milk per year. They vary much in milk production within the group (AL-MOTAIRY and HASHIMI, 1988). Al Maghateer camels grow well under natural range conditions and fast under improved feeding and management practices. Average birth weight is 40 kg. They reach 250 kg at one year of age and about 550 kg at maturity.

❒ *Al Homr*. They are red coloured camels found in many parts of Saudi Arabia and maintain their red colour when bred together or with other breed types. Al Homr are fair milking animals. They produce about 2,650 kg of consumable milk per year. Some individuals produced 3,592 kg a year under improved conditions (AL-MOTAIRY and HASHIMI, 1988). The average birth weight is 37 kg. They reach about 220 kg at 1 year of age and about 420 kg at maturity. They are also used as riding and pack animals.

Al-Shameya. It is found in the Syrian steppe, north of Jordan, north of Saudi Arabia and west of Iraq. These camels are characterized by fast growth and fair milk production. The average mature weight reaches 660-780 kg for males and 570-680 kg for females (ACSAD, 1983*b*; WARDEH, 1989*a*). Average milk production ranges from 2,550 to 5,400 kg in 300 days (ACSAD, 1983*a*).

Al-Khawar. They are found in northern steppes of Syria and western steppes of Iraq. The average mature weights reaches about 665 kg in males and 540 kg in females

(ACSAD, 1983*a*). Average milk production ranges from 1,800 kg to 2,000 kg in 15 to 18 months.

Meat camels

Meat camels are those breeds or breed characterized by the development of the hind quarters, large hump, rigid body, relatively short neck and large head, and heavy bones and muscles (WARDEH *et al*., 1991; WILSON, 1984).

Race camels

Race camels are characterized by their small heads and ears, alert eyes, fine and supple neck that is joined low down to the trunk, long and fine shoulders, very deep chest with well sprung ribs right to the back and terminating not far from pelvic bone, straight and fairly close forelegs, straight and well spaced hindlegs, well muscled quarters, medium feet, fine and supple skin, and easy and tireless pace. Race camels are also used in the police force in many countries (WARDEH, 1989*a*; WILSON, 1984).

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Dromedaries and camels, milking animals.
Actes du colloque, 24-26 octobre 1994,
Nouakchott, Mauritanie.
Montpellier, France, Cirad, 304 p. + X p. hors texte.
(collection Colloques)

Production and characterization of reference preparations for pituitary hormones from the dromedary (*Camelus dromedarius*): camLH, camFSH, camGH and camPRL and setting-up of homologous immunoassays (RIA and ELISA) for camPRL

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Abstract. The present paper reports on the purification and characterization of batches of camLH, camFSH, camGH and camPRL that were used as reference preparations and that are made available to all interested researchers. In addition, the authors have set up homologous ELISA and RIA for camPRL that should be valuable in the study of hormonal regulation of lactation in the dromedary as well as in the study of the possible role of PRL in the regulation of its hydro-mineral balance under dehydration conditions.

Key words. Dromedary, *Camelus dromedarius*, hormone, pituitary gland, immunology, ELISA, lactation, reproduction.

Résumé. Dans cet article sont présentées la purification et la caractérisation de lots d'hormones camLH, camFSH, camGH et camPRL qui ont été utilisés comme préparations de référence et qui sont mis à la disposition de tous les chercheurs intéressés. De plus, ont été mis au point des dosages ELISA et RIA homologues de la camPRL qui devraient être très précieux pour l'étude des régulations hormonales de la lactation chez le dromadaire ainsi que dans l'étude du rôle possible de la prolactine dans la régulation de l'équilibre hydrominéral en conditions de déshydratation.

Mots clés. Dromadaire, *Camelus dromedarius*, hormone, hypophyse, immunologie, test ELISA, lactation, reproduction.

Introduction

The measurement of plasma concentrations of pituitary hormones in the dromedary is performed in most laboratories with heterologous assay systems. Antibodies raised against LH, FSH, GH or PRL from other mammalian species together with radio-iodinated hormone also of non-cameline origin are successfully used. Nevertheless, although these systems allow determination of hormone profiles they do not permit absolute estimations of hormone concentrations and preclude lab-to-lab comparisons.

In order to circumvent this difficulty, the authors have decided to prepare and characterize batches of Luteinizing Hormone (camLH), Follicle-Stimulating Hormone (camFSH), Growth Hormone (camGH) and Prolactin (camPRL) that would be made available to all researchers in the field.

The authors have previously published the purification procedures for camLH (ANOUASSI *et al.*, 1987), camGH (MARTINAT *et al.*, 1990*b*) and camPRL (MARTINAT *et al.*, 1990*a*) which were used in the present work to obtain the highly-purified preparations. The camFSH preparation described here is only partly purified but is mostly devoid of LH activity and totally free of GH and PRL activities.

CamLH

For the purification of camLH, the authors used the method previously reported by their laboratory

(Anouassi *et al.*, 1987). They obtained a LH preparation that was found to be even more active (1.6 x) than the camLH A46 in the specific camLH ELISA set up in their laboratory (Anouassi and Combarnous, 1991). This preparation has been conditioned in ampoules of 50 µg together with 120 mg mannitol and was coded as camLH NZY 01 (NZY stands for Nouzilly) (see appendix 1).

This preparation can be used as a standard in radio-immunoassays (RIA), radio-receptor assays (RRA), *in vitro* culture assays as well as *in vivo* LH bioassays. Its purity also permits its radio-iodination and its use as a tracer in RIA and RRA.

CamFSH

In contrast to camLH, highly purified camFSH has not been obtained in large quantities. For this reason, the authors have chosen to propose a partially purified preparation of camFSH as a standard preparation. More than 80-90% of the LH activity is separated from FSH activity by fractionated precipitation with ammonium sulfate. However, there is 5-10 times more LH than FSH in camel pituitaries and even when only 10% of total LH is still present in the FSH fraction, the quantity of LH is more or less the same as the quantity of FSH.

In spite of this very important contamination of FSH by LH, the authors think that a partly purified camFSH preparation can be very helpful as a standard preparation in assays which are strictly specific for FSH (such as RRAs and a large number of immunoassays and bioassays). The measurement of FSH activity of this preparation in a specific RRA against a highly purified camFSH shows that it contains approximately 20% pure FSH. This preparation was coded as camFSH NZY 01 and is available as ampoules of 200 µg together with 120 mg mannitol (see appendix 2).

CamGH

The purification of the reference preparation of camel growth hormone (camGH) was achieved using the previously reported protocol set up in the laboratory (Anoussi *et al.*, 1987). Highly purified camGH was obtained which activity was 2.1 x pGH UCB in a RIA specific for porcine GH (Martinat *et al.*, 1990*b*). The pGH UCB is a highly purified porcine growth hormone equipotent with USDA GH B1. Since the camGH preparation is 2-fold more active than a highly purified pGH preparation and cannot be two-fold purer, it is obvious that camGH is more active than pGH itself in the pGH RIA used in the laboratory. Ampoules containing 50 µg highly purified camGH and 120 mg mannitol have been prepared and were coded as camGH NZY 01 (see appendix 3).

CamPRL

Finally, the authors have undertaken the preparation of a reference preparation of prolactin from the dromedary (camPRL) (figure 1).

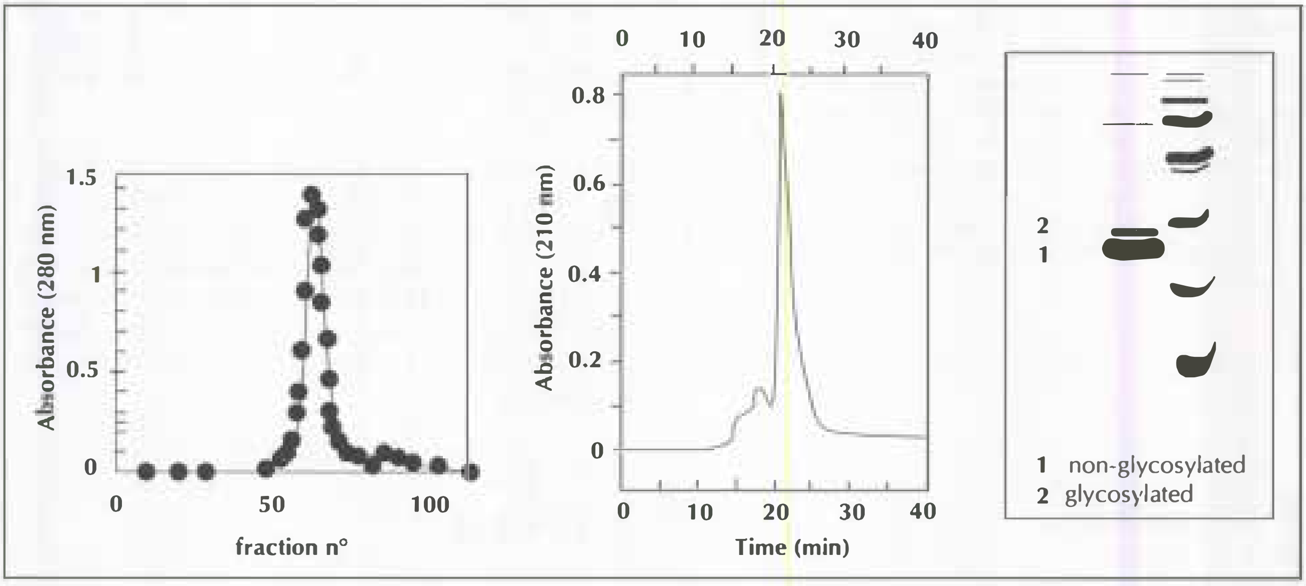

Figure 1. *Physico-chemical characterization of camPRL. Left: final step of purification of camPRL by gel-filtration on Sephacryl S200 column (2.5 x 84 cm). Right: High-performance Capillary Elecrophoresis and SDS-PAGE of highly purified hormone.*

Camel prolactin was purified using a protocol we have previously described (MARTINAT *et al.*, 1990*b*). The biological activity of this preparation was 0.9 pPRL NIH B1 in the Nb2 cell assay. Ampoules containing 50 µg of this preparation together with 120 mg mannitol were conditionned and coded as camPRL NZY 01 (see appendix 4).

The determination of camPRL concentrations using the *in vitro* bioassay in cultures of Nb2 cells is extremely difficult because it is very time and effort consuming and mainly because serum proteins affect the final response. It was therefore compulsory to set up an assay without these drawbacks. With this objective in mind, the authors developed three different immunoassays (RIA and competition and sandwich ELISAs) specific for camPRL. The specific antibody was raised by immunizing with the highly purified camPRL described above.

Radioimmunoassay (RIA) (figure 2). The standard and unknown samples were preincubated with the antiserum for 3 days at 4°C in 3-ml tubes before the radio-iodinated ^{125}IcamPRL was added. Incubation was then continued for 16 hours at room temperature. After immunoprecipitation of bound hormone with goat anti-rabbit IgGs serum, the radioactivity of the pellets was measured. The detection limit for camPRL in this RIA was 0.8 ng.ml^{-1} and camGH cross-reacted only 1% whereas no cross-reactivity was detectable for camFSH and camLH.

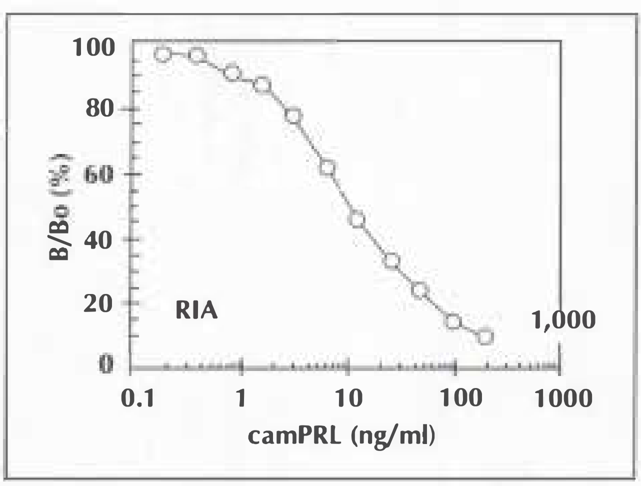

Figure 2. *Radioimmunoassay of camel prolactin.*

Competitive ELISA. 96-well microtitre plates were coated with camPRL and saturated with bovine serum albumin. The samples and antiserum were incubated overnight at room temperature. Aliquots of this medium were then transferred to the wells and incubated for three hours at room temperature. After washing the bound anti-camPRL IgGs were reacted with sheep anti-rabbit-IgGs conjugated to horseradish peroxidase, and detected at 492 nm after the reaction with O-phtaleine-diamine. This assay was found to be highly specific but exhibited a detection limit of 40 ng.ml^{-1} which is far too high for the measurement of PRL in dromedary plasma.

Sandwich ELISA (figure 3). Anti-camPRL IgGs were purified on DEAE-Trisacryl (IBF, France) and an aliquot of it was conjugated to horseradish peroxidase with glutaraldehyde. The wells were coated with anti-camPRL IgGs and the samples were incubated in the wells after saturation and washing. After the washings, anti-camPRL IgGs conjugated to horseradish peroxidase were added and incubated and the amount of bound peroxidase was determined using OPD as the substrate. This sandwich ELISA of camPRL is highly specific (camGH crossreactivity is less than 1% and those of camLH and camFSH are undetectable). The detection limit for camPRL is 0.8 ng.ml^{-1}, which is largelly better than that of the competitive ELISA and similar to that of the RIA.

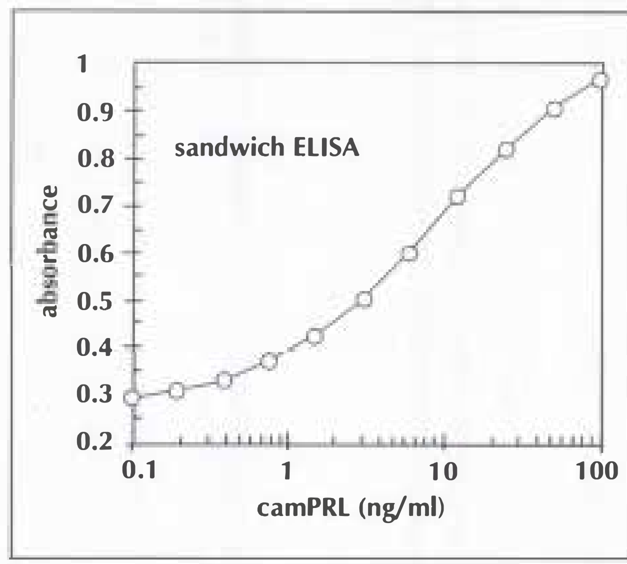

Figure 3. *Sandwich ELISA of camel prolactin.*

Discussion

The availability of pituitary hormone reference preparations from the dromedary should be of great interest for further endocrine studies in this very important species in arid areas. With these preparations, lab-to-lab comparisons will be possible between the measurements of these hormones using similar or different assay systems.

Concerning camPRL, which is of utmost importance for the study of lactation in this species, three different immunoassays are described among which two can be readily used for the measurement of PRL concentrations in plasma.

Prolactin is known not only to play a crucial role in the regulation of lactation and reproductive function but also in the hydro-mineral balance of vertebrates. The unique resistance of the dromedary to arid conditions makes it an interesting model for the study of the role of PRL in this function and possibly to point out relationships between lactation and hydro-mineral balance. The hormone preparations and assays described in the present paper should be of great help in these studies and will be made available to interested researchers.

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Appendix 1

CAMEL LUTEINIZING HORMONE *(document reproduced after authorization; available at Cirad-emvt, Montpellier, France).*

Camel Luteinizing Hormone

CamLH NZY 01

Highly purified. 1.6 x CamLH A46[1] (ELISA[2])

50 µg /vial
excipient: 120 mg mannitol /vial

iodination grade for radioimmunoassays (RIA) and radioreceptor assays (RRA)
Standard for RIA, RRA, and *in vitro* and *in vivo* bioassays

For use as "cold standard" for displacement curves, reconstitute the content of one ampoule with 1ml assay buffer.
Aliquots of this solution (50µg/ml) can be frozen and stored at -20°C until use. After thawing do not freeze again.

Keep vials at 4°C in dessicator

[1]Anouassi *et al* *Biochimie* (1987) 69, 647-654
[2]Anouassi and Combarnous *J. Reprod. Fertil.* (1991) 409-414

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Appendix 2

Camel follicle-stimulating hormone *(document reproduced after authorization; available at Cirad-emvt, Montpellier, France).*

Camel Follicle-Stimulating Hormone

CamFSH NZY 01

Partially purified.

200 µg /vial
excipient: 120 mg mannitol /vial

Standard for RIA, RRA, and *in vitro* and *in vivo* bioassays

For use as "cold standard" for displacement curves, reconstitute the content of one ampoule with 1ml assay buffer.

Aliquots of this solution (200µg/ml) can be frozen and stored at -20°C until use. After thawing do not freeze again.

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Appendix 3

CAMEL GROWTH HORMONE *(document reproduced after authorization; available at Cirad-emvt, Montpellier, France).*

critt ISIS

Camel Growth Hormone

CamGH NZY 01

Highly purified. 2.1 x porcine GH UCB[1] (RIA pGH)

50 µg /vial
excipient: 120 mg mannitol /vial

iodination grade for radioimmunoassays (RIA) and radioreceptor assays (RRA)
Standard for RIA, RRA, and *in vitro* and *in vivo* bioassays

For use as "cold standard" for displacement curves, reconstitute the content of one ampoule with 1ml assay buffer.
Aliquots of this solution (50µg/ml) can be frozen and stored at -20°C until use. After thawing do not freeze again.

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[1] Martinat et al (1990) *Domestic Animal Endocrinology* 7, 527-536

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Appendix 4

CAMEL PROLACTIN (*document reproduced after authorization; available at Cirad-emvt, Montpellier, France*).

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Camel PROLACTIN

CamPRL NZY 01

Highly purified. 0.9 x porcine PRL B1 [1] (Nb2 cell assay)

50 µg /vial
excipient: 120 mg mannitol /vial

iodination grade for radioimmunoassays (RIA) and radioreceptor assays (RRA)
Standard for RIA, RRA, and *in vitro* and *in vivo* bioassays

For use as "cold standard" for displacement curves, reconstitute the content of one ampoule with 1ml assay buffer.
Aliquots of this solution (50µg/ml) can be frozen and stored at -20°C until use. After thawing do not freeze again.

Keep vials at 4°C in dessicator

[1] Martinat et al (1990) *Comparative Biochemistry Physiology* 97, 67-674

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Milk production of Somali and Turkana type dromedaries under semiarid conditions in Kenya

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Abstract. Somali and Turkana are the most common types of dromedaries kept in northern Kenya, in nomadic herding systems as well as on commercial ranches. Besides for work or transport purposes, dromedaries are mainly kept for milk production in either production system. Determination of milk production performance requires long term data monitoring, and these data are rarely available for extensive production systems. On Ol Maisor Ranch in Laikipia District of Kenya, performance records of 500 dromedaries kept under extensive management are available for the past 8 years. This study uses these long term data to estimate the possible milk offtake of Somali and Turkana type dromedaries and their crossbreeds under extensive ranch conditions. Possible daily and annual milk offtake per animal is given for the respective dromedary types and related to parity and precipitation during lactation period. Milk offtake from dromedaries is compared to milk offtake from Boran cattle kept under the same management. The special importance of dromedaries for livestock production systems in semiarid environment is due to their capability to maintain the lactation during the dry season and even to a certain extent under drought conditions whereas lactation of cattle ceases under these conditions.

Key words. Dromedary, *Camelus dromedarius,* milk production, pastoralism, semiarid climate, Kenya.

Résumé. Les dromadaires de race Somali et Turkana sont les plus couramment élevés dans le nord du Kenya, à la fois dans le cadre de l'élevage pastoral traditionnel et en ranchs commerciaux. En plus de leur activité de transport, les dromadaires sont élevés principalement, et dans les deux types de cadre, pour la production laitière. La détermination et l'analyse de leurs performances laitières, qui sont rarement disponibles en élevage extensif, demandent des suivis à long terme. Cette étude tire parti des données recueillies depuis huit ans sur 500 dromadaires du ranch commercial d'Ol Maisor, dans le district kenyan du Laikipia. Les rendements laitiers des deux races camelines utilisées sont estimés dans leurs systèmes extensifs respectifs. Les productions laitières annuelle et quotidienne ont été estimées en relation avec la parité, la race, et la pluviométrie au cours des périodes successives de lactation, ainsi que comparées aux rendements des bovins Boran élevés dans les mêmes conditions. Il est rappelé que l'adaptation particulière des dromadaires aux zones semi-arides permet à cette espèce seulement, de fournir du lait en saison sèche, et même pendant certaines sécheresses.

Mots clés. Dromadaire, *Camelus dromedarius,* production laitière, pastoralisme, climat semi-aride, Kenya.

Introduction

Dromedaries are kept in arid and semiarid areas of northern Kenya, where rainfall is low and unevenly distributed and evaporation is high. Therefore, pasture vegetation is sparse and its availability varies throughout the year. To these conditions the dromedary is adapted by a number of anatomical, physiological and behavioural peculiarities. However, when fodder and water are available milk yields of dromedaries are said to be lower than those of cattle, but dromedaries seem to yield higher quantities when it comes to dry spells and drought conditions (EVANS and POWYS, 1984; SPENCER, 1973; STILES, 1983; STILES, 1984). Pastoral peoples keeping dromedaries in Kenya are the Somali, Borana, Gabbra, Rendille, Turkana and recently also the Samburu and Pokot. The Somali, Gabbra, Rendille and Turkana are the most common types of dromedaries in this region. Ethnological studies revealed that dromedary husbandry was not always common amongst these ethnic groups but was adopted in exchange for cattle keeping as environmental conditions deteriorated (STILES, 1983; STILES, 1984). During the past two decades, dromedary husbandry has also been introduced to a number of commercial ranches in Kenya in order to increase productivity of ranchland. Here, dromedaries are used for milk production, transport and working purposes (EVANS and POWYS, 1984).

Since long-term data collection and performance recording is difficult in pastoral systems, little comprehensive information is available on milk production of extensively managed dromedaries.

Based on records available since 1986 on Ol Maisor Ranch the present study aims at characterising milk offtake achieved for Somali and Turkana type dromedaries and their crosses, when they are kept under extensive ranch conditions.

State of knowledge

A comprehensive overview on milk production, both for dromedaries and Bactrian camels, is given by SIMPKIN (1985), reviewing literature from the Former Soviet Union, China, Pakistan, India, Israel, North Africa, Ethiopia, Somalia and Kenya, dated from 1927 to 1982. This review reveals a wide range of average daily milk yields, lactation lengths, lactation yields and annual milk yields (table I).

Table I. Milk production data ranges as given in a literature review by SIMPKIN (1985).

Main daily yield (kg/day)	**Total lactation yield** (kg)	**Lactation length** (months)	**Yield per 365 days** (kg)
0.1-13.6	945-8,190	7-27	913-4,125

KNOESS (1984) reported an exceptional situation where Pakistan camels under good conditions yielded 15-35 kg of milk per day and 5,475-12,775 kg total yield in a 12 month lactation. More recently, KNOESS *et al.* (1986) observed daily yields of 10.4 kg to 26.3 kg (average 18 kg) in Pakistan camels, including the milk suckled by the calf.

Studies referring to Kenya report average daily yields of 2.2-4.5 kg and lactation yields of 1,019-1,897 kg for a lactation period of 10-24 months (BREMAUD 1969; DAHL and HJORT, 1976; FIELD, 1979; FIELD, 1984; HARTLEY, 1984; SPENCER, 1973; TORRY, 1973). SIMPKIN (1985) found average daily yields of 2.83-5.33 litres per dromedary when kept on commercial ranches and 3.1 litres and 2.2 litres for nomadic herds with and without veterinary treatment. This results in an annual production of 1,033-1,945 litres, 1,139 litres and 799 litres for the respective groups.

If a study reports total milk, it is difficult to estimate which amount of that can be used for human consumption. It should therefore be distinguished between possible milk offtake for human consumption and total milk yield which includes the amount of milk suckled by the calf. However, it is difficult to measure milk yield or potential yield under extensive conditions where the calf is with its mother most of the time since the amount of milk suckled by the calf cannot be determined exactly (HERREN, 1990). In southern Somalia, milk offtake as reported by Somali herdsmen was recorded and average daily offtake ranged from 1.2 litre per animal to 5.2 litres for average milkers and up to 9.1 litres for exceptional milkers when they were with their calves. For animals whose calves had been slaughtered immediately after parturition in order to increase possible milk offtake from the dam, 9.4 litres and 12.2 litres were reported for average milkers and exceptional milkers at the peak of the rainy season. Lactation length averaged 15 months and the overall annual possible offtake per female was estimated at 600 to 700 litres (HERREN, 1990). Calf mortality has also to be taken into account when studying milk yield under nomadic conditions since milk offtake may well be increased by milking animals two or three times a day, but this probably adversely affects growth, health and survival of the calves. In the light of a generally low reproductive performance of dromedaries under extensive conditions, calf survival becomes even more important, since from a certain mortality threshold onward replacement of breeding stock will not be possible due to a lack of heifers. The same reason restrains selection for milk production because virtually all female offspring has to be used to replace the breeding stock (SCHWARTZ and WALSH, 1992).

Material and Methods

Production data recorded from 1986 to 1994 for a dromedary herd kept on commercial Ol Maisor Ranch in Kenya (ATKINS, 1987) were used in the present study to characterise milk offtake.

Ol Maisor Ranch covers an area of 29,714 acres (approximately 12,000 ha) and is situated in Kenya at 00°25′ N and 36°39′ E at an altitude ranging from 1,767-1,889 m.a.s.l. Annual rainfall averages 600 mm but shows wide variation (range 180-1,240 mm). Monthly rainfall distribution is given in figure 1.

Average daily maximum and minimum temperatures for the area are 24°C and 8°C respectively. The pasture

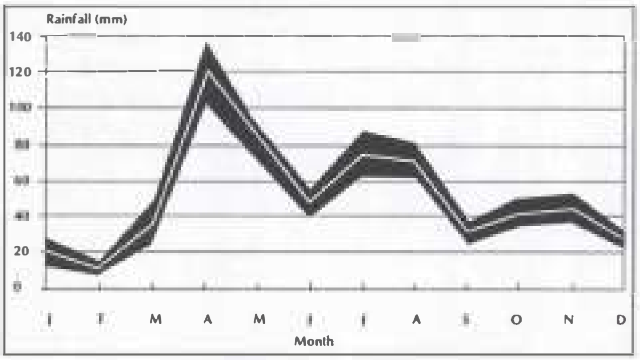

Figure 1. Monthly rainfall distribution on Ol Maisor Ranch for 1986 to 1993 (mean ± S.E. mean).

is a grass dominated thornbush savannah of the *Acacia-Themeda* type (PRATT *et al.*, 1962) and offers *Themeda, Cynodon, Hyparrhenia, Setaria*, and *Sporobulus* as grass species. *Acacia, Boscia, Balanites, Euclea, Grewia* and *Rhus* are the most common bush and tree species.

Five hundred dromedaries (approximately 170 breeding females), 3,000 heads of Boran cattle (approximately 850 breeding females), 3,000 sheep and goats are kept permanently on the ranch. This results in a stocking rate of approximately 5 ha per livestock unit (LU)[1], whereby dromedaries are not considered in the calculation of stocking rate since their selection for herbaceous and browse plants differs markedly from that of the other domestic livestock (ENGELHARDT *et al.*, 1992; EVANS and POWYS, 1984). All animals are kept in a "*boma*" or "*manyatta*" system, i.e. the animals gather at night in a thornbush enclosure (*boma*) and are grazing during daytime, herded by a ranch employee. The animals go out on pasture at about 7:00 a.m. and return to the *boma* at about 6:00 p.m. The dromedary and cattle calves are separated from their mothers during 10 hours at night and the dams are milked in the morning around 6:30 a.m. The calves are used to stimulate the milk letdown of their mothers and then pushed away while the dam is milked. After milking, the calves stay with their mothers during the day. While cattle milk is sold, dromedary's milk is used for home consumption by the ranch personnel and their families (EVANS and POWYS, 1984).

Since 1986 records on breed, parentage and date of birth, date of calving, date of weaning, of offspring, sex of calf, calf mortality and probable causes are kept for dromedaries on Ol Maisor Ranch. In addition, monthly records are kept on weight and weekly records are kept on milk production (ATKINS, 1987). For every lactating dromedary, the amount of milk obtained during one morning milking is measured with a portable scale once a week. From the weekly milk records the average monthly values for the amount of morning milk were calculated in the present study. These figures were then extrapolated to estimate the possible annual offtake of milk per lactating camel when milking once a day. Only lactations with more than 7 months of observation were included, leading to a sample size of 186 lactations from 140 animals with a total of 1,841 monthly observations. Fifty three animals were Somali type dromedaries, 44 were Turkana type and 43 were Somali x Turkana crossbreeds (SxT cross).

As factors influencing the possible annual milk offtake, breed, parity, and rainfall during the first 6 months as well as during 12 months of lactation were considered. Comparison of means and analysis of variance were carried out using the statistical software package SPSS.

The Ranch records on monthly milk sales for the Boran cattle herd[2] were used to compare the possible milk offtake from cattle and dromedaries herds under the same environmental conditions.

Results

The mean daily milk yield per animal and the possible annual milk offtake per animal for Somali, Turkana and SxT crossbred dromedaries is presented in table II. For Somali type dromedaries a milk offtake profile is shown in figure 2.

Results of the analysis of variance for possible annual milk offtake using the above factors are given in table III.

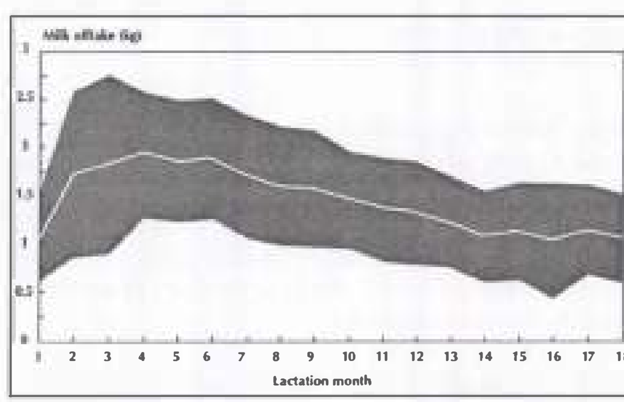

Figure 2. Average daily offtake profile for Somali type dromedaries during lactation from 1st to 18th lactation month (mean and st. dev.).

1. LU equals a mature breeding female cattle; cattle aged 1-3 years = 0.6 LU, cattle youngstock below 1 year = 0.3 LU, sheep and goats = 0.1 LU.

2. The authors like to thank John and Amanda Perret for making available the milk sale records.

	Somali	Turkana	SxT cross	All
Overall daily mean	1.48 0.44 (72)**	1.17 0.39 (63)	1.17 0.38 (51)	1.28 0.43 (186)
12 months daily mean*	1.56 0.49 (72)	1.21 0.39 (63)	1.14 0.37 (51)	1.34 0.46 (186)
Calc. yearly offtake	541	427	416	468

* Average daily milk offtake during the first 12 months of lactation.
**Values in brackets indicate number of lactations observed.

Table II. Daily milk offtake (kg) (mean ± st. dev.) from Somali, Turkana and SxT crossbred dromedaries on Ol Maisor Ranch (1986-1994).

Table III. Analysis of variance results for yearly milk offtake from dromedaries using factors breed, parity and rainfall following parturition.

Factor	Value	n**	Milk offtake (kg) (mean ± st. dev.)	
Breed	Somali	72	542	159
	Turkana	63	428	142
	SxT cross	51	416	134
Parity	1	58	412	151
	2	53	521	147
	3	37	520	146
	4	22	459	123
	5	12	423	209
	6	4	322	82
Rainfall 6 months*	200	39	473	156
	201-400	117	464	161
	401-600	20	456	137
	601-800	6	614	122
	> 800	4	395	110
Rainfall 12 months*	500	39	424	163
	501-700	96	463	155
	701-900	16	522	153
	> 900	35	508	145

* Cumulated rainfall for the period of 6 and 12 months respectively, following onset of lactation.
** n: number of lactations observed.

While breed and parity show a significant impact on possible milk offtake ($P \leq 0.001$), rainfall during 6 and 12 months following onset of lactation did not affect milk offtake significantly ($P > 0.05$). In figure 3 breed and parity were cross-tabulated and average milk yield, standard error of mean and sample size are given for the different combinations.

Milk yield obtained from Somali and SxT crossbred dromedaries is affected by parity, the yield for the second lactation being about 120 kg higher than for the first lactation (i.e. 27% and 31% in Somali and SxT crosses respectively). In Turkana type animals milk yields between subsequent parities did not differ much.

Data on monthly milk sales from the Boran cattle herd, representing the milk offtake from a herd of about 850 breeding females (1 milking per day) were compared to monthly milk offtake from the dromedary herd (170 breeding females, 1 milking per day) and plotted against the monthly rainfall in figure 4. The monthly milk offtake is given in relation to the average monthly milk offtake for dromedaries and cattle respectively, the average ratio being set as index “1”. The impact of rainfall on milk offtake was significant for the cattle ($P < 0,05$) but not significant for the dromedaries ($P > 0,05$).

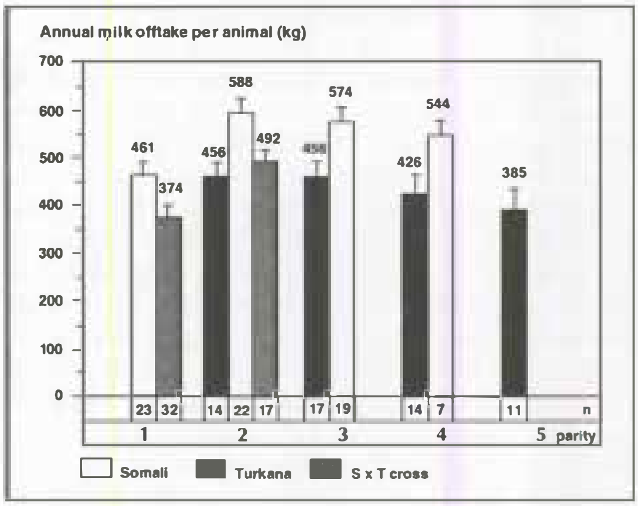

Figure 3. Annual milk offtake from Somali, Turkana and SxT crossbred dromedaries in relation to breed and parity (means and S.E. mean).

Discussion

The values obtained in the present study are well in accordance with those reported by Simpkin (1985) when doubled in order to make up for the difference between milking once and twice a day. Calculated milk offtake in the present study gives an indication of the dairy performance of the respective animals (i.e. the amount of milk the owner can get from the dromedary by milking once a day). However, the actual dairy potential of the animals cannot be estimated from the amount milked once a day. To get a realistic figure for dairy potential, milking frequency would probably have to be adjusted to the suckling frequency of the calf, because the dromedary does not have udder cistern and thus lower milk storage capacity in the udder. Frequent milking reduces milk pressure on the alveolar cell walls in the udder secretory tissue, which is a crucial

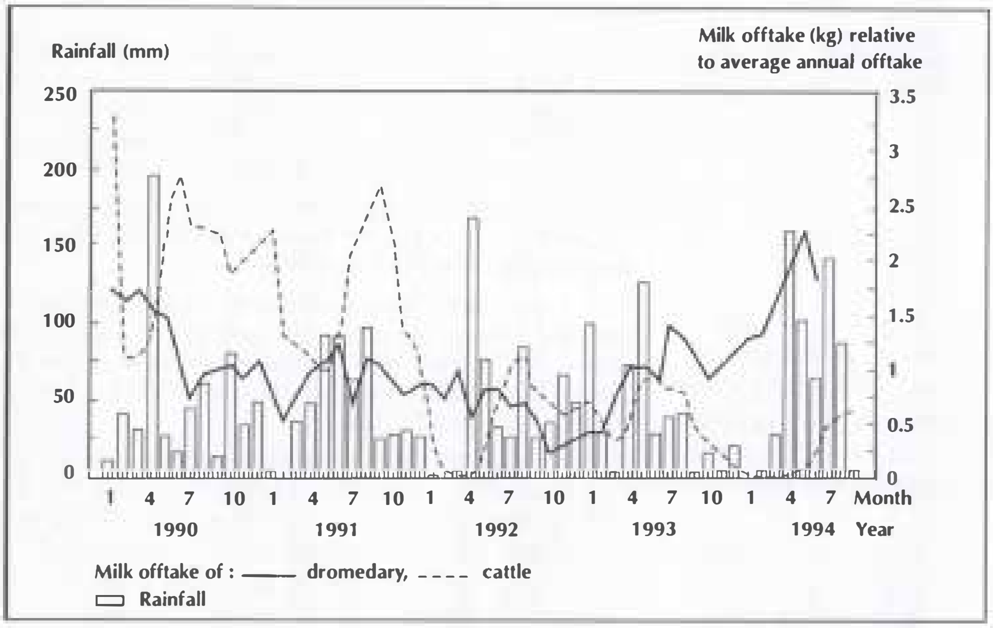

Figure 4. *Standardized milk offtake of cattle and dromedaries on Ol Maisor Ranch in relation to rainfall during the period of 1990 to 1994.*

factor for milk secretion in cattle and probably also for the dromedary. Long intervals between milking thus reduce milk secretion and hence milk yield. In addition, as dromedaries are not selected for good milk letdown the actual amount gained by milking depends a lot on the temperament of the animal, especially in the period immediately after calving, when dams frequently refuse to be milked.

Nevertheless, milk offtake can be used to assess the level of performance of the animals under study. When the same milking management is applied, values obtained can be used to compare different breeds or to determine factors which influence the performance level. In the present study milk offtake from Somali dromedaries exceeded milk offtake from Turkana dromedaries significantly by 27% on average. The offtake from SxT crossbred animals was significantly lower than that of the Somali and tended to be higher than that from the Turkana animals. This supports the general opinion that the Somali dromedary is a better milker whereas the Turkana dromedary is considered to be more robust and hardy under extreme conditions. This is probably due to the smaller body size and thus the lower maintenance energy requirement of Turkana dromedaries. However more detailed studies are required to elucidate this topic.

In dromedaries milk offtake at different parities resembles the pattern of milk yields in cattle. Heifers at first calving must be expected to produce less than females of higher parity. Milk yield seems to decrease again from the third lactation onwards. However, the difference between parities are less obvious in Turkana type animals.

Under extreme climatic conditions the reproduction of dromedaries is seasonal (i.e. parturition takes place during the rainy season to ensure adequate nutrition of the calf). In addition, due to its special adaptation to drought conditions the dromedary is said to maintain lactation longer during drought than other domestic livestock species. For dromedaries in Israel YAGIL and ETZION (1980) found no decrease in milk yields during the dry season, whereas camel herders from Somalia reported generally lower milk yields and offtake for all livestock species—including the dromedary—during the dry season when compared to the wet season. Drastic declines of milk offtake were reported during periods of drought (HASHI, 1988; HERREN, 1990). However, during long droughts lactation ceased to a much higher proportion in cattle and goats (52% and 75% respectively) than it did in camels (22%) and yields of those animals who were still lactating were reported to be higher than in cattle and goats. During short periods of drought, camels and goats were equally able to maintain lactation whereas yields decreased already markedly in cattle (HASHI, 1988). Among dromedary pastoralists in Kenya the percentage of dromedary's milk consumed by the household was close to 100% of overall milk consumption in dry season and droughts, whereas it was below 20% in the wet season. However, no absolute figures on milk consumption were given (SCHWARTZ, 1986). Mostly lactation cease during drought leads to the loss of the offspring, which heavily affects the production system. In the present study, rainfall during the 6 and 12 months period following onset of lactation did not affect possible milk offtake significantly, although the cumulative rainfall varied from 90 to 800 mm and 300 to 1,000 mm for the 6 and 12 months periods. However, a tendency can be observed that annual milk offtake increases with increasing 12 months cumulated rainfall following parturition. This indicates that camel's milk production is little affected by seasonal variations in biomass availability. This is not the case for cattle, where milk offtake is significantly affected by the rainfall and lactation often ceases completely during drought periods.

Conclusions

In studies dealing with extensive production systems emphasis should be put on the estimation and improvement of performance under the prevailing conditions and not on hypothetical potentials which can only be converted into offtake with high level of input.

Milk offtake from Somali type dromedaries is significantly higher than that from Turkana type dromedaries under the same conditions, giving room for genetic improvement.

Milk offtake from dromedaries is little affected by rainfall and hence pasture biomass availability, whereas in cattle it is heavily affected.

Milk offtake from cattle on a semiarid thornbush savannah in Kenya is higher than from dromedaries in times of pasture and water availability but the risk of production under given unreliable climatic conditions is very high.

The stability of production and the ability to maintain lactation during drought makes the dromedary a most important animal, both for the nomadic herder and for sedentary livestock producers in semiarid areas.

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Thème B/*Topic B*

Composition du lait/*Milk composition*

Caractéristiques du lait/ *Milk characterics and qualities*

Technologie laitière/*Dairy technology*

Produits laitiers/*Dairy products*

Président/*Chairman:* Z. FARAH

Animateur/*Facilitator:* ZIA-UR-RAHMAN

BONNET P. (éditeur), 1998.
Dromadaires et chameaux, animaux laitiers / *Dromedaries and camels, milking animals.*
Actes du colloque, 24-26 octobre 1994, Nouakchott, Mauritanie.
Montpellier, France, Cirad, 304 p. + X p. hors texte.
(collection Colloques)

Composition minérale du lait de chamelle du Sud marocain

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Résumé. Afin d'étudier la composition minérale du lait chez la chamelle en relation avec les concentrations plasmatiques et les apports alimentaires en minéraux, des prélèvements ont été réalisés sur trente chamelles allaitantes au premier mois de lactation à Laâyoune (Sud marocain). Ces animaux sont conduits selon le système nomade. Le sodium, le potassium, le calcium, le magnésium, le fer, le cuivre, le zinc et le manganèse ont été dosés par spectrophotométrie d'absorption atomique, le phosphore et l'iode par colorimétrie. Les teneurs du lait ont été de 6,95 ± 0,27 % pour les matières sèches, 902 ± 91 mg/l pour le sodium, 2 110 ± 294 mg/l pour le potassium, 1 462 ± 248 mg/l pour le calcium, 784 ± 103 mg/l pour le phosphore, 108 ± 13 mg/l pour le magnésium, 3 410 ± 745 µg/l pour le fer, 113 ± 49 µg/l pour le cuivre, 2 870 ± 814 µg/l pour le zinc, 1 930 ± 123 µg/l pour le manganèse et 98 ± 21 µg/l pour l'iode. Les corrélations entre la composition minérale du lait, les concentrations plasmatiques et les apports alimentaires en minéraux ont été étudiées. Les résultats sont discutés et comparés à ceux décrits dans la bibliographie chez le dromadaire et les autres ruminants domestiques.

Mots clés. Dromadaire, *Camelus dromedarius*, lait, minéraux, plasma sanguin, nutrition animale, Maroc.

Abstract. To study the mineral composition of camel's milk and its relation to the plasma and food intake mineral contents, samples were taken from thirty lactating she-camels at the first month of lactation in Laâyoune (South of Morocco). The animals were on a nomadic way of life feeding essentially on pasture. Sodium, potassium, calcium, magnesium, iron, copper, zinc and manganese levels were measured by atomic absorption spectroscopy, and phosphorus and iodine by colorimetry. Milk content was 6.95 ± 0.27% for dry matter, 902 ± 91 mg/l for sodium, 2,110 ± 294 mg/l for potassium, 1,462 ± 248 mg/l for calcium, 784 ± 103 mg/l for phosphorus, 108 ± 13 mg/l for magnesium, 3,410 ± 745 µg/l for iron, 113 ± 49 µg/l for copper, 2,870 ± 814 µg/l for zinc, 1,930 ± 123 µg/l for manganese and 98 ± 21 µg/l for iodine. Relationship between milk composition, plasma mineral concentrations and the level of minerals in food intake were studied. Results were discussed and compared to the available data in camel and other domestic ruminants.

Key words. Dromedary, *Camelus dromedarius*, milk, minerals, blood plasma, animal nutrition, Morocco.

Introduction

Les minéraux sont présents en quantités variables dans les organismes vivants, où ils interviennent dans divers processus métaboliques. Ils sont indispensables à la vie des animaux au même titre que l'énergie et les matières azotées. Or, le lait de chamelle constitue la principale ressource alimentaire pour les éleveurs de dromadaires au Sahara. Le métabolisme minéral est très peu étudié chez le dromadaire et les données sur les valeurs usuelles des paramètres minéraux sont très disparates sinon inexistantes. L'objectif du présent travail est d'étudier la composition minérale du lait en relation avec les concentrations plasmatiques des minéraux et leurs apports chez la chamelle conduite selon le système nomade.

Matériels et Méthodes

Animaux

Cette étude a été réalisée sur 30 femelles adultes âgées de 6 à 10 ans en début de lactation (20 à 30 jours). Les animaux appartiennent à la Station de recherches camelines de Laâyoune. Durant la période où les prélèvements ont été réalisés (avril), l'alimentation était basée essentiellement sur le pâturage dans les parcours naturels. Les principaux fourrages consommés pendant cette période sont : *Salsolla foetida, Salsolla tetragona, Anabasis* sp., *Zycophylum gaetulum, Frankeni thymifoli, Launea arborescens* et *Ozyris alba.*

Les animaux sont déparasités deux fois par an ; ils étaient, cliniquement, en bon état de santé au moment des prélèvements.

Prélèvements

Les prélèvements de lait ont été effectués le matin après la traite. Les prélèvements de sang ont été réalisés par ponction de la veine jugulaire dans des tubes en plastique contenant de l'héparine. Les échantillons de plasma et de lait ont été stockés à – 20°C jusqu'à l'analyse.

Cinq échantillons de chacune des principales plantes consommées ont été récoltés et séchés.

Méthodes

Méthodes analytiques

LAIT

Les échantillons de lait destinés au dosage du sodium, potassium, calcium, magnésium et phosphore ont été calcinés au four à 550°C pendant une nuit. Les cendres ont été reprises dans une solution de chlorure de césium pour le dosage du sodium et du potassium, par une solution de lanthane pour le calcium et le magnésium et par une solution d'acide nitrique pour le phosphore (BELLANGER, 1971). Le cuivre, le zinc et le manganèse ont été dosés dans le lait par spectrophotométrie d'absorption atomique après minéralisation par voie humide selon la méthode de BELLANGER (1971). L'iode du lait a été dosé par colorimétrie après calcination dans un four programmable, selon la méthode décrite par AUMONT et TRESSOL (1987).

PLASMA

Le sodium et le potassium plasmatiques ont été dosés par spectrophotométrie d'absorption atomique, après addition d'une solution de chlorure de césium. Le calcium et le magnésium plasmatiques ont été dosés par spectrophotométrie d'absorption atomique à la suite d'une dilution au lanthane. Les phosphates plasmatiques ont été dosés par colorimétrie (Kit Biotrol). L'iode inorganique plasmatique a été dosé par colorimétrie, après passage dans une colonne chromatographique qui permet de retenir l'iode organique (AUMONT et TRESSOL, 1987). Le cuivre, le zinc, le manganèse et le fer ont été dosés dans le plasma par spectrophotométrie d'absorption atomique après précipitation des protéines plasmatiques par le citrate trisodique (BELLANGER et LAMAND, 1975).

FOURRAGES

Après broyage, la minéralisation et le dosage des minéraux dans les plantes, ont été effectués de la même manière que pour le lait.

Méthodes statistiques

Les données ont été soumises à une analyse de la variance à un critère de classification. La corrélation entre les différents paramètres a été évaluée à l'aide de la régression simple.

Résultats

Concentrations plasmatiques en minéraux

Les concentrations plasmatiques des minéraux majeurs sont présentées dans le tableau I et celles des oligo-éléments dans le tableau II.

Tableau I. Concentrations plasmatiques en sodium, potassium, calcium, phosphates et magnésium chez la chamelle au début de la lactation.

Plasma	Na (mmol/l)	K (mmol/l)	Ca (mmol/l)	P (mmol/l)	Mg (mmol/l)
M ± E.T.	153 ± 4	5,1 ± 0,3	2,4 ± 0,1	2,0 ± 0,3	1,1 ± 0,2
Min-Max	144-162	4,6-5,8	2,2-2,6	1,3-2,5	0,7-1,4

Tableau II. Concentrations plasmatiques en fer, cuivre, zinc, manganèse et iode chez la chamelle au début de la lactation.

Plasma	Fe (µmol/l)	Cu (µg/100 ml)	Zn (µg/100 ml)	Mn (µg/100 ml)	I (µg/l)
M ± E.T.	21 ± 6	102 ± 253	34 ± 7	8,4 ± 1,2	82 ± 15
Min-Max	12-29	48-140	24-52	5,9-11,1	50-114

La natrémie varie de 144 à 162 mmol/l, la kaliémie de 4,6 à 5,8 mmol/l, la calcémie de 2,2 à 2,6 mmol/l, la phosphatémie de 1,3 à 2,5 mmol/l et la magnésémie de 0,7 à 1,4 mmol/l.

En ce qui concerne les oligo-éléments, la sidérémie varie de 12 à 29 µmol/l, la cuprémie de 48 à 140 µg/100 ml, la zincémie de 24 à 52 µg/100 ml, la manganésémie de 5,9 à 11,1 µg/100 ml et la concentration plasmatique de l'iode de 50 à 114 µg/l.

Teneurs du lait en minéraux

Les résultats des teneurs du lait en matières sèches et en minéraux figurent dans le tableau III.

La teneur moyenne en matières sèches du lait est de 6,95 ± 0,27 %.

Les concentrations moyennes du lait en minéraux majeurs (mg/l) sont de 902 ± 91 pour le sodium, 2 110 ± 294 pour le potassium, 1 462 ± 248 pour le calcium, 784 ± 103 pour le phosphore, 108 ± 13 pour le magnésium ; elles sont de 3 410 ± 745 µg/l pour le fer.

En ce qui concerne les oligo-éléments, les concentrations sont de 113 ± 49, 2 871 ± 814, 1 930 ± 123 et 980 ± 210 µg/l, respectivement, pour le cuivre, le zinc, le manganèse et l'iode.

Il existe une corrélation significative entre la magnésémie et la teneur du lait en magnésium ($r = 0,67$; $P < 0,05$) et entre la concentration du plasma et du lait en iode ($r = 0,42$; $P < 0,05$).

Composition minérale des plantes

Les teneurs moyennes des plantes en minéraux exprimés en mg/g de matière sèche varient de 1 à 341 pour le sodium, 3,7 à 22,2 pour le potassium, 7,3 à 23,1 pour le calcium, 0,6 à 2,5 pour le magnésium et 0,3 à 2,0 pour le fer.

Les teneurs moyennes des plantes en oligo-éléments (en µg/g de matières sèches) se situent entre 2,5 et 13,2 pour le cuivre, 6,9 et 18,1 pour le zinc, 38,8 et 87,4 pour le manganèse, 3,1 et 6,5 pour l'iode.

Discussion

Chez le dromadaire, les concentrations plasmatiques moyennes obtenues pour le sodium, le potassium, le calcium, les phosphates, le magnésium et le fer sont comprises dans les intervalles des valeurs relevées dans la bibliographie (Bengoumi, 1992). La natrémie est plus élevée que celle rapportée chez les autres animaux domestiques (Kaneko, 1989). En effet, le dromadaire, dans son biotope naturel, s'est adapté au manque d'eau par une augmentation de son électrolytémie et surtout de la natrémie. Ces résultats confirment les observations faites à ce sujet par Yagil *et al.* (1975) et Bengoumi *et al.* (1993). De plus, cette hypernatrémie est liée à l'apport alimentaire en sel, car certaines plantes consommées sont riches en sel avec des teneurs moyennes en sodium qui atteignent 341 mg/g de matière sèche.

La cuprémie moyenne est de 98 µg/100 ml avec des valeurs extrêmes allant de 48 à 140 µg/100 ml. Ces concentrations sont supérieures à celles rapportées par Faye et Grillet (1984) en Ethiopie et Faye *et al.* (1990) à Djibouti. Elles sont proches de celles relevées au Soudan par Tartour (1975), Abudamir *et al.* (1983) et Wahbi *et al.* (1984), en Egypte par Eltohamy *et al.* (1986), en Ethiopie par Faye *et al.* (1986) et aux Emirats Arabes Unis par Abdalla *et al.* (1988). Cette valeur moyenne est supérieure à la limite de carence préconisée pour les bovins (60 µg/100 ml) et des ovins et caprins (80 µg/100 ml). Le taux de valeurs inférieures à (80 µg/100 ml) est relativement faible (9 %). Ces valeurs indiquent que les animaux de la station ne souffrent pas d'une carence en cuivre. En effet, à l'exception d'*Osyris alba*, les principales plantes consommées ont des teneurs en cuivre supérieures à 5 µg/g de matière sèche, limite de carence pour les autres ruminants domestiques.

La zincémie moyenne observée est de 38 µg/100 ml avec des valeurs extrêmes de 24 et 58 µg/100 ml. Ces valeurs sont inférieures à celles rapportées par Faye *et al.* (1990) à Djibouti et par Abdalla *et al.* (1988) aux Emirats Arabes Unis, mais proches de celles trouvées par Faye *et al.* (1986) en Ethiopie. Les valeurs

Tableau III. Teneurs du lait en matières sèches, sodium, potassium, calcium, phosphates, magnésium, fer, cuivre, zinc, manganèse et iode.

Lait	MS (%)	Na (mg/l)	K (mg/l)	Ca (mg/l)	P (mg/l)	Mg (mg/l)
M ± E.T.	6,95 ± 0,27	902 ± 91	2 110 ± 294	1 462 ± 248	784 ± 103	108 ± 13
Min-Max	6,26-7,18	730-1 060	1 690-2 670	1 010-2 070	620-980	90-140
		Fe (µg/l)	Cu (µg/l)	Zn (µg/l)	Mn (µg/l)	I (µg/l)
M ± E.T.		3 410 ± 745	113 ± 49	2 870 ± 814	1 930 ± 123	98 ± 21
Min-Max		2 830-5 560	30-190	1 500-4 560	1 712-2 176	60-135

moyennes sont nettement inférieures à la limite de carence chez les bovins (60 µg/100 ml) et des ovins et des caprins (80 µg/100 ml). Le taux moyen des valeurs faibles en zinc plasmatique (< 60 µg/100 ml) est de 100 %. En effet, les principales plantes consommées par le dromadaire de la station de Laâyoune sont très pauvres en zinc, puisque leurs teneurs sont largement inférieures à la limite de carence pour les autres ruminants domestiques (soit 50 µg/g de matière sèche). Toutefois, lors d'études portant sur des comparaisons interspécifiques, il semblerait que le dromadaire ait tendance à réguler sa zincémie à un niveau sensiblement plus bas. D'ailleurs, la supplémentation quotidienne avec 180 mg de zinc pur chez les animaux recevant une ration équilibrée, n'engendre pas une augmentation sensible de la concentration plasmatique en zinc. Ces observations ont été récemment confirmées par une étude non encore publiée.

La manganésémie moyenne est de 8,7 µg/100 ml, elle est comparable à celle rapportée chez les autres ruminants domestiques (FAYE et BENGOUMI, 1994). La concentration plasmatique ne reflète pas l'état de carence en cet élément qui est mieux apprécié par les teneurs des fourrages consommés. Les principales plantes ingérées par le dromadaire ont des teneurs moyennes qui varient de 38 à 87 µg/g de matière sèche – teneurs supérieures à la limite de carence qui est de 50 µg/g de matière sèche. Par conséquent, ces animaux ne sont pas carencés en manganèse.

Les concentrations plasmatiques moyennes en iode (78 µg/l) sont comparables à celles décrites chez les autres animaux domestiques (KANEKO, 1989) mais légèrement inférieures à celles rapportées chez le dromadaire par ETZION *et al.* (1987). Les plantes consommées par ces animaux sont relativement riches en iode, puisque leurs teneurs sont supérieures à 0,2 µg/g de matière sèche, correspondant à la limite de carence fixée pour les autres animaux domestiques.

Les teneurs en matières sèches du lait (7 %) sont relativement plus faibles que celles rapportées chez le dromadaire dans les autres pays qui varient de 8 à 14 %. La teneur en matière sèche du lait de chamelle varie en fonction du stade de lactation et de l'état d'hydratation, elle diminue chez les animaux déshydratés (YAGIL et ETZION, 1980).

Les concentrations du sodium et du potassium dans le lait (902 ± 91 et 2 110 ± 294 mg/l) sont supérieures à celles décrites dans la littérature et qui varient respectivement de 220 à 690 mg/l et de 520 à 1 720 mg/l. Ces valeurs élevées peuvent être expliquées par la déshydratation, car les teneurs du lait en sodium et en potassium augmentent chez le dromadaire déshydraté (YAGIL et ETZION, 1980).

Les taux du calcium et du phosphore dans le lait (1 462 ± 248 et 784 ± 103 mg/l respectivement) sont comparables à ceux publiés pour le dromadaire dans les autres pays, soit 300-2 570 mg/l et 340-990 mg/l, respectivement.

Les teneurs du lait en magnésium (103 ± 13 mg/l) sont similaires à celles rapportées par YAGIL et ETZION (1980), ABDEL RAHIM (1987) et HASSAN *et al.* (1987), plus élevées que celles notées par MUKTAR (1990) et ELAMIN et WILCOX (1992) mais plus faibles que celles citées par GNAN et SHERIHA (1986) et ABULEHIA (1987). Les variations des teneurs du lait en magnésium sont essentiellement liées à l'apport alimentaire en cet élément. Dans nos conditions expérimentales, les teneurs en magnésium du lait confirment l'absence de carence en cet élément. Par ailleurs, il existe une corrélation significative ($r = 0,67$; $P < 0,05$) entre la magnésémie et la teneur du lait en magnésium. En effet, la magnésémie est un bon reflet de l'apport en magnésium et le lait est une voie d'excrétion du magnésium.

Les concentrations du fer dans le lait (3 410 ± 745 µg/l) sont plus élevées que celles rapportées par GNAN et SHERIHA (1986), ABDEL RAHIM (1987), ABULEHIA (1987) et MUKTAR (1990), mais proches de celles notées par ELAMIN et WILCOX (1992).

Les taux du cuivre et du zinc dans le lait (respectivement 113 ± 49 µg/l et 2 871 ± 814 µg/l), sont comparables à ceux rapportés par MUKTAR (1990), plus élevés que ceux rapportés par GNAN et SHERIHA (1986) et plus faibles que ceux trouvés par ABDEL RAHIM (1987) et ABULEHIA (1987).

La teneur du lait en manganèse (1 930 ± 124 µg/l) est comparable à celle rapportée par ABULEHIA (1987)soit 1 800 ± 20 µg/l. Le dosage du manganèse dans le lait ne reflète pas l'état nutritionnel en cet élément chez la chamelle, mais il indique que les chamelles ne sont pas carencées en cet élément et confirme les résultats des teneurs de manganèse dans le plasma et les plantes.

La concentration du lait de chamelle en iode (98 ± 21 µg/l) est plus élevée que celle des autres ruminants domestiques (30-80 µg/l) (HAENLEIN, 1980). L'absence de valeurs concernant les teneurs du lait de chamelle en iode ne permet pas aux auteurs de comparer leurs résultats. Par ailleurs, il est connu chez les autres animaux domestiques que le lait est l'une des principales voies d'excrétion de l'iode et, par conséquent, la concentration du lait en iode est un bon reflet de l'état nutritionnel en cet élément. Ainsi, les animaux de la station de Laâyoune ne sont pas carencés en iode, ce qui est confirmé par les teneurs de cet élément dans le plasma et les fourrages.

Conclusion

Ce travail préliminaire a permis d'étudier la composition minérale du lait de chamelle en sodium, potassium, calcium, phosphore, magnésium, fer, cuivre, zinc, manganèse et iode en relation avec les concentrations plasmatiques et la teneur des principales plantes consommées en ces minéraux.

Le lait de chamelle ne semble pas différer de celui des autres animaux domestiques et constitue un très bon apport en minéraux pour le chamelon et le consommateur.

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Processing options for camel's milk: field studies in north-eastern Kenya

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Abstract. A field study has been carried out in north-eastern Kenya to examine the possibility of manufacturing fermented milk and butter from camel's milk. The study showed that technically it is possible to establish a camel's milk processing plant, which should allow small-holder producers to process surplus camel's milk. However, detailed studies on milk production potential, organizational structure and financial feasibility are required.

Key words. Dromedary, *Camelus dromedarius,* milk, butter, cultured milk, dairy, Kenya.

Résumé. Une étude de terrain a été menée dans le nord-est du Kenya afin d'analyser la possibilité de fabriquer du lait fermenté et du beurre à partir de lait de chamelle. L'étude a démontré que, techniquement, il est possible de créer une usine de traitement du lait de chamelle qui permettrait aux petits éleveurs producteurs de transformer des excédents de lait de chamelle. Cependant, des études détaillées sur le potentiel local de la production laitière, sur l'organisation de la filière et sur la faisabilité financière du projet sont nécessaires.

Mots clés. Dromadaire, *Camelus dromedarius,* lait, beurre, lait fermenté, usine laitière, Kenya.

Introduction

In many arid areas, camels play a central role as milk suppliers. The comparative advantage of the camel as a dairy animal over the other species in the same environment is difficult to quantify. However, it is widely recognised that in absolute terms, the camel produces more milk and for a longer period of time than any other milk animal held under the same conditions.

In East Africa, where 60% of the world camel population are held, the consumption of camel's milk is not only limited to the pastoral nomads. Camel's milk is also commercialised and sold in the urban areas. These traditional dairy systems can be the basis for a dairy processing of camel's milk, particularly in countries where large camel populations are found. Certainly, the wide dispersal of pastoralists in the arid zone would make a formal milk collection, processing and marketing system difficult to establish and to maintain. However, before the difficulties can be identified and overcome, knowledge on camel's milk itself has to be broadened.

The present paper reports on some results of the research programme going on at the Swiss Federal Institute of Technology in collaboration with the University of Nairobi and Ol-Maisor camel farm in Rumuruti, Kenya. The programme have started first with basic research dealing with chemical properties and physical characteristics of camel's milk. Encouraging results of these studies which have been recently reported in a review (FARAH, 1993) have motivated the authors to carry out field studies in north-eastern Kenya, where camel's milk is an important component of the human diet. The aim of the field study was to improve the traditional camel's milk fermentation technique and examine the possibility of manufacturing butter and ghee from camel's milk.

Based on the results of the field study and on the authors' experiences in dairy development in Sub-Sahara Africa (BACHMANN, 1985), proposals for the promotion of a dairy in rural areas around Garissa, north-eastern province of Kenya, have been worked out. In the following these proposals are presented.

Location of the field study

The experiments were run in a field station in the town of Garissa, the administrative center of the north-eastern province of Kenya. The majority of the camel population in Kenya is concentrated in this province. Apart from a relatively narrow fertile band along the Tana River, this region is rather arid and consists predominantely of desert and grassland with average annual precipitation of 150 to 400 mm. The population is mainly made up of Somali nomads, who move from one grazing area to another with their mixed herds of camels, cattle and goats, and semi-nomads who spend part of each year in urban centres such as Garissa, living mainly from trade of animals.

Milk supply

The camel's milk suppliers are the nomadic pastoralists. Traditionally nomadic settlements are transient and their movements depend on where they can find adequate pasture and water for their herds. This picture of moving nomads has changed to a certain extent during the last decades. With growing urbanisation, the demand for milk among the city population has been increasing. On the other hand the demand for a number of goods such as grain, oil, sugar, clothes and other items of the town has increased among the pastoralists and the milk sales became recently the most important part of cash income of many camel owning pastoralists (Herren, 1992; Samantar, 1987). To ensure steady supply of camel's milk to the market, a new system of camel's milk marketing has emerged. However, the mechanism of this system from milk production through transportation and price-setting is fragmentary and often difficult to obtain.

Most of the camel's milk sold in urban centers in the north-eastern of Kenya comes at present from more or less permanent nomadic settlements around water bore-holes as far as 50 km from the towns. The milk is brought to collecting points along the roads and sold to urban market traders who transport and commercialise the milk. In wet seasons when camel's milk is abundant, nomadic women may bring milk to the urban centres themselves.

Milk collection and location of the dairy plant

Whenever possible, the dairy plant should be located near the suppliers. The near proximity of milk production and milk transportation allows milk to be collected without refrigeration which is always expensive and unreliable in developing countries. However, it is not always possible to put the dairy plant near the milk suppliers, as the location of a dairy plant is also dependent on other factors such as transportation facilities and water supply. Taking into account the existing structure of the camel's milk market, the best way to ensure a reliable supply is that suppliers deliver milk directly to the dairy plant.

It is advantageous if the milk is delivered at the processing centre directly by the producer. The dairy staff can check the quality of the milk in presence of the producer and, if necessary, sort out bad quality from good quality. This helps not only to collect the milk according to its quality but also to instruct the producer how to deliver good quality milk. This personal contact between milk producer and milk processor is extremely valuable.

Milk hygiene and quality control are an important part of the milk collection. At present it is not known how the methods for quality control normally applied for cow's milk can also be used for camel's milk. Therefore, the authors recommend the use of the quality tests generally used for cow's milk but specially adapted for warm conditions in developing countries (Bachmann, 1992). In the region of Garissa where the field study was carried out, most of the potential milk suppliers live round the town in a distance between 10 and 20 km along the Tana river, where the nomads keep their camels. Due to the availability of water, electricity and to the vicinity of milk suppliers, the town of Garissa is foreseen to be the ideal place to build the camel's milk processing unit.

Products

Any dairy product to be introduced must be based on the already existing traditional products, in order to have a chance to be accepted. Most of the camel's milk is consumed in the form of fermented milk. The milk is allowed to ferment naturally at ambient temperature and without prior heat treatment until it turns sour. The resulting fermented camel's milk is known as *"Susa"*. Due to the spontaneous nature of the fermentation, this traditional method results in a product with varying taste and flavour and is often of poor hygiene quality. In addition, because of the limited scale of production, the product can be sold only in the immediate vicinity of the herd. For production of fermented milk under controlled conditions, thermophilic or mesophilic lactic acid cultures are normally used. In warm countries, mesophilic lactic cultured milk offers the advantage that it can be incubated at ambient temperature of 20 to

30°C. The field study in north-eastern Kenya showed that the traditional *Susa* can be improved by using selected mesophilic lactic acid cultures.

During the field study a simple method has been developed which allows to obtain butter from camel's milk. Camel's milk butter is not a traditional product. In general, butter in Kenya is a luxury item, although it could be of great nutritional importance. In particular, in the Garissa region, it is only affordable for a small proportion of the population, as it originates from dairies in the Nairobi outskirts and must be transported by road over a difficult 400 km route, which greatly increases the retail price. Therefore, the process developed for producing camel's milk butter, met with great interest among the population.

Dairy plant

The primary aims of processing camel's milk is the creation of additional income for camel-owners and milk-traders, as well as the production of valuable food for self consumption. Of all milk types, camel's milk is the only one available all the year round in north-eastern Kenya, although it is more affodarable in wet season than in dry season. In this field study the authors do not analyse whether there is a need for processed camel's milk. Nevertheless, and according to their discussion with different groups of population from rural and urban centres, they assume that it seems to be the case. Their assumption is based on the following: camel's milk is the most appreciated milk. Both rural and urban population are eager consumers of camel's milk. The motivation for drinking camel's milk araises not only from the nutritional value but also from traditional value that surrounds all what comes from camel. In the investigated area in and around the town of Garissa, the camel's milk consumers can roughly be divided in two groups: private householders and establishments such as hotels, restaurants and government institutions. The former group buys the milk from the market, the later buys mainly processed cow's milk (milkpowder, butter, UHT-milk) from milk factories in Nairobi, about 500 km from Garissa. This group buys the processed cow's milk products due to its higher hygienic level and to longer shelf life, although they would prefer to buy processed camel's milk if it would be available. During the field study, the authors could not get reliable information on the amount of camel's milk available for processing, and on how much funds for capital investment can be obtained to set up the plant.

Under these circumstances two dairy plants with different capacities have been proposed: a small dairy which has the capacity to process 500 to 1,000 litres of milk per day and a medium scale dairy plant for 2,000 to 3,000 litres per day. Detailed processing methods for manufacturing fermented milk and butter have been published by FARAH *et al.*, 1989; FARAH *et al.*, 1990; HANGARTER and FARAH, 1989. In the following only the basic operations are described.

Small scale dairy plant with 500 to 1,000 litres daily

The plant is small and can be located almost anywhere as long as there are water facilities. The equipment used is straightforward. The dairy is to produce only the fermented milk *Susa*. The milk in a 40 to 50 litres churn is heated in a cooker with water bath fired by wood. When the temperature reaches 85 to 90°C, the churn is lifted from the cooker and put into an insulated box for 20 to 30 minutes. Solar heating systems can also be used if the milk is to be heated to 65°C for 30 minutes.

After pasteurization the milk is cooled to 22 to 25°C and inoculated with mesophilic starter culture. The cooling is done by placing the milk churn in a water bath. The water is recooled by circulation through a cooling tower. The circulation of water is done by hand pump. The milk is incubated for 24 hours in the water bath. Obtaining starter cultures could be a limiting factor for large scale production of fermented milk. However, simple commercial systems for producing frozen starter cultures which maintain their activity for years are in operation in Kenya (KURWIJILA, 1983; SCHULTHESS, 1988).

For packaging polyethylene bags of half litre capacity can be used as they are cheap and locally available. For sealing the bags a hand operated heat sealing unit which is also locally available can be used. An alternative to the plastic bags is to sell the milk in the milk churnes used in the processing. This would be cheaper both for the dairy and the consumer. The consumers would then have to bring their own vessels at retail purchase. This is the way camel's milk is sold on the market, and it would not be very much of a change for the consumer.

Medium scale dairy plant with 2,000 to 3,000 litres daily

A medium dairy plant can be considered if sufficient milk and capital are available. The dairy is to produce mainly fermented milk *Susa* but can be combined with the production of butter or ghee, which can be sold at higher price than fermented milk. This will help to maintain the price of fermented milk at a lower level and to encourage its consumption on a wider scale.

The fermented milk can be processed in a batch pasteurizer which is locally available. The pasteurizer is equipped with a heating coil for warm water or steam and a second coil for cooling with tap water. The batch pasteurizer is also equipped with a mechanical stirrer. If electric power fails, stirring can be performed manually. Milk is filled into the pasteurizer and withdrawn manually or by gravity. The use of milk pumps is avoided as far as possible. Heating-water and cooling-water is pumped. Water circuit is equipped with hand-operated stand-by pumps. If the batch pasteurizer is used for low-temperature pasteurization (63°C for 30 minutes), warm water from a solar heating system can be used. For manufacturing butter the milk is heated to 65°C and separated with hand made centrifugation. In this field study the highest recovery of 85% of butter fat, calculated on the basis of milk fat, was obtained at a churning temperature of 25°C and from cream with 22.5% of fat. The time needed to churn at this temperature was 11 minutes. For churning and mouldling the butter, wooden burrels and hand tools can be used. They can be manufactured locally by skilled carpenters. For manufacturing ghee different models of melting vats, which allow to separate the aqueous sediment from the butteroil, are locally available.

Concluding remarks

The model for a camel's milk processing plant proposed here is planed according to the specific situation in Garissa. The small scale dairy plant proposed (500-1,000 l/day) for fermented milk, enjoys a number of advantages which would allow small holder camel owners to commercialize milk which otherwise would not be normally marked. These advantages include no dependency on electricity, the use of simple production techniques and the process of a familiar product that appears to enjoy a good market. The medium scale dairy plant is more energy and capital intensive but most of the necessary equipments are available in Kenya. However, detailed studies on milk production potential, organizational structure and financial feasibility are required. Furthermore, the observed demand for processed camel's milk has to be confirmed.

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Isolation and characterization of dromedary camel κ-casein cDNA

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Abstract. In order to isolate and characterize the coding region of the κ-casein gene in the dromedary camel, the total RNA from the mammary gland of a Tunisian dairy camel was submitted to RT-PCR (Reverse Transcriptase - Polymerase Chain Reaction) using two 24 mer oligoprimers designed on the coding sequence of the homologous gene in cattle. A 24 mer primer corresponding to the 3' end of the coding sequence was used to synthesize the single strand DNA of the target RNA, using the reverse transcriptase. The addition of the primer corresponding to the 5' end of the cattle gene coding region determined the cDNA amplification. An amplification product of 614 bp was obtained. The fragment was cloned in the pBluescribe vector using the sites for BamH1 and EcoR1 restriction enzymes added to the primers. The obtained clone was called pCA4 and sequenced. The sequence analysis revealed the presence of several nucleotidic substitutions in the coding region of the κ-casein in the dromedary camel in comparison with the homologous sequence in cattle.

Key words. Dromadary, *Camelus dromedarius,* milk, casein, PCR, gene.

Résumé. Le but de cette étude a été d'isoler et de caractériser le gène codant pour la κ-caséine chez la chamelle. Dans cet objectif, l'ARN total provenant des glandes mammaires d'une chamelle d'origine tunisienne a été soumis au test RT-PCR (amplification génique après transcription inverse) en utilisant deux amorces nucléotidiques de 24 bases, choisies sur la séquence du gène homologue bovin. L'amorce de 24 bases choisie en position 3' de la séquence codante a permis de synthétiser un ADN simple brin à partir de l'ARN cible. L'amorce située en 5' du gène bovin a déterminé la taille du fragment d'ADNc amplifié. Le produit d'amplification obtenu a une longueur de 614 paires de base. Celui-ci a été cloné dans le vecteur pBluescribe en utilisant les sites de restriction des enzymes Bam HI et Eco RI qui ont été ajoutées aux amorces. Ce clone obtenu, nommé pCA4, a été séquencé. L'analyse de séquence a permis de déterminer plusieurs substitutions nucléotidiques chez la chamelle par rapport à la séquence homologue chez les bovins.

Mots clés. Dromadaire, *Camelus dromedarius,* lait, caséine, PCR, gène.

Introduction

The one-humped camel (*Camelus dromedarius*) is an important livestock species with a particular adaptation to arid and hot environment, and with a high economical value for people living in about forty countries of Africa and Asia. Its breeding is related with milk, meat and hair production and, in some areas, with transport and agriculture. Camel's milk production is conditioned by environmental, genetic, reproductive, nutritional factors and by management which influence the amount of milk produced per day and per lactation period. Camel's milk quality is different among breeds and in relation with climatic conditions of their living areas and fodder and water availability. The interest for milk production is variable in those areas. The entire product is consumed in nomadic populations as fresh or after a short fermentation. Actually, there is not a common use for cheese making since its difficult clotting (RAMET, 1989), but there is an increasing interest to the study of milk composition and its conditioning factors, aiming to improve cheese production. The evidenced difficult coagulation, in comparison with cow's milk, is directly related with the peculiar protein, fat, mineral (mainly calcium) and water content. In particular, there is a different balance among casein fractions with a consequent different micelles size distribution, playing an important role.

The caseins (αs1, αs2, β and κ) are the predominant proteins in the milk. They have been studied, particularly in cattle, with the aim to investigate on the biological meaning of their variability in relation with the milk employment in nutrition and dairy industry. These proteins are involved in raising the calcium and phosphate concentrations to levels well in excess in comparison with the product solubility of calcium phosphate, by forming loosely ordered aggregates, named micelles (ALBONICO, 1984; EIGEL *et al.*, 1984; GROSCLAUDE, 1988; MCLEAN, 1987; RUSSO and MARIANI, 1978).

The first three caseins are insoluble in the presence of calcium ion at the concentration at which it occurs in the milk. They are referred as calcium sensitive, while κ-casein is insensitive to the presence of calcium, acts as a micelles stabilizer. The bovine κ-casein is a polypeptide chain containing 190 aminoacidic residues: the N-terminal fragment (21 aminoacid signal peptide) and the 169 aminoacids mature protein, splitted by chimosin into two parts; an insoluble fraction, para-κ-casein, of 105 aminoacids and a soluble 64 C-terminal end, caseinomacropeptide (CMP). Two common electrophoretic variants, A and B, are known differing for two aminoacidic substitutions (Thr into Ile and Asp into Ala) at the positions 136 and 148 respectively (MARIANI, 1992).

Molecular studies of the genes coding for caseins have been recently carried out in cattle. In this species these genes are organized as an about 200 Kb tightly linked cluster, localized on the sixth chromosome (TREADGILL and WOMACK, 1990). The genes coding for the three calcium-sensitive caseins are evolutionarily related and constitute a small gene family, while the κ-casein gene is believed to be related to the gene of fibrinogen, the protein having an analogous function in the blood clotting cascade (JOLLES *et al.*, 1978).

The bovine κ-casein genomic sequence was reported by Alexander *et al.* (1988). This gene is known in four allelic forms (SCHLIEBEN *et al.*, 1991), two more common (A and B) and two (C and E) with a less diffusion among cattle breeds.

Studies on the genomic organization and expression mechanisms of the genes coding for milk proteins are not available up to now in the dromedary camel, and would allow a better understanding of molecular basis of milk production and cheese-making properties. In this paper, the isolation of a cDNA clone containing the coding sequence for the κ-casein, obtained by Reverse Transcriptase-Polymerase Chain Reaction from the total RNA of the mammary gland of a Tunisian camel, is reported.

Materials and Methods

Thermostable rTth reverse transcriptase RNA PCR

Total RNA was extracted from the mammary gland of a lactating Tunisian dairy camel using a guanidinium-based method (MANIATIS *et al.*, 1982 modified). Reverse transcription was performed in a total volume of 20 µl containing 200 µM of each dNTP, 5 units of rTth DNA Polymerase (Perkin Elmer Cetus), 1X of rTth buffer, 1mM of $Mncl_2$, 0.015 nmoles of "downstream" primer:
– (5' GAGACATCAAAGACGCAACAGAAG 3') and about 250 ng of total RNA. The RT mixture was incubated for 15 minutes at 70°C. Then the PCR mixture was added, containing in a total volume of 80 µL, 2.5 mM of $MgCl_2$, 0.8 X of chelating Buffer and 0.015 nmoles of "upstream" primer;
– (5' GGTGCAATGATGAAGAGTTTTTC 3'). The obtained mixture was incubated in a programmable Thermal Cycler (Perkin Elmer, Emeryville, CA) and the profile of the PCR reaction was 2 min at 95°C for 1 cycle, 1 min at 95°C and 1 min at 60°C for 35 cycles, followed by a final cycle at 60°C for 7 min. The length of the PCR product was verified by electrophoresis on 1% agarose gel. The oligoprimers used for RT and PCR amplification were purchased by Genset, Paris, and synthesized on the published sequence of bovine κ-casein gene (ALEXANDER *et al.*, 1988).

Cloning and sequence analysis

The amplification product was gel-eluited with QIAEX resine and the purified DNA fragment, digested with Eco R1 and Bam H1, was cloned into pBleuscribe vector. The TG1 bacteria host were transformed, recombinant plasmid was isolated and DNA prepared for sequencing (MANIATIS *et al.*, 1982). Sequencing was performed by the dideoxy chain termination method (SANGER *et al.*, 1977) using Sequenase version 2.0 (USB, Cleveland OH).

Results and Discussion

To obtain cDNA from total RNAs of the camel mammary gland, two primers corresponding to the 3′ and 5′ end coding region of the homologous bovine gene were used with RT-PCR. After amplification a fragment of expected length, 614 bp, was obtained.

This fragment has been cloned in EcoR1 and BamH1 sites of the pBluescribe vector and the corresponding clone was called pCA4. The sequence of this clone was for 97% homologous with the corresponding bovine sequence. In the 614 bp fragment, 19 nucleotide substitutions were observed, none in the sequence coding for the signal peptide, 4 in the segment coding for the para-κ-casein and 15 in the segment coding for the CMP, 3 are silent.

Some nucleotidic substitutions influenced the restriction pattern of this gene. In cattle two more common allelic forms are known, A with an XbaI site and B with HindIII and TaqI sites (ALEXANDER *et al.*, 1988). In the camel sequence, the substitutions of a G with an A at the position 355, and an A with a C at the position 512 create the target sequences for AflIII and HindIII restriction enzymes respectively. The presence of both sites for HindIII and XbaI and the absence of the Taq I site show a restriction pattern not comparable with the A or B variants of the homologous bovine gene (figure 1).

The comparison between the cow and camel sequences evidences an high level of conservation of the κ-casein gene in the Tunisian camel. This observation is interesting considering the taxonomic distance of these two species belonging to two suborders (*Tylopoda* and *Ruminantia*) of the order *Artiodactyla* (SCHWARTZ, 1992).

Camel:			5′tgca	atg	atg	aag	agt	ttt	ttc	cta	gtt	gtg	act	act	ctg	gca
Cow			------	---	---	---	---	---	---	---	---	---	---	---	---	---
46	tta	acc	ctg	cca	ttt	ttg	ggt	gcc	cag	gag	caa	aac	caa	gaa	caa	cca
46	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
94	ata	cgc	tgt	gag	aaa	gag	gaa	aga	ttc	ttc	aag	gac	aaa	ata	gcc	aaa
94	---	---	---	---	---	--t	---	---	---	---	-gt	---	---	---	---	---
142	tat	atc	cca	att	cag	tat	gtg	ctg	agt	agg	tat	cct	agt	tat	gga	ctc
142	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
190	aat	tac	tac	caa	cag	aaa	cca	gtt	gca	cta	att	aat	aat	caa	ttt	ctg
190	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
238	cca	tac	cca	tat	tat	gca	aag	cca	gct	gca	gtt	agg	tca	cct	gcc	caa
238	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
286	att	ctt	caa	tgg	caa	gtt	ttg	tca	aat	act	gtg	cct	gcc	aag	tcc	tgc
286	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
334	caa	gcc	cag	cca	act	acc	atg	aca	cgt	cac	cca	cac	cca	cat	tta	tca
334	---	---	---	---	---	---	---	g--	---	---	---	---	---	---	---	---
382	ttt	atg	gcc	att	cca	cca	aag	aaa	aat	cag	gat	aaa	aca	gaa	atc	cct
382	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
430	acc	act	aat	acc	att	gtt	agt	gtt	gag	cct	aca	agt	aca	cct	acc	acc
430	---	---	---	---	---	-c-	---	-g-	---	---	---	---	---	---	---	---
478	gaa	gca	ata	gag	aac	act	gta	gct	act	cta	gaa	gct	tcc	tca	gaa	gtt
478	---	---	g--	---	-g-	---	---	---	---	---	---	-a-	--t	c--	---	---
526	att	gag	agt	gta	cct	gag	acc	aac	aca	gcc	caa	gtt	act	tca	acc	gtc
526	---	---	--c	cc-	---	---	--t-	---	---	-t-	---	---	---	---	--t	-ca
												-3′				
574	gtc	taa	aaactcttaaggagacatcaaagaagacaacgcag										614			
574	---	---	----------------------------------										614			

Figure 1. Comparison between the pCA4 camel clone and the bovine κ-casein gene sequences. The primers used to obtain and for the amplification of the cDNA are underlined; the restriction sites for HindIII (1) and AflIII (2) are evidenced.

Few data are available on the comparison of the nucleotide sequence of the camel clone with homologous sequences from other species. NAKHASI *et al.* (1984) reported the isolation of the cDNA of κ-casein in rat. Several differences with the camel sequence are evidenced, particularly in the region coding for the active protein. GUARICCI *et al.* (1994), recently reported the isolation of the cDNA of the same gene in the River Buffalo whose milk is known for its particular cheese making properties. In this case a surprising total homology with the camel sequence was observed.

Conclusions

The established gene sequence of κ-casein in the camel, very similar to the cow's one and identical to the buffalo's is probably not involved in determining the difficult coagulation properties of camel milk. The analysis of this gene represents an initial contribution to the knowledge of the molecular basis, regulating milk production in dromedary camel. The cloned fragment is the first camel clone presently available, containing a coding sequence for a milk protein. This clone is useful for evaluations on the genomic organization of this gene compared with the homologous gene in other dairy species. Further studies are necessary to evidence eventual allelic forms of this gene, among different camel breeds, between dromedary and Bactrian camel and among camelids. Analogous investigations on other milk protein genes, would be necessary to define the implications of these results in order to improve the camel milk production and utilization.

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Milk production and composition in lactating camels injected with recombinating bovine somatotropin

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Abstract. Eighty healthy lactating camels, in their second to fourth lactation were selected. The effects of bovine somatotropin on yield and composition of milk in camels were studied. Somatotropin increased milk production as compared to the control animals. Neither fat nor protein percentages in milk at the time of maximum response were affected by the use of BST. However, a decrease in milk protein and increase in fat was observed during the first week after injection of BST.

Key words. Dromedary, *Camelus dromedarius*, milk, milk production, chemical composition, somatotropin, Paskistan.

Résumé. Quatre-vingts chamelles allaitantes ont été sélectionnées entre leur seconde et leur quatrième période de lactation. Les effets de la BST (somatotropine bovine) sur le rendement et la composition du lait chez les chamelles ont été étudiés. La somatotropine augmente la production de lait, par rapport à d'autres animaux témoins. Ni les taux de matières grasses ni ceux des protéines dans le lait, mesurés à la réponse maximale, n'ont été affectés par l'utilisation de BST. Cependant, une baisse temporaire du taux de protéines et une hausse du taux de matières grasses ont été observées durant la première semaine suivant l'injection de BST.

Mots clés. Dromadaire, *Camelus dromedarius*, lait, production laitière, composition chimique, somatotropine, Pakistan.

Introduction

Bovine somatotropin (BST) has increased milk yield from 15-25% in dairy cow without changing the quality of milk (BAUMANN *et al.*, 1989; MCBRIDE, *et al.*, 1988; SAWAYA *et al.*, 1984). In developing countries where governments are upgrading their dairy industries by genetic manipulation (crossbreeding and embryo transfer), the use of BST has great appeal. Bovine somatotropin is galactopoietic when injected in milking animals. Camels, in Pakistan, are utilized for their meat and milk. The physiology of camel may be different from that of other animals, however, under summer stress, camels are the only animals to produce milk in this harsh environment. The effect of bovine somatotropin on physiological and haematological profiles in camels has already been documented. Therefore, the objective of the present study was to determine the short term milk yield response in camels to the injection of BST.

Materials and Methods

Eighty healthy female milking camels were selected from the desert area of Bhakkar (Punjab) and were kept at the Rakhmani Sheep and Goat Farm. Prior to the trials, camels were acclimatised to housing and were tied in the stalls. After two days of adjustment, observations commenced on individual animal. Groups were blocked according to the milk production and randomly assigned to the treatment with block. Therefore, treatment group milk production were similar (3.62-3.97). Two groups were made comprising four animals in each group. Group 1 served as control and received placebo injection while group 2 received injections of BST (Elanco 320 mg) subcutaneously. Prior and during the study period, camels received a diet of concentrate and green fodder mixture, giving a crude protein of 18% and TDN of 70%. A mixture of chaffed green fodder was consumed *ad libitum*. Water was offered at morning and evening. The camels were hand-milked daily by a skillful person at 5:30h. and 16:30h. and milk yields were recorded. Blood and milk samples were taken prior to the treatment (day 0), 1 day after BST injection and after 7 and 13 days of injection from both the groups.

Fat was determined by milkotester, protein by pro-milk, solids-not-fat (SNF) were estimated using hydrometer. Appropriate statistics was applied to compare the difference between the means.

Results and Discussion

The present study lasted for 13 days. Average ambient temperature was 11.4-29.7°C and temperature humidity index was 59.0 (morning) and 70.0 (evening). On day 1 after injection of BST, camels responded with increased milk yields and continued until day 13 (figure 1). Maximum peak was observed during days 9-12. The response of individual camel injected with BST ranged from 4.9 to 8.9 kg/day while it was 3.3 to 7.4 kg/day in control group. The results of this short term study confirm that BST elicits a positive milk yield response in camels.

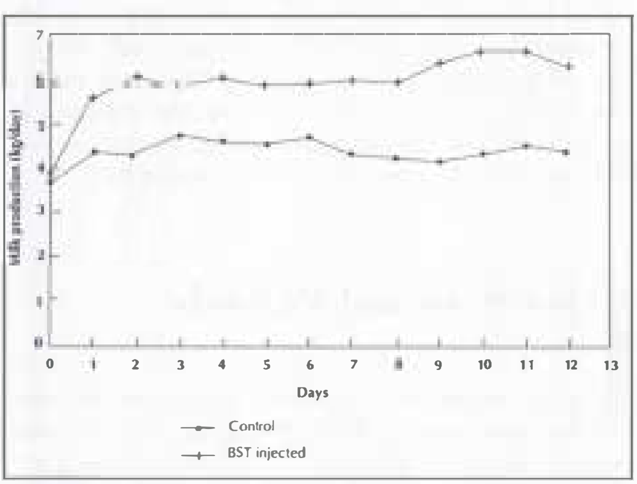

Figure 1. *Milk production of normal and BST injected camels over days.*

On day 1, milk fat and protein percentage did not change significantly following injection of BST. Similar observations were recorded by other workers (CHILLIARD, 1988*a*; CHILLIARD, 1988*b*). Protein contents of camel's milk were similar to those found by other workers (SAWAYA *et al.*, 1984) but somewhat lower reported by some other workers (MUKASA-MUGERWA, 1981). Many recent long term studies in cattle with BST showed that milk production almost always increased with very little concomitant change in fat and protein contents (ARMSTRONG, 1988; CHILLIARD, 1988*a*; CHILLIARD, 1988*b*). Protein percentage tend to decrease during week 1 (7 days) after injection of BST (table I). This tendency was reported previously (BAER *et al.*, 1989; BAUMANN *et al.*, 1985; THOMAS *et al.*, 1987). It has been suggested that these changes may be related to monetary variation in the energy balance, although emphasized that temporarily decrease in protein often accompanies negative N balance especially at the start of lactation (MCBRIDE *et al.*, 1988). The tendency for milk fat percentage was the opposite, it increased on day 7 and then decreased on day 13 (table I). At present, fatty acid and protein composition of milk are being analysed using GLC and HPLC once per week by treatment group. Likewise, trace elements are being investigated by using Atomic Absorption Photometer in control and BST injected camels.

Conclusion

As the camel's milk is gaining more popularity, several commercial herds are being set up to supply fresh milk. Net increase in milk volume for groups receiving somatotropin was 14-16% over control. The results of this short term study confirm that BST have a positive milk yield response in camel. Since the nature of the recombinant product is of bovine, further studies with camel somatotropin should be done. Also, longer studies are necessary to elaborate physiological and productive traits of these animals including possible immune response and subsequent effect on reproduction.

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Table I. Chemical composition of milk in control and BST injected camels at various time intervals.

Parameters (%)	Control (days)			BST injected (days)		
	1	7	13	1	7	13
Fat	2.85 ± 0.78	3.00 ± 0.50	3.20 ± 0.40	2.82 ± 0.80	4.00* ± 0.60	3.00 ± 0.42
Protein	2.67 ± 0.57	2.49 ± 0.25	2.96 ± 0.13	3.48* ± 0.83	2.12 ± 0.09	2.89 ± 0.40
TS**	9.07 ± 1.49	9.51 ± 1.64	9.84 ± 0.06	10.57 ± 2.14	11.13 ± 1.32	9.88 ± 5.92
SNF***	7.95 ± 1.50	6.98 ± 0.92	7.94 ± 0.42	7.79 ± 0.78	7.28 ± 0.56	7.45 ± 0.13
Acidity	0.17 ± 0.03	0.15 ± 0.02	0.16 ± 0.03	0.18 ± 0.07	0.16 ± 0.01	0.18 ± 0.006

*Significantly different at P ≤ 0.05 from corresponding control values; ** TS: total solid; ***SNF: solid not fat.

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Blood biochemical, hormonal profiles and milk composition of low and high yielding camel

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Abstract. To obtain information on the physiological mechanisms of milk producing in lactating camels, some serum metabolites and hormones were measured in low and high yielding animals. Milk analysis indicated that protein contents were higher in low yielding camels than those of high yielding animals. Blood urea nitrogen (BUN) was significantly lower in high yielding camels. A significantly high level of non-esterified fatty acid (NEFA) was observed in high yielding camel. Serum T_3 and cortisol concentration was lower in high yielding animals.

Key words. Dromedary, *Camelus dromedarius*, milk production, milk, hormone, urea, fatty acid, Pakistan.

Résumé. Afin d'obtenir des informations sur les mécanismes physiologiques de la production de lait chez les chamelles en lactation, certains métabolites sanguins et hormones ont été mesurés sur des animaux ayant un rendement laitier faible ou élevé. Les analyses de lait ont indiqué que les taux de protéines étaient plus élevés chez les chameaux à faible rendement par rapport à des animaux ayant un rendement élevé. L'azote mesuré sous forme d'urée sanguine (BUN) s'est révélé à un niveau plus bas chez les chameaux à rendement élevé. Un niveau significativement élevé d'acides gras non estérifiés (NEFA) a été observé chez les chameaux à rendement élevé. Les niveaux d'hormone T_3 sérique et de cortisol étaient plus faibles chez les animaux à rendement élevé.

Mots clés. Dromadaire, *Camelus dromedarius*, production laitière, lait, hormone, urée, acide gras, Pakistan.

Introduction

Nutritional studies in cattle have shown that at any level of feeding, the high-yielding animals will preferentially direct energy towards milk production and away from the deposition into the inner tissue, whereas converse is true to the low-yielding animals (BROSTER *et al.*, 1969). The ability of the animal to meet the high metabolic demand of the functional gland depends on the differing environmental or nutritional conditions and genetic capacity of animals. In camel, however, little is known of the physiological mechanism controlling these processes. Therefore, the present project was designed to study the metabolites and hormonal profiles of high and low-yielding camel matched for stage of lactation, and receiving the same diet.

Materials and Methods

Sixteen multiparous animals were selected from large herd on the basis of their ability to produce milk. Nine (MCSHANE *et al.*, 1989) low yielding camels with milk production of 6 ± 0.8 kg/day, were compared with seven (LINDSAY, 1975) high yielding (12.80 ± 1.8 kg/day) animals. All animals were on same diet when the milk and blood samples were taken. Blood samples were collected on the morning while the milk production was recorded at morning and evening. Milk samples for composition were collected during normal milking times. Milk samples were analysed using standard methods of ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (1980). These animals were also matched within few days evening for time of calving, and were housed at the same place. Serum glucose was determined by the method of Werner *et al.* and NEFA was estimated using a modified kit. The hormones T_3 and T_4 were estimated using radioimmunoassays kits (ICN Biomedicals). Cortisol was measured by solid phase radioimmunoassay kit (Diagnostic Products). Somatic cell counts were estimated using 10 ml of milk on microscopic slide, stained with methylene blue. Twenty stained fields were counted and were calculated as per ml of milk. Milk samples for composition were collected during normal milking time. Milk samples were analysed by using standard methods of ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (1980).

Total serum proteins, albumin, cholesterol, blood urea, serum creatine were estimated using kits from Mereko-test. Globulin concentration was obtained by subtracting the amount of albumin from the total proteins.

Results and Discussion

There was no clear difference in content of milk fat, lactose and water between low and high yielding camels. In cattle, higher fat content (BITMAN *et al.*, 1984; MUNNECKE *et al.*, 1988) or higher protein contents (EPPARD *et al.*, 1985) dependent on energy balance, have been described. Protein contents were significantly lower in high yielding camels. The number of somatic cells were quite variable between animals and difference between two groups of camels were not significant. However, there was a trend for a higher number of cells in the high yielding camels (table I). The number of somatic cells in milk are considered a guide to mastitis incidence. High milk production has been associated with increased clinical mastitis.

Table I. Milk production, composition and somatic cell count of low and high yielding camels.

Composition (%)	Milk production (kg/day)	
	Low yielding	High yielding
Fat	3.20 ± 0.28	3.60 ± 0.42
Protein	2.90 ± 0.04	2.61 ± 0.05*
Lactose	3.90 ± 0.08	4.30 ± 0.09
Total solids	11.10 ± 0.13	11.37 ± 0.21
Water	88.33 ± 0.27	86.38 ± 0.32
SCC (10^3 *x* ml)	60.00	78.60

* Significantly different at P ≤ 0.05.

Blood urea nitrogen was significantly lower in high yielding camels (table II). Angus heifer fed with a high energy diet had lower BUN compared with heifer fed with a low energy diet (MCSHANE *et al.*, 1989). It was also concluded that energy intake was inadequate for heifer on low energy diet to support optimal protein synthesis. Lower BUN reflected reduced amino acid oxidation by the mammary gland or increased milk protein synthesis (LOUGH *et al.*, 1988).

Table II. Mean serum biochemical and hormonal profiles of low and high yielding camels.

Composition (%)	Milk production (kg/day)	
	Low yielding	High yielding
Glucose (mg/dl)	44.80 ± 3.5	48.95 ± 2.6
Cholesterol (mg/dl)	110.11 ± 4.8	122.15 ± 4.3
BUN (mg/dl)	28.6 ± 1.4	24.30 ± 2.5*
Creatinine (mg/dl)	0.84 ± 0.03	0.97 ± 0.06
Total protein (g/dl)	7.13 ± 0.39	7.81 ± 0.42
Albumin (g/dl)	4.08 ± 0.22	3.91 ± 0.23
Globulin (g/dl)	3.05 ± 0.40	3.90 ± 0.38*
A/G ratio	1.33	1.00*
NEFA (U/L)	257 ± 10.0	330 ± 7.8*
Thyroxine (ng/ml)	47.8 ± 3.8	52.0 ± 3.0
Triiodothyroxine (ng/ml)	2.51 ± 0.04	1.22 ± 0.12*
Cortisol (ng/ml)	12.0 ± 0.91	7.8 ± 0.60*

* Significantly different at P ≤ 0.05.

Exogenous insulin has positive action on milk protein in cattle (SCHMIDT, 1966) and it is suggested that insulin is required for the uptake and utilization of glucose by the mammary gland (VAN BOGAERT, 1976). Higher level of insulin in Sahiwal cattle were accompanied by a lower rate of fat metabolism as indicated by the level of NEFA in these animals (ZIA-UR-RAHMAN, 1994).

A significantly higher level of NEFA indicates an increased rate of fat mobilization. So in the period of energy deficit GH may enhance the availability of energy yielding metabolite by oxidation of NEFA, thus by increasing the rate of fat mobilization and ketogenesis by the liver (LINDSAY, 1975). The fermentation pattern associated with feeding is generally considered to favour tissue deposition. The type of ration can give rise to glucose and decrease NEFA. These factors need to be born in mind when expressing the results and comparing them with those obtained in animals given more conventional diets.

Endocrine changes associated with low and high yielding animals show reduced serum T_3 and cortisol concentration in high yielding camels (table II). No effect was found on serum T_4 concentration between two groups. The greater depression of T_3 is expected because of a negative feed back of increased heat production in high yielding animals. T_3 is an hormone that directly induces calorigenesis, so such an effect may assist the animals to control body temperature. It has been indicated that T_4 concentration was lower in lactating cow than in non-lactating and was negatively correlated to the milk production (VAN JONACK and JOHNSON, 1975).

Serum cortisol was also lowered in high yielding camel. Increased glucose production may cause a decrease in serum cortisol that was probably due to glucose-sparing effect in high yielding camels. The availability of glucose is required for lactose synthesis and is one of the primary factors limiting milk production in high yielding cows (KRONFIELD, 1976).

Conclusion

The results of the present study have demonstrated some differences between low and high yielding camels. The increased NEFA concentration in the high yielding camel might have been used by the mammary gland for lipogenesis and as an energy source. Milk production and blood metabolites between low and high yielding camel are also indicative of that these animals were in different metabolitic states. More research work is required to full understand the mechanism of metabolic state of these animals.

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Evolution de la composition du lait de dromadaire durant la lactation : conséquences technologiques

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Résumé. L'auteur expose les résultats d'un suivi laitier réalisé dans un cadre expérimental, sur des chamelles, en Tunisie. Il présente les performances quantitatives de production laitière en fonction des conditions de traite et des conditions d'alimentation, et aborde la variation de la qualité du lait durant la lactation et en fonction des saisons. La qualité obtenue limite la capacité de transformation fromagère des laits d'été.

Mots clés. Dromadaire Negga, *Camelus dromedarius*, lait, qualité, composition chimique, production laitière, fromage, Tunisie.

Abstract. Twenty six lactations of she-camels have been followed up in an experimental station in Tunisia. The author reports the results for the assessment of milk yield and milk quality of different animal batches. It is concluded that the quality of the milk during summer limits the processing ability of the product.

Key words. Negga dromedary, *Camelus dromedarius*, milk, quality, chemical composition, milk production, cheese, Tunisia.

Introduction

Malgré l'importance du lait dans l'alimentation des populations nomades (KAMOUN, 1990*b* ; KAMOUN, 1990*c* ; KAMOUN, 1995), il n'existe que très peu d'études complètes rapportant les productions sur des lactations entières et précisant les conditions de la traite et la qualité du lait produit.

L'objectif de ce travail est d'estimer le potentiel laitier des « Negga Maghrabi » suivant une alimentation connue, et de souligner les facteurs qui peuvent influencer la quantité et surtout la qualité du lait produit.

Matériels et Méthodes

L'étude se déroule dans la ferme expérimentale de l'Ecole supérieure d'agriculture de Mateur, située au nord de la Tunisie, à environ 60 km au nord-ouest de Tunis. Les dromadaires sont des animaux de race Maghrabi de type bréviligne. Les femelles adultes mesurent entre 1,60 et 1,76 m au garrot, les poids varient avec l'animal, l'état physiologique et la saison. Dans le troupeau, les adultes pèsent entre 450 et 650 kg. La robe est habituellement fauve ou claire, couleur café-au-lait.

Au total, vingt-six lactations ont été suivies. Huit femelles étaient entretenues en stabulation entravée, et nourries de fourrage et de concentré (apport de la ration : 0,79 UFL et 115 g de MAT par kilo de MS intégrée). Les dix-huit autres suivis ont été réalisés avec des femelles en lactation qui passent la nuit et une partie de la journée (de 12 h à 14 h) dans l'étable, où elles ont à leur disposition de l'eau, de la paille à volonté, et 4 kg de son de blé par tête et par jour. Le reste de la journée, les animaux sont conduits au pâturage à 7 h 30 après la traite du matin et à 14 heures après celle de midi. Les animaux sont rentrés à la tombée de la nuit, avant la traite du soir.

La traite est quotidienne, et les contrôles sont effectués tous les quatorze jours. La fréquence des traites va de deux à quatre par jour. Pour le contrôle laitier, nous avons retenu après étude une fréquence de trois traites par jour. La traite complète est faite sur deux quartiers (un postérieur et un antérieur). Les deux autres sont réservés au petit. Le volume recueilli est alors multiplié par deux.

La date du pic de production (tmax = b/c), le niveau de production maximale (PLmax = a $(b/c)^b$ e^{-b}) et la persistance de la production ont été estimés après ajustement des courbes de lactation par une fonction de type Gamma, selon la méthode proposée par Wood : PL (t) = a t^b e^{-ct} (PL (t) = production litres par jour ; t = stade de lactation ; a, b et c paramètres du modèle).

Le lait, collecté dans les conditions hygiéniques requises, est immédiatement soumis aux analyses.

Les différentes analyses élémentaires (acidité, pH, densité, matière sèche, matières grasses, protéines, cendres et minéraux) sur les laits ont été réalisées selon les méthodes officielles tunisiennes qui découlent de celles décrites par la FIL.

Résultats

Influence des conditions de la traite sur la quantité et la qualité du lait produit

La présence du jeune au pis de sa mère est indispensable pour initier la descente du lait. La Negga ne donne pas de lait en l'absence de son petit. En effet, dès sa libération, le jeune masse les quatre tétons du pis de sa mère. Quelques secondes après, le pis se gonfle et la traite peut commencer sur deux quartiers (un postérieur et un antérieur), les deux autres étant réservés au petit.

Sur ving-sept séances de chronométrage, on a constaté que le petit met en moyenne 43 secondes pour préparer sa mère, et qu'en présence du jeune la traite dépasse rarement 3 minutes. La présence du trayeur dérange souvent l'animal, provoque la remontée du pis et bloque la sécrétion du lait. La quantité de lait récolté dépend de la dextérité et de la vitesse du trayeur.

Pour estimer la quantité de lait retenue par la Negga, on a procédé à une injection intramusculaire d'ocytocine dès la fin de la traite. La dose injectée est de 4 UI/100 kg PV. Le pis se regonfle au bout de 3 minutes et la traite dure en moyenne 1 minute 46 secondes. La quantité résiduelle de lait récoltée après injection d'ocytocine représente 10 à 15 % de la quantité produite avant l'injection. Elle augmente avec la production. Ce lait est riche en matières grasses (64 g/l). Au bout de la cinquième injection, les Negga ne réagissaient plus à l'action de l'ocytocine. L'augmentation de la dose d'ocytocine injectée a provoqué des alertes d'avortement.

En règle générale, la production laitière augmente avec la fréquence des traites. Le passage de deux à trois traites par jour augmente la production journalière de 28,5 % et celui de trois à quatre traites n'augmente la production que de 12,5 %. L'auteur a opté pour trois traites par jour, et ceci malgré l'augmentation de la production due à la quatrième traite. Cette augmentation de 12,5 % ne justifie pas l'effort supplémentaire qu'elle engendre. Ainsi, pour la suite du travail, les Negga ont été traites le matin, à midi et le soir.

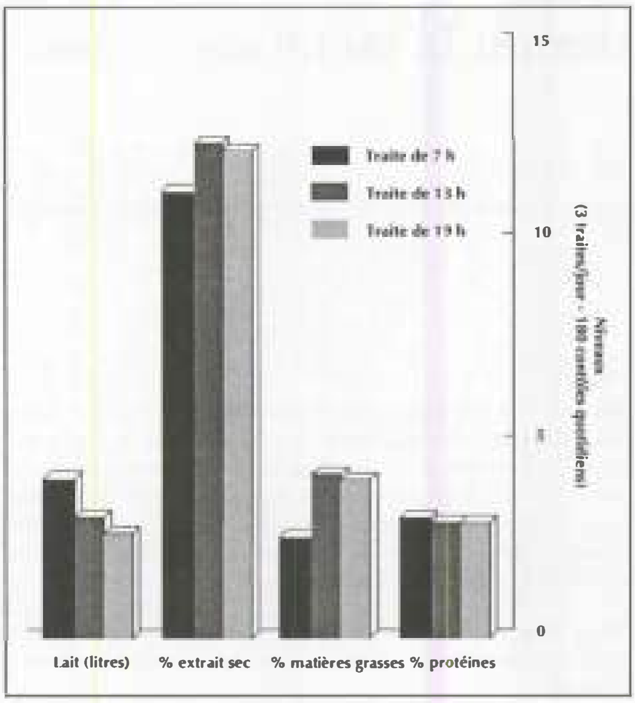

Figure 1. Influence du rang de la traite sur la quantité et la qualité du lait de dromadaire.

La quantité et la qualité du lait évoluent avec le rang de la traite (figure 1). Les quantités produites sont différentes d'une traite à l'autre, la traite du matin donne plus de lait, mais ce lait est pauvre en matières grasses, et par conséquent plus dense que celui des deux autres traites.

Quantités de lait produites en trois traites

Les observations ont porté sur vingt-six lactations (tableau I). Dans quatorze contrôles, la traite s'est poursuivie jusqu'à un stade avancé de gestation ; dans ces cas, le recouvrement gestation-lactation varie de 2 à 8,5 mois.

Les quantités de lait produites quotidiennement et en une lactation diffèrent selon les individus (figure 2). La production moyenne journalière de lait passe de 7,4 litres la seconde semaine à 11,9 litres vers la dixième semaine pour retrouver un niveau de 5,6 litres à 8 mois.

Tableau I. Contrôle laitier du troupeau camelin de l'école supérieure d'agriculture de Mateur.

Nombre d'observations = 26		**Lactation Durée** (jours)	**Production quotidienne maximale** (litres)	**Total par lactation** (litres)	**Recouvrement lactation gestation** (jours)
Amplitude	de	160	4,5	942	0
	à	404	13,7	3 300	253
Moyennes		265	8,44	2 025	–
Ecarts types		59	2,8	632	–

Le pic de lactation apparaît dans la majorité des cas au cours du troisième mois entre le 64[e] et le 94[e] jour (72 ± 14 jours, n = 13). La durée moyenne de lactation est d'environ 9 mois avec des extrêmes qui vont de 5,5 à 13,5 mois. Les coefficients de persistance (100-200/0-100) sont compris entre 49,8 et 89,6, soit en moyenne 70 ± 15 %. Ces différences s'expliquent par le recouvrement entre la lactation et la gestation. Les plus faibles coefficients de persistance s'observent chez les Negga qui ont un court intervalle mise bas/conception (1 à 2 mois) et dont la production de lait se poursuit jusqu'à un stade avancé de la gestation. Les pentes les plus douces s'observent sur les courbes de lactation de Negga non gestantes.

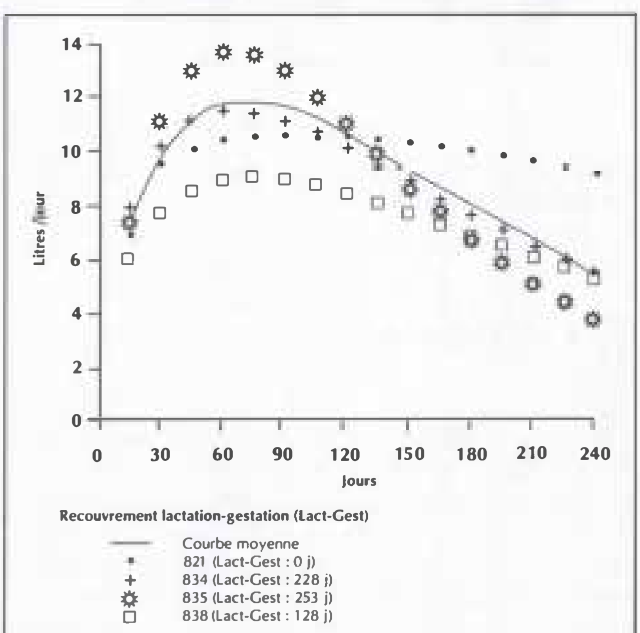

Figure 2. *Courbes de lactation chez les femelles dromadaires (Negga).*

Evolution de la composition du lait durant la lactation

Des contrôles quotidiens, effectués dès la mise bas, ont permis de situer entre le 8[e] et le 9[e] jour la fin de la phase colostrale (figure 3). A la mise bas, le colostrum était de couleur crème, translucide, épais, collant, acide, très dense (d >1,050) et riche en extrait sec (179 g/l). Cinquante-quatre pour cent de cet extrait sec étaient des protéines solubles. Le taux de matières grasses était très faible, de 1 à 3 g/l. Les caractéristiques du colostrum ont évolué progressivement vers celles du lait.

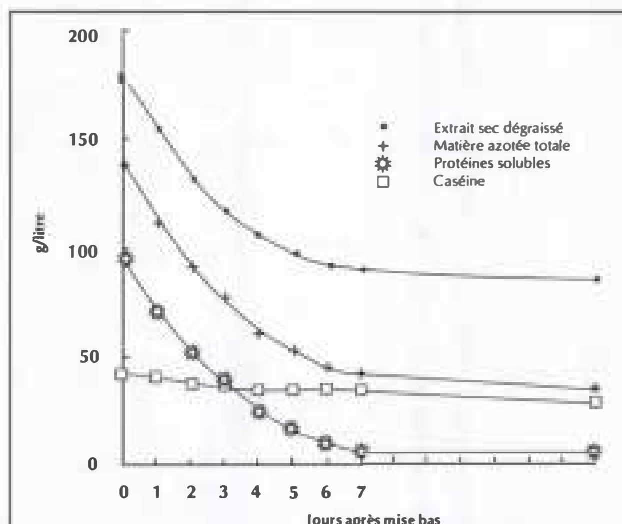

Figure 3. *Composition chimique du colostrum de Negga.*

Les constantes physiques et la composition chimique moyenne du lait sont résumées dans le tableau II. L'extrait sec total (EST) est de 121,3 g/l dont 30,8 % de matières grasses (MG). La caséine représente respectivement 34,5 % de l'extrait sec dégraissé (ESD) et 84,3 % de la matière azotée totale (MAT).

Dans la figure 4 est résumée l'évolution des principaux constituants du lait en fonction du stade de lactation. La composition du lait n'est pas constante tout au long de la lactation. Durant les deux premiers mois de lactation, on observe une diminution du taux des protéines et du taux butyreux du lait. Ces constituants passent par un minimum qui coïncide avec le pic de la lactation et retrouvent à la fin un niveau comparable à celui du départ. Toutefois, on constate qu'en dehors de la phase colostrale, le rapport caséine sur matière azotée totale varie très peu au cours de la lactation.

Tableau II. Caractéristiques du lait des dromadaires conduits en stabulation entravée.

	Dromadaire (n = 115)	
	Moyennes	**Ecarts types**
Constantes physiques		
pH (à 20 °C)	6,53	0,13
Acidité titrable	15,6	1,4
Densité (à 20 °C)	1,028	0,002
Composition chimique (g/l)		
Matière sèche totale	121,3	9,7
Matières grasses	37,6	7,2
Matières protéiques	34,3	4,4
Caséine	28,8	3,5
Cendres	8,1	0,8
Composants minéraux (g/l)		
Ca	1,16	0,10
P	0,88	0,01
Na	0,39	0,14
K	1,76	0,20
Cl	1,99	0,53

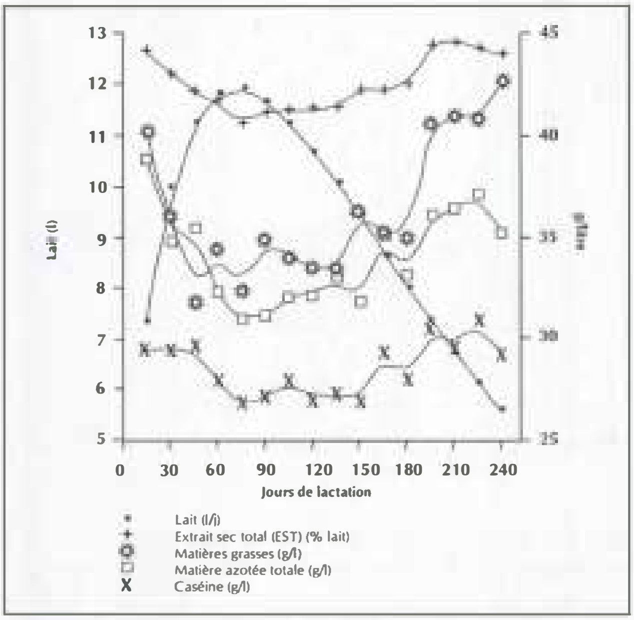

Figure 4. Influence du stade de lactation sur la composition du lait de dromadaire.

Avec des animaux conduits dans une étable en stabulation entravée et constamment nourris de fourrage et de concentré, le facteur saisonnier constituerait la cause la plus importante de la variation de la composition du lait en dehors du stade de lactation. En effet, en été, on observe une chute de l'extrait sec total résultant de la diminution du taux butyreux, des protéines et plus particulièrement de la caséine (figure 5). L'ensemble de cette évolution a une grande influence sur les transformations laitières. La diminution du taux butyreux et du taux de la caséine dans le lait a pour conséquence une chute des rendements fromagers. Les faibles taux de matières azotées durant la saison estivale expliquent les difficultés rencontrées par ceux qui transforment le lait de dromadaire en plein été.

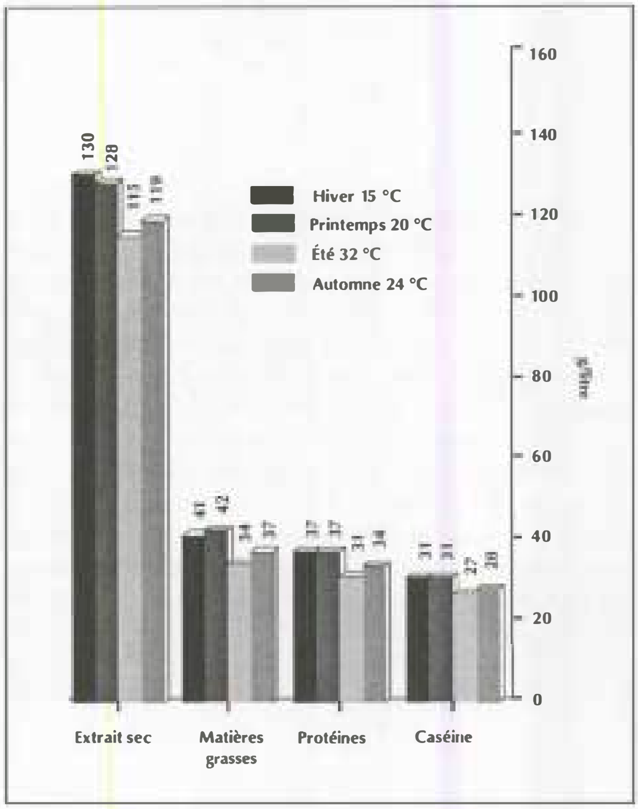

Figure 5. Evolution de la composition du lait de dromadaire en fonction de la saison.

Conclusion

Cette étude montre qu'au sein des dromadaires Maghrabi existent des animaux dont le potentiel laitier mériterait d'être valorisé. Le lait produit a des particularités qui limitent sa transformation pendant la saison estivale. Toutefois, moyennant des adaptations technologiques, ce lait devient transformable avec des rendements et des qualités organoleptiques satisfaisants (Kamoun, 1990*a* ; Kamoun, 1995 ; Kamoun et Bergaoui, 1989 ; Kamoun et Ouizini, 1989 ; Kamoun *et al.*, 1991). Ceci constitue une voie intéressante pour mieux exploiter le potentiel laitier des zones arides, et régulariser, sinon enrichir, l'apport alimentaire des populations. De plus, la possibilité d'acheminer des produits laitiers moins périssables vers des grands centres de consommation devrait autoriser l'introduction progressive de schémas d'intensification et l'orientation de l'élevage camelin vers un système mixte, viande et lait.

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Montpellier, France, Cirad, 304 p. + X p. hors texte.
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Fermentation ability of camel's milk

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Abstract. Camel's milk samples were collected from El-Assa Camel Project, about 160 km south of Tripoli, and the cow's milk samples from the College of Agriculture Farm, Tripoli. All samples were sterilized immediately after arrival at 84°C for 15 minutes and inoculated with 2% of culture, then incubated at 37°C for 18 hours. The main objective of this study was to compare the fermentation ability of camel's milk with cow's milk, by studying pH decrease, titratable acidity increase, and total plate count at an hourly interval for five hours and at the end of the 18th hour. Results indicate less activity on camel's milk for the three cultures studied, *Lactobacillus acidophilus* was found to be less active compared to other cultures. The colonies obtained from camel's milk samples were very small in size compared to colonies from cow's milk samples. This may indicate the presence of antimicrobial compounds in camel's milk. For the characteristics of appearance and consistancy, camel's milk samples failed to give a gel-like structure after 18 hours of incubation.

Key words. Dromedary, *Camelus dromedarius*, cow, milk, lactic fermentation, Libya.

Résumé. Des échantillons de lait de chamelle ont été collectés au projet camelin d'El-Assa, à environ 160 km au sud de Tripoli, et des échantillons de lait de vache à la ferme du collège agricole de Tripoli. Dès leur arrivée, tous les échantillons ont été stérilisés à 84°C pendant 15 minutes et inoculés avec 2 % de culture bactérienne, puis incubés à 37°C pendant 18 heures. Le but principal de cette étude était de comparer la capacité de fermentation du lait de chamelle à celle du lait de vache, en étudiant la baisse du pH, la variation de l'acidité titrable et les numérations bactériennes toutes les heures pendant 5 heures, et au bout de 18 heures. Les résultats montrent un développement moindre dans le lait de chamelle pour les trois cultures étudiées, *Lactobacillus acidophilus* étant considéré comme le moins actif comparé aux autres cultures. Les colonies bactériennes obtenues à partir des échantillons de lait de chamelle étaient beaucoup moins importantes comparées à celles obtenues à partir des échantillons de lait de vache. Ceci pourrait démontrer la présence de composés antimicrobiens dans le lait de chamelle. Du point de vue de l'aspect et de la consistance, les échantillons de lait de chamelle ne permettent pas de former un coagulat après 18 heures d'incubation.

Mots clés. Dromadaire, *Camelus dromedarius*, vache, lait, fermentation lactique, Libye.

Introduction

Camel's milk is one of the most valuable food resources in arid and semi-arid zones (WILSON, 1984). It contains all the essential nutrients in proportion similar to that of cow's milk (FARAH, 1986). The exact information about the milk production potential of camel is limited. However, available data indicate that an healthy camel with good feed can produce about 4-10 litres milk per day (FARAH *et al.*, 1989). Most of the camel's milk is consumed fresh in the production areas. However, in many occasions, the milk is allowed to ferment naturally and without prior heat treatment. In warm countries, mesophylic lactic acid culture offers some advantages as it can be incubated at ambient temperature (20-30°C) and as the fermentation stops at 1-1.2% of lactic acid, eliminating the need of cooling to stop further fermentation (KURWIJILA, 1983). In Kenya, the fermented camel's milk (*Susa*), a poor hygienic quality product, can be improved by the use of mesophylic culture (FARAH *et al.*, 1989). On the basis of observation by RAMET (1985), it is obvious that camel's milk had a satisfactory self production system which inhibited natural acidification within about five hours compared to cow's milk. Looking to the action of rennet on camel's milk, it was noticed that the coagulum obtained from camel's milk was a precipitate in the form of flocks and that no curd was formed. The coagulation time of camel's milk was two to three times longer than that of cow's milk (FARAH and BACHMANN, 1987). The inhibition of the pathogenic bacteria (*Clostridium pefringens, Staphylococcus aureus, Shigella dysenteriae*) by camel's milk was observed by BARBOUR *et al*. (1984), and it was related to whey lysozyme and stage of lactation. The lacto peroxidase thiocyanate, hydrogen peroxide (LP) system strongly reduces the activity of thermophylic starter culture in milk (DE VALDES *et al*., 1988). ZAIKA *et al*. (1983) reported that increasing concentrations (0.5-8 g/litre) of organo rosemary, sage and thyme, progressively delayed growth and acid production of *Lactobacillus plantarum* and *Pediococcus acidilactici* used in some fermentations processes. There is very limited studies on controlled fermentation of camel's milk by various lactic cultures. Therefore, the present work was undertaken to evaluate the activity of three different lactic cultures on camel's milk and to compare it with cow's milk.

Materials and Methods

Source of samples

Camel's milk samples were collected from El-Assa Camel Project about 160 km southwest of Tripoli and the cow's milk samples from the College of Agriculture experimental station, University of El-Fateh, Tripoli. This study deals with one-humped dromedary camels, raised in the desert without any supplementary feed. The samples were collected under hygienic condition and sent immediatelly under refrigeration to the laboratory.

Cultures

Freeze dried culture of *Lactobacillus acidophilus* (CH-Z), cheese culture (CH-Normal) and yogurt culture were obtained from CHR-Hansen's laboratory, Denmark.

Reconstitued whole milk powder was used as a propagation medium, and many transfers were made to activate the cultures before employed in the fermentation test.

Fermentation studies

All milk samples were sterilized at 84°C for 15 minutes using hot water bath. After cooling to 37°C, the milk was inoculated with 2% culture differently. After thorough mixing, the content was divided into six 250 ml flasks, and then incubated at 37°C for 18 hours. Changes in pH, titratable acidity and total plate count were studied at an hourly interval for 5 hours and at the end of the 18th hour.

The pH was determined by using pH meter (WTW, Laboratory equipment, West Germany), titratable acidity by titration with 0.1 n sodium hydroxide and total plate count as specified by Standard Methods for the Examination of Dairy Products.

The composition of different milk samples were measured by Milko Scan 104 (Foss Electric, Denmark). The Milko Scan was calibrated for fat by Babcock method, for protein by Kjeldal and for water and lactose by AOAC methods.

Results and Discussion

The average composition of camel's and cow's milk is shown in table I. There is no significant difference between camel's and cow's milk which may affect the growth of cultures. Total solids in camel's milk were 9.56% and in cow's milk 10.49%. This has a little effect on consistancy and flavour of end product, as well as pH and titratable acidity changes.

Table I. Average composition of camel's and cow's milk (%).

Component	Camel's milk	Cow's milk
Fat	2.58	3.12
Lactose	4.83	4.42
Protein	2.15	2.95
Water	90.40	89.51

Results of plate count for the three different cultures are shown in table II. In all cultures, camel's milk samples showed less activity than cow's milk. *Lactobacillus acidophilus* was the least active due to its slower growth. Camel's milk suppressed the growth of cheese culture more than yogurt culture. However, yogurt culture contains *Lactobacillus acidophilus* and *Streptoccocus thermophilus* which are more sensitive to inhibition. This could be due to symbiosis and high inoculum in yogurt culture. Decrease in pH and increase in titratable acidity for the three cultures are shown in figures 1, 2 and 3. In all cultures results showed lower changes in camel's milk than in cow's milk (with *Lactobacillus acidophilus* as the least), this correlates very well with total plate count. In cow's milk the whey separation and the characteristic lactic acid smell as well as a strong odor are noticed at the end of the 5th hour; however, camel's milk took longer time to show these changes.

Table II. Total plate count of camel's and cow's milk samples inoculated with different cultures (CFU/ml).

Time of incubation (h)	*Lactobacillus acidophilus*		Yogurt culture		Cheese culture	
	Camel's milk	Cow's milk	Camel's milk	Cow's milk	Camel's milk	Cow's milk
0	< 10^2	3 x 10^2	10^4	10^4	10^3	2 x 10^3
1	< 10^2	200 x 10^2	130 x 10^4	140 x 10^4	10^3	30 x 10^3
2	150 x 10^2	230 x 10^2	180 x 10^4	220 x 10^4	38 x 10^3	58 x 10^3
3	170 x 10^2	280 x 10^2	200 x 10^4	240 x 10^4	50 x 10^3	108 x 10^3
4	200 x 10^2	300 x 10^2	178 x 10^4	260 x 10^4	56 x 10^3	130 x 10^3
5	190 x 10^2	300 x 10^2	160 x 10^4	270 x 10^4	49 x 10^3	144 x 10^3
18	TNTC	TNTC	TNTC	TNTC	TNTC	TNTC

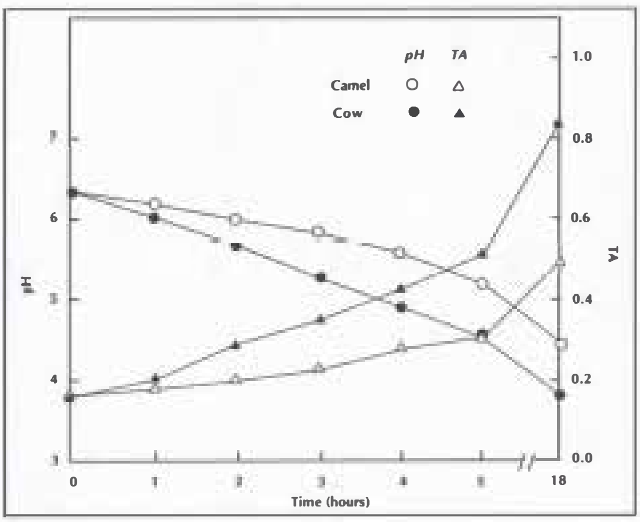

Figure 1*. pH and titratable acidity (TA) of camel's and cow's milk samples inoculated with cheese culture and incubated at 37°C for 18 hours.*

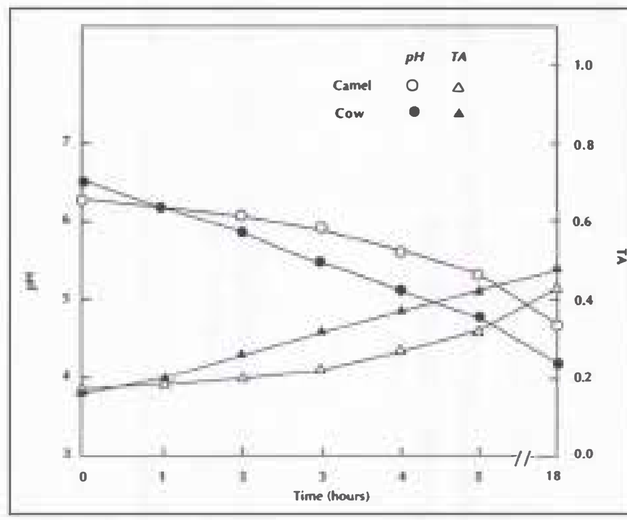

Figure 3*. pH and titratable acidity (TA) of camel's and cow's milk samples inoculated with* Lactobacillus acidophilus *and incubated at 37°C for 18 hours.*

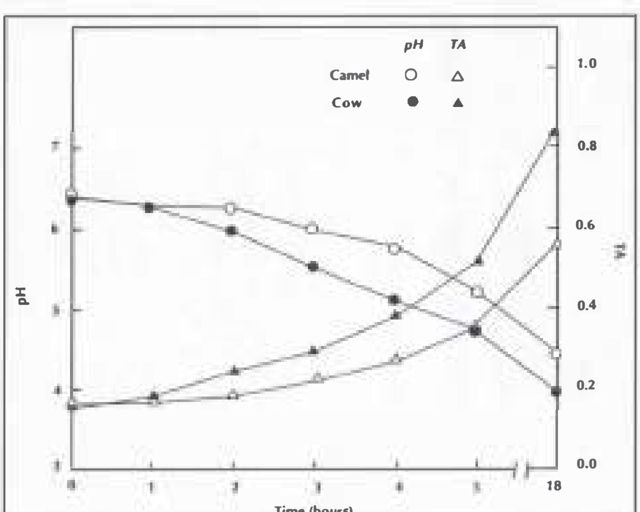

Figure 2*. pH and titratable acidity (TA) of camel's and cow's milk samples inoculated with yogurt culture and incubated at 37°C for 18 hours.*

At the end of fermentation there was a clear and clean curd in cow's milk with a thin layer of whey on the surface for the three cultures, while camel's milk was characterized by the presence of three layers; a very soft and particle like curd on the surface, a soft layer in the middle, and a stronger one, like a curd, in the bottom. This could be due to structure of camel's milk casein (Farah and Bachman, 1987; Farah and Streiff, 1989). The fermentation activity of the three cultures was observed to be less in camel's milk than in cow's milk with *Lactobacillus acidophilus* being the least active. This suppression in growth could be due to the high content of lysozyme and stage of lactation (De Valdes *et al.*, 1988; Farah, 1986). Colonies size were very small (pin-hole size) in camel's milk samples as compared with cow's milk, which suggest the existence of many inhibitors in camel's milk hindering the growth of colonies. More investigation is needed to clarify these questions.

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Montpellier, France, Cirad, 304 p. + X p. hors texte.
(collection Colloques)

Camel's colostrum. Antimicrobial factors

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Abstract. Concentrations of IgG_1, IgG_2, lysozyme and lactoferrin were estimated in daily samples of camel's (*Camelus dromedarius*) colostrum and milk during the first week after parturition, and also in later samples. The results obtained showed that the content of all antimicrobial factors varied considerably in the samples examined. The concentrations of IgG_1, IgG_2 and lactoferrin were at their highest in the first day and dropped markedly in the following days. Lysozyme concentration was highest in the second day, then decreased, however on day 5 there was a slight increase before it decreased later. The first day colostral whey had the following concentrations on average: IgG_1 (53.80 mg/ml), IgG_2 (4.94 mg/ml), lactoferrin (0.84 mg/ml) and lysozyme (1.03 µg/ml). However, in the mature milk whey (day 14), the corresponding concentrations were: IgG_1 (1.35 mg/ml), IgG_2 (0.11 mg/ml), lactoferrin (0.04 mg/ml) and lysozyme (0.73 µg/ml). Moreover, in milk at 14 days *post-partum*, the concentrations of IgG_1, IgG_2 and lactoferrin were decreased to 2.51%, 2.23%, and 4.76% respectively. In addition, lysozyme declined to a low level (70.87%). On the other hand, the results showed that IgG_1 represented 91.6% of the total IgG at day 1, while IgG_2 represented only 8.4%. This shows that IgG_1 is the dominant isotype in camel's colostrum.

Key words. Dromedary, *Camelus dromedarius,* colostrum, immunoglobulin, lactoferrin, lysozyme, Egypt.

Résumé. Les concentrations d'IgG_1, d'IgG_2, de lysozyme et de lactoferrine ont été observées sur des échantillons de colostrum et de lait de dromadaire (*Camelus dromedarius*), prélevés quotidiennement durant la première semaine après la parturition, mais aussi sur des échantillons ultérieurs. Les résultats obtenus montrent que le niveau de tous les facteurs antimicrobiens a varié considérablement dans les échantillons observés. Les concentrations d'IgG_1, d'IgG_2 et de lactoferrine ont atteint le niveau le plus élevé dès le premier jour et ont chuté brutalement dans les jours suivants. En revanche, la concentration de lysozyme qui était à son plus haut niveau le deuxième jour a diminué ensuite, puis s'est légèrement relevée le cinquième jour pour diminuer à nouveau. Sur le colostrum du premier jour on obtenait en moyenne les concentrations suivantes : IgG_1 (53,80 mg/ml), IgG_2 (4,94 mg/ml), lactoferrine (0,84 mg/ml) et lysozyme (1,03 µg/ml). Cependant, dans le lait (14^e jour), les concentrations correspondantes étaient : IgG_1 (1,35 mg/ml), IgG_2 (0,11 mg/ml), lactoferrine (0,04 mg/ml) et lysozyme (0,73 µg/ml). De plus, dans le lait du quatorzième jour *post-partum*, les concentrations d'IgG_1, d'IgG_2 et de lactoferrine ont diminué respectivement de 2,51, 2,23 et 4,76 %. Enfin, le lysozyme y atteint son plus bas niveau (70,87 %). D'un autre côté, les résultats ont montré que les IgG_1 ont représenté 91,6 % du total des IgG au premier jour, tandis que les IgG_2 n'ont représenté que 8,4 % du total. Ceci démontre que les IgG_1 sont l'isotype dominant dans le colostrum du dromadaire.

Mots clés. Dromadaire, *Camelus dromedarius*, colostrum, immunoglobuline, lactoferrine, lysozyme, Egypte.

Introduction

For all mammalians, colostrum is considered as a vital food for the newborn within the first days after birth, due to its high concentration of transfer-immunity factors (e.g. immunoglobulins, in addition to its nutritive value). Another source of protection in colostrum is the role of nonspecific inhibitory system (i.e., lysozyme, lactoferrin, lactoperoxidase and xanthin oxidase) (REITER, 1985). These nonantibody factors play an important role in immunity not only by augmenting antibody action but also by offering protection before the immune response becomes effective. Therefore, more information are needed to establish more complete knowledge on colostrum.

Several investigators have studied the antimicrobial factors in colostrums from different species as bovine (KORHONEN, 1977), buffalo (ELAGAMY, 1992), human (MCCLELLAND *et al.*, 1978) and sheep (SHUBBER *et al.*, 1979). Also the antibacterial and antiviral activity of these proteins were studied in camel's milk (ELAGAMY, 1992). However, little attention was directed to camel's colostrum. ELAGAMY (1994) studied the physicochemical and microbiological properties of camel's colostrum.

The present work was conducted to study the antimicrobial factors concentrations in camel's colostrum and postcolostral milk.

Materials and Methods

Materials

Colostrum samples

Nine individual camel's colostrum samples were collected from she-camels daily during the first week of parturition and also at day 14. Samples were obtained from three different areas around Alexandria, Egypt.

Chemicals and reagents

Eggwhite lysozyme (E.C.3.2.1.17) and *Micrococcus lysodeikticus* were obtained from Difco, Detroit, USA.

Methods

Purification of immunoglobulins and lactoferrin

IgG_1 and IgG_2 were purified from camel's serum. Morever, lactoferrin was purified from camel's milk as described by ELAGAMY (1989). Isolated proteins were tested for purity using SDS-PAGE (LAEMMLI, 1970) and immunoelectrophoresis (AXELSEN *et al.*, 1973).

Lactoferrin content determination

The lactoferrin concentration in colostral whey was determined with a radial immunodiffusion assay (CARLSSON *et al.*, 1989).

Lysozyme activity assay

The lysozyme concentration was quantified by the modified lysoplate method as described by LIE *et al.* (1986). The test was carried out in agarose gel containing *Micrococcus lysodeikticus.*

Immunoglobulins concentrations

The concentrations of IgG_1 and IgG_2 were determined using the radial immunodiffusion technique as described by CARLSSON *et al.* (1989). The test was carried out in agarose gel containing rabbit antiserum to camel's IgG_1 or IgG_2.

Production of antisera (immunization)

The production of antisera to camel's serum IgG_1, IgG_2 and lactoferrin were performed according to the procedure described by JOHNSTONE and THORPE (1985) with modification. On day one of immunization, rabbits were injected intramuscular at multiple sites with a mixture of 0.5 ml of protein solution and 0.5 ml Freund's complete adjuvant (Difco). Thereafter rabbits were boosted subcutaneously every 10 days with 0.5 ml protein sample emulsified in 0.5 ml Freund's incomplete adjuvant. On day 40, rabbits were bled for measuring the antibodies titer.

Results and Discussion

Table I presents the means and ranges of the contents of various antimicrobial factors in the colostrum of nine she-camels for seven successive milkings and in milk at day 14 after parturition. The results showed that the amounts of IgG_1, IgG_2 and lactoferrin were highest in the first day milkings. However, the contents dropped markedly in the milkings of day 14 (figure 1). In contrast to immunoglobulins and lactoferrin, the content of enzymatically active protein (i.e., lysozyme) was rised in the second day milkings and then gradually dropped in low rate as the milk secretion becomes normal (figure 2). Similar results were reported in bovine colostrum (KORHONEN, 1977) and ewes colostrum (SHUBBER *et al.*, 1979). On the other hand, MCCLELLAND *et al.* (1978) studied the concentration of antimicrobial factors in daily samples of human milk. They found that the concentrations of total IgG fell rapidly to low values in mature milk, in contrast to lysozyme, which was high at first day and decreased slightly in normal milk.

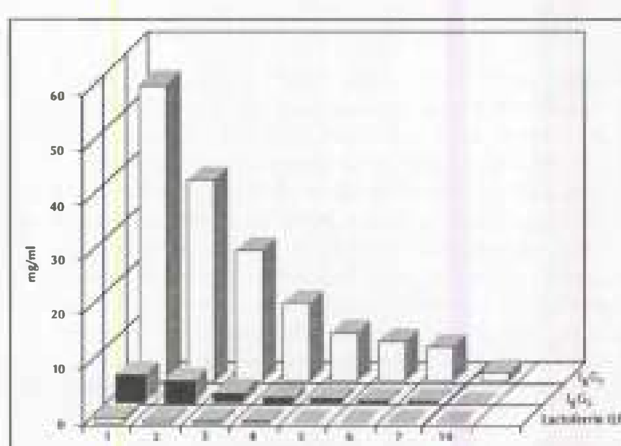

Figure 1. *Concentrations of IgG_1, IgG_2 and LF in camel's colostrum and mature milk (day 14).*

Table I. The concentration of antimicrobial factors in camel's colostrum and mature milk (day 14).

Days *post-partum*	IgG_1 (mg/ml)		IgG_2 (mg/ml)		Lactoferrin (mg/ml)		Lysozyme (µg/ml)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
1	(25.56 - 84.25)	53.80	(1.81 - 6.02)	4.94	(0.20 - 1.80)	0.84	(0.43 - 1.97)	1.03
2	(18.66 - 70.91)	36.67	(1.33 - 5.02)	3.68	(0.16 - 1.22)	0.63	(0.69 - 2.02)	1.28
3	(13.06 - 40.12)	23.69	(0.92 - 2.84)	1.83	(0.12 - 0.74)	0.46	(0.54 - 1.98)	1.06
4	(6.99 - 27.24)	14.23	(0.49 - 1.93)	0.95	(0.10 - 0.29)	0.21	(0.52 - 1.92)	0.90
5	(4.76 - 17.35)	8.55	(0.34 - 1.23)	0.62	(0.09 - 0.17)	0.12	(0.57 - 1.96)	0.93
6	(4.29 - 12.04)	7.15	(0.30 - 0.85)	0.49	(0.08 - 0.14)	0.10	(0.54 - 1.93)	0.92
7	(4.11 - 10.07)	6.02	(0.29 - 0.71)	0.40	(0.05 - 0.12)	0.07	(0.46 - 1.88)	0.87
14	(1.01 - 2.29)	1.35	(0.07 - 0.16)	0.11	(0.02 - 0.08)	0.04	(0.42 - 1.35)	0.73

A comparison of the contents of the antimicrobial proteins tested has been carried out in the colostrum or the milk samples; the results showed that there are considerable individual differences for all factors. The mean values of IgG_1, IgG_2 and lactoferrin content at first day were 53.80, 4.94 and 0.84 mg/ml. While, the corresponding values in milk 14 days *post-partum* were: 1.35, 0.11 and 0.04 mg/ml respectively. Regarding the lysozyme content at first day, it was 1.03 µg/ml and 0.73 µg/ml at day 14. It reveals that IgG_1 and IgG_2 have dropped in their concentrations at day 14, i.e. to 2.51% and 2.23% from the initial values at day first respectively. Similarly, lactoferrin has decreased to 4.76% at day 14. Whereas, lysozyme has declined to its lower extent (70.87%).

The results obtained indicate also that IgG_1 and IgG_2 represented at first day 91.6% and 8.4% of the total IgG respectively. This result indicates that IgG_1 is the dominant isotype in camel colostrum. In comparison to that, several investigators have reported that IgG_1 is the dominant isotype also in bovine colostrum (BUTLER, 1983; DEVERY-POCIUS and LARSON, 1983).

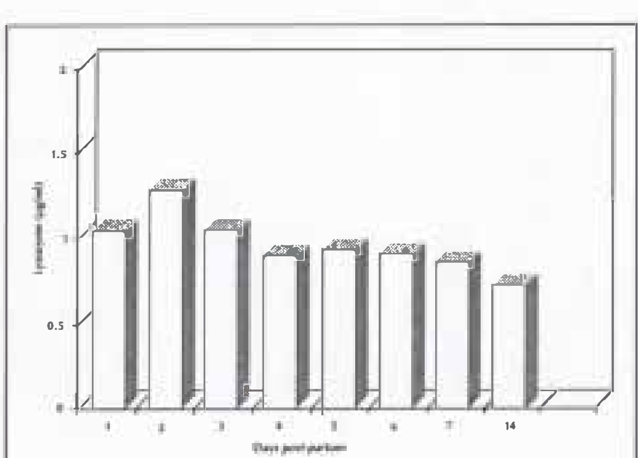

Figure 2. Concentration of lysozyme in camel's colostrum and mature milk (day 14).

Moreover, it is known that immunoglobulins in bovine mammary secretions are serum-derived or produced by local plasma cells (NORCROSS, 1991), and most of IgG_1 is transported from serum, while IgG_2 can be derived from serum or locally produced. Therefore, this study suggests that the high ratio of IgG in camel colostrum is derived from serum, mainly IgG_1.

The relevant concentrations of IgG_1 and IgG_2 in bovine colostrum were reported as 46.4 mg/ml (30.0-75.0) and 2.87 mg/ml (1.9-4.0) and were in milk as 0.58 mg/ml (0.33-1.2) for IgG_1 and 0.055 mg/ml (0.037-0.06) for IgG_2 (BUTLER, 1983).

Lactoferrin concentration is low in bovine colostrum (1 mg/ml) (SENFT *et al.*, 1981) and milk (0.1-0.5 mg/ml) (PERSSON, 1992), but increases during involution and inflammation of the mammary gland (KORHONEN, 1977; CARLSSON *et al.*, 1989). On the other hand, relative high level of human lactoferrin in colostrum (6.0-8.0 mg/ml) was detected (MCCLELLAND *et al.*, 1978). However, no data have been presented in the literature on the relevant concentration of lactoferrin in camel's colostrum to enable a comparison among them. The results of this study indicate that the level of camel's colostrum lactoferrin is closer to that value in bovine species and far from that of human colostrum.

Regarding the content of camel's colostrum lysozyme, the results obtained indicated that it was on average higher in the colostrum than in the milk and that the maximum concentration was not found in the first day milkings as it is the case with IgG_1, IgG_2 and lactoferrin. At the contrary, it was in the second day milkings.

The concentration of lysozyme in camel's milk was reported as 2.88, 5.00 and 0.15 µg/ml (BARBOUR *et al.*, 1984; DUHAIMAN, 1988; ELAGAMY, 1989). Bovine colostrum contains an average of 0.03-0.65 µg/ml (REITER, 1985) and 0.13 µg/ml in milk (PERSSON, 1992). Therefore, it can be concluded that lysozyme concentration in camel's colostrum is higher than that of bovine colostrum.

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Recombined camel's milk powder

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Abstract. Low heat (LH) and high heat (HH) camel's milk powders were manufactured from fresh camel's milk (FM) of the Majaheem breed. The titratable acidity (TA), pH, protein, fat, lactose and total solids of FM were 0.15%, 6.55, 3.20%, 3.20%, 4.95% and 12.5%, respectively. The corresponding values for recombined low heat milk (RLHM) were 0.165%, 6.51, 3.20%, 3.22%, 5.03% and 12.25%, respectively. Similarly, the values for recombined high heat milk (RHHM) were 0.165%, 6.52, 3.20%, 3.22%, 5.10% and 12.30%, respectively. Low heat powder had 2.30% fat, 0.08% free fat (FF), 3.22% moisture, 0.20 solubility index, 55.7 wettability and 70.6 sinkability, whereas for high heat powder the corresponding values were 2.50% fat, 0.10% FF, 1.58% moisture, 0.29 solubility index, 38.3 wettability, and 55.5 sinkability. Overall acceptability of FM was significantly higher than that of RLHM and RHHM.

Key words. Dromedary, *Camelus dromedarius,* milk, powdered milk, reconstituted milk, organoleptic analysis.

Résumé. Des poudres de lait de camelins traitées à basse et haute températures ont été fabriquées à partir de lait frais (FM) de dromadaire de race Majaheem. Les mesures de l'acidité titrable (TA), du pH, des protéines, des matières grasses, du lactose et des matières totales du lait frais ont été respectivement de 0,15 %, 6,55, 3,20 %, 3,20 %, 4,95 % et 12,15 %. Les valeurs correspondantes pour le lait reconstitué traité à basse température (RLHM) étaient respectivement de 0,165 %, 6,51, 3,20 %, 3,22 %, 5,03 % et 12,25 %. De même, les valeurs du lait reconstitué traité à haute température (RHHM) étaient respectivement de 0,165 %, 6,52, 3,20 %, 3,22 %, 5,10 % et 12,30 %. La poudre issue du lait traité à basse température contient 2,30 % de matières grasses, 0,08 % de matières grasses libres et a une valeur d'humidité de 3,22 %, un indice de solubilité de 0,20, un indice de mouillabilité de 55,7 et un indice de dépôt de 70,6, alors que pour la poudre traitée à haute température, les valeurs correspondantes étaient de 2,50 % de matières grasses, 0,10 % de matières grasses libres, 1,58 % d'humidité, 0,29 de solubilité, 38,3 de mouillabilité et 55,5 de dépôt. Le lait frais est globalement plus apprécié que le lait reconstitué, que ce soit à basse ou à haute température.

Mots clés. Dromadaire, *Camelus dromedarius,* lait, lait déshydraté, lait reconstitué, analyse organoleptique.

Introduction

There is a steady increase in the utilization of skim milk powder (SMP) in the manufacture of recombined dairy products or as an additive in other food. Recombined milk (RM) is produced commercially in Saudi Arabia and other countries in the Middle East. Recombined milk products which mainly depend on SMP manufactured from cow's milk represent about 55% of total milk production in Saudi Arabia (SALJI *et al.*, 1984).

Although SMP prices have increased three times since 1986, approximately doubling the price, there is still a good economical environment in favor of using recombined milk, because it is much cheaper than locally produced fresh cow's milk (FM) in Saudi Arabia. WHIPPLE (1983) suggested that a blend of RM and FM in which the content of recombined milk is greater than 50% was rejected by consumers accustomed for drinking cow's fresh milk.

No attempt has been made to manufacture camel's milk powder. Whey protein has a high nutritional value and its high content in camel's milk (ABU-LEHIA, 1987) should be of nutritional benefit to many consumers. The objective of this research is to study the effect of several types of milk powder processes on the physico-chemical characteristics of camel's milk powder and the acceptability of recombined milk.

Materials and Methods

Milk samples

Two batches of Majaheem camel's milk were obtained monthly from the camel's farm (King Abdulaziz City for

Science and Technology) and transported under refrigerated conditions at 6°C. A fifteen litre batch of camel's milk was separated at 45-50°C into a cream and skim milk. The skim milk, preheated at 75°C for 30 s was divided into three portions.

The first portion was kept as a fresh milk control (FM), the second portion was concentrated to 30% TS, and the third portion was heated to 95°C for 10 min before concentrating to 30% TS. The concentration process was carried out at a temperature of 60°C using a Corning Climbing film evaporator (Corning Co., England). To manufacture low heat (LH) and high heat (HH) skim milk powder, the second and third portions were spray dried in a Niro Atomizer Spray dryer (Niro Atomizer Co., Copenhagen, Denmark) with inlet air temperatures of 160 and 195°C and outlet air temperatures of 75 and 95°C respectively (KIESEKER *et al.*, 1985).

Reconstituting dried milks

Reconstituted milk was prepared by mixing the milk powder with water at 40°C (10% W/V) for 3 min in a blender. Reconstituted milk was stored in a refrigerator at 5 ± 1°C for 4 to 6 hours before testing. Camel's milk cream (50% fat) was added to reconstituted milk in order to adjust fat content to 3.2% before sensory evaluation.

Chemical and physical analysis

Moisture, TA, total protein (% nitrogen X 6.38) were measured as outlined by the Association of Official Analytical Chemists (1980). Fat content was obtained using Gerber Method (BRITISH STANDARD INSTITUTE, 1969). Lactose was measured using the phenol method (MARIER and BOULET, 1959). The pH value was determined using a Jenway pH meter (Jenway Co., USA). Sinkability, wettability and WPNI of the powder were obtained by the methods of BULLOCK and WINDER (1960), ASHWORTH and GUNTHARD (1954) and the AMERICAN DRY MILK INSTITUTE (1971), respectively.

Sensory evaluation

Sensory analysis for recombined milk samples of LH and HH skim milk powder, and fresh liquid milk was conducted by a seven member experts in the camel's milk. The expert panel were asked to evaluate smell, color, body, taste and overall acceptability (OA) of samples.

Statistical analysis

Sensory data were analyzed by using analysis of variance (ANOVA) and according to the STATISTICAL ANALYSIS SYSTEM (1979) at the computer services of King Saudi University. Differences among means were assessed during Dunkin's multiple range (STEEL and TORRIE, 1960).

Results and Discussion

The data presented in table I shows the physico-chemical characteristics of recombined camel's milk. Although there was a small variation between the physico-chemical characteristics of recombined low heat milk (RLHM) and recombined high heat milk (RHHM), there was a wider variation between FM and both RLHM and RHHM in the titratable acidity (TA), pH and lactose.

The TA of FM was lower significantly ($P \leq 0.05$) than that of RLHM and RHHM (0.155 vs 0.165 and 0.165% respectively). Lactose content of FM was lower significantly ($p \leq 0.05$) than both RLHM and RHHM (4.95 vs 5.03 and 5.10% respectively). This increase in TA and decrease in lactose content might be attributed

Table I. Physico-chemical analysis of fresh and recombined camel's milk*.

Type of milk	Titratable acidity (%)	pH	Protein (%)	Fat (%)	Lactose (%)	Total solids (%)
Fresh milk	b 0.155 ± 0.04	a 6.55 ± 0.04	a 3.20 ± 0.02	a 3.20 ± 0.03	b 4.95 ± 0.03	a 12.15 ± 0.10
Recombined low-heat powder	a 0.165 ± 0.04	a 6.51 ± 0.02	a 3.20 ± 0.03	a 3.22 ± 0.04	a,b 5.03 ± 0.04	a 12.25 ± 0.08
Recombined high-heat powder	a 0.165 ± 0.06	a 6.52 ± 0.03	a 3.20 ± 0.03	a 3.22 ± 0.03	a 5.10 ± 0.04	a 12.30 ± 0.12

* Mean of 5 replicates ± standard deviation.
a,b: means in column not followed by the same letter are significantly different ($p \leq 0.05$).

to the increase in the formation of formic and lactic acids as a result of partial thermal decomposition of lactose during the heating and drying process (PARRY, 1974).

Some physico-chemical characteristics of camel's skimmed milk powder are presented in table II. As a result of using low drying and outlet temperatures, the moisture content of LH powder (3.32%) was significantly ($p \leq 0.05$) higher than that of HH camel's skimmed milk powder (1.58%). A similar trend was reported by WESTERGAARD (1983) for cow's milk powder.

As shown in table II, the solubility index of HH camel's milk powder was higher than that of LH powder (0.29 vs 0.20 respectively). This increase could be attributed to preheating and drying temperatures which result in the coagulation of casein (KNIPSCHILDT, 1986). However, an opposite trend was reported by THOMAS *et al.* (1977) during manufacture of cow's skimmed milk powder. This might be attributed firstly to the high content of whey protein of camel's milk and secondly to the instability of camel's milk casein micelles exposed to a temperature of more than 100°C (unpublished data). As for the free fat (FF) content, there was no significant difference ($p \leq 0.05$) between HH and LH camel's milk powder (table II).

The mean of wettability index for LH powder (55.7) was higher than that of HH powder (38.3). This trend was in agreement with another work reported by THOMAS *et al.* (1977) although the values attained in this study were considerably higher than the corresponding value for cow's skimmed milk powder.

The sinkability of LH powder was considerably higher than that of HH powder (70.6 vs 55.5), indicating that the high heat process exerted an adverse effect on wettability. These results were not in agreement with those reported by THOMAS *et al.* (1977) for cow's milk powder. This might be attributed to the decrease occluded air and size of LH camel's milk powder particles (unpublished data), resulting in a high sinkability value (THOMAS *et al.*, 1977; KING, 1965).

Whey protein nitrogen index of camel's FM (11.2) was higher than that of RLHM (7.2) and RHHM (4.8) powder (table III). However, these indices were higher than the corresponding ones for cow's milk powder (KNIPSCHILDT, 1986). The higher value obtained in this study could be attributed to the higher whey protein content of camel's milk (ABU-LEHIA, 1987).

Table III. Whey protein nitrogen index of low-heat and high-heat camel's skimmed milk powder*.

Type of milk	Whey protein nitrogen index (mg/g powder)		
	Min.	Max.	Average
Fresh milk	9.8	12.7	11.2 ± 1.8 a
Low-heat milk powder	6.2	9.1	7.2 ± 1.9 b
High-heat milk powder	4.1	5.7	4.8 ± 0.9 c

* Average of 5 replicates with ± standard deviation.

a, b, c: means in column not followed by the same letter are significantly different ($p \leq 0.05$).

Results of the sensory evaluation are presented in table IV. These results show that the smell and color of FM were significantly different ($p \leq 0.05$) from those of RLHM (8.75 and 8.71 vs 6.79 and 7.36 respectively), which in turn differed significantly ($p \leq 0.05$) from those of RHHM. These trends were in agreement with results of KIESEKER *et al.* (1985). In addition, body and taste of FM and both RLHM and RHHM were significantly different ($p \leq 0.05$). However, there was no significant difference ($p \leq 0.05$) between RLHM and RHHM.

The acceptability of recombined camel's milk might be improved by using LH milk powder partially replaced by FM. WHIPPLE (1983) reported that the acceptability of RM could be increased by replacing 50% of it with fresh milk in a study of cow's milk powder. There is a need for further studies to improve the quality of recombined camel's milk using evaporation before drying and agglomeration of particles of the powder.

Table II. Some physical and chemical characteristics of camel's skimmed milk powder*.

Type of milk powder	Fat (%)	Free fat (%)	Moisture (%)	Solubility index	Wettability	Skinability
Low-heat skimmed milk powder	2.30 ± 0.17 a	0.08 ± 0.02 a	3.32 ± 0.05 a	0.20 ± 0.03 a	55.7 ± 12.1 a	70.6 ± 10.2 a
High-heat skimmed milk powder	2.50 ± 0.15 a	0.10 ± 0.02 a	1.58 ± 0.02 b	0.29 ± 0.04 a	38.3 ± 8.5 b	55.5 ± 9.3 b

* Mean of 5 replicates ± standard deviation.

a,b: means in each column not followed by the same letter are significantly different ($p \leq 0.05$).

Table IV. Sensory evaluation of fresh and recombined camel's milk*.

Type of milk	Smell	Color	Body	Taste	Overall acceptability
Fresh milk (control)	a 8.57	a 8.71	a 8.50	a 8.57	a 8.57
Low-heat milk powder	b 6.79	b 7.36	b 7.93	b 6.57	b 6.57
High-heat milk powder	c 5.57	c 6.20	b 7.43	b 5.50	b 5.57

* Average of 5 replicates by 7 assessors.
a, b, c: means in each column not followed by the same letter are significantly different ($p \leq 0.05$).
Hedonic scale: 9 = like extremely; 1 = dislike extremely.

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Antimicrobial activity of camel's milk

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Abstract. The antimicrobial activity of camel's milk was compared with cow's milk using two different methods, plate count and disk inhibition zone. Eight microorganisms were used: *Escherichia coli, Proteus melanovogenes, Klebsiella pneumoniae, Streptococcus pyogenes, Staphylococcus aureus, Saccharomyces cerevisiae, Bacillus anthracis* and *Bacillus megaterium.* Results indicated a very high antimicrobial activity of camel's milk compared to cow's milk. This is obvious in plates containing 15 and 30% of camel's milk. More inhibition was observed with *E. coli* and *S. cerevisiae.* The disk inhibition zone method showed almost the same results. After separation of whey and casein in camel's milk, more inhibition was noticed with whey, which suggests a need for more investigation.

Key words. Dromedary, *Camelus dromedarius,* cow, milk, microbe, Libya.

Résumé. L'activité antimicrobienne du lait de chamelle a été comparée à celle du lait de vache en utilisant deux méthodes : le dénombrement bactérien et l'étude de la capacité à inhiber la croissance bactérienne sur gel. Huit micro-organismes ont été utilisés : *Escherichia coli, Proteus melanovogenes, Klebsiella pneumoniae, Streptococcus pyogenes, Staphylococcus aureus, Saccharomyces cerevisiae, Bacillus anthracis* et *Bacillus megaterium.* Les résultats montrent une activité microbienne élevée dans le lait de chamelle par rapport au lait de vache. Ceci est évident sur les essais contenant 15 et 30 % de lait de chamelle. Une inhibition plus importante a été observée avec *E. coli* et *S. cerevisiae.* La deuxième méthode d'évaluation a donné pratiquement les mêmes résultats. Après la séparation du petit lait et de la caséine dans le lait de chamelle, une inhibition maximale a été constatée avec le petit lait, ce qui conduit à mener d'autres recherches.

Mots clés. Dromadaire, *Camelus dromedarius,* vache, lait, microorganisme, Libye.

Introduction

Camel's milk is considered as one of the most valuable food in arid and semi arid areas (WILSON, 1984). It contains all the essential nutrients similar to that of cow's milk (FARAH, 1986). RAMET (1985) indicated a satisfactory self production system of camel's milk which inhibited natural acidification within about five hours compared to cow's milk. The inhibition of pathogenic bacteria (*Clostridium perfringens, Staphyloccocus aureus, Shigella dysenteriae*) by camel's milk was observed by BARBOUR *et al.* (1984), and it was related to the whey lysozyme and the stage of lactation. In 1988, DE VALDES *et al.* reported that lactoperoxidase, thiocyanate, hydrogen peroxidase (LP) system strongly reduce the activity of thermophylic starter culture in milk.

Until now, no much references are available in the area of camel's milk as compared to other animals; however, some references pointed the importance of camel's milk in treatment of some diseases especially tuberculosis and liver disorders. Therefore, more work is needed to investigate the antimicrobial activity of camel's milk against some important microorganisms and to determine which components of camel's milk are more active.

Materials and Methods

Camel's milk samples were obtained from El-Assa Camel's milk Project, about 160 km southwest of Tripoli, and cow's milk samples from the College of Agriculture experimental station, University of El-Fateh, Tripoli, Libya.

This study deals with one-humped dromedary camels, raised in the desert without any supplementary feed. The samples were collected under hygienic condition and sent immediatelly under refrigeration to the laboratory. All tests were carried as specified in reference (AMERICAN PUBLIC HEALTH ASSOCIATION, 1978).

After arrival, all samples were heated to 84°C for 15 minutes using hot water bath. Eight different microorganisms were used in this study: *Escherichia coli, Proteus melanovogenes, Klebsiella pneumoniae, Streptococcus pyogenes, Staphylococcus aureus, Saccharomyces cerevisiae, Bacillus anthracis* and *Bacillus megaterium.*

Comparing the antimicrobial activity of camel's milk with cow's milk was conducted by two methods, disk inhibition zone and total plate count.

For disk inhibition zone, plate count agar was sterilized at 121°C for 15 minutes, cooled to 40°C and inoculated with freshly prepared culture (10^6-10^7 CFU/ml) to yield a lawn of growth. After solidification of the agar, a sterilized filter disk (1 cm diameter) was dipped in camel's milk and another one in cow's milk, and each placed in one sector of the plate. After incubation at 32°C for 24-48 hours, the antimicrobial activity was measured as the zone of inhibition of microorganism growth around the disk (in mm).

For plate count agar method, the plate agar medium was prepared as a control, at the same time a media with 15% and 30% of camel's milk and of cow's milk were prepared. After preparation all media were sterilized at 121°C for 15 minutes, then cooled to 40°C, inoculated with 0,1 ml of each culture, and incubated at 32°C for 48 hours. The procedure followed was as indicated in AMERICAN PUBLIC HEALTH ASSOCIATION reference (1978). The same experiments were run for whey and casein. They were separated by heating the milk to 20°C, separating fat by centrifugal force at 2,000 rounds per minute for 10-15 minutes, then the pH was adjusted to pH 4.5 by hydrochloric acid for cow's milk and to pH 1.6 for camel's milk up to total separation which takes place within 2 to 8 hours. The pH is readjusted to 6.6 by sodium hydroxide before the experiment.

Results and Discussion

Results for plate count method are shown in table I. It is obvious that camel's milk has a stronger antimicrobial activity compared to cow's milk; there is a reduction in total count as camel's milk is added to the medium. As the percentage of camel's milk added increases, the inhibition increases. Cow's milk causes less inhibition. The inhibition was strong against *E. coli* and *S. cerevisiae*. In all samples where camel's milk was added the colonies were very small in size and this needs more investigation.

Table I. Antimicrobial effect of camel's and cow's milk by total plate count technique (CFU/ml x 10^4); n=4.

Micro-organism used	Control	Camel's milk		Cow's milk	
		15%	30%	15%	30%
1	300	18	11	100	120
2	250	130	100	150	140
3	260	100	80	170	140
4	230	56	50	150	130
5	280	50	90	80	160
6	300	25	20	70	90
7	200	50	40	80	150
8	290	90	60	150	110

1. *E. coli*; 2. *K. pneumoniae*; 3. *P. melanovogenes*; 4. *S. aureus*; 5. *S. pyogenes*; 6. *S. cerevisiae*; 7. *B. anthracis*; 8. *B. megaterium*.

Results of disk inhibition zone method are shown in table II. The inhibition zone was clearer with *E. coli, K. pneumoniae, P. melanovogenes* and *Sacharomyces cerevisiae*, and this correlates very well with results of total plate count.

Table II. Antimicrobial effect of camel's and cow's milk by disk inhibition zone technique (mm); n=4.

Microorganism used	Camel's milk	Cow's milk
1	7	3
2	12	2
3	11	2
4	9	1
5	4	-
6	11	2
7	6	-
8	4	-

Table III shows results for whey and casein by disk inhibition zone technique. It is clear that whey has more effect than casein, this correlate with BARBOUR *et al.* (1984). The inhibition was maximum with *K. pneumoniae, S. cerevisiae, S. aureus, P. melanovogenes* and *B. anthracis*. Inhibition due to casein was less effective and this is due to the fact that camel's milk whey contains more antimicrobial components than casein (BARBOUR *et al.*, 1984).

Table III. Antimicrobial effect of camel's milk whey and casein by disk inhibition zone technique (mm); n=4.

Microorganism used	Camel's milk whey	Cow's milk casein
1	9	6
2	15	8
3	13	11
4	12	8
5	8	0
6	11	8
7	11	7
8	6	0

In conclusion, there is an antimicrobial compound in camel's milk against many microorganisms and this effect increases as separation of whey takes place. This do certify the presence of high antimicrobial compounds in whey, thus more study is needed to isolate the fractions responsible for this effect.

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Camel's (*Camelus dromedarius*) milk: properties important for processing procedures and nutritional value

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Abstract. Milk collected from individual camels of a single herd at the same occasion showed large variation in composition. Special attention should be paid to the fact that camel's milk, besides the essential poly-unsaturated fatty acids, linoleic (C18:2) and linolenic (C18:3) acids, contains high contents of the mono-unsaturated fatty acids, palmitoleic (C16:1) and oleic (C18:1) acids. The casein in camel's milk appeared to contain similar types of cheese proteins as cow's milk, α_{s1}-, α_{s2}-, ß- and κ-casein. There was evidence that the amount of a κ-casein like fraction was positively related to the coagulation rate of fresh camel's milk. Rennet coagulation of native camel's milk resulted in soft flocks, suitable for making soft cheese. Addition of a dromedary cheese whey culture to the same milk reduced the rennet clotting time, a firm and consistent curd was formed and a *Grana* type hard cheese could be made. The yield was 5 kg/100 l of milk. About 50% of the milk fat, mounting to ≥ 2%, remained in the very nutritious camel cheese whey.

Key words. Dromedary, *Camelus dromedarius*, milk, casein, coagulation, cheese, Somalia.

Résumé. Le lait collecté sur des chamelles sélectionnées dans un même troupeau et au même moment montre une grande différence de composition. Le lait de chamelle présente certaines caractéristiques de composition. En plus des acides gras polyinsaturés essentiels comme l'acide linoléique, et l'acide linolénique, ce lait contient de fortes proportions d'acides gras monoinsaturés comme l'acide palmitoléique, ainsi que de l'acide oléique. La caséine du lait de chamelle montre les mêmes types de protéines fromagères que dans le lait de vache : α_{s1}-, α_{s2}-, β- et κ-caséine. Il est montré que la quantité de κ-caséine (et de ses fractions homologues) est corrélée au degré de coagulation du lait de chamelle frais. La coagulation après emprésurage du lait de chamelle fournit une masse molle utilisable pour la fabrication de fromage à pâte molle. L'ajout du lactosérum réduit le temps de coagulation, et conduit à un caillé ferme et consistant pouvant fournir un fromage de type pâte dure tel que le *Grana*. Le rendement fromager est de l'ordre de 5 kg/100 l de lait. Environ 50 % des matières grasses laitières disponibles restent cependant dans un lactosérum riche en nutriments, contenant environ plus de 2 % de matières grasses.

Mots clés. Dromadaire, *Camelus dromedarius*, lait, caséine, coagulation, fromage, Somalie.

Introduction

The present work was a part of the multidisciplinary Somali camel research project performed as a joint Somali/Swedish undertaking over the years 1982-1990. It was evident that increased knowledge about the properties of camel (*Camelus dromedarius*) milk is a prerequisite for estimation of the nutritional value and for development of camel milk based dairy technology. Specific problems with respect to cheese-making were encountered (WILSON, 1984; YAGIL, 1982). The present work concerned chemical composition in general (MOHAMED, 1985; MOHAMED, 1993), and special attention was paid to the cheese proteins (LARSSON-RAZNIKIEWICZ and MOHAMED, 1986; MOHAMED and LARSSON-RAZNIKIEWICZ, 1991), the caseins, and their contribution to the curdling properties of camel milk (LARSSON-RAZNIKIEWICZ and MOHAMED,1993; MOHAMED *et al.*, 1989). Preliminary trials to make hard cheese were successful (MOHAMED *et al.*, 1990).

Materials and Methods

Composition

Milk samples from 12 camels (*Camelus dromedarius*) were collected in the area between Wenle-Weyn and Bur-Hakaba, northwest of Mogadishu. Once the samples reached the laboratory, pH at room temperature (27°C), density at 15°C and general composition were determined (MOHAMED, 1985; MOHAMED, 1993).

The nitrogen contents were determined (by the Kjeldahl method) in full milk and in milk being depleted its protein (precipitated with 24% trichloroacetic acid) to be able to estimate the protein and non-protein nitrogen contents.

Fat contents were determined by the Gerber method. The contents of total solids were estimated using Richmond's formula, which is based on the relation between the density and the fat contents.

For fatty acid determination (MOHAMED, 1993), the milk sample was heated at 37°C for 30 minutes, the fat was then removed from the skimmed milk, after centrifugation at 3,000 x g for 30 minutes at 2°C, extracted with ether and hexane and saponificated. The fatty acids were re-esterificated with methanol and analysed by gas liquid chromatography.

For determination of ash, 10 ml of milk was introduced into a capsula and heated to dryness in a water-bath at 100°C. The residue was introduced into a muffle and ignited at 530-550°C to constant weight (MOHAMED, 1985; MOHAMED, 1993).

The ash was analysed for minerals (MOHAMED, 1993) by atomic absorption spectrometry and for phosphorous by a colorimetric method.

Effects of heat treatment on the casein fraction (MOHAMED and LARSSON-RAZNIKIEWICZ, 1991)

The milk samples were from the Jezira area, about 15 km south of Mogadishu. The milk was divided into two equal parts. One part was kept in a water-bath at 35-37°C for 30 minutes and then centrifuged at 3,000 x g for 30 minutes to remove fat. The other part was heat-treated at 73-75°C for 10 minutes immediately cooled to 37°C and then centrifuged to remove fat. The casein was prepared by acidification to pH 4.6 (standard procedure).

Coagulation time

Rennet tablets were from Chr. Hansen's laboratory, Copenhagen. One tablet (should curdle about 100 l of cow's milk) was dissolved in about 25 ml of cold distilled water containing a few grains of salt (MOHAMED *et al.*, 1990). Alternatively a solution (5 mg/ml) of calf stomach chymosin (from Sigma) was used. Milk (1 ml) was placed in a bifurcated glass tube and warmed at 32-35°C for 30 minutes. An aliquot (1-6 ml) of rennet solution was then added. The coagulation time was determined visually as the time taken for the first solid particles to appear in the moving film on the glass wall.

Cheese-making trials (MOHAMED *et al.*, 1990)

Cheese whey culture of dromedary milk was used as starter. This was obtained from a previous cheese-making trial in which a whey culture of cow milk was used. After removing the curd the whey culture was incubated for about 18 hours at room temperature (27°C) and then stored in a refrigerator (4°C). The pH was about 3.5.

For primary cheese-making trials 10 ml of milk was warmed at 32-35°C for 30 minutes, rennet solution (5 ml) was added. The type of coagulum formed was tested visually to decide the conditions for cheese-making in larger scale.

Milk (3-5 l) was poured into small vats and warmed at 32-35°C for 30 minutes. The whey culture (100 ml) and rennet solution (1.5 ml) were then introduced. The curd was cut into pieces with steel wire, 6.3 mm in diameter, and stirred for 10-15 minutes to permit it to float freely in the whey. The temperature was raised to 42°C and held for 15 minutes. The mixture was then scalded for 15 minutes by heating to 52°C. The whey was removed. The curd was collected in a cloth and pressed into a mould, then transferred into steel hoops and kept for about 6 hours, while being turned and pressed. The steel hoops were removed and the cheese was dressed in wooden bands for about 18 hours at 22°C, turned regularly. Dry salt was rubbed on the surface of the cheese, which was left for 24 hours, floated in brine (15%) for a week, and left to ripen for 5 days at 18°C, turned daily, removed to another ripening room for 5 days at 12°C and then stored at 8°C.

Results

In milk samples collected the same day from 12 camels in an area northwest of Mogadishu in May 1984 the following values were obtained:

❒ **General composition** (MOHAMED, 1985; MOHAMED, 1993). Individual values ranged as follows, in percentage (w/v), protein 2.0-4.2, fat 2.5-6.2, total solids 11.1-14.6 and ash 0.4-1.0. Average values are presented in table I.

❒ **Mineral composition** (MOHAMED, 1993). Individual values ranged as follows, in mg/100 ml of milk, calcium 55-113, magnesium 2.6-6.4, sodium 22-69, potassium 92-288, iron 0.05-0.10, zinc 0.16-0.52, copper 0.01-0.08 and phosphorous 34-75. Average values are presented in table II.

❒ **Fatty acid composition** (MOHAMED, 1993). Individual values ranged as follows, in percentage (w/v), C4:0 0-0.1, C6:0 0.1, C8:0 0.1, C10:0 0.1-0.2, C:12:0 1.0, C14:0 9-14, C16:0 28-33, C16:1 6-11, C18:0 13-21, C18:1 26-30, C18:2 2, C18:3 1.2-1.9. Average values are presented in table III.

Table I. pH, density (g/ml) and general composition [%, weight per volume (w/v)] of camel's milk from different countries (from MOHAMED, 1985; MOHAMED, 1993).

Country	pH	Density	Protein	Fat	TS	NFTS	Ash
Somalia, average	6.5	1.026	3.0	4.6	13.1	8.4	0.60
Saudi Arabia (SAWAYA *et al.*, 1984)	6.5	–	3.0	3.6	–	–	0.79
India (DESAL *et al.*, 1982)	6.5	1.026	2.7	3.2	9.8	6.6	0.60
Sudan (EL-AMIN, 1979)	–	–	3.6-4.7	4.0-5.5	–	–	0.8-1.0
Libya (GNAN and SHERIHA, 1986)	6.8	–	3.3	3.3	–	–	0.82
Egypt (HASSAN *et al.*, 1987)	6.4	1.028	0.4	3.5	10.9	7.4	0.81
Ethiopia (KNOESS, 1977)	–	–	4.5	5.5	14.4	8.9	0.90

TS = total solids; NFTS = non-fat total solids content.

Table II. Mineral composition (mg/100 ml) of camel's milk from different countries (from MOHAMED, 1993).

Country	Ca	Mg	Na	K	Fe	Zn	Cu	P
Somalia, average	76	4	39	161	0.07	0.28	0.03	49
Saudi Arabia (SAWAYA *et al.*, 1984)	106	12	69	156	0.26	0.44	0.16	63
Libya (GNAN and SHERIHA, 1986)	131	14	27	45	0.04	0.012	0.0014	51
Egypt (HASSAN *et al.*, 1987)	116	8	36	62	–	–	–	71

Table III. Fatty acid composition [%, weight per volume (w/v)] of camel's milk fat from different countries (from MOHAMED, 1993).

Acid	Somalia average	Kenya (FARAH *et al.*, 1989)	Egypt (HAGRASS *et al.*, 1987)	Saudi Arabia (SAWAYA *et al.*, 1984)[a]	Libya (GNAN and SHERIHA, 1986)	Cow's milk (HAGRASS *et al.*, 1987)
4:0	0.08	0.63	1.26	0.0	0.7	3.30
6:0	0.10	0.36	1.24	0.1	–	1.60
8:0	0.10	0.29	1.97	0.1	0.2	1.30
10:0	0.15	0.87	3.21	0.1	0.3	3.00
10:1	–	0.17	–	–	–	–
12:0	0.94	0.81	3.86	0.7	0.8	3.10
12:1	–	–	–	–	0.1	
13:0	–	–	–	0.2	0.1	
14:0	11.50	12.75	13.30	9.8	10.4	9.50
14:1	–	1.15	0.62	1.4	1.5	–
15:0	–	1.23	–	1.6	0.9	–
15:1	–	0.25	–	–	–	–
16:0	31.20	31.75	40.88	25.8	29.0	26.3
16:1	8.20	10.30	1.43	10.5	9.9	2.30
17:0	–	0.83	–	1.2	0.6	–
17:1	–	0.55	–	–	0.6	–
18:0	17.30	12.75	5.54	11.9	12.0	14.60
18:1	27.04	19.54	26.08	27.1	27.0	29.80
18:2	1.91	3.42	0.49	3.8	2.6	2.50
18:3	1.52	1.41	–	3.7	–	–
20:0	–	0.96	–	0.7	0.2	–

[a] 1.5% of acids 20:2, 20:4, 20:5, 22:0, 23:0, 24:0 and 24:1.

❒ **Caseins.** Amino-acid analyses of casein fractions (isolated from acid precipitated casein by anion-exchange chromatography) indicated (LARSSON-RAZNIKIEWICZ and MOHAMED, 1986) that similar caseins occur in milk from camel and cow, α_{s1}-, α_{s2}-, ß- and κ-casein. Anion-exchange chromatography (figure 1) and gel electrophoresis (at neutral and basic pH, respectively) showed that the α_{s1}- and ß-caseins in camel milk had lower negative charges than their counterparts in cow milk. κ-casein appeared mainly to have a corresponding higher negative charge.

The amount of a κ-casein related fraction, corresponding to peak I in figure 2b (isolated from acid precipitated casein by gel filtration on Sephacryl S-300 in urea under non-reducing conditions, when κ-caseins were supposed to aggregate) appeared (MOHAMED *et al.*, 1989) related to the coagulation rate of fresh camel milk (figure 2c).

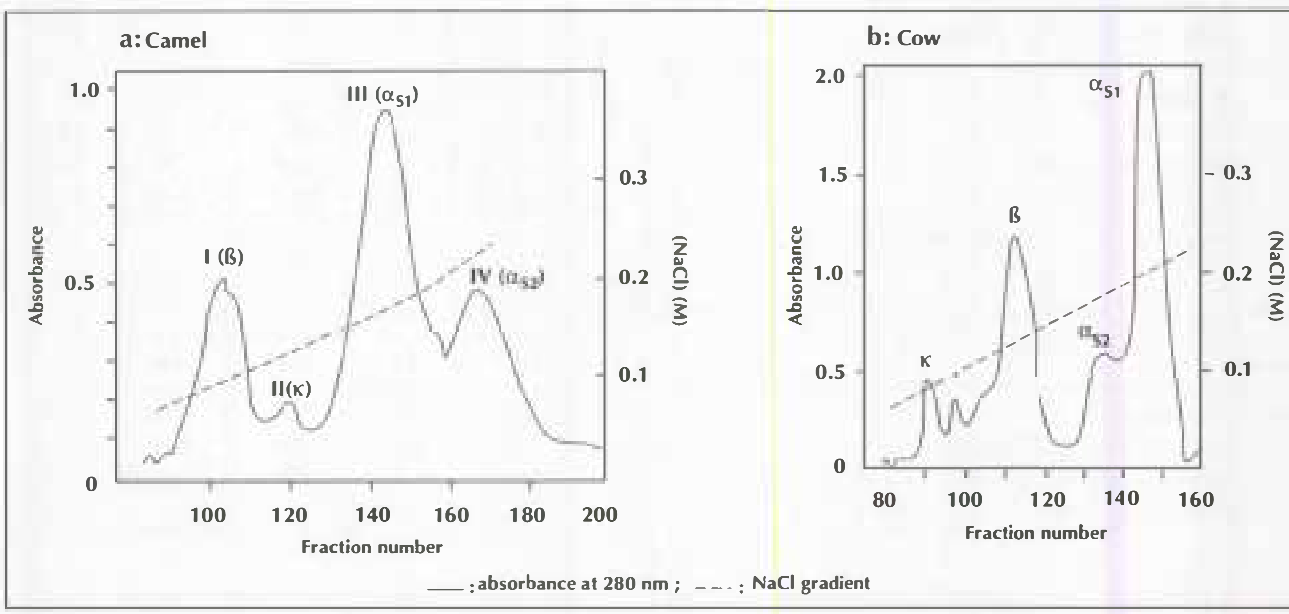

Figure 1. *Ion exchange chromatography on DEAE-cellulose of acid precipitated casein (150-200 mg) from camel's* **(a)** *and cow's* **(b)** *milk. Column dimensions: 30 x 4 cm; flow rate: 8 ml/h; fraction volume: 6* **(a)** *and 7* **(b)** *ml. (From* LARSSON-RAZNIKIEWICZ *and* MOHAMED, *1986.)*

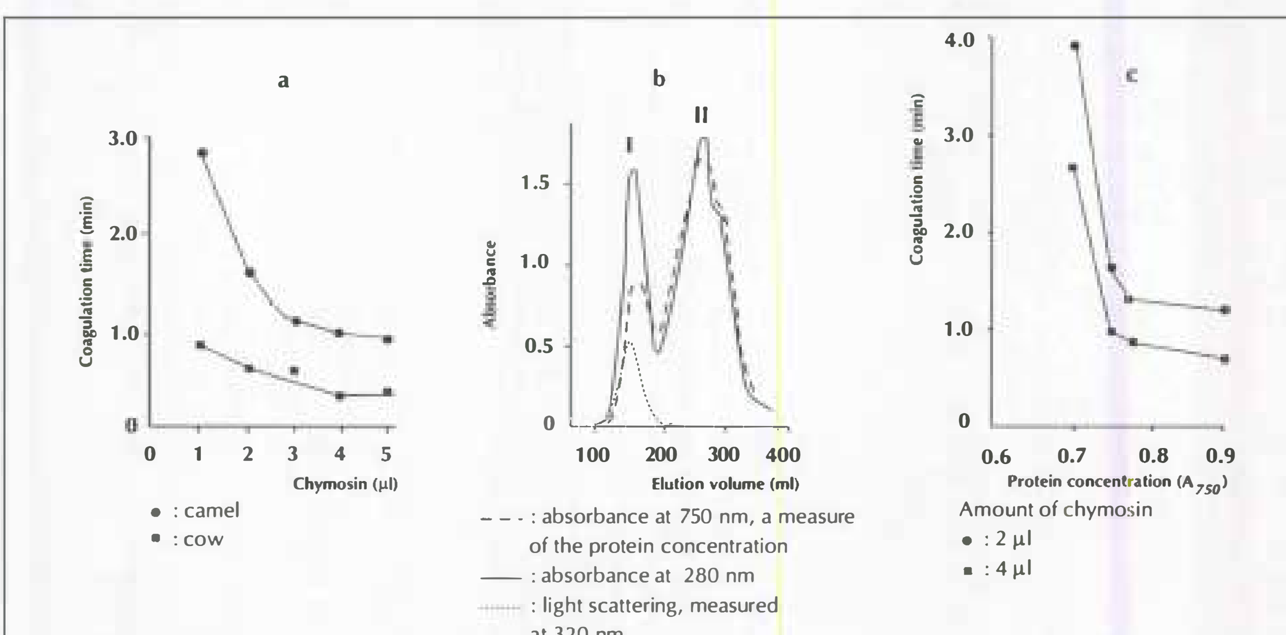

Figure 2. a: *coagulation time for milk from camel and cow at varying concentration of chymosin.* ***b:*** *camel's milk casein after gel filtration chromatography on Sephacryl S-300.* ***c:*** *coagulation time versus the protein content in peak I (figure 2b) of four individual camel's milk samples. (From* MOHAMED *et al., 1989.)*

More of that fraction caused decreased coagulation time of fresh camel milk. Heat-treatment for 10 minutes at 73-75°C increased the amount of protein in the κ-casein related fraction (MOHAMED and LARSSON-RAZNIEKIEWICZ, 1991), thus complementary studies are needed.

❒ **Rennet coagulation of full milk** (MOHAMED *et al.*, 1990). Rennet treatment of camel milk, containing 130 mg of calcium/100 ml of milk, caused precipitation in form of soft flocks to occur.

Milking containers are generally disinfected with firewood of special trees, such as *Acacia horrida benadirensis*. That gives milk a smoked flavour. Rennet treatment of that milk caused formation of soft flocks also. The rennet clotting time of smoked milk was somewhat shorter than of non-smoked milk. The latter phenomenon was probably linked with the fact that the pH of smoked milk was 0.1-0.2 units lower than of non-smoked milk (FARAH and BACHMAN, 1987; RAMET, 1987). Smoked milk was used in the following section.

❒ **Trials of making hard cheese** (MOHAMED *et al.*, 1990). Rennet coagulation of native camel milk formed a curd suitable for making soft cheese (table IV). If a dromedary cheese whey culture was added to the same milk before rennet was introduced the coagulation time of camel's milk was shortened, and a firm, consistent, coagulum was formed and a hard cheese could be made (table IV). Addition of calcium ions had no effect in the present case. The characteristics (texture and hardness) of the cheese (figure 3) closely resembled those of the *Grana* cheese (SCOTT, 1986) made from cow's milk. The cheese yield was 5 kg/100 l of camel milk. About half of the fat in the milk was left in the whey, which contained ≥ 2% of fat (bulk milk from the same herd at three different occasions) (table V). Whey from cow milk usually contains 0.05-0.4% of fat (WALSTRA and JENNESS, 1984). The whey drainage was white, not yellow, as in the case of whey from cow milk. Also when acid precipitated casein was prepared from camel milk a white whey was obtained. Heating to about 80°C made the whey proteins to precipitate and a clear yellow solution remained.

Table IV. Effects of calcium and whey culture on coagulation time (CT) and type of cheese (from MOHAMED *et al.*, 1990).

Sample	$CaCl_2 . 2H_2O$ (mg)	Whey culture (ml)	CT (min)	Cheese
I	0	0	35	Soft
I	0	100	30	Hard
I	250	100	30	Hard
II	0	0	35	Soft
II	0	100	30	Hard
II	250	100	30	Hard
III	0	100	30	Hard
III	417	100	30	Hard

Smoked milk was collected on 3 different occasions, I-III; 3 litres of I and II and 5 litres of III were used; the same amount of rennet solution (1.5 ml) was used in all experiments.

Table V. Parameters of the smoked dromedary milk used for producing hard cheese (from MOHAMED *et al.*, 1990).

Sample	pH	Density (g/ml)	Fat (%)	
			Milk	Whey
I	6.5	1.024	4.2	2.2
II	6.5	1.026	4.2	2.0
III	6.5	1.025	4.3	2.3

The samples are identical with those given in table IV.

Discussion

Composition

Large variation in general composition of milk samples from individual camels in the same area was found. The lactation stage, which to large extent influences the composition, was unknown. The number of lactation varied from three to eight. An important point is that

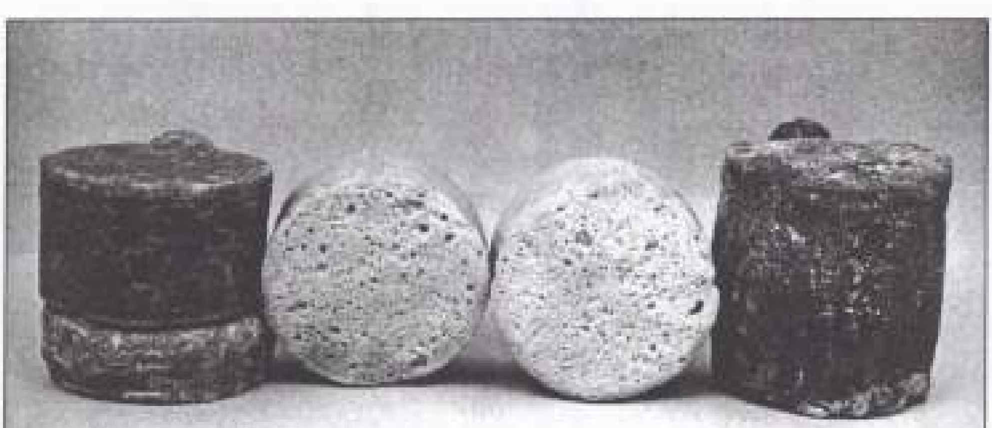

Figure 3. *Characteristics of hard cheese from dromedary's milk. The colour varies from white to dark grey, due to smoking of the milking containers. (From* MOHAMED *et al., 1990, with authorization.)*

the individual values, as the average values, were close to those reported by others (table I). The average values were even not far from those obtained for cow's milk (ABU-LEHIA, 1987). Of note is that the calcium and magnesium contents were very low (table II), possibly due to, for example, quality or availibility of drinking water and/or fodder in the area where the milk samples were collected in May 1984. YAGIL and ETZION (1980) showed that at the end of a dehydration period the calcium and magnesium values approached these low values. From data in table I, it appeared that the water content was about 87%, close to the values found (YAGIL and ETZION, 1980) for hydrated camels. It has been shown (FARAH and BACHMANN, 1987) that addition of calcium ions improve the coagulation properties. Our cheese-making experiments were made on milk that was fairly high in calcium, 130 mg/100 ml. A careful test of effects of calcium and also magnesium on the cheese-making properties might still have been important.

Very small amounts of low-chain fatty acids (C4-C10) were obtained, similar to values earlier presented for camel's milk from Saudi Arabia (table III). The content of poly-unsaturated fatty acids was similar to what was found in cow's milk, and as in cow's milk the monosaturated oleic acid, C18:1, content was very high. It might be of interest to note that the content of mono-unsaturated palmitoleic acid, C16:1, was about three times as high in camel as in cow's milk. Special attention should be paid to the mono-unsaturated fatty acids, as they are thought to possess important nutritional qualities.

κ-caseins importance for the size distribution of casein micelles and for the coagulation properties

The κ-casein is very important for the stability (homogeneity) of milk. In native milk it protects the casein micelles from forming a curd, properties that κ-casein looses, for example after treatment with rennet (or any other similar enzyme/enzyme system) or after acidification of milk. In both cases, a cheese curd is formed but the mechanisms for curd formation is different depending on the cheese products produced (compare hard and soft cheese with cottage cheese, respectively). For the same coagulation rate camel's milk was shown to need more rennet or chymosin (the main clotting enzyme in rennet) than did cow's milk (figure 2a), sometimes much more (MOHAMED *et al.*, 1990; WILSON, 1984). A higher κ-casein content appeared to decrease the coagulation time, for both camel (figure 2c) and cow's milk (figure 4), probably via an indirect effect on the size distribution of the casein micelles (EKSTRAND *et al*, 1980; EKSTRAND *et al.*, 1981). Increasing amount of κ-casein contributes to increase number of smaller casein micelles.

As shown in the present paper the calcium content can vary a lot. Also calcium ions are needed for the casein micelle formation. They are important for the micellar size (MUNYA and LARSSON-RAZNIKIEWICZ, 1980), as well as for the coagulation phase. The coagulation rate was suggested to be related also to the citrate content (EKSTRAND *et al*, 1981), probably an effect on the free calcium concentration, which affects for example the parameters discussed in the present section of this paper.

Breed differences in many of the above parameters certainly cause variation in coagulation properties. That was obvious in comparative studies of milk from different breeds of cattle (EKSTRAND *et al.*, 1981).

Cheese-making trials (MOHAMED *et al.*, 1990)

A *Grana* type of hard cheese was produced. *Grana* cheese from cow's milk is usually made from low-fat milk (2.8-3.2%), obtained by mixing whole milk and

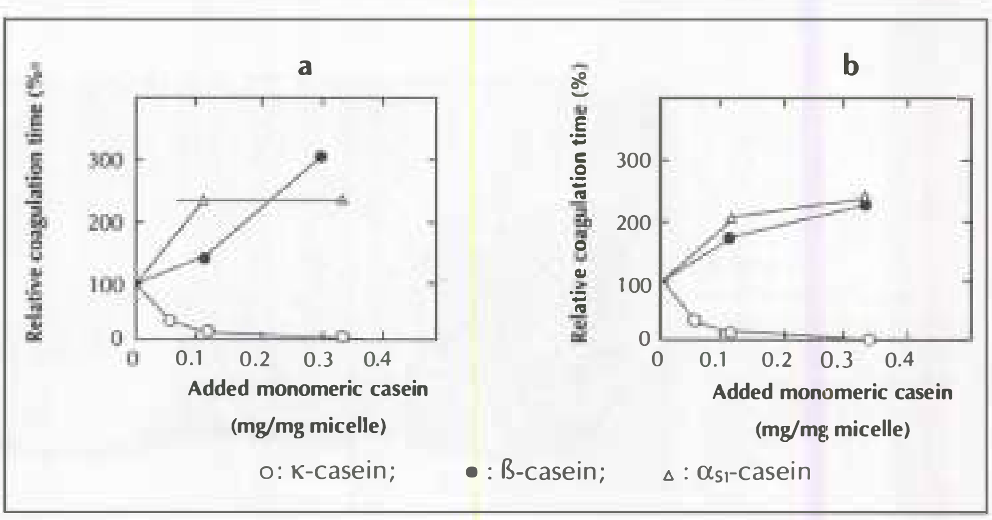

Figure 4. *Coagulation time of isolated cow casein micelles incubated with increasing amounts of various monomeric caseins before the coagulating enzyme chymosin (**a**) or rennet (**b**), respectively; was added: κ–casein; ß-casein; α_{s1}-casein. (From EKSTRAND* et al.*, 1980.)*

skimmed milk (SCOTT, 1986). That results in cheese containing 35-38% of fat. Such semi-fat cheese appeared to be obtained from dromedary's milk without standardization, using bulk's milk. Because of its high fat and protein contents, the whey from dromedary's milk is very nutritious. It should be suitable for preparation of other milk products.

Conclusions

Dromedary's milk has a very good nutritional status. It is mostly consumed fresh or sour. To make cheese should be to preserve and to concentrate the most essential components of the milk and at the same time to produce a highly nutritious food. The present results demonstrated that it is possible to make cheese from dromedary's milk, even hard cheese. Possibilities to make soft cheese were presented by others (FARAH and BACHMANN, 1987; MEHAIA, 1993; RAMET, 1987). In Nouakchott, a dairy factory has been put up in order to pasteurize and to make cheese of camel's milk (ABEIDERRAHMANE, 1993). Still some work, including both basic and empirical research, is needed to find the standard conditions for the cheese-making at optimal conditions and to use the whey, which appeared to be very nutritious.

A dromedary can find pasture in arid land at very severe drought, and still produce milk, but the milk composition varies a lot with the environmental conditions. That is probably one of the reasons to the diverging results, more or less positive, of studies on coagulation properties and cheese-making presented by different researchers. Questions arise how to take care of the special characters of a dromedary and to serve mankind in a proper way.

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Soft cheeses from dromedary camel's milk

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Abstract. Two experiments on the manufacture of soft cheeses from camel's milk were carried out in Saudi Arabia. In the first experiment, camel's milk with different percentages of fat, salt and two lactic starter cultures were used. In the second experiment, soft cheese was made from camel's, cow's milk and from a mixture of both. Chemical composition, components recovery, yield and organoleptic evaluation of the cheeses were compared. Composition of soft cheeses obtained from camel's milk compared favorably with Domiati cheese composition obtained with cow's milk. Among cheeses made with camel's milk, the yield was highest with cheeses made from milk with starter cultures (1.5% fat and 3% salt), whereas the yield was lowest with whole milk (3.9% fat and 0% salt). The average fresh cheese yield obtained from camel's milk was about 65% of that obtained from cow's milk. In general, the greatest soft cheese yields were accompanied by higher recovery of milk solids. However, more than 55% of the milk total solids was retained in the whey during soft cheese making with camel's milk. Taste panel results indicated that the cheese made from 100% cow or from 75% cow and 25% camel's milk were the most acceptable, whereas the least acceptable cheeses were those made from whole camel's milk. Yields, component recovery and overall acceptability of cheeses were significantly improved by increasing the ratio of cow to camel's milk in cheese milk. However, more research is needed to improve the quality and the yield of this type of cheese.

Key words. Dromedary, *Camelus dromedarius*, soft cheese, cheese making, camel's milk, cow's milk, organoleptic analysis, Saudi Arabia.

Résumé. Deux expériences de fabrication de fromages à pâte molle à base de lait de chamelle ont été menées en Arabie Saoudite. Dans la première expérience, divers laits à différentes teneurs en matières grasses et en sel, ainsi que deux *starters* de culture lactique ont été utilisés. Dans la deuxième expérience, le fromage à pâte molle était fabriqué à partir de lait de chamelle, de lait de vache et d'un mélange des deux. La composition chimique, le pouvoir de rétention en constituants nobles du lait, le rendement et l'évaluation organoleptique des fromages ont été comparés. La composition des fromages à pâte molle obtenus à partir du lait de chamelle a été favorablement comparée à celle du fromage Domiati obtenu avec du lait de vache. Parmi les fromages fabriqués avec du lait de chamelle, le rendement était le plus élevé avec ceux fabriqués avec des *starters* culturaux (1,5 % de matières grasses et 3 % de sel), tandis que le rendement fromager était le plus faible avec du lait entier (3,9 % de matières grasses et 0 % de sel). Le rendement moyen du fromage frais obtenu à partir du lait de chamelle était d'environ 65 % de celui obtenu à partir du lait de vache. En général, les rendements les plus élevés de fromage à pâte molle étaient accompagnés d'une meilleure récupération de matière solides nobles du lait. Cependant, plus de 55 % du total des matières solides lactées sont retenues dans le petit lait pendant la fabrication du fromage à pâte molle utilisant du lait de chamelle. Les résultats des analyses sensorielles sur panels de consommateurs ont montré que les fromages fabriqués à partir de 100 % de lait de vache, ou à partir de 75 % de lait de vache et 25 % de lait de chamelle sont les mieux acceptés, alors que les fromages les moins bien acceptés sont ceux fabriqués uniquement avec du lait de chamelle. Les rendements, la rétention des composés solides du lait et le goût manifesté pour les fromages étaient significativement accrus en augmentant la part du lait de vache par rapport à celle du lait de chamelle. Cependant, des recherches complémentaires sont nécessaires afin d'améliorer la qualité et le rendement de ce type de fromage.

Mots clés. Dromadaire, *Camelus dromedarius*, fromage à pâte molle, fabrication fromagère, lait de chamelle, lait de vache, analyse organoleptique, Arabie Saoudite.

Introduction

The total population of camels in the world is about 19 million of which 14 million are in Africa and 4.9 million in Asia (FAO/WHO/OIE, 1992). The vast majority of camels are dromedaries (one-humped *Camelus dromedarius*) and found particularly in desert arid areas, whereas Bactrians (*Camelus bactrianus*, two-humped camels) are more prevalent in the cooler areas (CHAPMAN, 1987). The population of camels in Saudi Arabia is estimated to be 0.6 million (CHAPMAN, 1987);

most of their milk is consumed fresh, as raw milk, or when soured. However, most Bedouin families pool the surplus camel's milk with goat's milk and convert it to a dry fermented product, *"oggtt"* (AL RUQAIE *et al.*, 1987). However, pasteurized camel's milk has been introduced recently to the local Saudi Arabian market.

Although camel's milk has been consumed for centuries, camel's milk products are not common. However, the recent manufacture of camel's milk products, such as ice cream (ABU-LEHIA, 1989), butter (FARAH *et al.*, 1989) and fermented camel's milk (FARAH *et al.*, 1990), has been reported. Reports of possible methods for cheese making from camel's milk are rare and often contradictory. Some authors (FARAH and BACHMANN, 1987; LARSSON-RAZNIKIEWICZ and MOHAMED, 1986; MEHAIA, 1992; MEHAIA *et al.*, 1988; RAMET, 1987; RAMET, 1989; WILSON, 1984; YAGIL, 1987) reported that the addition of calcium chloride and rennet to camel's milk caused a clotting reaction and allowed the formation of a soft light coagulum; but others (GAST *et al.*, 1969) stated that camel's milk alone cannot be coagulated with rennet. However, RAO *et al.* (1970) and YAGIL (1982) reported that cheese can be successfully produced from camel's milk, but only after it is mixed with the milk of other species (goats, ewes, or buffalo). Morever, MOHAMED *et al.* (1990) reported that hard cheese could be made from camel's milk if whey culture is included.

The aim of this report is to summarize and evaluate the author's recent work (MEHAIA, 1993*a*; MEHAIA, 1993*b*) on the manufacture of soft cheeses (Domiati-type) from dromedary camel's milk.

Materials and Methods

Materials

Fresh milk samples were obtained from both the Majaheim dromedary camel's herd, and the Friesian cow's herd of King Saud University, Riyadh, Saudi Arabia. Milk was immediately cooled to 5°C, transported to the pilot plant of the Department of Food Science and maintained cold until used. Camel's skimmed milk was prepared by separation of raw camel's milk at 43°C, using an Electrem 1 Separator (Electro Ecremeuse Constructeur, France). Rennet powder, calcium chloride, yoghurt B-6 starter (a mixed strain of *Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*) and lactic fermentation CH-normal 01 starter (a mixed strain of *Lactococcus lactis* ssp. *cremoris*, *Lactococcus lactis* ssp. *lactis* and *Lactococcus lactis* ssp. *diacetylactis*) were obtained from Chr. Hansen's Laboratories A/S (Copenhagen, Denmark). Salt was obtained from a local market.

Cheese making

Two experiments were conducted to study the manufacture of soft cheese from camel's milk. In the first experiment, camel's milk was used alone, in four trials, to produce soft cheeses using three different methods (figure 1) as described by MEHAIA (1993*a*). In the second experiment, a study has been carried out in an attempt to improve quality and yield of soft camel's milk cheeses by mixing camel's milk with cow's milk as described by MEHAIA (1993*b*). Table I summarizes the treatments used to manufacture cheese samples. Each trial was designed as a randomized complete block design according to SNEDECOR and COCHRAN (1967).

Chemical analysis

Milk, whey and cheese samples were analyzed for moisture, fat, salt, and total nitrogen, as described by LING (1963). Lactose was calculated by difference. Titratable acidity, pH and ash were determined according to AOAC (1980). Cheese yields were calculated as a weight of cheese divided by weight of milk expressed as percentage. Component (protein, fat and milk total solids) recovery was calculated as the weight of the component in the cheese divided by the original weight of the component in the milk expressed as a percentage.

Organoleptic evaluation

Organoleptic evaluation of cheeses was performed after one day of storage at 5 + 1°C. The acceptability of the cheese samples was assessed by a panel of 15 University faculty staff members and students who were familiar with the soft cheese (Domiati-type). Sensory attributes of appearance, texture, flavour and overall acceptability were considered by the panelists. A 1-9 point hedonic scale (STONE and SIDEL, 1985) was utilized in this study (with 9 = like extremely, 5 = neither like nor dislike, and 1 = dislike extremely). Panelists were also asked to list defects, if any were detected. The cheeses in each trial were randomly coded and served at one time. Sensory attributes were analyzed for significance along with the other measurements as described below.

Statistical analysis

Results from the cheese-making trials were analyzed using analysis of variance of the SAS package (SAS, 1985). Standard error of the means was derived from the error mean square term of the ANOVA. If the F test for the treatments within each trial was significant ($P < 0.05$), a protected least significant difference test (LSD) was used to compare treatments.

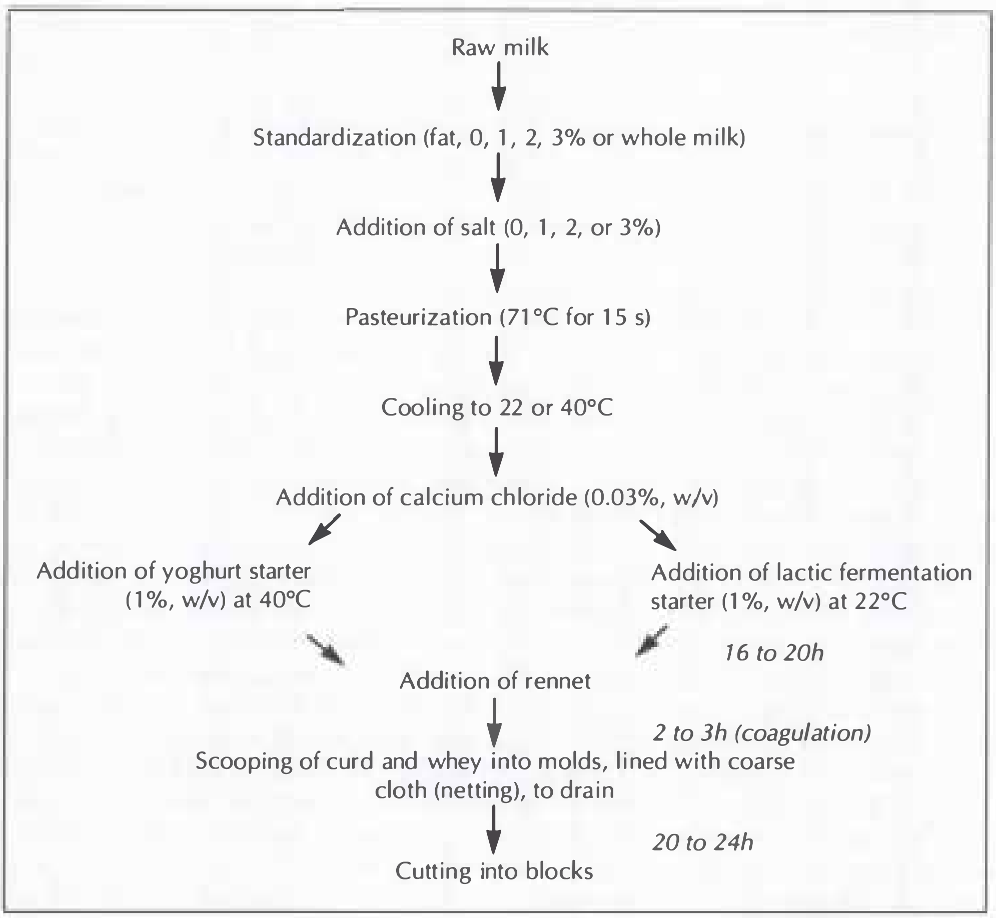

***Figure 1.** Manufacturing procedures for fresh soft cheese from camel's or cow's milk using different percentage of salt and fat, with or without yoghurt or lactic fermentation starter culture.*

Trial N°	Treatment N°	Description
Experiment 1, cheese from camel's milk		
1	1	Whole milk and 0% salt
	2	Whole milk and 1% salt
	3	Whole milk and 2% salt
	4	Whole milk and 3% salt
2	1	Milk, 3% salt and 0.3% fat
	2	Milk, 3% salt and 1.0% fat
	3	Milk, 3% salt and 2.0% fat
	4	Milk, 3% salt and 3.0% fat
3	1	Skimmed milk, 3% salt and no culture
	2	Skimmed milk, 3% salt and yoghurt culture
	3	Skimmed milk, 3% salt and lactic fermentation
4	1	Milk 3% salt, 1.5% fat and no culture
	2	Milk 3% salt, 1.5% fat and yoghurt starter
	3	Milk 3% salt, 1.5% fat and lactic fermentation
Experiment 2, cheese from camel's (3% fat) and cow's (3% fat) milk, with 3% salt and yoghurt starter culture.		
1	1	100% camel's and 0% cow's milk
	2	75% camel's and 25% cow's milk
	3	50% camel's and 50% cow's milk
	4	25% camel's and 75% cow's milk
	5	0% camel's and 100% cow's milk

Table I. Description of treatments used to manufacture cheese.

Results and Discussion

Milk and cheese composition

Mean composition of milk used to manufacture cheese samples is shown in table II. In the first experiment, the percentage of total solids in milk used to manufacture cheese samples in trial 1 was significantly higher than in milk used for other trials. This difference reflects the lower fat content of milk used to manufacture samples in other trials. No significant difference occurred in the protein content of the milk used for trials 1 and 2 or for trials 3 and 4. The percentage of protein in milk used for trials 3 and 4 was significantly higher than in milk used for trials 1 and 2; this difference appears to be related to the variations of camel's milk composition (ABU-LEHIA, 1987; MEHAIA, 1992; MEHAIA *et al.*, 1988; MEHAIA and AL-KANHAL, 1989), which are mainly affected by the feeding and drought conditions (YAGIL, 1987; YAGIL and ETZION, 1980). The pH, titratable acidity, and ash of the milks used in all trials were not significantly different. In the second experiment, no significant difference occurred in the pH, protein and lactose content of the standardized cow's and camel's milk. The total solids and ash content of camel's milk were significantly higher and the titratable acidity was significantly lower than that of the cow's milk. These results were comparable to those in other studies (ABU-LEHIA, 1987; MEHAIA and AL-KANHAL, 1989).

Table III shows mean composition of fresh soft cheeses made from camel's and cow's milk. In the first experiment, cheese made from whole camel's milk and with different percentages of salt (trial 1) were similar in titratable acidity, moisture, fat, and protein contents but significantly different in ash and salt contents. These cheeses had lower moisture and higher fat content than those made in the other three trials. Cheeses made from milk with 3% salt and different percentages of fat (trial 2) were similar in titratable acidity, ash and salt contents but significantly different in fat and protein contents, reflecting the difference in milk composition. The titratable acidities of cheese made in trials 1 and 2 are in agreement with those reported (ABOU-DONIA, 1986; IBRAHIM *et al.*, 1974; KALLAFALLA *et al.* 1973; NAGUIB *et al.*, 1974) for fresh Domiati cheese made without the addition of starter culture. In trial 3 or 4, no significant differences occurred in moisture, fat, protein, ash and salt contents between cheeses made with or without the addition of starter cultures. However, cheeses from trial 3 had higher moisture contents than did cheeses from trial 4. This difference appears to be due to the difference in fat and protein contents of cheeses. The percentage of titratable acidity (within trial 3 or 4) was significantly higher, and the pH was significantly lower, in cheeses made with yoghurt or lactic fermentation culture than in other cheese samples. In the second experiment, no significant difference occurred in pH, titratable acidity and moisture content of cheeses. However, fat and protein contents of cheese produced from milk with higher percentage of cow's milk (samples 4 and 5) were significantly higher than that produced from milk with higher percentage of camel's milk (samples 1 and 2). This was due to losses of curd and fat in camel's cheese whey, which was white, reflecting the differences in renneting properties and curd firmness between cow's and camel's milk (FARAH and BACHMAN, 1987; MEHAIA, 1993*a*; RAMET, 1987; RAMET, 1989). As curd firmness highly depends on the casein content of milk, curd obtained with camel's milk was much less firm than that obtained from cow's milk. This may be because the camel's milk had less casein nitrogen and more non-casein nitrogen than cow's milk (ABU-LEHIA,

Trial Milk N°	pH	TA[2] (%)	TS[3] (%)	Fat (%)	Protein[4] (%)	Lactose (%)	Ash (%)
Experiment 1							
1 Whole milk	6.61^a	0.14^a	11.94^a	3.90^a	2.54^b	4.71^b	0.79^a
2 Skimmed milk	6.60^a	0.14^a	8.78^d	0.30^c	2.47^b	5.19^a	0.82^a
3 Skimmed milk	6.65^a	0.14^a	9.65^c	0.15^d	3.51^a	5.18^a	0.81^a
4 Standardized milk	6.66^a	0.14^a	11.05^b	1.50^b	3.52^a	5.21^a	0.82^a
Experiment 2							
1 Standardized cow's milk	6.68^a	0.16^a	11.70^b	3.0^a	3.07^a	4.85^a	0.78^b
1 Standardized camel's milk	6.70^a	0.14^b	11.79^a	3.0^a	3.06^a	4.84^a	0.89^a

a,b,c,d: means in the same column, within each experiment, and with different superscripts are significantly different ($P < .05$).
1. Means of duplicate analyses on each of three vats.
2. TA = Titratable acidity.
3. TS = Total solids.
4. Protein = total nitrogen times 6.38.

Table II. Composition[1] of the milk used to manufacture cheese samples.

Trial N°	Treatment[2] N°	pH	Titratable acidity (%)	Moisture (%)	Fat (%)	Protein (N X 6.38) (%)	Ash (%)	Salt (%)
Experiment 1								
1	1	6.57^{a}	0.14^{a}	54.5^{a}	26.2^{a}	13.65^{a}	1.85^{d}	0.10^{d}
	2	6.53^{a}	0.14^{a}	53.6^{a}	26.1^{a}	13.90^{a}	13.90^{a}	0.78^{c}
	3	6.54^{a}	0.15^{a}	53.5^{a}	26.2^{a}	13.93^{a}	3.10^{b}	1.36^{b}
	4	6.55^{a}	0.14^{a}	54.1^{a}	26.2^{a}	13.73^{a}	3.70^{a}	1.80^{a}
2	1	6.56^{a}	0.13^{a}	68.7^{a}	2.5^{d}	19.10^{a}	4.50^{a}	1.75^{a}
	2	6.57^{a}	0.14^{a}	65.4^{b}	7.1^{c}	16.41^{b}	4.10^{b}	1.74^{ab}
	3	6.54^{a}	0.14^{a}	63.4^{bc}	11.5^{b}	14.90^{c}	3.90^{bc}	1.73^{b}
	4	6.59^{a}	0.14^{a}	62.5^{c}	16.1^{a}	13.51^{d}	3.60^{c}	1.71^{c}
3	1	6.60^{a}	0.14^{c}	70.6^{a}	1.0^{a}	20.41^{a}	4.10^{a}	2.20^{a}
	2	6.05^{b}	0.30^{b}	68.2^{a}	1.0^{a}	20.61^{a}	4.30^{a}	2.20^{a}
	3	4.40^{c}	1.20^{a}	68.0^{a}	1.0^{a}	20.10^{a}	4.20^{a}	2.30^{a}
4	1	6.60^{a}	0.14^{c}	64.8^{a}	9.0^{b}	16.72^{a}	4.30^{a}	2.20^{a}
	2	5.90^{b}	0.29^{b}	64.5^{b}	9.2^{a}	16.91^{a}	4.10^{a}	2.30^{a}
	3	4.60^{c}	1.12^{a}	65.0^{a}	9.1^{ab}	16.81^{a}	4.20^{a}	2.30^{a}
Experiment 2								
	1	5.75^{a}	0.39^{a}	60.2^{a}	14.6^{b}	13.6^{b}	4.16^{b}	2.25^{a}
	2	5.70^{a}	0.36^{a}	61.2^{a}	14.7^{b}	13.7^{b}	4.06^{a}	2.18^{a}
	3	5.71^{a}	0.37^{a}	60.4^{a}	15.5^{a}	14.1^{a}	3.91^{ab}	2.03^{a}
	4	5.70^{a}	0.38^{a}	59.6^{a}	15.3^{a}	14.3^{a}	3.76^{b}	2.10^{a}
	5	5.70^{a}	0.38^{a}	59.8^{a}	15.1^{a}	14.1^{a}	3.62^{b}	2.03^{a}

a,b,c,d: means in the same column within a trial having different superscripts are significantly different ($P < .05$).
1. Means of duplicate analyses on each of three vats.
2. See table I for description of treatments.

Table III. Composition[1] of fresh soft cheeses made from camel's and cow's milk, on a wet weight basis.

1987; MEHAIA, 1993*b*; MEHAIA and AL-KANHAL, 1989). In general, the composition of all cheeses, over all trials, was within the normal composition range for soft Domiati cheese (ABOU-DONIA, 1986).

Cheese yields and components recovery

Cheese yield is one of the most economically important aspects of cheese manufacturing. Yield and recovery of protein, fat, and milk total solids of cheeses made from camel's and cow's milk are shown in table IV, which indicates that cheese yield is proportional to the percentage of fat in the cheese milk (experiment 1, trial 2). DAVIS (1965) reported that the fat content of cheese milk controls its yield. Other workers (EL NESHAWY *et al.*, 1988; HAMDY and EL KOUSSY, 1964; IBRAHIM *et al.*, 1975) found that the yield of Domiati cheese was higher when the fat content of milk was increased. In the first experiment, yields were highest for cheeses made with yoghurt or lactic fermentation starter cultures, because of increased recovery of proteins and fat. ASKER *et al.* (1982) observed that the yield of fresh Domiati cheese was increased by direct acidification of milk before renneting, which indicates that curd firmness plays an important role in determination fat recovery because acidification normally improves curd firmness. The yield was lowest (10.10%) with whole camel's milk and 0% salt. This low yield may have been caused by the lower moisture content in the cheese and by less recovery of protein, fat, and solids of cheeses. Table IV, experiment 2, indicates that cheese yield is proportional to the ratio of camel's to cow's milk in cheese milk. The yield was highest (19.0%) for cheese made from 100% cow's milk (3% fat). This results was comparable to those reported in literature (ASHOUR *et al.*, 1986; IBRAHIM *et al.*, 1974). However, the average soft cheese yield (12.29 ± 1.63%) obtained from camel's milk was lower than that obtained from cow's milk (19.0%).

Cheese recovery values for protein, fat, and milk total solids are shown in table IV. In the first experiment, fat recovery (68 to 90%) was higher than protein recovery (54 to 86%), whereas total solids recovery (31 to 44%) was very low. This difference may be because the camel's milk has less casein nitrogen and more non-casein nitrogen than cow's milk (ABU-LEHIA, 1987; MEHAIA, 1993*b*; MEHAIA and AL-KANHAL, 1989). MOHAMED *et al.* (1990) reported that hard cheese yield from camel's milk was about 5%, and about one-half of the fat in the raw milk was lost with the whey. However, greater cheese yields (treatments 2 and 3 of trials 3 and 4) are accompanied by higher milk solids recovery (42 to 44%). In the second experiment, protein, fat and total solids recovery were significantly increased by increasing the ratio of cow's milk over camel's milk in cheese milk. On the other hand, the author's subjective observations of curd firmness at ladling indicated that the curd obtained from camel's milk was much less firm than that obtained from cow's milk and the curd firming rate with camel's milk was slower than that with cow's milk. Differences in curd firmness between camel's and cow's milk is certainly one of the most important reason for the variation in fat and protein recovery. This again indicates that curd firmness plays an important role in determining fat and protein recovery. However, the highest fat recovery (96-97%) was in the cheese made from cow's milk with 3% fat, and the lowest fat recovery (56%) was in the cheese made from camel's milk with 3% fat.

Table IV. Mean[1] yields and recovery of protein, fat, and milk total solids of fresh soft cheeses made from camel's and cow's milk.

Trial N°	Treatment[2] N°	Yield (%)	Protein recovery (%)	Fat recovery (%)	Solids recovery (%)
Experiment 1					
1	1	10.1^{c}	54^{b}	68^{b}	38^{b}
	2	10.3^{b}	56^{b}	69^{b}	39^{b}
	3	10.9^{a}	60^{a}	73^{a}	41^{a}
	4	11.1^{a}	60^{a}	74^{c}	41^{a}
2	1	10.8^{d}	86^{a}	90^{a}	36^{d}
	2	11.6^{c}	80^{b}	77^{b}	39^{c}
	3	12.8^{b}	80^{b}	74^{c}	41^{b}
	4	13.9^{a}	80^{b}	75^{c}	42^{a}
3	1	11.1^{b}	65^{c}	74^{b}	31^{b}
	2	13.6^{a}	80^{a}	90^{a}	42^{a}
	3	13.5^{a}	78^{b}	90^{a}	42^{a}
4	1	12.9^{b}	61^{b}	77^{b}	39^{b}
	2	14.7^{a}	71^{a}	90^{a}	44^{a}
	3	14.8^{a}	71^{a}	90^{a}	44^{a}
Experiment 2					
	1	11.5^{e}	51^{e}	56^{e}	39^{e}
	2	13.6^{d}	61^{d}	66^{d}	44^{d}
	3	16.1^{c}	74^{c}	83^{c}	54^{c}
	4	17.8^{b}	83^{b}	91^{b}	61^{b}
	5	19.0^{a}	87^{a}	96^{a}	95^{a}

a,b,c,d: means in the same column within a trial having different superscripts are significantly different (P < .05).
1. Means of three vats of cheese.
2. See table I for description of treatments.

Organoleptic evaluation

Mean scores of the sensory panels for cheese made from camel's and cow's milk are listed in table V. These data show that appearance, texture, flavour, and overall acceptability of cheeses were affected by fat and salt contents of the cheese milk, by the addition of yoghurt or lactic fermentation starter culture to cheese milk, and by the ratio of cow's to camel's milk in cheese milk. The cheese made from camel's milk with lower fat content scored lower for appearance and texture than that from camel's milk with > 1.5% fat, whereas the cheese made from camel's milk with higher fat content, without lactic culture, scored lower for flavour and overall acceptability than that from milk with < 1.5% fat, with or without lactic cultures.

Table V. Taste panel scores for fresh soft cheeses made from camel's and cow's milk[1].

Trial N°	Treatment[3] N°	Appearance	Texture	Flavour	Overall acceptability
		Mean[2]			
Experiment 1					
1	1	6.81^{b}	7.21^{b}	3.00^{c}	4.10^{b}
	2	6.75^{b}	7.11^{b}	3.91^{b}	4.75^{b}
	3	6.61^{c}	7.40^{a}	5.83^{a}	6.14^{a}
	4	7.30^{a}	7.31^{a}	6.11^{a}	6.39^{a}
2	1	5.86^{b}	4.95^{c}	5.01^{b}	5.26^{a}
	2	6.03^{b}	6.60^{b}	5.90^{a}	6.23^{a}
	3	7.61^{a}	7.71^{a}	5.85^{a}	6.41^{a}
	4	7.71^{a}	7.61^{a}	5.10^{b}	5.20^{b}
3	1	6.10^{b}	5.10^{b}	5.50^{b}	5.50^{b}
	2	7.40^{a}	7.50^{a}	7.80^{a}	7.50^{a}
	3	7.50^{a}	7.60^{a}	7.90^{a}	7.70^{a}
4	1	7.50^{b}	6.80^{b}	5.50^{b}	6.50^{b}
	2	7.80^{a}	7.50^{a}	7.90^{a}	7.60^{a}
	3	7.70^{a}	7.60^{a}	8.10^{a}	7.80^{a}
Experiment 2					
	1	7.60^{a}	7.50^{b}	5.30^{e}	5.10^{d}
	2	7.50^{a}	7.60^{b}	5.60^{d}	6.10^{c}
	3	7.60^{a}	7.80^{ab}	7.50^{c}	7.70^{b}
	4	7.40^{a}	7.80^{ab}	8.20^{b}	8.30^{a}
	5	7.50^{a}	8.20^{a}	8.50^{a}	8.50^{a}

a,b,c, d: means in the same column within a trial having different superscripts are significantly different (P < .05).
1. Nine point scale (9 = like extremely, 5 = neither like nor dislike, and 1 = dislike extremely).
2. Means of three vats of cheese.
3. See table I for description of treatments.

In the first experiment, the mean scores for flavour and overall acceptability of cheeses made with yoghurt or lactic fermentation starter culture (treatments 2 and 3 of trials 3 and 4) were significantly higher than mean scores for other cheeses, indicating that cheeses made with cultures were the most acceptable cheeses. The least acceptable cheeses were those made from whole camel's milk and 0 or 1% salt. Among cheeses made with camel's and cow's milk (experiment 2), samples 4 and 5 received the best flavour and overall acceptability scores, whereas sample 1 received the least scores. According to the panel members the declining flavour and overall acceptability scores of cheese made from milk with higher percentage of camel's milk fat was due to greasy taste and poor mouthfeel. This may be because the melting point of camel's milk fat was significantly higher than that of cow's milk fat, as reported by ABU-LEHIA (1989), RUEGG and FARAH (1991).

Conclusions

Manufacture of soft cheese (Domiati type) from camel's milk appears to be feasible. Composition of cheeses obtained from camel's milk compared favorably with Domiati cheese composition obtained from cow. The average cheese yield obtained from camel's milk was lower than that obtained or reported for cow's milk (ASKER *et al.*, 1982; IBRAHIM *et al.*, 1974). Fresh soft cheeses made from camel's milk with starter cultures were the most acceptable. The least acceptable cheeses were those made from whole camel's milk (3.9% fat and 0 or 1% salt).

On the other hand, an acceptable soft (Domiati) cheese with a satisfactory gross composition and yield and with good flavour and overall acceptability can be made of a mixture of camel's and cow's milk as follows: 50% camel's and 50% cow's milk, and 25% camel's and 75% cow's milk. The quality and yield of camel's milk cheese were greatly improved by increasing the ratio of cow's to camel's milk in cheese milk. However, the economic feasibility for making soft (Domiati) cheese from camel's milk is clearly low.

However, more research is needed to study the mechanism of enzymatic coagulation of camel's milk, to improve the quality and the yield of camel's milk cheeses and to utilize the nutritious whey that is produced from cheese making with camel's milk.

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Trace elements in camel's milk from Aswan city and desert (Egypt)

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Abstract. Four major elements of biological interest (sodium, potassium, calcium and magnesium) and nine trace elements (silver, cobalt, copper, chromium, manganese, nickel, iron, lead and zinc) were determined in milk of camels from Aswan city farm, the experimental farms at Kalabsha, and from the Allaqi desert at the South Eastern Desert of Egypt. These elements were determined also in the feeding plants (clover, barley straw) and in the desert plants which include *Indigofera argentea, Lotononis platycarpa, Astragalus vogellii* and *Tamarix nilotica*; as well as in the soil of these areas which was contaminated with the alluvium and the water of the River Nile and The High Dam Lake. The present study gives a new picture on trace element levels in camel's milk related to the different environmental conditions such as sites, the feeding plants, soil contamination and the drinking water used by camels. The results reveal higher levels of sodium, potassium, magnesium, silver, cobalt, manganese, nickel, lead and zinc in milk of the camel from the Allaqi desert than those from Kalabsha and Aswan city farms as a result of the high levels of these elements in the feeding plants and soil of the Allaqi desert. Trace element levels in the studied camel's milks were at the safe baseline level for both camel's calf and human uses.

Key words. Dromedary, *Camelus dromedarius*, milk, minerals, trace elements, feed crop, Egypt.

Résumé. Quatre minéraux majeurs d'intérêt biologique (sodium, potassium, calcium et magnésium) et neuf oligo-éléments (argent, cobalt, cuivre, chrome, manganèse, nickel, fer, plomb et zinc) ont été mesurés dans le lait des dromadaires de la ferme de la ville d'Aswan, dans les fermes expérimentales de Kalabsha et du désert d'Allaqi au sud-est du désert d'Egypte. Ces éléments ont également été trouvés dans des plantes fourragères (trèfle, paille d'orge) et dans des plantes du désert, telles que *Indigofera argentea, Lotononis platycarpa, Astragalus vogellii* et *Tamarix nilotica*, de même que dans le sol de ces régions qui était enrichi par les alluvions et l'eau du Nil et du lac du barrage supérieur. Cette étude apporte une connaissance nouvelle des quantités d'oligo-éléments présents dans le lait de dromadaires élevés dans différentes conditions relatives au site, aux plantes fourragères consommées, au degré de concentration du sol et à l'eau absorbée. Les résultats montrent des niveaux plus élevés en sodium, potassium, magnésium, argent, cobalt, manganèse, nickel, plomb et zinc dans le lait du dromadaire du désert d'Allaqi que dans celui des dromadaires des fermes de Kalabsha et de la ville d'Aswan, en raison de la quantité élevée de ces éléments dans les plantes fourragères et dans le sol du désert d'Allaqi. Les quantités d'oligo-éléments résiduelles des laits de dromadaire atteignent un bon niveau de sécurité, tant pour le chamelon que pour l'homme.

Mots clés. Dromadaire, *Camelus dromedarius*, lait, minéraux, oligo-éléments, plante fourragère, Egypte.

Introduction

Camels, in addition to their service as pack animals and for farm traction, provide useful amounts of milk. This milk contains high nutritional values of trace elements which are useful for both the growth of the calves and the human population, as the trace elements play an important role in health and metabolism. The levels of trace elements in camel's milk are dependent on the feed containing large amount of these elements, soil contamination related to feeding and the drinking water used by camel (BARRETT and LANRKINC, 1974).

Limited information was available on element concentrations in camel's milk in Egypt (HASSAN *et al.*, 1987; RASHED, 1992), but there was no previous work about the trace element levels in camel's milk in the region around the High Dam Lake and the Allaqi desert at the South Eastern Desert of Egypt, where some Arab families are living using camels. This work was carried out to study the levels of trace elements and minerals: sodium, potassium, magnesium, calcium, iron, silver, cobalt, copper, chromium, nickel, lead and zinc in camel's milk from these regions, with different environments including Aswan city, Kalabsha farms and the Allaqi desert (figure 1).

Materials and Methods

Sample collections

Milk samples

Camel's milk from three different places were collected from camels at Aswan city farm, feeded with clover and straw; camels from the experimental farms of the high Dam Lake Development Authority at Kalabsha in the South Western Desert of Egypt, feeded with clover, barley straw and grazing plants (*Tamarix nilotica*), and camels from the Allaqi desert, a South Eastern Desert of Egypt. These camels used grazing plants found in the area. Five hundred milliliters of milk was collected from each one of 10 camels, representing a batch from each region. The milk was collected from the three regions during the lactation period between February and October 1991. The milk samples were collected under strict hygienic conditions, then transported under refrigeration (at 4°C, packed in ice).

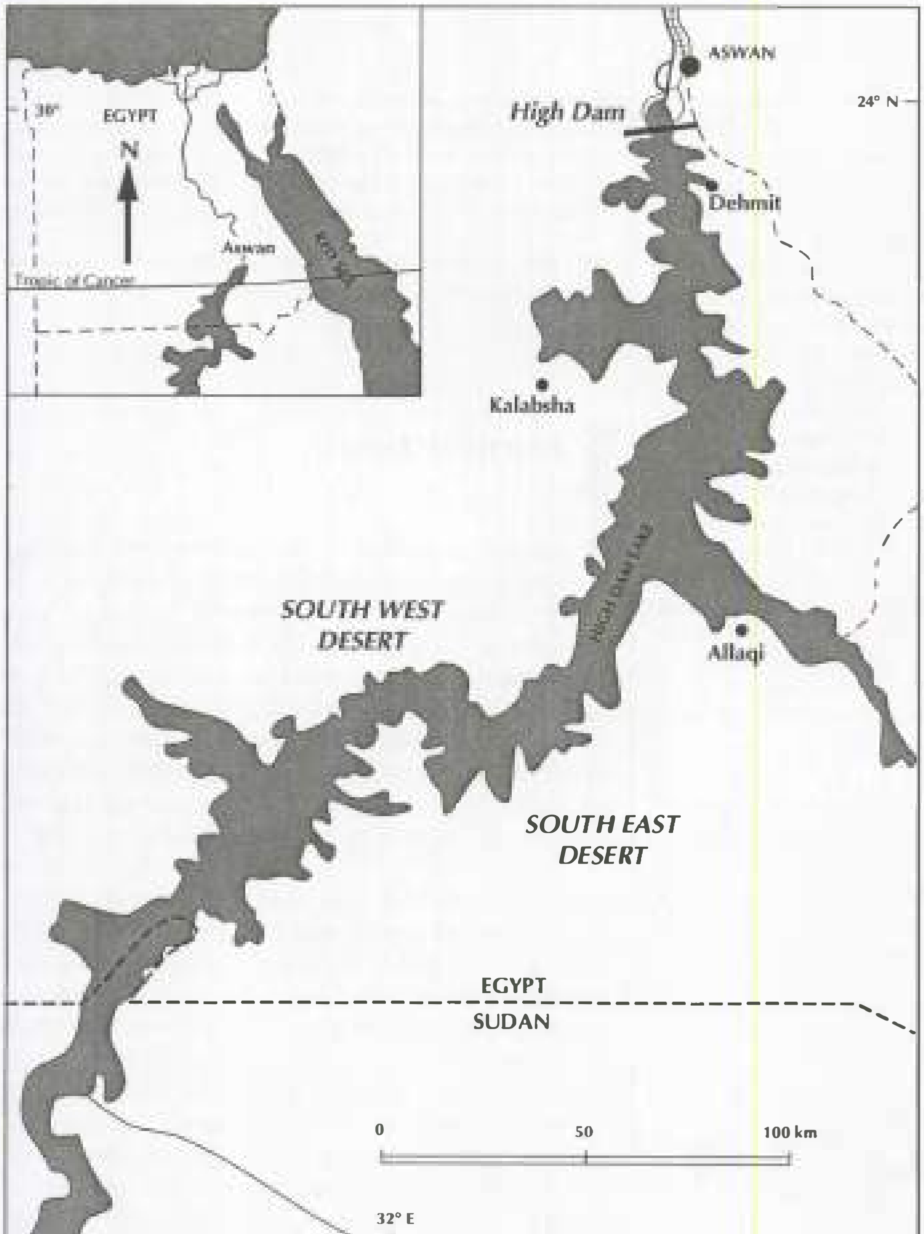

Figure 1. Location map of the study areas.

Plant and soil samples

Clover, barley straw and soil samples were collected from camel farms at Aswan city and Kalabsha. Grazing plants, *Indigofera argentea, Lotononis platycarpa, Astragalus vogellii* and *Tamarix nilotica* were collected from the Allaqi desert as well as the soil samples. Plant samples were washed separately successively with tap and bidistilled water, followed by deionised water, and allowed to drain, then dried in an electrical furnace at 105°C for 12 hours and blended in a stainless steel blender. Soil samples were dried then oven dried at 105°C for 5 hours, grounded and powdered using agate mortar. The powdered samples of plants and soils were kept in very clean polyethylene bottles.

Water samples

One litre of water sample was collected from the River Nile at Aswan city and from the High Dam Lake in the front of Allaqi, and stored in polyethylene bottles.

Sample preparation for chemical analysis

Milk samples

Milk samples were dry ashed in silica crucible at 550°C for 4 hours in muffle furnace. After cooling, 3 ml conc. hydrochloric acid (HCl) was added to 1 mg of the ash, thus the content was heated and the cooled residue was brought to 25 ml with bidistilled water (AOAC, 1975).

Soil samples

One gram of the oven dried sample was dissolved in 20 ml 1:1 hydrochloric/nitric acids mixture and heated till dryness, thus the residue was extracted with 2N HCl and brought to 50 ml with bidistilled water (AOAC, 1975).

Plant samples

Two grams of each oven dried plant samples were wet ashed in a teflon beaker, using 20 ml nitric/perchloric acids mixture, thus followed by addition of 3 drops of hydroflouric acid. The content was evaporated and the cooled residue was dissolved in conc. HCl and brought to 50 ml with bidistilled water (AOAC, 1975).

Reagents and standard solutions

Atomic absorption spectroscopic standard solutions (mg . ml^{-1}) for silver (Ag), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), nickel (Ni), lead (Pb), zinc (Zn) and calcium (Ca) were purchased from BDH (England). Working standard solutions were prepared by diluting the stock ones. All used acids were of Anala® quality (BDH, Merck and Prolabo).

Analytical determination

A SP 1900 Pye Unicam Flame Atomic Absorption Spectrophotometer with digital and direct readout concentration, with air-acetylene and nitrous oxide-acetylene burners, was used in the analysis. Also, single element hollow cathode lamps (Pye Unicam) for the elements Ag, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Ca, Pb and Zn were used at the recommended currents.

Results

Comparing the results of chemical analysis of trace elements in camel's milk from Aswan and Kalabsha with those from the Allaqi desert (table I), it shows that some elements are present in higher concentration in the milk from the Allaqi desert than in the milk from Aswan and Kalabsha.

These elements include sodium (Na), potassium (K), magnesium (Mg), silver (Ag), cobalt (Co), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn), while some elements show lower concentration as iron (Fe), copper (Cu) and chromium (Cr). In camel's milk from Kalabsha farm and the Allaqi desert, it also shows that the milk from the Allaqi desert exhibit high level of sodium, potassium, magnesium, silver, cobalt, manganese, lead and zinc, while iron shows no variation, and copper and chromium are present in lower level. Mean values of calcium, magnesium, sodium and potassium in camel's milk from two other regions of Egypt (North Egypt), namely, the North-Western Coastal Desert and Southern Behera Desert were 116, 84, 36 and 36 mg/100 ml, respectively (HASSAN *et al.*, 1987).

The chemical analysis results of Allaqi grazing plants show that *Lotononis platycarpa* exhibit higher concentrations of iron, cobalt, chromium, manganese, nickel and lead than *Indigofera argentea, Astragalus vogellii* and *Tamarix nilotica* (table II) while *Tamarix nilotica* exhibit higher levels of sodium, potassium, magnesium, copper and zinc than the others (table II). As Allaqi land is occupied by dense growth of *Tamarix nilotica* shrub, it is utilized by nomads as fuel and partially consumable for camels. The camels gain most of sodium, potassium, magnesium, copper and zinc from *Tamarix nilotica*, while the needs of other trace elements are taken from the other grazing plants especially *Lotononis platycarpa*. Clover from Aswan city and Kalabsha exhibit higher levels of copper, manganese and zinc than in the grazing plant of the Allaqi desert (table II), while barley straw exhibit higher levels of potassium, iron, manganese and calcium than in all the other plants and this was confirmed with other report (FARID *et al.*, 1987).

Soil of the Allaqi desert (table III) contains higher levels of iron and silver than the others from Aswan and Kalabsha, while soil from Aswan city farm contains higher levels of sodium, magnesium, colbalt, chromium, copper, manganese, nickel and calcium than in the others. Soil of Kalabsha farm contains higher levels of potassium, lead, zinc and calcium than soil from the others (table III).

Some elements contamination resulted from the drinking water used by camels; the High Dam Lake contains higher levels of sodium, iron, silver, cobalt, chromium, copper, nickel and calcium than in the River Nile water (table III), while potassium, magnesium, manganese and lead were present in higher concentrations in the Nile water than in the lake.

Comparing the results of trace elements in camel's milk from Aswan city and the Allaqi desert with other reported milks from goat and ewes (RASHED, 1992), it is shown that camel's milk from Aswan city exhibit higher levels of silver, lead, calcium and potassium than in goat's and ewe's milks from the same region (Aswan). Camel's milk from the Allaqi desert shows higher levels of silver, zinc, lead and calcium than in camel's milk from Aswan (table I; figures 2 and 3). In his study of trace elements in milk of animals from Aswan city, RASHED (1992) has revealed higher levels of silver, lead and calcium in camel's milk than in milk from cow, goat, ewe and buffalo of the same region.

Table I. Trace element concentrations in camel's milk from Aswan city, Kalabsha farm and the Allaqi desert.

Location	Aswan city			Kalabsha farm			Allaqi desert		
Elements	M	SD	CV %	M	SD	CV %	M	SD	CV %
mg/g									
Na	44.0	0.57	1.2	45.0	0.46	1.0	48.0	0.57	1.1
K	46.0	0.26	0.5	58.0	0.31	0.53	56.0	0.29	0.51
Mg	7.9	0.69	0.7	8.1	0.11	1.3	9.1	0.55	6.0
Fe	0.13	0.002	1.5	0.12	0.03	25.0	0.12	0.002	1.6
µg/g									
Ag	6.9	1.8	26.0	7.0	0.9	12.0	7.3	0.90	0.20
Co	8.7	0.25	2.8	9.1	0.20	2.1	12.5	0.25	2.0
Cr	1.6	0.05	3.2	1.1	0.05	4.5	1.0	0.04	4.0
Cu	15.0	0.36	2.4	11.0	0.35	3.1	13.0	0.35	2.6
Mn	3.2	0.11	3.4	5.3	0.13	2.4	7.8	0.15	1.9
Ni	4.1	0.10	2.7	4.0	0.05	1.2	3.8	0.09	2.3
Pb	35.0	0.57	1.6	38.0	0.44	1.1	40.0	0.69	1.7
Zn	406	5.7	1.4	410	6.0	1.4	420	6.6	1.5
Ca %	10.0	0.2	1.9	11.0	0.2	1.8	10.0	0.2	2.0

M, SD and CV %: mean concentration (dry ash), standard deviation and coefficient of variance for 10 camel's milk samples.

Table II. Trace elements (in dry ash) in feeding plants from Aswan city, Kalabasha farm and the Allaqi desert.

Elements	Na	K	Mg	Fe	Ag	Co	Cr	Cu	Mn	Ni	Pb	Zn	Ca %
	← mg . g⁻¹ →				← µg . g⁻¹ →								
Indigofera argentea													
Mean	0.65	7.90	2.50	0.72	1.20	4.80	6.70	4.70	29.3	8.20	13.3	12.5	2.60
SD	0.04	0.20	0.12	0.02	0.07	0.21	0.20	0.20	1.60	0.20	0.18	1.80	0.12
CV %	6.10	2.50	4.80	2.70	5.80	4.30	2.90	4.20	5.70	2.40	1.30	14.0	3.00
Lotononis platycarpa													
Mean	2.80	9.40	5.60	1.63	0.63	11.0	24.0	10.3	149	23.0	16.0	20.0	1.00
SD	0.12	0.20	0.47	0.12	0.10	0.40	0.47	0.62	10.0	0.80	0.62	0.43	0.11
CV %	4.20	2.10	8.30	7.30	15.0	3.60	1.90	6.00	9.70	3.50	3.80	2.30	6.00
Astragalus vogellii													
Mean	0.95	8.80	1.80	0.89	0.63	3.10	4.70	5.20	32.0	4.70	7.70	13.0	0.60
SD	0.04	0.16	0.02	0.01	0.10	0.004	0.20	0.20	0.81	0.20	0.20	0.40	0.08
CV %	4.20	1.80	2.20	1.10	15.0	1.20	4.20	3.80	2.50	4.20	2.50	2.90	5.00
Tamarix nilotica													
Mean	4.00	18.3	6.60	0.65	0.23	2.10	5.00	12.0	38.0	8.0	12.5	26.5	2.30
SD	0.07	0.27	0.33	0.07	0.02	0.12	0.25	0.50	0.07	1.0	0.25	0.10	0.02
CV %	1.70	1.40	5.00	10.0	11.0	5.70	5.00	0.83	0.18	12.0	2.00	0.38	0.87
Clover													
Mean	0.38	0.06	0.67	0.52	0.27	0.49	3.40	19.6	42.0	8.20	8.10	50.0	1.50
SD	0.01	0.002	0.02	0.02	0.01	0.005	0.05	0.41	0.05	0.37	0.30	0.57	0.11
CV %	2.60	2.90	2.90	3.80	3.70	1.00	0.11	2.00	0.11	4.50	3.70	1.10	2.00
Barley straw													
Mean	1.40	61.0	3.40	3.10	0.25	2.30	1.60	4.40	60.0	3.30	3.40	13.7	3.90
SD	0.16	3.0	0.18	0.05	0.00	0.10	0.02	0.50	4.00	0.30	0.50	0.40	0.30
CV %	11.0	4.90	5.20	1.60	0.00	4.30	1.20	11.0	4.40	9.00	14.0	2.90	7.60

M, SD and CV %: mean concentration (dry ash), standard deviation and coefficient of variance for 10 camel's milk samples.

Table III. Trace elements concentrations in soil of Aswan city, Kalabsha farm and the Allaqi desert and the water samples.

	Soil									Water					
Location	**Aswan city**			**Kalabsha farm**			**Allaqi desert**			**River Nile**			**High Dam Lake**		
Elements	M	SD	CV %	M	SD	CV %	M	SD	CV %	M	SD	CV %	M	SD	CV %
	← mg . g^{-1} →									← mg . l^{-1} →					
Na	9.50	1.50	1.50	0.41	0.12	2.90	0.93	0.01	1.20	11.3	1.4	0.12	16.8	3.40	20.0
K	0.17	0.04	2.30	5.10	0.20	3.90	4.30	0.12	2.70	5.1	0.5	9.0	4.0	0.40	10.0
Mg	15.2	0.55	3.60	9.90	0.10	1.00	8.20	0.05	0.60	9.7	0.5	5.1	8.6	10.70	8.0
Fe	38.8	3.40	8.70	34.6	9.10	2.60	42.0	0.70	0.60	0.01	0.0	0.0	1.4	0.49	30.0
Ca	–	–	–	–	–	–	–	–	–	28.8	1.5	52.0	27.0	5.50	20.0
	µg.g^{-1}									µg.l^{-1}					
Ag	1.70	0.25	1.40	1.00	0.02	2.00	2.00	0.10	5.0	9.0	1.0	11.0	16.0	2.0	12.0
Co	20.0	1.00	4.80	19.0	0.90	4.70	17.3	1.70	2.1	100	8.0	8.0	131	23.0	17.0
Cr	38.0	1.20	3.00	37.00	0.15	0.40	21.0	0.26	1.2	80.0	11.0	13.0	112	75.0	40.0
Cu	37.0	0.28	0.74	54.0	0.30	0.55	17.0	0.10	0.5	30.0	1.1	3.6	200	0.0	0.0
Mn	567	10.0	1.70	357	5.00	1.30	310	1.70	5.5	130	15.0	11.0	15.0	57.0	12.0
Ni	48.0	0.76	1.60	32.0	0.80	2.50	20.0	0.60	0.3	90.0	12.0	13.0	93.0	23.0	24.0
Pb	6.4	1.10	1.70	29.0	0.40	1.30	12.0	2.00	2.5	25.0	0.0	0.0	5.0	0.0	0.0
Zn	78.0	0.76	0.97	181	2.00	1.10	31.0	0.45	14.0	60.0	3.0	5.0	180	20.0	11.0
Ca %	3.0	0.02	2.00	3.30	0.09	2.70	2.40	0.03	1.5	–	–	–	–	–	–

M, SD and CV %: mean concentration (dry ash), standard deviation and coefficient of variance for 10 camel's milk samples.

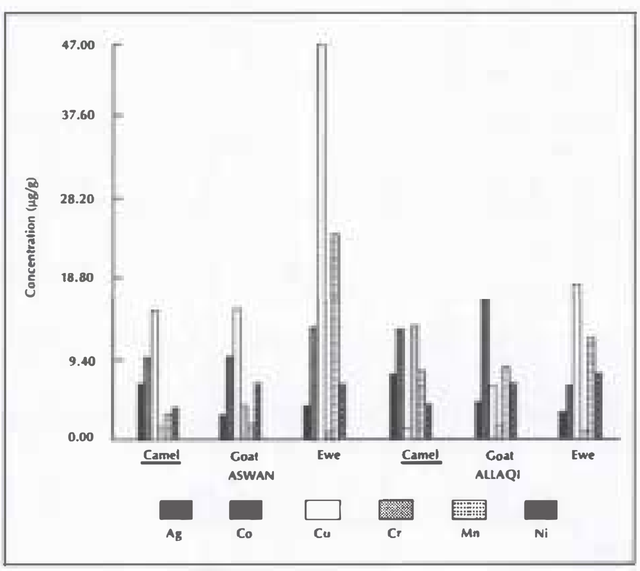

Figure 2. Trace elements in animal milk from Aswan and Allaqi.

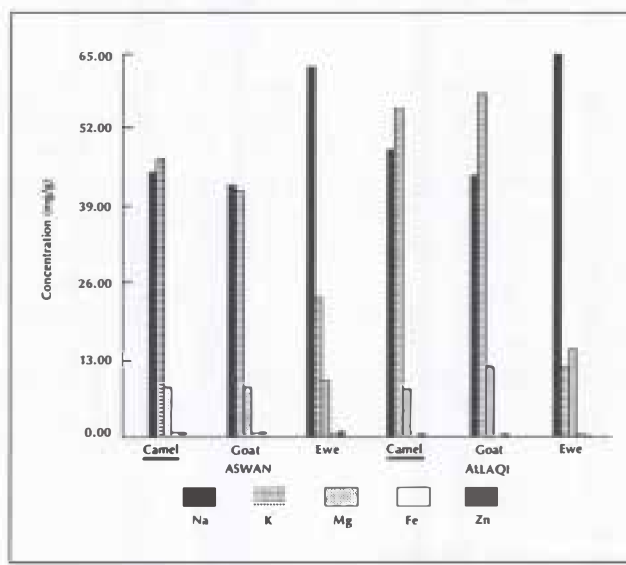

Figure 3. Major elements in animal milk from Aswan and Allaqi.

Discussions

The presence of some elements in camel's milk in larger concentrations in one region than in the others, are related to their presence in the feed plants, soil contamination and drinking water (Barrett and Larkinc, 1974; Kandil *et al.*, 1987). The presence of higher levels of elements in camel's milk from Allaqi than in those from Aswan city and Kalabsha farm are related to their presence in high levels in Allaqi plants, especially *Lotononis platycarpa* and *Tamarix nilotica*, and in the contaminated soil and lake water. Trace elements play an important role in human and animal health and metabolism. Their presence in camel's milk are important to camel's calves and for human uses. Inadequate intake of calcium may cause low milk production and the increased demand for calcium at parturition may result in milk fever (McDowel, 1985). The majority of potassium excretion is in the urine and also via sweat secretion (Lee, 1977). There is more potassium in milk than any other elements, and its increase in feed may increase milk yield. When the diet contains insufficient manganese, clinical signs can be observed (McDowell, 1985). It was reported that dairy cattle compensate for low zinc diet and thus could cause zinc decrease in milk. Lead may enter the animal body through the respiratory tract and skin (NATIONAL ACADEMY OF SCIENCE, 1972). Very limited lead is deposited in the milk. The livestock exposure to lead is mainly derived from lead in battery plate storage, water pipe, used gasoline and feed containers (NATIONAL ACADEMY OF SCIENCE, 1972). The symptoms of sodium deficiency in camel, include a lower milk yield (BARRETT and LARKINC, 1974). Magnesium is essential for carbohydrate and protein metabolism, and milk is not an adequate source of magnesium (BARRETT and LARKINC, 1974). It is observed that a level of 17 mg of iron per litre in pasture irrigation water causes scouring and decreases milk production of animals (MCDOWELL, 1985). The increase of copper and nickel in feed are not related to their increase in milk, but their decrease may cause lower levels in milk (BARRETT and LARKINC, 1974). Silver, cobalt, chromium and zinc are useful for hair growth and increase milk production for pregnant females (KANDIL *et al.*, 1987; VALKOVIC, 1975). Copper and iron are needed in the body for formation of hemoglobin in the blood. Thus, calves fed with milk containing low levels of iron and copper will suffer from anemia (REAVES and HENDERSON, 1963).

Lead is known to react with free sulfhydryl groups which makes them unavailable for certain enzyme catalyzed reactions (FRICKE *et al.*, 1979; LEE, 1977). All elements essential as dietary nutrients for livestock are present in water. It is generally believed that nutrient elements are available in water to about the same extent than in feedstuff (MCDOWELL, 1985). Iron, chromium, cobalt, copper, magnesium and zinc are found in water, generally at low levels, and in soluble form, and are toxic only in excessive concentration (NATIONAL RESEARCH COUNCIL, 1974). Water intake by ruminants has been found to increase milk production (MCDOWELL, 1985).

Conclusion

From the results of this study, it can be concluded that trace elements of biological interest in camel's milk were affected by their presence in the feed, soil contamination from the pasture and the drinking water used by camels. So, camel's milk from desert contains higher levels of some important trace elements than in the milk of camels which are fed with clover and barley straw in the city. Trace element levels in the studied camel's milk were in the safety baseline level for camel's calves and human uses (NATIONAL RESEARCH COUNCIL, 1980).

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Thème C/*Topic C*

Economie de la filière lait frais/ *Dairy sector economics*

Systèmes laitiers/*Milk production system*

Stratégies pour la transformation du lait/*Planning the cheese and milk production processes*

Président/*Chairman:* D. RICHARD

Animateur/*Facilitator:* M.F. WARDEH

BONNET P. (éditeur), 1998.
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Actes du colloque, 24-26 octobre 1994, Nouakchott, Mauritanie.
Montpellier, France, Cirad, 304 p. + X p. hors texte. (collection Colloques)

La pasteurisation du lait de chamelle : une expérience en Mauritanie

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Résumé. Une entreprise privée mauritanienne pasteurise, dans une mini-laiterie moderne, du lait de chamelle et de vache collecté auprès d'éleveurs du secteur traditionnel. L'introduction de l'activité n'a pas été sans problèmes, tant du côté de l'approvisionnement en lait, que de celui de la commercialisation, car il s'agit de la première tentative de production de lait pasteurisé dans le pays. La communication retrace l'historique des difficultés rencontrées dans tous les domaines au cours des cinq années d'activité. Les retombées favorables de l'unité sont désormais mieux perçues. Pour résoudre le problème des fluctuations de l'offre et de la demande, la laiterie envisage de produire du fromage de chamelle.

Mots clés. Dromadaire, *Camelus dromedarius*, pasteurisation, lait pasteurisé, lait de chamelle, lait de vache, usine laitière, commercialisation, offre et demande, saison, Mauritanie.

Abstract. A private Mauritanian enterprise, with a modern mini-dairy, pasteurizes camels' and cows' milk collected from herdsmen belonging to the traditional production sphere. Implementation of the operation — the first attempt at producing pasteurized milk in the country — has been fraught with difficulties, both on the milk supply side and on the marketing side. The communication tells the tale of all sorts of hurdles encountered throughout the unit's five years' operation. The beneficial repercussions of the unit are now becoming more apparent. In order to overcome the difficulty of fluctuating supply and demand trends, the dairy is contemplating the production of camel's milk cheese.

Keys words. Dromedary, *Camelus dromedarius*, pasteurizing, pasteurized milk, camel's milk, cow's milk, dairy, marketing, supply balance, season, Mauritania.

Introduction

La *Laitière de Mauritanie* a démarré ses activités en avril 1989.

Le montant de l'investissement initial a été d'environ 1 500 000 FF, dont 1 000 000 FF financés par un prêt de la Caisse française de développement, auxquels se sont ajoutés progressivement des auto-investissements d'environ 750 000 FF.

La capacité nominale de l'installation est de 600 litres par heure, ce qui la classe dans la catégorie des mini-laiteries. En fait, la cadence de conditionnement des emballages de 0,5 litre ne dépasse pas 900 par heure.

En 1994, l'unité emploie plus de 26 personnes et traite plus de 3 000 litres de lait de chamelle et de vache par jour.

Historique

L'unité a été fondée à l'origine sur une idée très simple : l'arrière-pays constitue un grand réservoir de lait, et la capitale un grand réservoir de consommateurs n'ayant auparavant accès qu'au lait cru ou au lait de longue conservation importé (UHT, concentré, en poudre). Aussi la promotrice — ingénieur ne possédant pas de connaissances particulières en technologie laitière — a-t-elle prévu simplement une unité de pasteurisation du lait frais.

Le choix du lait de chamelle a découlé de considérations purement pragmatiques : c'était, à l'époque, le seul lait frais disponible à Nouakchott et dans ses environs. Certes, compte tenu de la tradition locale qui veut que le lait de chamelle ne soit pas bouilli, la promotrice ne savait pas si ce lait supporterait la pasteurisation ni si les consommateurs l'accepteraient sous cette forme.

Les seuls éléments encourageants étaient, d'une part, l'information selon laquelle on trouvait du lait de chamelle pasteurisé en Arabie Saoudite, et, d'autre part, l'appréciation favorable de quelques Mauritaniens l'ayant goûté.

Pour des raisons expliquées ci-après, la laiterie ne put collecter pendant deux ans qu'une moyenne de 200 litres de lait par jour. Cependant, si par hasard l'approvisionnement atteignait 300 litres, le marché ne l'absorbait pas, car le prix était élevé. La perte cumulée ainsi au cours des trois premiers exercices dépassa le montant de l'investissement.

Heureusement, l'activité put être maintenue, et, à la fin de 1990, profitant d'une conjoncture favorable, les prix d'achat et de vente furent réduits de 25 %. L'effet se fit sentir immédiatement, et, à partir de ce moment, les courbes de production et de vente commencèrent à monter.

La figure 1 montre l'évolution de la production de lait de chamelle (et de lait de vache, à titre de comparaison) entre le 1er janvier 1991 et le 28 février 1994. Les chiffres correspondent à la vente nette moyenne (ventes moins retours) journalière calculée sur chaque mois. La progression apparaît clairement, ainsi que les grandes fluctuations saisonnières et annuelles qui seront expliquées plus loin.

Expérience

L'idée simple du départ allait se heurter à de solides obstacles, dus principalement à la sous-estimation de l'inertie qu'oppose tout système à l'introduction de nouveautés.

Les difficultés considérables rencontrées par la laiterie au cours de ses premières années peuvent être résumées dans plusieurs domaines.

Approvisionnement en lait

Les producteurs

La laiterie, devant l'évidente nécessité de disposer d'un approvisionnement autonome, opta pour l'achat de lait auprès des producteurs existants, c'est-à-dire du secteur quasi traditionnel, sans tenter d'introduire de modifications à ce niveau, choix qui respecte la biodiversité et prévoit d'inciter aux améliorations plutôt que de les imposer. N'ayant pas les moyens d'avoir son propre élevage, la promotrice obtint des promesses de la part de plusieurs propriétaires de troupeaux.

Or, il existe un fort préjugé traditionnel (tabou) contre la vente du lait, considérée comme une activité mesquine et génératrice de misère, préjugé qui fut sous-estimé. Les promesses ne s'étant pas matérialisées, la laiterie n'a trouvé, dès le départ, que deux catégories de fournisseurs.

❒ D'abord un certain nombre d'éleveurs qui fournissaient déjà du lait aux revendeurs de lait cru de la ville. Ces opérateurs citadins, qui présentent l'avantage de changer de chamelles chaque année, en revendant celles en fin de lactation, et donc capables d'assurer une fourniture assez régulière, considérèrent tout d'abord la laiterie comme un dangereux concurrent, et entretinrent avec elle des rapports conflictuels et ambigus, l'accusant de casser les prix.

Dès son démarrage, la laiterie se trouva engagée dans ce qu'elle avait cherché à éviter : une concurrence avec le lait vendu en l'état. Or, du fait de la faible quantité disponible sur le marché, ce lait cru avait imposé des niveaux de prix très élevés. Fluctuant selon les saisons, il atteignait 200 UM le litre (à comparer avec le prix du lait importé à l'époque, qui était de 70 ou 80 UM le litre). Dans l'étude du projet de laiterie, il était prévu d'acheter le lait à 40 UM et de le vendre à 80 UM le litre (équivalent à 6,66 FF, soit un prix suffisamment élevé pour un produit de large consommation). D'âpres négociations au moment du démarrage permirent

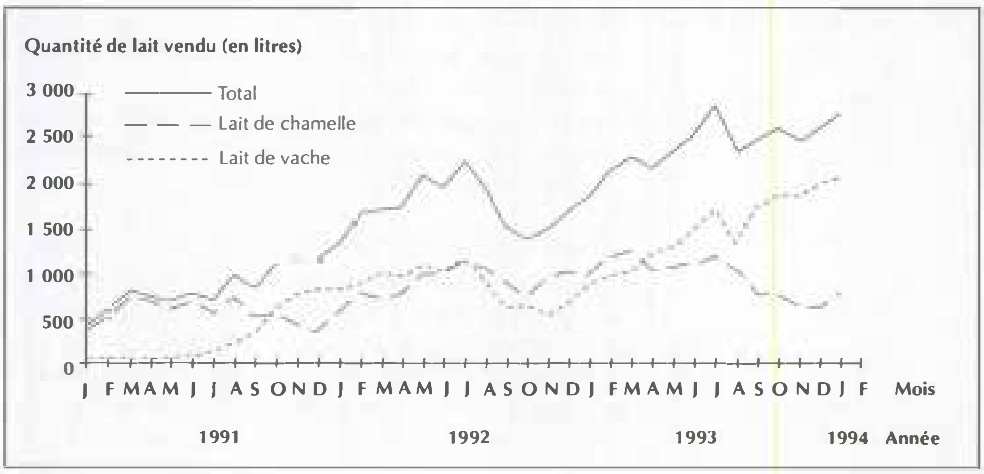

Figure 1. *Ventes nettes moyennes journalières.*

d'acheter une quantité de lait à 100 UM le litre, conduisant à un prix de vente qui, sans assurer la rentabilité, classait le produit dans les marchandises de luxe, à savoir 160 UM au détail, ou 80 UM le demi-litre (6,40 FF au taux de change de 1989).

En fait, contrairement aux craintes des vendeurs de lait, la laiterie, en prélevant une partie du lait disponible, entraîna une hausse des prix du lait cru, se privant de ce fait de son approvisionnement au bénéfice de la vente directe.

D'ailleurs, après un début mouvementé, ces opérateurs cessèrent de fournir du lait à la laiterie. Ils la combattirent longtemps encore. Par la suite, ils changèrent d'avis, et ils apportent maintenant régulièrement du lait.

❒ La deuxième catégorie comprend un groupe de petits propriétaires, socialement défavorisé et donc moins sensible aux pressions de l'opinion, dont la ville et les environs de Nouakchott étaient les terrains de nomadisation ancestraux.

Ces éleveurs ne peuvent fournir du lait qu'au gré des naissances dans le troupeau familial, auquel ils sont attachés. Ils se caractérisent en outre par des habitudes de nomadisation saisonnière fortement ancrées, qui ont imposé de sévères contraintes au niveau de la collecte. Leurs finances sont organisées strictement au jour le jour.

La collecte

En général, la laiterie organise un circuit de collecte avec ses propres véhicules. Les bidons sont en principe fournis et surtout nettoyés par la laiterie. Un prix est fixé pour le lait rendu usine, tandis qu'un petit montant est prélevé sur le prix du lait collecté pour compenser en partie les frais de transport.

Les éleveurs sont payés selon une échéance variable conforme à leur demande : certains chaque jour, d'autres à moyen terme. A certaines périodes, la laiterie achète de l'aliment en gros, et le cède aux éleveurs presque au même prix, à crédit remboursable par déduction du prix du lait. Il s'agit d'un crédit à très court terme, destiné à fidéliser et sécuriser les éleveurs, et à maîtriser les coûts de production.

Alimentation du bétail

Les troupeaux fournisseurs de lait étant concentrés et partiellement sédentarisés autour de la ville, la sécheresse aggravée par le surpâturage entraîne un manque de fourrage naturel. Il n'y a pas de production nationale de fourrage, autre que les sous-produits de rizerie, ni de production continue d'aliment « industriel ». Tout l'aliment pour le bétail est donc importé de l'étranger, en particulier le tourteau d'arachide, source préférée de protéines pour les camelins, et qui vient du Sénégal. Les arrivages sont irréguliers et les prix sujets à de grandes fluctuations au gré du marché. La méconnaissance des règles d'alimentation des ruminants conduit les éleveurs, à la recherche d'un rendement maximal, à donner des quantités importantes de tourteau très riche en protéines, entraînant un probable gaspillage et avec des coûts réels élevés. Les éleveurs de camelins sont par ailleurs très réticents à essayer de nouveaux aliments.

Le besoin de maximiser l'usage du pâturage et d'éviter les conditions malsaines de l'environnement urbain (prévalence de gale, parcours dans les déchets urbains) conduit les éleveurs à s'éloigner de la ville, parfois jusqu'à 100 km. La collecte se fait dans des bidons, et, malgré la bonne conservation du lait de chamelle, il y a un compromis à trouver entre l'altération du lait en fonction du temps de transport et la qualité du pâturage. Le personnel de la laiterie est obligé d'assurer une permanence, le soir, pour la réception du lait, qui se prolonge parfois en saison des pluies jusqu'à minuit ou au-delà, compte tenu du peu d'organisation des producteurs et de leur subordination aux caprices de leur cheptel.

Rendement laitier

Le rendement laitier des camelins dans un environnement si aride est très faible, en particulier compte tenu des remarques citées ci-dessus sur l'alimentation. A titre d'exemple, il est courant qu'une chamelle reçoive (avec son chamelon) 10 kg d'aliments par 24 heures, pour une production commercialisable de 3 ou 4 litres de lait.

La figure 2 montre l'évolution du nombre de fournisseurs. On peut calculer que la quantité moyenne fournie par éleveur s'échelonne entre 15 et 60 litres par jour, suite à deux traites, suivant la saison (et donc l'alimentation) et selon la prédominance d'éleveurs de la première ou de la deuxième catégorie. En fait, la production de la laiterie est le résultat de l'addition patiente de livraisons souvent dérisoires, parfois même de 2 ou 3 litres.

Fluctuations saisonnières : contraintes et perspectives

Nombre d'animaux en lactation

La période de lactation des dromadaires, d'environ douze mois, est favorable à un approvisionnement constant en lait, à condition que les mises bas soient régulières d'une année sur l'autre. Ceci n'est pas toujours le cas, et, à titre d'exemple, l'hiver 1993-1994 a enre-

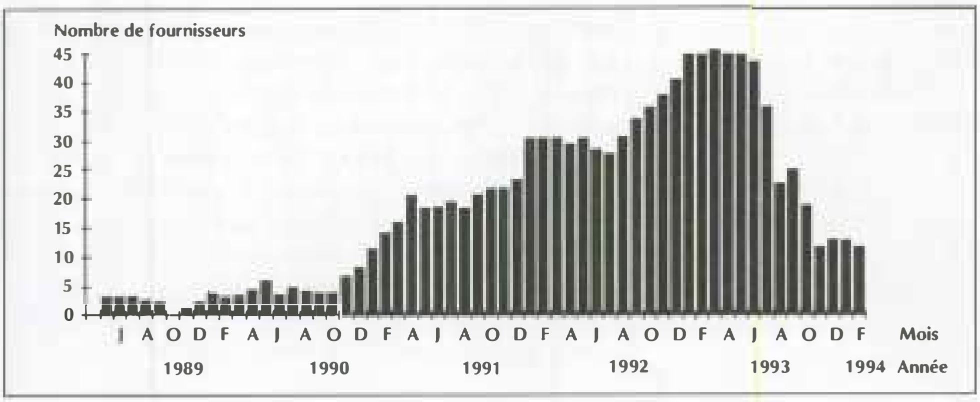

Figure 2.
Nombre de fournisseurs de lait de chamelle.

gistré, suite à une année 1992 extrêmement sèche, une pénurie spectaculaire de lait faute de naissances en 1993 (la figure 2 montre que, à l'exception de quatre ou cinq éleveurs, tous les producteurs de la deuxième catégorie ont fait défaut).

Habitudes des éleveurs

Les fournisseurs semi-nomades restent très attachés à certains parcours de pâturage en saison des pluies, et préfèrent même profiter de ceux-ci plutôt que de vendre le lait. La collecte du lait en saison des pluies est problématique, car il faut quotidiennement retrouver les fournisseurs en déplacement, tandis que certains éleveurs arrêtent complètement la production de lait, préférant aller vers des régions éloignées.

Le maximum de l'offre de lait se situe toujours au premier semestre, quand de nombreux propriétaires de camelins déplacent les femelles en lactation près de la ville afin de leur fournir une alimentation complémentaire, et financent celle-ci par la vente du lait. D'ailleurs, l'offre de lait à la laiterie est systématiquement à son maximum, au moment du minimum de la demande, surtout lorsque le prix d'achat dépasse celui offert par les revendeurs de lait cru.

Un effet de cercle vicieux fait que :
– lorsque la demande est faible, le bas prix du lait cru a une influence défavorable sur les ventes de la laiterie, amplifiant l'excédent de l'offre sur la demande ;
– lorsque la demande est forte, le prix élevé du lait cru prive la laiterie de sa matière première, amplifiant l'excédent de la demande sur l'offre.

Habitudes des consommateurs

Pendant l'été 1993, très pluvieux, l'usine a subi un effondrement de son approvisionnement en matière première, dû à une forte concurrence de la part des habitants de Nouakchott, partis en masse passer l'été sous la tente et achetant le lait directement aux éleveurs.

On peut résumer en disant que les fluctuations saisonnières ou annuelles ont des origines diverses et souvent imprévues.

Perspectives

Il est important pour la laiterie de disposer d'un moyen d'écouler les excédents de lait, pour sécuriser et fidéliser les éleveurs, sûrs ainsi de vendre la totalité de leur production pendant toute l'année. Le seul produit élaboré par la laiterie à partir du lait de chamelle était le lait fermenté, très utilisé localement en boisson, mais ce lait s'est avéré difficile à écouler, d'une part parce qu'il ne peut être produit qu'en période d'excédent, donc de faible demande de produits laitiers, et d'autre part parce que son coût de production est supérieur à celui du lait frais, tandis que traditionnellement le lait fermenté est vendu moins cher que le lait frais cru.

Le lait de chamelle ne se prêtait pas à la fabrication de produits de report, jusqu'à la découverte par le Professeur Ramet de l'enzyme permettant de le coaguler, et donc d'en faire du fromage. Malheureusement, les Mauritaniens n'ont pas l'habitude de manger du fromage et il faut donc envisager de l'exporter (voir annexe, p. 286-287).

Traitement du lait

La laiterie, conçue seulement au départ pour la pasteurisation du lait, est équipée d'un système simple mais très moderne, construit autour d'un pasteurisateur à plaques Microtherm d'Alfa Laval et d'une conditionneuse de marque NOVA. Tout l'équipement est en acier inoxydable, et satisfait aux normes les plus exigeantes. Le lait est conditionné en unités d'emballage en carton imperméabilisé Variopak type « gable-top » (voir annexe, p. 286-287).

Le choix de cet emballage, relativement cher à l'unité, de préférence aux sachets ou aux bouteilles en matière plastique, a été dicté par une étude du mode de consommation du lait à Nouakchott : c'est une boisson « sociale », au même titre que les boissons gazeuses, qui doit avoir accès aux salons, aux bureaux, aux voitures.

Deux problèmes majeurs se posent au niveau de la production :

L'hygiène

Le personnel, recruté sans qualification à l'origine, a du mal à mettre spontanément en pratique les notions d'hygiène imparties. L'environnement est défavorable (chaleur, vent de sable, insectes). Malgré cela, une propreté méticuleuse est maintenue dans les locaux, construits en béton et carrelés jusqu'à 2 m de hauteur. Le nettoyage des équipements se fait en circuit fermé, avec soude, désincrustant et désinfectant (importés). L'entreprise fournit au personnel des tenues dont elle assure le blanchissage quotidien, et impose le port du turban, qui couvre toute la tête sauf les yeux, en guise de masque.

A l'arrivée, le lait cru subit les tests d'acidité et de densité. Le contrôle de la qualité du lait pasteurisé se fait à l'extérieur, par le laboratoire du Centre national d'élevage et de recherches vétérinaires (CNERV). On a pu constater une nette amélioration de la propreté du lait reçu, et les éleveurs ont appris l'importance du nettoyage des ustensiles de traite. L'eau étant rare en brousse, il est difficile de leur demander de grands lavages, mais la laiterie assure le lavage et la désinfection de transport.

Faute d'une maîtrise de la qualité du lait cru, les analyses bactériologiques montrent que le lait pasteurisé reste parfois un peu en deçà des normes françaises, mais il représente un gain de qualité inestimable par rapport au lait cru.

La Mauritanie n'a pas de normes propres, adaptées aux circonstances de production, concernant le traitement du lait. Le souci principal de la laiterie a toujours été de s'assurer que le lait ne contient pas de germes pathogènes, et que le taux de coliformes reste en-dessous des normes.

La maintenance

Les premiers temps ont été très difficiles, faute de personnel qualifié. La mise en route de l'unité a été assurée pendant vingt jours par un ingénieur français, qui a formé le personnel au fonctionnement. D'importants défauts dans les équipements ont été corrigés sous garantie. La majorité des problèmes de maintenance se concentrent sur la conditionneuse automatique. L'entreprise n'a jamais eu les moyens d'avoir un stock important de pièces détachées, et à certaines périodes il a été difficile de les faire venir, mais un technicien local assure maintenant avec compétence la maintenance préventive de toute l'installation, et la réparation rapide des pannes. Aussi, au cours de l'année 1993, aucune journée de travail n'a été perdue pour des raisons techniques. Pour cela, il faut souvent faire preuve d'imagination et de souplesse dans les solutions retenues.

Commercialisation

L'option retenue pour la commercialisation tient compte de la structure particulière du commerce de détail à Nouakchott : un réseau dense de « boutiquiers », équipés de réfrigérateurs, couvre toute la ville. Ces échoppes, ouvertes de 6 heures du matin à minuit, proposent une variété remarquable de marchandises, y compris des boissons fraîches. La laiterie décida d'utiliser ce réseau tout prêt, d'autant plus que l'un des buts de l'unité était de rapprocher le lait frais (auparavant seulement disponible en certains points de la ville) de chaque consommateur.

La laiterie dispose de plusieurs véhicules (dont deux charrettes à âne aménagées en forme d'emballage de lait) qui livrent le lait directement aux détaillants, avec un suivi individuel de chacun. La laiterie reprend le lait invendu à la date de péremption, mais fixe le prix de vente au détail, qui laisse une marge de 10 % pour le détaillant. Chaque détaillant est desservi en principe tous les deux jours, mais il peut téléphoner en cas de besoin. Ce système convient particulièrement aux consommateurs de Nouakchott, qui achètent le lait de préférence le soir (probable atavisme d'une société d'éleveurs), et ne le conservent pas avant de le consommer (faute de réfrigérateur ou parce que, dans les foyers, il n'y a pas de contrôle sur le contenu du réfrigérateur). Le demi-litre est vendu actuellement à 90 UM (4 FF) au détail.

Les difficultés qui se sont posées à ce niveau sont surtout celles de l'introduction d'un produit entièrement nouveau à double titre : le lait pasteurisé n'existait pas, et à plus forte raison le lait de chamelle conditionné.

L'une des erreurs majeures de la promotrice a été de supposer que le lait pasteurisé serait accepté rapidement par le public et qu'il suffirait d'un fonds de roulement modeste.

Les consommateurs n'avaient au départ aucune idée sur la pasteurisation, ni même sur les germes que peut contenir le lait, symbole traditionnel de pureté et de « baraka » (chance en arabe). Ils se méfiaient en outre de tout produit national, accordant plus de confiance au lait importé. Le prix de vente était un handicap, d'autant plus que les consommateurs ne se rendent pas compte des frais entraînés par la transformation, et considèrent toujours que le lait est trop cher. Quand on fait remarquer que le lait pasteurisé est moins cher que la matière première, à savoir le lait vendu en l'état, la réaction est de supposer que la laiterie ajoute de l'eau, ou fait quelque chose de suspect, car par définition le lait cru est meilleur car « plus naturel », et donc peut être vendu plus cher. La laiterie est ainsi prise « entre le marteau et l'enclume » :

– à l'achat du lait, le fournisseur se détourne de la laiterie, préférant vendre son lait 50 à 100 % plus cher en période de forte demande (en revanche, si la situation se renverse et que la demande faiblit, la laiterie est assaillie de fournisseurs faisant pression pour que leur lait soit acheté) ;

– à la vente, le prix du lait UHT (qui bénéficie de la subvention européenne, d'un tarif douanier favorable et de l'absence de contrôle de qualité ou de durée) exerce une forte influence à la baisse.

De grandes fluctuations existent dans la consommation du lait :

– d'une part, celles dues à la météorologie, qui est, hélas, particulièrement imprévisible à Nouakchott. En toute saison, le meilleur allié de la laiterie est un vent chaud et sec, tandis qu'une journée fraîche et nuageuse peut entraîner une chute brutale de 50 % des ventes. De manière générale, la demande de lait est très forte en saison chaude, avec un probable effet d'atavisme en saison des pluies, et beaucoup plus faible en saison fraîche ;

– d'autre part, celles liées à l'influence de certains phénomènes sociologiques sur les variations saisonnières, tels que le mois du Ramadan, très favorable aux ventes, tandis que le mois suivant est tout à fait son contraire, ou le départ des familles aisées pendant les vacances scolaires.

La figure 3 montre l'évolution de l'achat de lait par la laiterie comparée à celle de la vente. On pourra constater qu'à certaines périodes il y a eu de grands écarts, néfastes pour le compte d'exploitation. Ceux-ci étaient dus à la réticence de la laiterie à rompre des engagements d'achat. Par la suite, la politique d'achat est devenue plus pragmatique, et les pertes de lait ont diminué.

L'entreprise, ayant manqué de fonds de roulement, n'a jamais les moyens de faire de la publicité, et a dû se contenter des effets du bouche à oreille.

La laiterie et l'Etat

Malgré ses retombées favorables, la seule aide apportée par l'Etat a consisté en un régime fiscal spécial, aux avantages assez limités. En effet, les organismes internationaux qui régissent les politiques économiques du pays exigent un libéralisme quasi absolu en théorie, et rejettent fermement le protectionnisme. Dans le cas de la Mauritanie, le tarif douanier favorise en fait le lait importé (taxé à 10 % alors que les emballages de la laiterie sont taxés à 32 %).

L'accès aux devises en vue de l'achat des emballages (seule importation de l'entreprise) se fait en concurrence avec tous les autres importateurs, entraînant parfois des ruptures de stock d'emballages. Heureusement, le contact assez direct entre la laiterie et les consommateurs permet des solutions parfois originales pour éviter l'arrêt de l'activité.

Par ailleurs, il aurait été souhaitable que les pouvoirs publics s'intéressent aux avantages du lait pasteurisé pour la santé publique, et entreprennent des actions

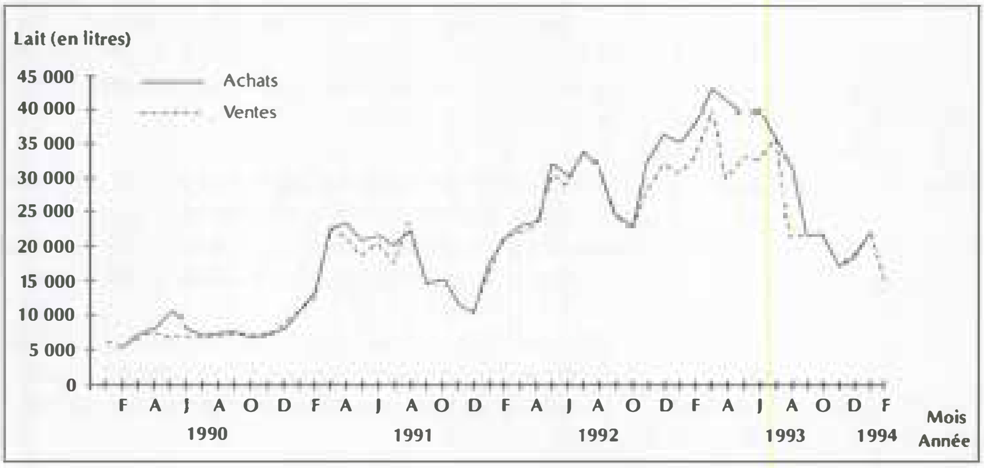

Figure 3. *Achats et ventes de lait de chamelle.*

d'éducation pour la santé, et de contrôle de la qualité du lait importé et du lait cru. Cependant, la même politique de libéralisme semble limiter toute démarche « qualité » de ce genre, du moment qu'il s'agit d'une entreprise privée. La laiterie elle-même n'a jamais eu les moyens financiers d'entreprendre ce type d'actions, qui ne sont pas considérées de son ressort.

Cependant, le soutien moral important exprimé à plusieurs reprises par le Président de la République, S.E. Monsieur Sid'Ahmed Ould Taya, semble s'étendre progressivement à d'autres secteurs de l'administration.

Conclusion

Aspects positifs du bilan

Malgré toutes ces difficultés et après cinq ans d'exploitation, on peut dire que le lait pasteurisé a gagné des parts de clientèle sur le lait UHT, et s'est imposé avec force sur le marché, grâce à ses qualités organoleptiques, à la régularité de sa distribution et de son prix, et grâce à la politique consistant à reprendre le lait périmé, garantissant d'une part au consommateur la fraîcheur du lait, et d'autre part au revendeur un bénéfice assuré, moins risqué que celui du lait UHT parfois avarié.

Du côté des éleveurs, l'activité de vente du lait commence à être perçue comme une réalité économique intéressante. Il est à prévoir que dans quelques années il sera possible de constater des changements importants dans ce domaine, tant par le nombre d'exploitants que par les méthodes d'exploitation.

Les retombées favorables de l'activité sont maintenant évidentes pour de nombreux observateurs :
- distribution de revenus dans le secteur rural ;
- amélioration de l'alimentation du bétail, sécurisation contre la sécheresse ;
- protection de l'environnement ;
- fixation des populations rurales ;
- amélioration de la santé de la population urbaine ;
- économie de devises.

Le lait de chamelle face au lait de vache

Le lait de vache a été introduit progressivement à partir de l'été 1990, lorsque des Mauritaniens revenus du Sénégal ont installé quelques vaches à Nouakchott pour en vendre le lait en l'état. Son développement, tant du côté de la production que de celui de la consommation, a été beaucoup plus puissant et rapide que celui du lait de chamelle. La facilité d'alimentation des vaches et leurs mises bas annuelles y sont pour quelque chose, mais aussi l'excellente saveur et le fort taux de matières grasses qui plaisent à de nombreux consommateurs.

Le lait de vache et le lait de chamelle sont traités de manière identique, dans le même circuit de pasteurisation-conditionnement, avec des rinçages intermédiaires. Bien entendu, les cuves de stockage sont séparées.

Le lait de vache n'est pas du tout considéré, au sein de l'entreprise, comme un concurrent du lait de chamelle, bien au contraire.

La Mauritanie est l'un des rares pays où le consommateur peut choisir entre le lait de chamelle et le lait de vache, tous deux pasteurisés et conditionnés. Les informations fournies par les consommateurs permettent de relever certains faits :
- la plupart des adeptes du lait de chamelle lui restent fidèles. On enregistre quand même certaines défections en faveur du lait de vache ;
- les consommateurs originaires des régions ayant de fortes traditions chamelières achètent plus volontiers le lait de chamelle ;
- les hommes sont largement majoritaires parmi les consommateurs de lait de chamelle, l'immense majorité des femmes (qui recherchent un certain embonpoint) préférant le lait de vache ;
- il faudrait une étude spéciale pour le confirmer, mais il semblerait que la consommation du lait de chamelle soit plus sensible à la météorologie que le lait de vache, ce qui signifierait qu'il est davantage assimilé à une boisson rafraîchissante (à juste titre d'ailleurs) ;
- les consommateurs signalent que pour obtenir une qualité optimale du lait de vache fermenté, il faut y mélanger entre un quart et un tiers de lait de chamelle. De nombreux ménages achètent en effet le lait pasteurisé pour préparer leur propre lait fermenté.

Au niveau de l'exploitation, le lait de vache a assuré la survie de l'unité, compensant des fluctuations saisonnières et même annuelles, en particulier celles enregistrées pendant l'hiver 1993-1994, où l'approvisionnement en lait de chamelle a baissé jusqu'à atteindre 400 litres par jour (alors que pendant l'hiver 1992-1993, presque 2 000 litres étaient disponibles mais ne purent être vendus qu'en partie).

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Dromedaries and camels, milking animals.
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Camels' milk marketing in India: restoring the economical viability of camel pastoralism

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Abstract. In India, camel utilization is traditionally transport oriented and the food potential of this species is largely ignored. The camel breeding community of Raikas (Rebaris) observes cultural restrictions against the sale of camel's milk. Nevertheless, in some parts of southern Rajasthan and northern Madhya Pradesh a thriving and expanding peri-urban camel's milk market has developed that until now has gone unnoticed. This communication gives a preliminary description of the extent and scope of the camel's milk market as well as the production and marketing systems. It is concluded that the sale of camel's milk represents an option for making camel pastoralism once again a viable economic option.

Key words. Dromedary, *Camelus dromedarius*, camel's milk, marketing, peri-urban market, pastoralism, economic viability, Madhya Pradesh, Rajasthan, India.

Résumé. En Inde, traditionnellement, le chameau est surtout utilisé pour le transport, et les atouts de cette espèce pour l'alimentaiton humaine sont largement ignorés. La communauté d'éleveurs de camelins des Raikas (Rebaris) observe d'ailleurs des restrictions culturelles quant à la vente du lait de chamelle. Cependant, dans quelques zones du sud du Rajasthan et du nord du Madhya Pradesh, existe un marché péri-urbain florissant et en pleine expansion pour la vente de lait de chamelle, ce qui n'avait jamais encore été observé. Cette communication donne une description préliminaire de l'étendue et des possibilités du marché de lait de chamelle, ainsi que des systèmes de production et de marché existant. On en conclut que la vente du lait de chamelle représente une voie intéressante et apporte au pastoralisme une opportunité économique viable.

Mots clés. Dromadaire, *Camelus dromedarius*, lait de chamelle, commercialisation, marché péri-urbain, pastoralisme, viabilité économique, Madhya Pradesh, Rajahstan, Inde.

Introduction

India's 1.4 million camels serve predominantly as a means of transportation and a source of traction. Until now, their food potential has remained largely ignored. Because of prevailing Hindu beliefs, camels are never slaughtered or used for meat. It has also been observed that camel's milk is not marketed in any organized system. It is only used for household consumption within the camel keeping society. The traditional camel breeding community of Raikas has a negative attitude towards the sale of camel's milk (KOHLER-ROLLEFSON, 1992). The only reference to camel's milk marketing in India pertains to the area of Kutch in the state of Gujarat, but no further details are available (RATHORE, 1986).

However, recent field investigations revealed a thriving and expanding peri-urban camel's milk market in south eastern Rajasthan and adjacent pockets of northern Madhya Pradesh. In this area, camel pastoralists have overcome their ingrained restrictions against the selling of camel's milk and have developed it into the main source of income from their herds. Because of the substantial profits gained from milk sales, camel breeding is being revived in this area, and herd sizes are increasing. This situation is in marked contrast to the classic camel breeding areas in western and central Rajasthan where camel pastoralism has often become economically obsolete and is regarded as a way of life without a future.

Materials and Methods

Data on the camel's milk market were collected from March to May 1994, mostly through informal interviews with camel's milk producers, distributors and buyers in and around the towns of Udaipur and Chittorgarh in Rajasthan, and Jawra in Madhya Pradesh. Information was elicited with the help of a member of the camel breeding community who also collected data on his own using simple questionnaires. Background data on other aspects of Rajasthan's camel production system, as well as on cultural attitudes towards camel's milk consumption and processing had been amassed previously through both informal and semi-structured interviews and questionnaires (KOHLER-ROLLEFSON, 1992; KOHLER-ROLLEFSON, in prep.).

Results

The traditional camel production system

The social group most closely associated with camel breeding is a Hindu caste called Raika or Rebari. In the past the Raikas acted as caretakers for the breeding herds belonging to the Maharajahs and other feudal landlords; since the beginning of the century, these camel holdings passed into their ownership. While the majority of large breeding herds belong to Raikas, members of other castes also engage in camel-breeding, such as Muslim groups, Rajputs, Jats and Gujjars (KOHLER-ROLLEFSON, 1992).

Camel breeding is conducted under extensive management conditions. In Rajasthan's extreme west where the climate is most arid, camels range freely for most of the year and are supervised only during the rainy season. In Rajasthan's semi-arid parts, camels are herded throughout the year and pastured on a combination of wasteland, fallowed or harvested fields and forest vegetation.

The rationale of the breeding system is to produce male animals for sale as draught animals. Because the production system is oriented exclusively towards the production of male offspring, reproduction parameters differ significantly from those reported for systems in other geographical areas, especialy the milk-oriented production systems in East Africa. Notably, calf's mortality is very low, not exceeding 5% in normal years. On the other hand, the abortion rate can be excessively high in some years, amounting to 33% in 1991/1992 in herds under study in Rajasthan's semi-arid Pali district. In the same area, breeding herds were composed of 57% adult females, 1% breeding males, 2% burden camels, 13% young males and 27% females below reproductive age (KOHLER-ROLLEFSON, in prep). With herdsizes averaging 25 heads, only about 3-4 male camels can be sold in an average year. Basically, current herd sizes are too small to yield sufficient income for making camel breeding economically worthwhile. In bad years, when losses are high, expenses incurred for trypanosomosis prophylaxis and treatment as well as by grazing fees charged by the forest department, can exceed income.

Traditional attitude towards camel's milk

In the traditional Raika system, milk, together with wool and dung, represents only a minor by-product of camel production, and it is consumed only by the men looking after the herds. Because camels are usually pastured at some distance from the villages, family members not involved in taking care of them rarely drink camel's milk. Moral convictions and superstition prohibit and prevent the marketing of camel's milk. Popular sentiment equates the selling of camel's milk with selling one's sons. Evidence is also cited that people who started selling milk were subsequently afflicted with evil fate, such as the death of all their camels. Other beliefs pertaining to camel's milk utilization stipulate that it should always be drunk fresh and without heating (whereas the milk from other animals is always boiled). Furthermore, it should not be processed into curd or other products. This tenet is usually attributed to local deities or to gurus. Sometimes more "rational" reasons are advanced, for instance, that camel's milk cannot be heated, because it curdles in the process. However, camel's milk is sometimes used for making *kir* (rice pudding). The herdsmen also process excess colostrum into an invigorating and delicious tonic called *miyavat* by heating it and adding sugar.

Muslim people tend to have a very positive attitude towards camel's milk consumption. They say it gives great strength and is good for one's health. In southern Rajasthan camel's milk is attributed therapeutic qualities, especially against typhoid, and it is said that drinking three cups of camel's milk daily for three days will cure this disease.

Geographic extent and scope of camel's milk marketing

According to information provided by the Rebaris themselves, camel's milk is currently marketed in Udaipur, Nathdwara, Chittorgarh, Bilwara, Rajsamand, Kota, Bhawanimandi, and Nimbahera. In Madhya Pradesh, peri-urban camel's milk markets include Mandsaur, Jawra, Ratlam, Indore, and Ujjain.

In Udaipur, about 20-25 quintels (i.e. 2,000-2,500 kg) of camel's milk are said to be sold per day. They are delivered from several villages within a radius of 15-20 km, including Isval, Javar, Mandkala, Puriya Kheri, and Rebariyon ka Gura. Camel's milk is also sold to the local dairy where it is mixed with milk from other animals. The amount of milk sold per herd ranges between 10-40 kg.

In Chittorgarh, there are about 20 camel's milk vendors, each selling 50-70 kg per day. In the village of Savta, about 10 km to the north, there are six camel's milk producers. With camel holdings averaging 16-17 female breeding camels, they supply between 5 and 50 kg (average 35.8 kg) per day (table I).

Table I. Number of female camels owned and amount of milk delivered per day to Chittorgarh by different breeders from Savta.

Owner	Number of female camels	Amount of milk delivered per day (kg)
1	20	50
2	20	50
3	20	40
4	30	50
5	6	15
6	5	10

In Jawra, camel's milk is estimated to compose about 20% of the whole milk market. Because of its famous Muslim shrines that attract pilgrims from as far as Pakistan and Iran, there is a large number of tea-stalls where camel's milk is often used because of its lower price. In addition, Muslims tend to be favourably inclined towards the drinking of camel's milk. Fearing for their share of the market, the milkmen who sold buffalo's and cow's milk in 1991 rose up against the sale of camel's milk, accusing it of being detrimental to human health. However, the Muslim population, the District Collector, and the Chief of Police as well as several doctors took a position in favour of camel's milk. This was confirmed by a written testimony obtained from the Udaipur dairy.

Jawra furnishes ideal circumstances for the production of camel's milk, since it is surrounded by wasteland with excellent vegetation for camels, such as the mimar tree (*Acacia* sp.). The grazing fee charged by the goverment of Madhya Pradesh is 40 Rupees per animal per year and is regarded as reasonable by the camel owners. These factors explain that herd sizes and amounts of milk delivered per producer are substantially larger than in Chittorgarh, averaging 79 female breeding camels and 75 kg of milk delivered per day (table II).

Table II. Camel's milk production near Jawra (Madhya Pradesh).

Owner	Herd size (females)	Milk delivered (kg)	Transportation
1	110	50	3 bicycles
2	150	150	3 bicycles
3	50	40	bicycle
4	30	30	bicycle
5	60	70	bicycle
6	100	100	mortocycle
7	50	30	motorcycle
8	40	30	bicycle
9	150	90	bicycle
10	50	60	bicycle
Total	790	750	

Milk production system

The herds are usually stationed within a distance of 10-15 km from the cities, and camels are kept exclusively on natural graze, mostly consisting of tree vegetation. Favourite forage plants include babul (*Acacia nilotica*), khejra (*Prosopis cineraria*), kanter, ker (*Capparis decidua*), higont (*Balanites aegyptiaca*), kulai, bant, bor (*Ziziphus glabrata*). The mimar tree, an *Acacia* species found only in Madhya Pradesh, not in Rajasthan, is supposed to have especially beneficial effects on milk yields. During the rainy season (chaumasa), which lasts from mid June to mid October, some camel herds from Jawra and Chittorgarh withdraw to the Bijapur range in the Aravalli Hills, others to the Shri Nathji Oran near Nathdwara. Where forage is scant, such as in Udaipur, herds are sometimes split up and only the lactating animals kept in the vicinity of the town.

The camels are milked twice ot thrice per day, usually at night-time and in the early morning. For instance one herd in Jawra is milked at 9:00 p.m., 2:00 a.m., and 6:00 a.m. Another herd in Udaipur was milked at 10:00-11:00 p.m. and at 6 a.m. The average amount of milk obtained per day from one camel is about 2 kg, although some owners assert that maximum yields can be as high as 6 kg/day. The suckling camels are never separated from their mothers, although at night-time they have no opportunity to drink.

Distribution and marketing system

Not all milk producers transport the milk to the cities themselves; some of the more enterprising ones collect it from them for delivery to the buyers. These collectors usually pay 3 rupees per kg to the producers (i.e. about half the market rate). They all appear to maintain their own herds and to be members of the Rebari caste so these seem to be arrangements among relatives, and not exploitation. Transportation to the cities is usually undertaken by bicycle; only the very affluent milk dealers can afford motorbikes. Some people use the bus.

Most of the camel's milk is bought by teastall owners, although some private households are also regular purchasers. In India tea always contains a large proportion of milk or is even made without any water. Camel's milk is significantly cheaper than buffalo or cow's milk, selling at 5-6 rupees per kg, as compared to 8 rupees for cow's milk and 10-12 rupees for buffalo's milk. This factor explains, to a significant extent, the popularity of camel's milk with teastall owners. In addition, camel's milk is said to have a neutral taste, and some informants claimed that the best tea is made from camel's milk.

Another important consideration for teastall owners is the proven long shelf life of camel's milk. Since cooling facilities are generally not available, the milk delivered in the morning is kept unrefrigerated until night-time, even if temperatures soar above 40°C.

Economics

The income generated from camel's milk sales is regarded as substantial and generally exceeds that obtained from selling male camels. Moreover it creates a steady flow income throughout all or most of the year, whereas profits made from the sale of male calves only accrue once a year, at the fairs that are held at Pushkar and Jhalawar Patan in the month of Kartik (October-November).

One example of a particularly successful milk entrepreneur is Ramchanderji Raika whose native village is near Chittorgarh, but who supplies camel's milk to Jawra. He owns about 100 female camels from whom he collects 75 litres/day; in addition he collects 75 kg from other Raikas. Buying milk at 3 IR (Indian rupees)/kg and selling it at 6 IR/kg, his daily income is 675 IR/day or 20,000 IR/month. He has no income during the three months of the rainy season when he pastures his animals in the Aravalli forests. Expenses include the grazing tax of 40 IR charged by the state of Madhya Pradesh per year and per adult camel; 100 IR/day for petrol and wages for 6-7 gauris (herdsmen) that take care of and milk his herd at 6,000-7,000 IR/year/person. Injections against trypanosomosis cost 80 IR/dose. He also receives income from the sale of male calves which fetch about 2,000 IR when sold at Pushkar in their first year.

Constraints

In southern Rajasthan, the scarcity of forage acts as a severe constraint to camel productivity. Especially the herds kept in the Udaipur area were in extremely bad nutritional status because of lack of grazing opportunities. This almost permanent state of starvation imposes a limit on milk yields. In Jawra there is ample grazing available within a short distance of the town, which is one of the reasons why camel breeders from southern Rajasthan have moved their herds there. However, they themselves remark that the vegetation cover has thinned down considerably during the last decade.

Diseases also take their toll. Trypanosomosis is a constant problem, especially in years with relatively good rainfall. It usually manifests itself in abortions. Another disease of economic importance is locally known as *"magravala"*. Lack of veterinary care and the irregular availability of prophylactic medication against trypanosomosis poses severe problems to camel breeders. Even if available, they often have been tampered with and produce unsatisfactory results, according to the breeders.

Discussion

Several aspects of the camel's milk market, such as the following, appear noteworthy.

One aspect is the spontaneous nature of its development. Without any involvement of the government or non-governmental organizations, the Rebaris have overcome their traditional restraints towards the commercial utilization of camel's milk and seized the opportunity, probably the only one for putting camel production once again on a sound economic basis. The idea is said to have originated with two Rebaris from a village near

Nathdwara. One of them settled in Rebariyon ki Guda at the outskirts of Udaipur and was driven by poverty to selling the milk of his camels. He started marketing the milk from 7-10 camels at 1.5 rupee/litre about 25 years ago. Now his son has increased the herdsize to 80 animals and sells about 30-40 kg per day. The other Rebari moved to Chittorgarh and began selling milk about 23 years ago for 1.25 rupee/kg.

It is also extraordinary that the reorientation of the pastoral system towards milk production apparently has had no negative effect on herd reproduction rates. No systematic study of reproductive parameters has been undertaken so far, but the Rebaris did not indicate any rise in neonatal and calf mortality due to the diversion of milk. This state of affairs is very different from that in other milk oriented systems, such as in East Africa where mortality is proclaimed to be 30% or more.

Another aspect that deserves emphasizing is the positive attitude of the milk producers compared with that of non-milk selling camel owners. Whereas the latter generally complained about their bad lot and their loss of interest in camel breeding, the former were extremely enthusiastic about their venture and eager to learn about possible improvements in their management and production system.

Conclusion

Milk marketing seems to be the logical remedy for the economic plight of many of Rajasthan's camel pastoralists. The traditional single-purpose production system is no longer economically viable in the current situation of shrinking grazing resources that precludes extensive management systems based on large herd holdings. The added income generated from milk sales can once again make it possible to earn a reasonable living from camel breeding, even if smaller herds are kept. Thus the example set by a relatively small group of Rebaris outside the core camel breeding areas is of great interest to the camel breeders from western and central Rajasthan that still cling to the old system.

However, certain caveats are in order, and camel's milk marketing should not be hailed as a panacea for the economic woes of traditional camel pastoralists. At present, camel's milk has a competitive advantage over milk from other species because it can be produced cheaper—by relying only on natural graze and without input of fodder. Since some of the Rebaris themselves attest that the vegetation cover of the wasteland areas has thinned out over the last few decades, there is reason to believe that camel pastoralists overexploit them. It is therefore imperative to monitor the effect of camel grazing on the resource base, to institute controls that prevent its degradation and to initiate conservation and regeneration programs if necessary. Ecological sustainability should be a key consideration.

Secondly, it needs to be emphasized that camel's milk marketing is only feasible in contexts that juxtapose two circumstances: sufficient pasturing opportunities within a reasonable distance of an urban consumer base. This situation is rare in Rajasthan. For the purpose of making camel's milk marketing feasible outside such scenarios, it is necessary to investigate ways of processing milk into products with a longer shelf life, especially cheese.

Both these concerns (i.e. quantity and distance) are crucial components of CHIP (Camel Husbandry Improvement Project) that is being launched by the School of Desert Sciences and the League for Pastoral Peoples.

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Condensed camel's milk : a new approach to food security in Kenya

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Abstract. The regions inhabited by the pastoral communities are arid and semi-arid rangelands where the major land use activity is livestock herding. These zones are characterised by erratic rainfall with wide variations in monthly and annual totals. The pastoral livestock production system forms the basis of a subsistence economy sustaining the nomads. Development aimed at self sufficiency in food supply cannot therefore afford to ignore this important aspect. On the other hand, with irrigation these dry areas can grow almost anything. Unfortunately, this is not within the means of most African governments, which leaves us with few possible options. During times of plenty there is an abundance of milk with a reasonable proportion going to waste. The peak period during which milk is abundant is normally not more than a few weeks after which the long dry spell starts. Thus there is need to preserve such surplus milk whenever available so that the pastoralist has something to turn to during the times of scarcity. This communication describes one possible method of preservation, namely as condensed milk. Not only will the condensed milk alleviate the food shortage during the dry periods but it will also go a long way in supplementing relief supplies which are more often than not unreliable and inadequate. If encouraged, such food preservation and storage will, to a reasonable degree, lessen the dependencies created by relief supplies. An analysis of the process of preparing condensed milk indicates that it is economically realistic. Preliminary field trials have shown that it is popular. Further research and trials need to be conducted to ascertain its nutritional value, alternative methods of preparation and involvement of communities in its distribution and development.

Key words. Dromedary, *Camelus dromedarius*, camel's milk, evaporated milk, food security, pastoralism, arid zones, semiarid zones, Kenya.

Résumé. Les régions habitées par les populations pastorales sont des zones arides et semi-arides où la principale activité agricole est l'élevage du bétail, et en particulier des camelins. Ces zones sont caractérisées par des chutes de pluies irrégulières avec des variations considérables dans les pluviométries mensuelle et annuelle. Le système de production du bétail pastoral constitue la base d'une économie de subsistance pour les nomades. Les politiques de développement visant à créer une indépendance alimentaire ne peuvent pas se permettre d'ignorer cet aspect. Cependant, l'irrigation de ces zones sèches permettrait de presque tout cultiver ; malheureusement, les moyens financier de la plupart des gouvernements du continent africain laissent peu de choix possibles au développement agricole. Pendant les périodes d'abondance, la production de lait est suffisante, et on déplore même du gaspillage. La période pendant laquelle le lait est abondant ne dure normalement pas plus de quelques semaines après lesquelles les longues périodes de sécheresse commencent. Aussi est-il nécessaire de conserver les excédents de lait dès que possible, afin que les pasteurs puissent disposer de réserves alimentaires pendant les périodes de pénurie. Cette communication décrit une méthode de conservation : le lait condensé. Non seulement celui-ci peut améliorer la situation alimentaire pendant les périodes de sécheresse, mais, en outre, il peut permettre de compléter les réserves alimentaires, le plus souvent incertaines et inadaptées. Si cette méthode est encouragée, une conservation et un stockage tels des aliments peuvent réduire de façon raisonnable les dépendances à l'aide alimentaire. Une analyse du procédé de préparation du lait condensé montre que ceci est économiquement réalisable. Les premiers essais sur le terrain en ont démontré la popularité. D'autres recherches et essais doivent être conduits pour vérifier la valeur nutritionnelle du lait condensé, évaluer d'autres méthodes de préparation et le rôle des populations dans sa distribution et son développement.

Mots clés. Dromadaire, *Camelus dromedarius*, lait de chamelle, lait concentré, sécurité alimentaire, pastoralisme, zone aride, zone semi-aride, Kenya.

Introduction

Drought and the consequential degradation of arid rangeland coupled with wider socio-economic forces of modernization, have diminished the viability of the livestock based pastoral production systems of the arid and semi-arid lands (ASAL) of Kenya. Government as well as international donors and non-governemental organizations have largely ignored pastoralism and the nomadic peoples except for famine assistance during extreme drought (FARM AFRICAN CAMEL IMPROVEMENT PROJECT, 1993).

Building on the premise that "food is the best medicine" the FARM Africa Camel Improvement Project (CIP) now known as the Pastoralists Development Project (PDP) aimed to improve the capacity of pastoralists to increase livestock productivity under their traditional nomadic and transhumant systems in the districts of Samburu and Marsabit.

With a combined area of just over 90,000 sq km, these districts comprise about 16% of the country and include some of the most arid conditions where potential evaporation rates may exceed rainfall by forty times.

Five years ago, the human population in these two districts approached a quarter of a million, many of whom were dependent on the camel for their livelihood. It was the livestock species with the greatest unutilized potential and also best adapted to arid lands, as well as being the least destructive of the environment. It became the natural focus for Project interventions. In order to reach camel owning pastoralists the Project adopted a highly mobile approach to deliver services that included training, veterinary supplies, improved breeding stock and community health (among others) to the target groups. The Project maintains Mobile Outreach Camps (MOCs) to enable its personnel and services to enter, join and move with communities of nomadic pastoralists. The main activity in the delivery of Project services is a series of interactive workshops held across the area in the locations of nomadic camel owning pastoralists. Workshops are characterised by group participatory training methods involving problem posing and solving approaches. These are followed up by the creation of groups of camel owners which become known as Camel Improvement Groups (CIGs), as well as Women's groups. These groups have become the main structures for sustaining the community development process by undertaking further training activities and small scale income generating projects on a self help basis (FARM AFRICAN CAMEL IMPROVEMENT PROJECT, 1993).

Among pastoralists and group members the health of their animals is of primary interest. This is because sickness frequently contributes to a rapid and dramatic loss of productivity. Subsistence pastoralists keep the majority of their animals for milk which is a potentially renewable and sustainable food resource. In ASAL regions, the camel is *par excellence* the most reliable and consistent producer of milk and nomadic pastoralists have become heavily dependent on it for food security as well as transport.

With increasing human populations in a degrading environment, the camel is one of the few possibilities which offers some hope with which to buy time while man comes to grips with the major population issues. This communication describes a possible method of maximizing the value of camel's milk to needy ASAL communities.

Camels as food security

Given a choice of environments camels prefer areas of high ambient temperature (range 25-40°C), low mean annual rainfall (100-300 mm) and relative humidity (40-60%). They prefer warm saline water to drink and halophytic and dwarf shrubs to browse. By contrast, the ideal environment for cattle has a temperature range of 13-18°C, a mean annual rainfall in excess of 500 mm and a relative humidity of 60-70%. They prefer cool fresh water to drink and grass to eat. When temperatures exceed 40°C cattle stop eating, milk production, breeding and movements, such as walking to pasture and water, are hindered (FIELD, 1993). A cow starts to cool itself by sweating at temperatures above 25°C. Kept for subsistence needs it requires a lot of water to produce milk. Water lost through sweating leads to reduced milk supply or necessitates more frequent drinking to replace losses. This in turn limits the distance a cow can graze from permanent water. During droughts cattle soon exhaust grazing near to water and are the first to die from hunger rather than thirst.

In contrast, camels have a great ability to adapt which helps them to tolerate the extremes of arid environments. Among these may be listed the following:

- behavioural avoidance of direct radiation;
- physical avoidance of reflected radiation;
- efficient heat convection;
- good insulation against solar radiation;
- low respiration rates and water loss from lungs;
- maintenance of adequate blood volume during dehydration;
- drink less than other livestock, weight for weight;
- thermolabile;
- the forestomach is a dynamic reservoir;
- excrete concentrated urine through efficient kidneys;
- lose latent heat of evaporation when urinating on hind legs;
- produce faecal pellets of low moisture;
- recycle nitrogen as urea;
- large pad like feet help walking on soft sand;
- protect nostrils and eyes from dust.

The abbreviated list above includes mostly adaptations which minimize water loss and enable camels to survive for legendary periods of from five days to a month without drinking. Indeed, if the moisture content of their forage is sufficient, it is questionable whether they would ever need to drink. The low requirements for water means that more is available for milk production which in turn is less subject to the vagaries of surrounding environment.

Camels are able to maximize feeding time in pasture untouched by other livestock because it lies beyond their physiological limits. Furthermore they do not waste much time and energy walking to and from water through barren land.

It is frequently observed that the lactation of camels is not seriously disrupted by extremes of drought. Indeed while cattle and smallstock are dying, camels may continue to lactate (maximum 30 months) and only dry off some two months after pregnancy which invariably occurs during a wet season. This explains why former cattle cultures in Kenya like the Maasai, Samburu and Boran, adopt camels when their cattle fail to meet the needs of their expanding population during drought.

The economic advantages of camels as a food source have been summarised by NJIRU (1993) as follows:
– they produce more milk than other animals in arid regions;
– they produce milk longest into a drought when yields from other animals drop rapidly or the animals die;
– they produce high quality milk with a higher vitamin C content than milk from other animals when kept under very dry conditions and proteins that are easier to digest. The milk keeps better than milk from other livestock. It has a higher water content than milk from other animals when kept under very dry conditions;
– they provide a regular supply of blood to supplement decreasing milk supplies in dry periods because they do not lose condition like other stock;
– at the height of drought fattened animals, specially kept as a drought reserve, can be slaughtered, and fat and meat used for food.
In addition, during extremes of famine even camel hides can be prepared and eaten!

Reasons to conserve milk - fluctuations in supply

The countries of the Horn of Africa, which include Kenya, support the largest concentration of camels anywhere in the world. The majority of pastoralists keep camels primarily for milk. Although camel's meat is nutritious, it is considered a luxury which cannot be afforded regularly. In Kenya only the Somali pastoralists have a system of storing meat as "*nyiri nyiri* ", dried, fried and kept in fat.

Milk from the family herds fluctuates considerably from times of abundance to times of acute scarcity. Data illustrating these fluctuations presented in FIELD *et al.* (1984) and FIELD and SIMPKIN (1985) are summarised for livestock monitored in Marsabit district over several lactations (table I). These indicate that an average pastoralist household among the Ariaal Rendille of eight persons owns 12 camels, 101 sheep and goats and 11 cattle. Maximum daily milk production (with a veterinary input) for approximately a quarter of the family herd which are lactating, amounts to a little over 26 litres.

Of this 50% is derived from camels. The minimum during dry periods amounts to 4.5 litres which in severe drought, may fall to 2 litres when all lactating livestock dry off except camels.

Without veterinary input maximum milk production may fall by as much as one-third to 18 litres per day.

The peaks of milk production of the different livestock species do not necessarily coincide. This is because although rainfall in the ASAL regions of Kenya is clearly bimodal and growing pasture triggers breeding and conceptions, gestation periods vary according to species. Sheep and goats with six month gestation are likely to give birth in the following wet season, while camels with a twelve month gestation have calving peaks in the same wet season a year later. Cattle however, with

Table I. Average pastoralist (Rendille) herd data and peak milk yields (figures in litres) (from FIELD *et al.*, 1984; FIELD and SIMPKIN, 1985).

Species	Herd size	Female lactating p.a. (%)	Number lactating	Peak yield per animal	Total daily yield	%
Camels	12	27.5	3.3	4.1	13.53	50.6
Goats	60	40	24	0.225	5.4	20.2
Sheep	41	40	16.4	0.175	2.87	10.5
Cattle	11	36	4	1.250	5	18.7

Family herd total daily yield = 26.80 l—Household requirements = 16.00 l—Balance remaining for condensed = 10.80 l/day—Total for peak production period (1 month) = 324.0 l.

a nine month gestation may not be able to synchronise calving with rainfall. Nevertheless the table shows that the main producers of milk are camels and smallstock, which if synchronised and under a veterinary health programme of management, may produce 22 litres of milk per day.

During such times of plenty, livestock owners drink milk and little else. Thus an average of two litres of milk per person (3 adults, 5 children) per day may be consumed. The consumption of 16 litres a day leaves 11 litres for disposal. Very often poor livestock owners deliberately live with their stock close to towns to serve the market from this peri-urban milk supply (SIKANA *et al.*, 1993).

This option has the advantage of proximity to the consumer, and minimizes transport costs, but it may be more than offset by the poor quality of pasture and high disease challenge experienced near towns. Average to rich stock owners prefer to keep their lactating animals in better pasture which is usually 15 km or more from town. Transportation is difficult, expensive and time consuming; often surplus milk is given away to passers by or even fed to donkeys! At best it reaches a town market infrequently where the value is depressed because of a surplus throughout the region.

Contrast this with the serious deprivations during prolonged drought and the expensive importation of famine relief food with all its attendant disadvantages, and there is a clear case for preserving milk products from times of plenty to be used during shortages.

The peak during which milk is abundant and families may expect a surplus of 10 litres or more per day lasts for not more than a month. This means that a family may expect to be " flooded " with more than 300 litres of surplus milk with no good market, but a strong justification for preservation.

Possible ways of conserving camel's milk

It has been noted that camels may outperform all other livestock in terms of milk production in ASAL regions if due advantage is taken of their unique physiology which enables them to remain in good pasture far from water. Indeed there is a Rendille proverb which says that the only problem faced by a camel lies with its owner! (i.e. restricting its access to distant pastures). It follows that the most abundant supply of milk may occur furthest from towns where modern preservation methods (e.g. refrigeration, ultra heat treatment) are not available. Bearing this in mind there remain only four practical ways of conserving camel's milk under these remote conditions. They are:
- as cheese;
- as fermented milk;
- as condensed milk;
- as powdered milk.

Camel's cheese

Soft cheese can be made from camel's milk (YAGIL, 1982) although with difficulty (PURCHASE, 1943). Fat is bound to the milk proteins and the milk does not curdle readily. The X-casein in camel's milk has different properties to cow's milk (LARSSON-RAZNIKIEWICZ and MOHAMED, 1986).

Nevertheless, examples of camel's cheese making are available:
- from the USSR using rennet coagulated milk (DILANYAN, 1959);
- mixing with milk of other animals (RAO *et al.*, 1970);
- among the Bedouin and Touareg a dry cheese called " *Afig* " (GAST *et al.*, 1969);
- in Kenya a soft cheese made with some difficulty as the correct pH is apparently critical (ATKINS and FARAH, personal communication);
- in Mauritania.

Fermented milk

After fresh milk, fermented milk is perhaps the most common form in which milk is traditionally consumed in northern Kenya where it is known as " *susa* ".

The milk is left to stand in containers in half shade for one to three days until it becomes sour. Because of high ambient temperatures and high contamination rates (of bacterial cultures) acidification proceeds spontaneously, and products with varying sour taste result (FARAH and STREIFF, 1987). The high acidity most likely prevents the multiplication of certain harmful bacteria.

In order to improve the quality of traditional *susa*, FARAH and STREIFF (1987) used selected lactic acid bacteria as starter cultures. The manufactured product has a more uniform fresh taste but is otherwise similar to *susa*.

Condensed milk

About seven years ago it was suggested (ATKINS and SCHULTHESS, personal communication) that it should be possible to condense camel's milk in a similar manner to the well known condensed cow's milk. This has now been done experimentally and at the village/community level and provides new opportunities for the more prolonged preservation of camel's milk. This takes advantage of surpluses at time of peak yields and enables their storage without modern equipment (e.g. refrigeration) until there is a food shortage. Cane sugar is used but otherwise no other preservatives.

Sun dried and powdered milk

Another method of preserving milk is practised by the Turkana tribe. It involves sun drying milk poured into a surface such as a camel hide. The dried milk is later scraped off in flakes prior to storage.

Condensed milk

The principle

Most fresh milk does not survive storage for long at ambient temperatures because it is a good medium for bacterial growth, the chemical by-products of which render milk unpalatable or distasteful. Apart from high temperatures, bacteria also require water and nutrients. The simultaneous extraction of water by evaporation with the addition of cane sugar (sucrose) permits the total sugar content (including lactose) to rise to 68%. At this level, bacteria no longer thrive, water is minimal, and the product may be stored without refrigeration for later consumption.

The process

In 1986, when the condensation of camel's milk was first practised in the field as a demonstration for pastoralists, a method was devised using a balance arm for weighing milk and sugar and then reducing the combined weight, through evaporation, by about half.

This method proved to be impracticable under the circumstances. Pastoralists have little experience of weighing especially under windy conditions, and invariably forgot some essential detail. It was noticed that they preferred to use their own judgement and make condensed milk "by eye". Nevertheless it is important to standardise the starting ingredients, and this can be done simply by volumetric ratios. Thus one part of sugar by volume is dissolved in four parts of camel's milk by volume in a clean, open, metal pan. The mixture is brought to the boil gently, stirring all the while. After 45 minutes to 1 hour it begins to thicken appreciably, and when the volume is reduced by about two-thirds it has the consistency of treacle. Care should be taken at this stage not to burn the contents especially if the pan is of thin metal. Larger volumes take longer, for example the condensing process takes 3-5 hours to make about 5 litres of condensed milk, depending on the size of the cooking pot. In this case, the first hour or so requires only occasional attention but for the final half hour, regular stirring is needed and the consistency of the milk must be watched very carefully. Condensed milk is more liquid (less viscous) when hot but becomes more solid on cooling. Milk which has not been boiled sufficiently will not keep for so long, as the water content is still too high. Over-cooked milk however, becomes quite solid on cooling and forms "fudge" or even "toffee".

The condensed milk is then transferred to either an aluminium tin with a press down lid or a glass jar with a screw down lid. The containers should have large mouths, and the milk decanted while still warm and flowing readily. The containers should be sterile.

Nutrition/palatability issues

Longevity

The shelf life of condensed camel's milk appears to depend on several factors. Longevity is maximised if the water content is low, the airspace within the container is minimized, the lid remains closed, and a wax layer or paper covers the surface of the milk. Under these conditions, condensed milk may be kept for up to six months; frequently however, there is some contamination and either yeasts or moulds develop on the surface. There are no known yeasts which are harmful to man, but moulds may be and if formed, should be physically removed.

Once the container is opened further contamination may be introduced so it is advisable, once the tin is opened, to finish the contents without undue delay. The life of condensed milk is therefore appreciably longer than that of fermented milk and soft cheese, but probably not as long as hard cheese and sun dried milk.

Portability

One problem facing nomads is their limited capacity to carry household effects and food. For example, they possess limited furniture or musical instruments, which are light weight.

It would be difficult to carry all the 324 litres of surplus milk in the form of *susa* as this would require about four load camels in addition to those used for carrying the household.

In the form of condensed milk there is a reduction of 70% of the overall weight. In order to make 1 kg of condensed milk the following ingredients are required:

fresh camel's milk	2.67 litres = kg
cane sugar	0.67 kg
combined total	3.34 kg

During processing there is virtually no weight loss of sugar which means that only one-third of the weight of condensed milk is actually camel's milk, while the rest is sugar. Thus 2.6 litres of fresh milk are condensed to 0.33 kg of condensed milk, a reduction of 87.6% through the evaporation of water. A nomad with a surplus of 324 litres which is then condensed, only has to carry 120 kg which requires about one or two transport camels—a much more realistic proposition. Furthermore, the condensed milk will contain a high proportion of sugar which can boost their energy deficient diets.

Portability on a large scale would be difficult using tins with press down lids. Hermetically sealed tins or vacuum packed heavy plastic would be preferable.

Water content

There is always a risk that if milk is purchased it may have been diluted prior to condensing. An empirical reduction in volume will produce an inferior product with reduced shelf life. A rule of thumb test may be applied where the correct moisture content is reached when the milk will barely flow from a spoon under gravity.

From the point of view of shelf life and portability, water content should be minimised. However some water is desirable to enable the product to flow in a manageable way. Palatability and the various ways in which condensed milk may be consumed are discussed below.

Nutritional value

To date the authors have not been able to conduct detailed chemical and nutritional analyses to determine the nutritional value of condensed camel's milk, although this is planned shortly.

They anticipate that the prolonged boiling process may destroy some of the more delicate molecules, especially of vitamins. At this stage therefore they would not recommend condensed milk for babies, except possibly as a supplement or during weaning.

Nevertheless fresh milk while being a good source of protein, is a poor source of energy. Pastoralists must drink about twice the volume of milk to obtain their daily energy needs as they do for their protein requirements. When family herds were large, this was possible, now it is a luxury which very few can afford.

One method to supplement energy intake is to sell surplus male goats and purchase grain or sugar. The latter of course may be used to condensed milk and thereby prepare a product rich in both protein and energy.

Palatability

Condensed camel's milk is a highly palatable product. Indeed, it may be so popular with children as to defeat its main purpose of being a means to postpone consumption. Once children taste condensed milk they invariably find it irresistible. Among adults the only persons who may not like it are slimmers, diabetics and people with traditional aversion to camels, lactose intolerance.

Condensed milk may be presented in different ways. The most popular is to dissolve it in strong, hot tea. It may be spread on bread or mixed with porridge.

In this respect it has an advantage over cheese and fermented milk which cannot be mixed with tea.

Enterprise cost of production

FARM Africa has, for the past 3 years, kept a herd of between 100 and 250 camels under optimal nutritional and health conditions at Mogwooni ranch, 30 km NW of Nanyuki in Kenya. All lactating camels are of the Somali breed, and surplus milk is condensed on a routine basis by an employee who lives at the camel camp. The condensed milk is made daily over an open fire using very basic utensils.

A budget for this activity is shown in table II.

The following items are required as capital investment for the preparation of condensed milk:
- 2 x cooking pots of suitable capacity to hold one day's excess milk;
- 1 x large sieve;
- 1 x large wooden spoon for stirring;
- a pot support (large stones may be used);

Table II. Processing costs in Kenyan shillings per litre condensed milk, Mogwooni ranch, Kenya, February 1994.

Item	Unit	No. of units	Cost per unit*	Total cost	%
Fresh milk	litre	2.67	20.00[1]	53.40	48.5
Sugar	kg	0.67	38.00	25.46	23.1
Labour	unit	1	25.00[2]	25.00	22.7
Fuelwood	kg	2	0.00[3]	0.00	0.0
Equipment	unit	1	1.13[4]	1.13	1.0
Container	unit	1	5.00	5.00	4.6
	Total procession cost			109.99	99.9

* in US dollars (US$) = 1,86 per litre with US$ 1 = K.Sh. 59

1. Marketes cost of milk at farm gat, Nanyuki—2. Payment made to concessionaire per litre milk produced—3. Fuelwood is cut for free on the ranch; labour included in 2—4. Depreciation on cooking and camping equipment.

– washing up utensils including soap;
– suitable containers for condensed milk; FARM Africa uses sterilized second hand beverage tins with well fitting lids;
– a traditional, portable house;
– a safari bed.

The above budget cannot be applied directly to a pastoralist family, and the following economic considerations are relevant.

Value of labour

The Mogwooni ranch project operates on a concession basis, by the kilogramme of condensed milk produced. The concessionaire is supplied with camp equipment, utensils, milk and sugar but is expected to collect wood. The present concessionaire felt that the activity was financially attractive provided that she was supplied with at least 12 litres of milk a day. This would be sufficient for 4.5 kg of condensed milk giving a minimum daily income of K.Sh. 112.50 (US$ 1.91). The value of labour in a pastoralist family would depend on who was doing the condensing.

If they could be gainfully employed in alternative activities, labour spent in condensing milk would need to be valued at its opportunity cost, that is its value in the next most profitable activity (Overseas Development Agency, 1988). The task is not difficult, but tedious. It would be an ideal activity for an older lady no longer involved in raising children.

Value of milk

For FARM Africa the farm gate price of camel's milk is used, since at the volumes produced there is a steady market for fresh milk in Nanyuki and so the milk could be sold if it were not being preserved. Under pastoralist conditions, the opportunity cost of the milk should be used. If all the camel's milk produced can be consumed by the family or sold, then its opportunity cost is its market price (cash or barter); if it cannot all be used, the opportunity price will be less. If its next best alternative use is to be thrown away the opportunity cost is zero although this is never likely to happen. It could be given to poor neighbours and thereby create allegiance or left entirely for calf growth and meat production.

Cost of fuel

At Mogwooni ranch the camel project is part of a bush clearing scheme. The firewood cut or collected for fuel has a nuisance value, and its cost is the cost of the labour used to cut it. For a pastoralist family in a fuel scarce area this item of the budget would assume considerable importance. If purchased it would probably be expensive, if cut it would be time consuming and may keep women from other activities of importance to the family. For financial and ecological reasons fuel should be a highly valued resource. This more than any other consideration might make other methods of preservation preferable to condensing in extreme desert areas. In the less extreme areas camels browse woodlands far from settlements where ample dead firewood is available.

The present market

Within Kenya

The preparation of condensed camel's milk for marketing has been developed gradually over the past 18 months.

Main constraints have been as follows:
– drought affecting most of camel ranges in Kenya, thus limiting production to the FARM herd kept at Mogwooni ranch;
– the number of camels lactating;

– seasonal fluctuations in production;
– the availability and motivation of concessionaires.

Nevertheless, the following sales have been recorded (table III).

Table III. Production and sales of condensed camel's milk.

Period	Production (kg)	Price per kg (K.Sh.)	Total income
Jan.-Mar. 1993	29.4	50/=	1,470
April-June 1993	34.5	70/=	2,516
July-Sept. 1993	168.3	80/=	13,465
Oct.-Dec. 1993	100.0	90/=	9,017
Jan.-Mar. 1994	76.0	90/=	6,840
April-June 1994	290.7	90/=	26,163
Total	698.9		59,471

During the period of collection there were an average of 23 lactating camels of the Somali breed. They produced an average of 2.32 litres milk per camel per day. Other areas of consumption were:
– herdsmen, relatives and friends;
– fresh and fermented milk sold in Nanyuki town.

Condensed camel's milk has been sold throughout Kenya but most notably in FARM Africa's working area of Samburu and Marsabit districts. This is most probably for three reasons:
– camels are popular in Northern Kenya and less so in the South. There is no prejudice against condensed camel's milk in the area where they live;
– the two districts were visited frequently by the project;
– the two districts were subject to severe drought and shortages of dairy products which are the traditional diet of pastoralists.

In one instance condensed milk was supplied as a supplement to the diet of six month old triplets in a Gabbra nomadic family. The triplets were very weak and the family unable to cope owing to the ravages of the drought. Owing to a tradition of infanticide in cases of multiple births, these are probably the first surviving triplets among the nomads.

International

To date condensed camel's milk has been taken to only two other countries apart from Kenya, namely the United Kingdom and South Africa. It has proved popular in both countries.

Reasons for the limited international dispersal are that:
– it is intended to be used in the home of the producer/manufacturer;
– packaging is still simple (and cheap) and in such a form the milk does not travel well.

Questions to be answered

From the foregoing it is clear that a number of questions remain to be answered before camel's condensed milk is commercially viable.

By research

Further research is needed to answer the following questions:
– How does the nutritional value of camel's milk change during the process of condensing?
– If essential vitamins are denatured, can they be added later and at what cost?
– Does the addition of sugar lead to a more balanced diet?
– In desert areas, where fuel is scarce and expensive, would it be possible to develop a cost effective solar-powered cooker to evaporate moisture?
– How can contamination be prevented?

By field trials and development

Other questions are better answered by conducting field trials both with the producers and consumers. They may include the following:
– How to obtain information regarding the seasonal availability of milk surplus?
– How can we involve self-help groups in pooling condensed milk production for central (vacuum?) packing, marketing and distribution?
– How can we motivate self-help groups to preserve condensed milk for future home consumption rather than fresh milk or *susa* for cash?

Conclusions and Recommendations

The first steps have been taken to condense camel's milk for later use. It can be made using simple techniques and equipment under field conditions. Storage is possible without refrigeration for up to six months, but contamination by yeasts and moulds often occurs. The preparation is not expensive and the end product is highly palatable and popular.

Given the right conditions, and community awareness motivation it should be possible to prepare condensed camel's milk on a self basis and thereby reduce the reliance of communities on famine relief food.

As several questions remain to be answered it is recommended that research, development and field trials be undertaken.

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Montpellier, France, Cirad, 304 p. + X p. hors texte.
(collection Colloques)

Amélioration de l'aptitude à la coagulation des laits de dromadaire, chèvre et vache par supplémentation en lait de brebis

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Résumé. Les auteurs décrivent l'effet que produit l'ajout de lait de brebis à celui de chamelle, et d'autres espèces de ruminants (chèvre et vache), sur l'aptitude à la coagulation de ces laits.

Mots clés. Dromadaire, *Camelus dromedarius*, lait de chamelle, lait de brebis, lait de chèvre, lait de vache, coagulation.

Abstract. The study describes how the processing ability of camel's milk and other ruminants' milk (such as goat's and cow's milk), is improved by addition of ewe's milk.

Key words. Dromedery, *Camelus dromedarius*, camel's milk, ewe's milk, goat's milk, cow's milk, coagulation.

Introduction

Comparativement aux autres laits étudiés (dromadaire, chèvre, vache), le lait de brebis est très riche en protéines coagulables et en minéraux, et aussi en matières grasses (ANYFANTAKIS, 1986 ; LE JAOUEN et REMEUF, 1990). Le lait de brebis est considéré comme un lait « noble » ; il présente une excellente aptitude à la coagulation.

Les carences observées au niveau de la coagulation (par la présure) du lait de dromadaire (RAMET, 1986), l'existence sur un même espace géographique des troupeaux de brebis et de dromadaires conjuguée à l'excellente aptitude à la coagulation du lait de brebis, nous ont amené à penser à l'utilisation du lait de brebis comme moyen de correction de la coagulation enzymatique du lait de dromadaire (RAMET, 1990).

L'objectif de cette étude est de montrer que la supplémentation en lait de brebis améliore l'aptitude à la coagulation des laits de dromadaire, chèvre et vache en réduisant le temps de coagulation et en augmentant la fermeté du gel obtenu.

Matériel et Méthodes

Les laits de chèvre et de vache utilisés sont des laits de mélange, entiers, qui proviennent de la traite de troupeaux de race respectivement Alpine et Frisonne-Holstein appartenant à la ferme de l'ENSAIA à la Bouzule, près de Nancy (France). Le lait de brebis provient de troupeaux de race Lacaune, d'une ferme située dans les Vosges (France). Le lait de dromadaire est un mélange issu de la traite de 20 femelles dromadaires élevées au « Range and Animal Development Research Centre » situé à Al-Jawf (Arabie Saoudite).

Une méthode optique non destructive, basée sur la réflexion de la lumière (SCHER et HARDY, 1986), a été utilisée pour suivre la coagulation du lait. Une sonde turbidimétrique est placée horizontalement dans une cuve thermostatée remplie de lait. La lumière incidente provenant d'une source monochromatique est canalisée par l'intermédiaire de fibres optiques, puis réfléchie par les particules de caséine et de matières grasses ou par le réseau constituant le gel. La lumière réfléchie est reprise par d'autres fibres optiques, et l'intensité lumineuse est transformée en unités néphélométriques de turbidité (NTU). Un appareil rhéologique simple, le « Gelograph », permet de suivre la gélification et le raffermissement du gel. Une lame vibrante est placée dans la cuve, l'amplitude de vibration de la lame est importante au début de la coagulation puis elle diminue lorsque la coagulation est initiée pour atteindre une valeur fixe lorsque le gel est formé. L'inverse de cette dernière valeur (1/G à t = 60 minutes) peut être considérée comme une mesure de la fermeté du gel.

Résultats et Discussion

Les profils de turbidité au cours du temps pour les quatre laits sont présentés sur la figure 1. On observe des profils similaires pour les laits de chèvre et de vache, avec une période de latence, suivie d'un accroissement et d'un épaulement du signal lorsque le gel est formé. Un profil assez semblable est obtenu pour le lait de brebis, avec néanmoins une diminution de la turbidité pour des temps plus longs, sans doute due à un début de synérèse.

L'accroissement du signal turbidimétrique se fait plus rapidement pour le lait de brebis (dans les dix premières minutes) révélant une coagulation plus rapide. Cette coagulation rapide entraîne une augmentation

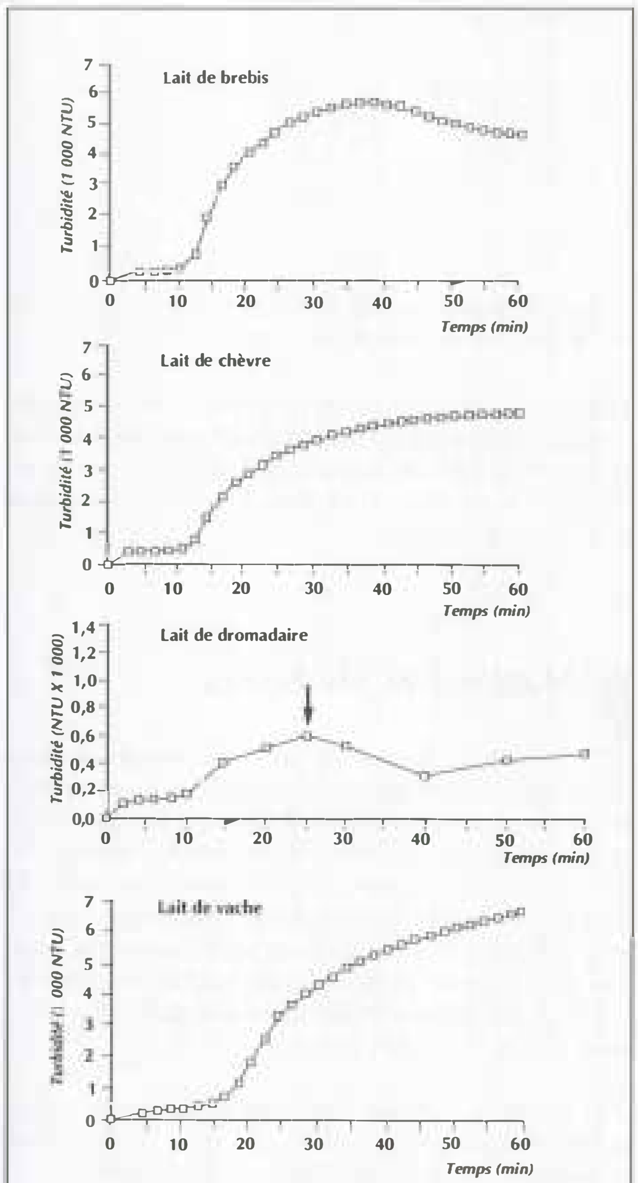

Figure 1. Evolution de la turbidité des laits de brebis, chèvre, dromadaire et vache au cours de la coagulation enzymatique. (Conditions de coagulation : présure = 0,25 ml/l ; température = 37°C ; pH = 6,50.)

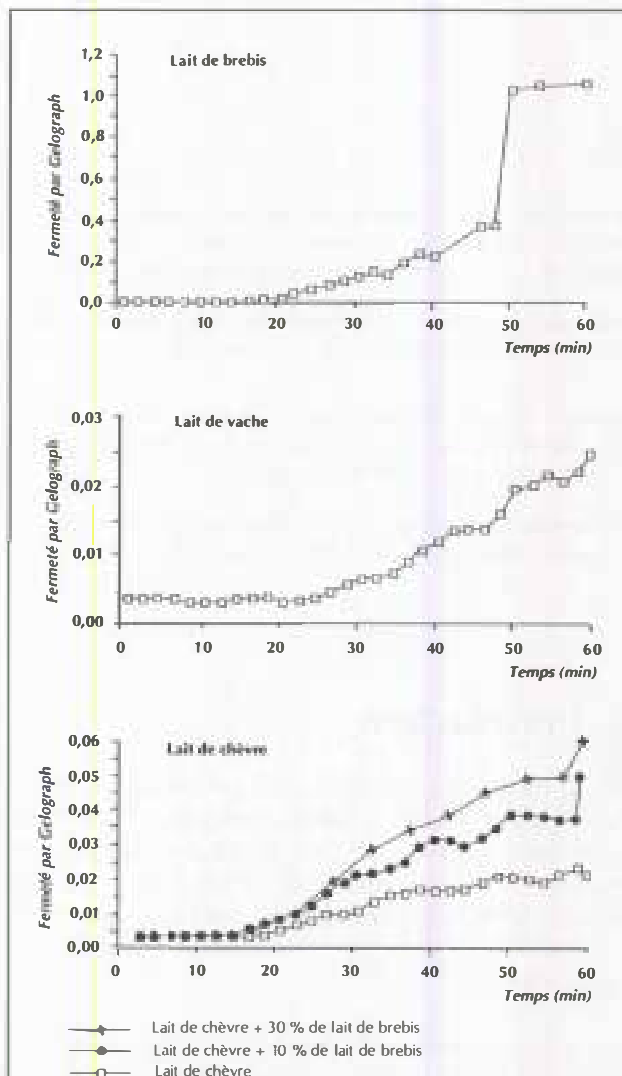

Figure 3. Evolution de la fermeté (par Gelograph) du gel des laits de brebis, vache et chèvre au cours de la coagulation enzymatique. (Conditions de coagulation : présure = 0,25 ml/l ; température = 37°C ; pH = 6,50.)

rapide de la fermeté du gel conduisant à une contraction du gel observable à des temps relativement courts, comparativement aux laits de vache et chèvre où il faut attendre un temps plus long pour voir la turbidité diminuer.

Le lait de dromadaire présente un profil différent avec toujours cette période de latence, suivie d'une montée significative du signal jusqu'à un maximum voisin du temps de floculation visible. Une chute de turbidité apparaît ultérieurement et est suivie ensuite d'une nouvelle augmentation du signal.

L'ajout du lait de brebis aux laits de chèvre, dromadaire et vache entraîne une diminution du temps de coagulation (figure 2) et une augmentation de la fermeté du gel obtenu (figure 3).

L'accroissement de la turbidité correspondant au début de la coagulation est d'autant plus rapide que la quan-

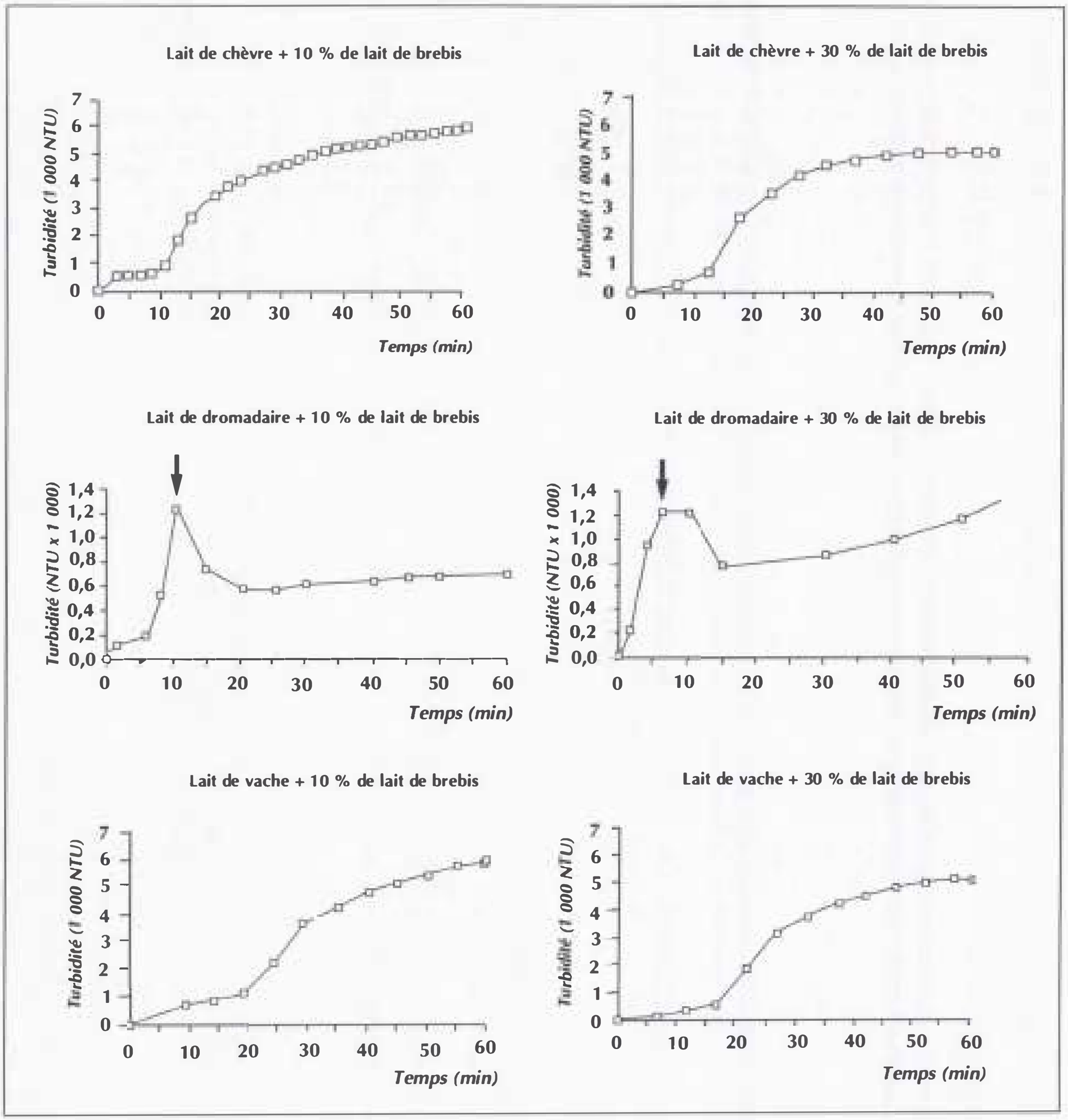

Figure 2. Evolution da la turbidité des laits de chèvre, dromadaire et vache en fonction du taux (en pourcentage) du lait de brebis ajouté. (Conditions de coagulation : présure = 0,25 ml/l ; température = 37°C ; pH = 6,50.)

tité ajoutée du lait de brebis est importante. Les valeurs obtenues avec le gélographe sur les différents gels (figure 3) permettent de voir que le gel obtenu avec le lait de brebis est le plus ferme, tandis que celui obtenu avec du lait de chèvre est le plus mou.

Conclusion

La supplémentation en lait de brebis des laits de chèvre, dromadaire et vache permet d'améliorer leur aptitude à la coagulation en diminuant le temps de coagulation et en augmentant la fermeté du gel obtenu. Ce moyen de correction présente un intérêt indéniable dans le cas du lait de dromadaire car il permet de pallier les carences de sa coagulabilité, rendant ainsi un service considérable aux populations pastorales obligées souvent de consommer le lait juste après la traite, à condition toutefois qu'elles disposent de lait de ce type.

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Les aspects scientifiques et technologiques particuliers de la fabrication des fromages au lait de dromadaire

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Résumé. L'auteur propose une revue des caractéristiques naturelles de la transformation fromagère du lait de chamelle, depuis la coagulation jusqu'à l'affinage. Il passe ensuite en revue les différentes étapes qui peuvent être améliorées le long de la chaîne de fabrication. Il présente enfin l'application de diverses recommandations sur la température, la qualité de la matière première, l'utilisation de procédés simples de concentration, de filtration, d'addition d'autres laits, de sels de calcium, ou de pepsine, dont le résultat est une augmentation notable du rendement fromager et de la qualité du produit.

Mots clés. Dromadaire, *Camelus dromedarius*, fromage, lait de chamelle, fabrication fromagère, coagulation, séchage, mûrissage, qualité.

Abstract. The author presents the natural charcteristics of camel's milk processing. He peculiarly focuses on the coagulation ability (enzymatic and acid), the draining ability and the maturation ability. He makes thus a review of different means for improving the cheese processing ability of camel's milk, all along the processing steps, ending with recommendations for optimal temperatures. Then more accurate corrections are proposed, by mean of concentration, filtration, milk powder and other ruminants milk addition in order to reduce the dry matter ratio. It is also proposed to regulate the ionic balance in order to activate the coagulation, by addition of calcium salts. Finally, he presents how the coagulation process is also improved by use of pepsin, and what kind of recommendations could be used in the final steps of the process (draining, maturation).

Key words. Dromedary, *Camelus dromedarius*, cheese, camel's milk, cheesemaking, coagulation, drying, ripening, quality.

Introduction

Le lait, comme la plupart des matières premières d'origine biologique, est un milieu très périssable qui s'altère rapidement par voie enzymatique et par voie microbienne. La forte dégradabilité naturelle du lait a plusieurs origines : sa composition riche et variée favorise la prolifération de la plupart des germes contaminants : les caractéristiques physico-chimiques du lait frais [pH voisin de la neutralité, activité de l'eau (A_w) proche de 1, potentiel Redox élevé], ne sont pas limitantes dans la plupart des cas pour la croissance des germes et les réactions enzymatiques d'altérations. Ces phénomènes sont par ailleurs fortement influencés par la température et sont les plus rapides lorsque celle-ci est comprise entre 25 et 35 °C. Ces évolutions indésirables peuvent conduire à une déstabilisation de l'état physique (coagulation, séparation de phases) ainsi qu'à une détérioration de la qualité organoleptique et hygiénique du milieu qui le rendent impropre à la consommation.

La fabrication du fromage regroupe un ensemble de procédés visant à différer cette consommation pendant une période pouvant s'étendre de quelques jours à plusieurs mois. Le principe de conservation repose sur un abaissement simultané et contrôlé de l'A_w et du pH, dont l'équilibre est particulier à chaque catégorie de fromages. Cette évolution est réalisée, en pratique, lors des deux premières étapes de la fabrication, de la coagulation, et de l'égouttage. Il convient de souligner qu'à l'issue de cette phase, la stabilisation du milieu vis-à-vis des réactions biologiques n'est pas complète. Cette situation ouvre la possibilité de faire évoluer la composition du substrat par voies enzymatique et microbienne lors de la phase d'affinage final du produit (tableaux I et II). Le fromage occupe donc parmi les différents aliments un statut tout particulier qui se situe en position intermédiaire entre les conserves stables et les denrées périssables.

Tableau I. Caractérisation des différentes catégories de fromages par effets pH et A_w.

Catégories	pH	A_w
Pâtes fraîches	4,3 – 4,5	0,980 – 0,995
Pâtes molles	4,5 – 4,8	0,970 – 0,990
Pâtes pressées	4,8 – 5,2	0,940 – 0,970
Pâtes dures	5,0 – 5,2	0,885 – 0,905

Tableau II.
Relations entre les caractéristiques de la coagulation, de l'égouttage et du fromage.

Mode de coagulation	Voie enzymatique	Voie fermentaire
Mécanisme d'action	• Hydrolyse spécifique de la caséine κ • Perte des propriétés stabilisantes de la fraction κ sur la micelle entière • Déstabilisation en présence de Ca^{++} • pH réaction : 6,6	• Enrichissement du milieu en H^+ • Neutralisation des charges électronégatives de la micelle • Déminéralisation corrélative de la micelle • pH réaction de 6,5 à 4,6
Coagulum		
Composition	• Phosphoparacaséinate de Ca • Etat micellaire peu altéré	• Caséine déminéralisée • Etat micellaire altéré ou disparu (selon pH)
Propriétés	• Minéralisé • Elastique • Non friable • Imperméable • Aptitude à synérèse importante • Nécessité d'action mécaniques, thermiques, chimiques (acidification limitée) indispensables pour exploiter le pouvoir de synérèse du gel	• Peu minéralisé • Ferme • Friable • Perméable-poreux • Potentialité de synérèse réduite • Application possible de traitements mécaniques et thermiques de faible intensité (exception centrifugation des fromages frais)
Sérum	• Non acide, peu minéralisé	• Acide, minéralisé
Fromage	• Pâte cohérente • Durée d'affinage longue • Gros format • Non déformable • A_w basse • pH élevé • Bonne aptitude à la conservation	• Pâte peu cohérente • Durée d'affinage courte ou nulle • Petit format • Déformable • A_w élevée • pH bas • Aptitude réduite à la conservation

L'aptitude fromagère limitée du lait de dromadaire

Si l'on se réfère aux traditions pastorales des sociétés du désert pratiquant l'élevage du dromadaire, on remarque que la transformation du lait de dromadaire en fromage n'est pratiquée que très exceptionnellement. Quelques rares fromages sont fabriqués de manière régulière par des nomades localisés en Ahaggar et dans la péninsule du Sinaï. Ce produit est obtenu par chauffage de lait préalablement acidifié : les protéines thermocoagulées se présentent sous forme d'une pâte humide et sont rassemblées en balles ou galettes qui peuvent être consommées rapidement ou subir un séchage naturel au vent et au soleil (GAST *et al.*, 1969 ; YAGIL, 1982). Il ne s'agit pas en réalité de fromages véritables, car il n'y a pas utilisation d'enzyme coagulante pour réaliser la coagulation.

Les différents essais entrepris pour réaliser des fromages de manière classique, par voie enzymatique et par voie acide conjointe à partir de lait de dromadaire, font état de nombreuses difficultés rencontrées pour conduire les différentes étapes de la fabrication dans des conditions satisfaisantes.

Aptitude à la coagulation enzymatique

Une première difficulté concerne la coagulation du lait par voie enzymatique. Si l'on tente de coaguler le lait dans les conditions habituelles utilisées pour la transformation en fromages du lait de vache, de chèvre ou de brebis, on constate que la gélification n'apparaît pas ou est très tardive. Des observations déjà anciennes ont montré qu'il convenait de multiplier par 50 à 100 fois la concentration en présure pour obtenir une floculation dans un délai acceptable (GAST *et al.*, 1969 ; LARSSON-RAZNIKIEWICZ et MOHAMED, 1986 ; MOHAMED *et al.*, 1990 ; WILSON, 1984). Des recherches plus spécifiques ont confirmé récemment que la coagulation par la présure du lait de dromadaire est effectivement de 2 à 4 fois plus lente que pour le lait de vache traité de manière homologue (FARAH et BACHMANN, 1987 ; FARAH et FARAH RIESEN, 1985 ; MOHAMED *et al.*, 1990 ; RAMET, 1985*b* ; RAMET, 1987*b*).

Ce comportement a été observé avec la plupart des préparations coagulantes utilisées pour coaguler le lait de fromagerie ; toutefois, l'effet d'inhibition de l'activité coagulante constatée dans le lait de dromadaire varie selon l'enzyme considérée. Des essais ont montré que la pepsine bovine présente la meilleure affinité pour coaguler le lait de dromadaire ; la présure de veau et la protéase coagulante de *Mucor miehei* présentent une affinité analogue, mais plus faible que celle de la pepsine bovine ; la chymosine et la protéase coagulante de *Endothia parasitica* ont l'affinité la plus faible (RAMET, 1985*b* ; RAMET, 1990) (tableau III).

Tableau III. Rapport des temps de floculation observés dans le lait de dromadaire (TFD) à ceux mesurés dans le lait de vache (TFV) (d'après RAMET, 1990).

Type d'enzyme coagulante	TFD/TFV
Présure de veau	2,2
Protéase coagulante de *Mucor miehei*	2,3
Chymosine	6,2
Protéase coagulante de *Endothia parasitica*	17,7
Pepsine bovine	0,2

Le statut privilégié de la pepsine pour coaguler le lait de dromadaire est corroboré par le fait que certains nomades du Ahaggar semblent pouvoir réaliser des fromages à partir du lait de dromadaire, à condition d'utiliser exclusivement comme agent coagulant des morceaux d'estomac provenant d'un lapin du désert (GAST *et al.*, 1969 ; YAGIL, 1982). Cet organe renferme, comme chez tous les mammifères, de la pepsine. Aucune étude ne semble avoir été faite à ce jour pour connaître la nature des enzymes coagulantes présentes dans les sécrétions stomacales du chamelon.

Une originalité de l'enzyme de *Mucor miehei* est de présenter en outre, lorsqu'elle est utilisée à faible concentration dans le lait de dromadaire, une inhibition partielle qui est révélée par la non-linéarité de la relation entre le temps de floculation et l'inverse de la concentration en enzyme (figure 1). Ce phénomène, qui a été mis en évidence également dans le lait de vache, est dû à une complexation de la protéase coagulante avec les protéines solubles ; cela nécessite, en pratique fromagère, de surdoser légèrement l'enzyme coagulante. L'effet inhibiteur disparaît après traitement thermique du lait dans des conditions de temps et de température correspondant à la pasteurisation (RAMET, 1985*a*).

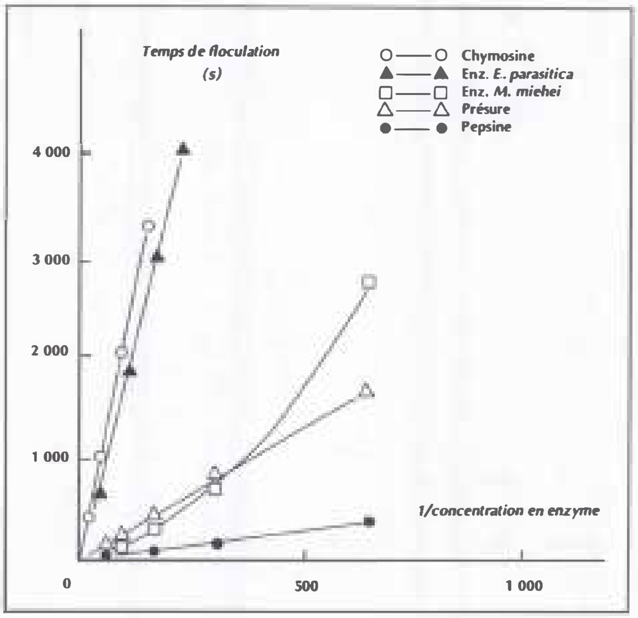

Figure 1. Relation entre le temps de floculation et l'inverse de la concentration en enzyme coagulante pour différentes protéases coagulantes (d'après RAMET, 1990).

Les différences d'affinité observées entre enzymes coagulantes peuvent être expliquées en partie par l'incidence particulière des facteurs de milieu (pH, température, environnement ionique, etc.) qui régulent l'activité enzymatique de chaque protéase coagulante ; l'origine principale de cette disparité apparaît plus vraisemblablement consécutive à la présence d'inhibiteurs de protéases dans le lait de dromadaire et/ou à une structure spécifique des micelles de caséine qui pourrait limiter de manière sélective l'accessibilité de la protéase à la caséine kappa. Il ne s'agit là que d'hypothèses qui restent à vérifier.

Une seconde particularité de la coagulation du lait de dromadaire concerne la grande difficulté rencontrée pour apprécier le début de la coagulation ; la transition liquide-gel est peu nette en raison de la persistance d'un état floconneux. La structuration ultérieure du gel, qui se traduit habituellement par un accroissement rapide de sa viscoélasticité, est ici très lente et peu prononcée, et sa friabilité est très grande (FARAH et BACHMANN, 1987 ; RAMET, 1985*b* ; RAMET, 1991). Ce comportement rhéologique spécifique peut être aisément constaté par des méthodes empiriques (GAST *et al.*, 1969 ; Mohamed *et al.*, 1990 ; Ramet, 1985*b* ; Ramet, 1987*b*) ainsi que par des méthodes instrumentales (Bayoumi, 1990 ; Farah et Bachmann, 1987 ; Ramet, 1990) (figures 2 et 3).

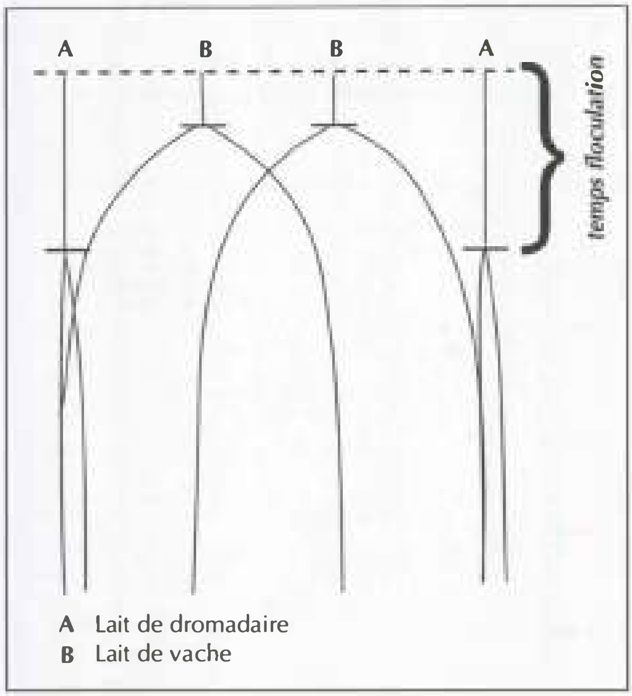

Figure 2. *Rhéogramme obtenu lors de la coagulation du lait par la présure (d'après Farah et Bachmann, 1987).*

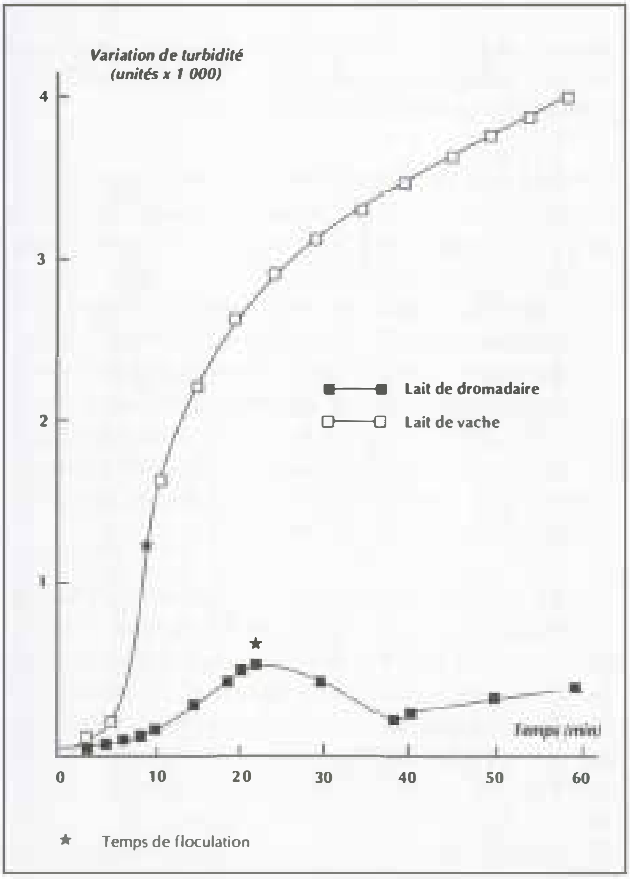

Figure 3. *Evolution de la turbidité du lait de dromadaire après addition de présure (d'après Ramet, 1990).*

L'originalité de comportement du lait de dromadaire à l'action des enzymes coagulantes trouve son origine dans sa composition spécifique en caséine et en minéraux.

Des recherches récentes ont montré en effet que l'équilibre des fractions de caséine est très différent de celui du lait de vache : on note en particulier que la proportion de caséine kappa est limitée à 5,1 % de la caséine totale alors qu'elle est de 13 % pour le lait de vache (Jardali-Maatouk, 1994) (tableau IV).

Une seconde caractéristique originale de la caséine du lait de dromadaire est qu'elle se trouve sous forme de micelles de grande taille dont le diamètre moyen est environ le double (300 mm) de celui du lait de vache (160 mm) (Farah et Bachmann, 1987 ; Farah et Ruegg, 1989 ; Jardali, 1988 ; Jardali-Maatouk, 1994).

Le tableau V indique les valeurs mesurées dans des laits collectés dans des troupeaux ayant des origines génétiques et géographiques très différentes ; malgré cette diversité, les valeurs mesurées sont homogènes, elles confirment le caractère très spécifique du lait de dromadaire.

Une médiocre aptitude du gel au raffermissement apparaît être une conséquence du moindre degré de réticulation des micelles consécutif à leur taille élevée et à la faible teneur en calcium colloïdal. Cette teneur est plus faible (35 %) que pour le lait de vache (65 % du calcium total) (Jardali, 1988) et tend à diminuer en cas de privation d'eau (Yagil et Etzion, 1980).

Ce rôle majeur du calcium est corroboré par le fait qu'un enrichissement du lait de dromadaire en calcium ionique, susceptible d'établir les liaisons calciques entre particules, réduit considérablement le temps de floculation visible et renforce la rigidité des gels formés d'une manière très marquée (Farah et Bachmann, 1987 ; Ramet, 1985*b* ; Ramet, 1987*a* ; Ramet, 1990).

Il convient de remarquer que des corrélations semblables liant la taille des micelles et leur aptitude à la coagulation ont été mises en évidence lors de variations saisonnières de la composition du lait de vache. Elles résultent d'interactions avec le milieu comme la température, la disponibilité alimentaire et le rythme nycthéméral. En saison chaude, les micelles sont plus grosses ; elles sont moins riches en caséine kappa et présentent une aptitude à la coagulation réduite par rapport à celles des laits d'hiver, qui se traduit par des temps de coagulation par la présure plus longs et une fermeté moindre des gels obtenus (Scher, 1988). A l'inverse, en hiver, les micelles, de taille réduite, présentent un taux élevé de caséine kappa, coagulent plus rapidement sous l'action de la présure et génèrent des coagulums plus fermes (Niki et Arima, 1984 ; Scher, 1988).

Tableau IV.
Proportions moyennes des différentes caséines (%) du lait de vache et du lait de dromadaire obtenues par chromatographie d'échange d'ions (JARDALI-MAATOUK, 1994).

	Lait de vache	Lait de dromadaire				
Pays d'origine	France (ALAIS, 1984)	Tunisie	Somalie	France	Arabie	Moyenne
Mois	-	06	10	03	03	
Année	-	1987	1989	1989	1990	
Fraction caséinique						
Nombre d'échantillons		3	3	3	3	
Caséine α						
Moyenne	46,0	69,4	66,3	63,1	54,4	63,3
Ecart-type		4,6	5,2	4,3	4,0	4,5
Coefficient de variation (%)		6,7	7,8	6,9	7,3	7,2
Caséine β						
Moyenne	34,0	24,7	27,3	27,4	29,7	27,3
Ecart-type		4,2	2,9	3,1	5,0	3,8
Coefficient de variation		16,7	10,6	11,4	16,8	13,9
Caséine γ						
Moyenne	3,0	3,0	2,3	3,3	2,0	2,7
Ecart-type		0,4	0,5	0,4	0,1	0,4
Coefficient de variation		13,3	21,7	12,1	5,0	13,0
Caséine κ						
Moyenne	13,0	4,2	1,0	5,2	7,0	5,1
Ecart-type		0,3	0,1	1,0	0,5	0,5
Coefficient de variation		7,2	2,5	19,2	7,1	9,0

Tableau V.
Taille moyenne des micelles de caséine du lait de vache et du lait de dromadaire de différentes origines (JARDALI-MAATOUK, 1994).

	Lait de vache	Lait de dromadaire					
Pays d'origine	France	Tunisie	Somalie	France	Arabie	Niger	Moyenne
Mois	06	06	10	03	03	06	
Année	1987	1987	1989	1990	1990	1990	
Diamètre des micelles							
Nombre d'échantillons (n)	4	6	6	13	9	4	
Moyenne (M)	160,0	304,5	321,3	317,8	286,2	286,3	303,2
Ecart-type (σ)	13,2	18,3	11,7	11,1	17,5	18,9	15,3
Coefficient de variation (CV)	8,2	6,0	3,6	3,2	6,1	6,7	5,1

Une dernière cause de la moindre rigidité des gels issus des laits de dromadaire est la teneur en matière sèche réduite et la petite taille de ses globules gras. Ces effets sont plus marqués en saison chaude, lorsque les animaux subissent un stress hydrique qui accroît la teneur en eau du lait. Il a été ainsi noté que le passage d'un régime hydraté à un régime pauvre en eau faut chuter très sensiblement le taux de matière sèche totale de 14,3 à 8,8 % ; dans les mêmes conditions, le taux de protéines diminue de 4,6 à 2,5 % et celui de matière grasse est abaissé de 1,3 à 1,1 % (YAGIL et ETZION, 1980).

Aptitude à la coagulation par voie acide

La coagulation par voie acide du lait de dromadaire apparaît également plus difficile à réaliser que pour les autres laits habituellement transformés. On note, en particulier, une plus faible aptitude à l'acidification, qui se traduit par une phase de latence prolongée et par un gradient plus faible dans le développement de la prise d'acidité (RAMET, 1985*b* ; RAMET, 1987*b*). Ces différences résultent de la composition particulière du lait de dromadaire qui possède des systèmes anti-microbiens efficaces caractérisés par une forte teneur en lyzozyme (BARBOUR *et al.*, 1984), en vitamine C (KNOESS, 1979 ; KON, 1972 ; YAGIL *et al.*, 1984) et en lactopéroxydase (EL SAYED EL AGAMI *et al.*, 1992) ainsi que par un pouvoir tampon plus marqué que pour le lait de vache (FARAH *et al.*, 1990 ; RAMET, 1985*a* ; RAMET, 1987*a*).

Dans le lait de dromadaire soumis à acidification, il n'est pas possible de mettre en évidence avec précision un point de début de coagulation acide. Il n'y a pas non plus formation d'un coagulum véritable. Le milieu reste de structure floconneuse et s'apparente plus à un précipité ; celui-ci tend à décanter lentement avec séparation d'un surnageant très blanc constitué par le lactosérum (RAMET, 1985*b* ; Ramet, 1987*a* ; FARAH *et al.*, 1990).

Aptitude à l'égouttage

L'aptitude à l'égouttage des gels des laits de dromadaire présente également des particularités. Une première originalité concerne la fragilité extrême du coagulum qui entraîne une destruction quasi inévitable lors des opérations de moulage. De ce fait, la plus grande partie de l'extrait sec du lait est perdue dans le lactosérum et le taux de récupération de la matière sèche est limitée à 30 % de la teneur en matière sèche totale du lait (RAMET, 1987*b* ; RAMET, 1991). Ce taux de recouvrement est très peu élevé comparativement aux fabrications au lait de vache où ce taux se situe à environ 50 % et à plus de 68 % pour le lait de brebis.

La teneur en matière sèche totale du lactosérum du lait de dromadaire est en général un peu plus élevée que pour le lait de vache ; elle est de l'ordre de 7 % et 6,5 % respectivement (KAMOUN et BERGAOUI, 1989 ; RAMET, 1987*b* ; RAMET et KAMOUN, 1988). Il a été noté que le taux de matière grasse y est très élevé, de 3 à 4 fois supérieur à celui mesuré dans le lactosérum de fromages homologues fait à partir du lait de vache. Cette perte correspond à près de 60 % de la teneur initiale du lait en matière grasse (MOHAMED *et al.*, 1990 ; RAMET, 1987*a* ; Ramet, 1987*b*) ; elle résulte vraisemblablement de la faiblesse du réseau protéique et de l'étroite liaison des globules gras aux protéines.

L'aspect du lactosérum du lait de dromadaire est caractérisé par une couleur blanche très marquée, contrairement au sérum du lait de vache qui est verdâtre (MOHAMED *et al.*, 1990 ; RAMET, 1987*b* ; RAMET et KAMOUN, 1988). La charge élevée du milieu en particules en suspension (globules gras, agrégats micellaires), ainsi que la pauvreté du lait de dromadaire en riboflavine peuvent expliquer ce phénomène.

L'égouttage du lactosérum provenant des coagulums de lait de dromadaire présente une rapidité remarquable (RAMET, 1987*b*). Ce phénomène apparaît consécutif à la forte teneur en eau du lait et à la faible capacité d'hydratation de la caséine (FARAH, 1986 ; RAMET, 1987*b*).

La cinétique d'acidification du lactosérum en cours d'égouttage est un peu plus lente que pour les fabrications au lait de vache ; elle s'explique par l'aptitude légèrement atténuée du lait de dromadaire à l'acidification lactique (voir ci-dessus).

Aptitude à l'affinage

Il n'existe que très peu d'observations sur l'affinage des fromages au lait de dromadaire, compte tenu du nombre très restreint d'essais de fabrication. Elles mentionnent essentiellement des éléments relatifs à la qualité organoleptique des produits et n'indiquent pas d'éléments de caractérisation des propriétés physiques et chimiques du substrat.

Au niveau du goût, les fromages fabriqués à partir de lait de dromadaire présentent une saveur faible sans dominante notable. La saveur parfois légèrement salée du lait de dromadaire ne persiste pas dans le fromage (RAMET, 1985*b*). Il a été relevé de manière transitoire ou définitive une saveur amère dans certains lots de produits. Cette situation paraît résulter de l'accumulation de peptides amers consécutive à l'utilisation de doses de présure très élevées lors de la coagulation et nécessitées par l'aptitude très réduite du lait de dromadaires à la coagulation enzymatique (MOHAMED *et al.*, 1990 ; RAMET, 1987*b* ; RAMET et KAMOUN, 1988).

La texture des fromages obtenus est généralement considérée comme de qualité moyenne. Deux défauts sont assez fréquemment rencontrés en particulier dans les fromages présentant un extrait sec élevé :

– le premier correspond à la présence d'un caractère peu onctueux de la pâte. Ce défaut apparaît consécutif au taux réduit de matière grasse retrouvé dans le fromage à la suite des pertes élevées dans le sérum ainsi qu'à la faible hydratation des protéines du lait retenues dans le fromage (MOHAMED *et al.*, 1990 ; RAMET, 1987*b*) ;

– un second défaut de texture qui a été parfois relevé concerne un caractère très collant de la pâte lors de la mastication ; le fromage tend à adhérer aux parois de la cavité buccale et laisse persister après déglutition une impression assez désagréable apparentée à la présence d'un film de matière grasse. Aucune explication précise n'a été donnée au phénomène (Ramet, 1987*b* ; RAMET et KAMOUN, 1988), mais il est vraisemblable que des interactions existent avec les températures spécifiques de fusion et de solidification de la matière grasse du lait de dromadaire, ainsi qu'avec la force de pression exercée sur la pâte lors du pressage du fromage pendant l'égouttage (RAMET, 1991).

Amélioration de l'aptitude fromagère du lait de dromadaire

Sélection d'un lait de bonne qualité

Pour réaliser la fabrication fromagère dans de bonnes conditions, le lait doit répondre à un certain nombre de critères de qualités physico-chimique et microbienne. Il convient en particulier d'éliminer les laits anormaux issus d'animaux malades, en début de lactation ou soumis à des privations en aliments et en eau.

Le lait doit être de bonne qualité microbienne et doit être collecté proprement et transformé rapidement après la traite.

Préparation du lait

Traitement thermique

Le lait cru renferme toujours une population de micro-organismes dont l'importance et la variété dépendent principalement de l'état sanitaire de l'animal, des conditions hygiéniques observées lors de la traite, de la collecte du lait, de la durée et de la température de conservation. Dans cet ensemble, plusieurs catégories de germes sont redoutées dans la mesure où elles peuvent transmettre des maladies à l'homme (germes pathogènes) ou provoquer au plan technique des accidents de fabrication (germes producteurs de gaz, germes protéolytiques et lipolytiques). Selon leur gravité, ces accidents se manifestent en perturbant le cycle de fabrication, en provoquant l'apparition de défauts organoleptiques dans le fromage (gonflements, textures indésirables, saveur amère ou rance) ou conduisent à l'obligation de détruire le produit fini.

L'emploi d'un traitement thermique qui permet de détruire les germes indésirables apparaît hautement souhaitable avant de procéder à la mise en coagulation du lait.

Des essais réalisés dans le sud de la Tunisie (Ramet, 1987*a*) ont montré que des conditions de chauffage égales ou supérieures à celles d'une thermisation (62 °C – 1 minute) permettaient d'assurer une stabilisation microbienne du lait de dromadaire et d'éviter les gonflements accidentels du coagulum (tableau VI). En revanche, les résultats indiquent que l'aptitude à la coagulation et à l'égouttage est altérée lorsque le chauffage est pratiqué dans des conditions plus sévères. On note, en particulier, une prolongation des temps de floculation, une diminution de la fermeté du gel ainsi qu'un accroissement de sa friabilité. Des évolutions analogues ont été mises en évidence après chauffage du lait de vache ; elles sont dues à plusieurs modifications chimiques importantes ; le retard à la coagulation s'explique par une formation d'un complexe entre caséine κ et β-lactogobuline ainsi que par une insolubilisation du calcium qui réduit la réactivité à la coagulation enzymatique (Ramet, 1985*a* ; Webb *et al.*, 1974).

Une autre conséquence du chauffage est une diminution très importante de l'aptitude à l'égouttage (figure 4). Ces modifications des propriétés du coagulum résultent principalement de la dénaturation thermique des protéines sériques dont la capacité d'hydratation est fortement accrue ; il s'ensuit une fragilisation et une rétention d'eau corrélative plus importantes du coagulum ; parallèlement, les pertes en matière sèche dans le lactosérum augmentent légèrement par accumulation de fines particules de caillé engendrées par la friabilité du gel.

Au vu de ces résultats, il apparaît nécessaire, pour éviter de réduire l'aptitude à la coagulation et à l'égouttage du lait de dromadaire, de moduler le traitement thermique en fonction de l'extrait sec final souhaité dans le fromage à la fin de l'égouttage. Le lait destiné à la fabrication de fromage humide pourra être chauffé selon un barème correspondant à une pasteurisation basse, soit entre 72 et 75 °C durant 15 à 30 secondes, alors que pour les fromages plus secs de types pâtes molles, pâtes pressés et pâtes dures, il conviendra de pratiquer une simple thermisation, soit 62 °C pendant 1 minute.

Température chauffage lait (°C)	**34**	**62**	**65**	**75**	**85**
Coagulation					
Temps floculation (min)	4	4	5	6	6
Fermeté gel	+++++	++++	++++	++	+
Friabilité gel	friable				très friable
Egouttage après 5 h					
pH	6,00	6,65	6,65	6,65	6,65
Gonflement gel	+	–	–	–	–
Matière sèche sérum (%)	5,40	5,65	5,75	5,89	5,97
Matière grasse sérum (%)	0,80	0,80	0,80	0,80	0,80

D'après Ramet, 1987*a*.

Tableau VI. Influence du chauffage du lait de dromadaire sur l'aptitude à la coagulation et à l'égouttage (chauffage : 1 min).

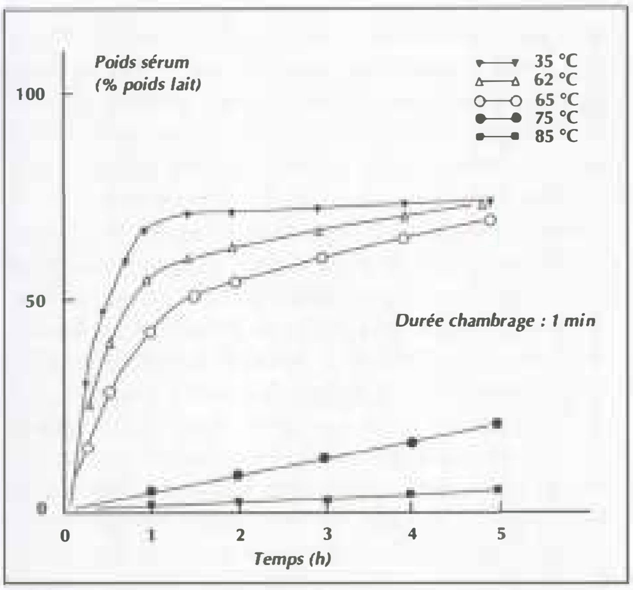

Figure 4. *Influence du chauffage du lait de dromadaire sur la cinétique d'égouttage du lactosérum (d'après* RAMET, *1987*a*).*

Il y a lieu de souligner que ces conclusions résultent d'observations faites en traitant un lait produit en période très chaude (juin-juillet 1987) par des animaux tenus en élevage extensif traditionnel sur des parcours naturels et comportant un seul abreuvement tous les 8-10 jours ; par suite de ce stress hydrique, le taux de matière sèche totale (9,4 %) dont 2,7 % de matière grasse, était particulièrement bas et de ce fait peu adapté à la fabrication fromagère. Les recommandations du traitement thermique précisées ci-dessus peuvent donc vraisemblablement être corrigées à la hausse pour des laits présentant une matière sèche supérieure ; dans ces conditions, il apparaîtrait possible, comme cela se pratique avec le lait de vache, d'améliorer le rendement fromager par récupération des protéines sériques dénaturées sans pour autant induire la formation de gels tardifs, friables et trop hydratés. Des expérimentations complémentaires sont nécessaires pour préciser l'adéquation du traitement thermique de la matière première avec les autres contraintes de la fabrication fromagère, en particulier celles attachées aux exigences de rendement et de qualité organoleptique des produits finis.

Correction de la teneur en matière sèche

Un des points critiques de la transformation du lait de dromadaire en fromage provient de son extrait sec relativement bas et des particularités de sa composition en caséine et en calcium. D'un point de vue pratique, il est possible d'envisager plusieurs traitements de correction qui peuvent être utilisés isolément ou simultanément lors de la préparation des laits de fromagerie. Ils ont pour effet principal de réduire les temps de floculation et d'améliorer les propriétés rhéologiques des gels formés.

CONCENTRATION PAR ÉVAPORATION

Une première alternative consiste à réaliser une concentration de la matière sèche totale du lait de dromadaire par évaporation de l'eau ; la température utilisée doit être douce (45-60°C) pour éviter les incidences négatives d'un chauffage excessif sur la coagulation et la synérèse. Cette opération peut être pratiquée au plan artisanal en récipient ouvert de petite capacité ou au plan industriel par évaporation sous vide. Compte tenu du coût énergétique de l'opération, il semble raisonnable de limiter le taux de concentration à 15-20 % de matière sèche.

CONCENTRATION PAR ULTRAFILTRATION

Une méthode plus sophistiquée pourrait faire appel à l'ultrafiltration. Cette technique permet, après écrémage préalable, de concentrer uniquement la phase protéique ; par analogie à la pratique industrielle largement répandue pour le lait de vache, un ajustement à un taux protéique de 3,6-3,8 % pourrait être adéquat. Il n'existe toutefois à ce jour aucune donnée publiée faisant état d'expérimentation pour le lait de dromadaire. Il y a lieu de souligner que les procédés par ultrafiltration restent délicats à utiliser ; ils nécessitent en particulier le respect de normes de nettoyage et de désinfection très rigoureuses, une sécurité absolue dans l'alimentation en fluides et un personnel technique hautement qualifié. Par ailleurs, les équipements disponibles sur le marché ont pour la plupart des capacités de traitement élevées. Ces diverses raisons font que cette technique ne peut être réservée qu'à des unités importantes de traitement du lait établies en sites industriels.

AJOUT DE POUDRE DE LAIT

Le renforcement de l'extrait sec du lait de dromadaire à l'aide de poudre de lait permet de raffermir considérablement le gel et de le travailler dans des conditions correctes (RAMET, 1987*a*). Un ajout de l'ordre de 4 à 8 % paraît suffisant pour améliorer la transformation en fromage, sans pour autant modifier sensiblement la qualité organoleptique du produit fini, et accroître le coût de production. Le choix d'une poudre présentant une bonne qualité fromagère est nécessaire ; en ce sens, les poudres séchées à basse et moyenne températures *(low-medium heat)* sont les plus adaptées.

A moins de disposer d'une poudre de lait de dromadaire, l'utilisation de poudres de laits d'autres espèces animales disponibles sur le marché peut poser un problème réglementaire relatif à une appellation « fromage au lait de dromadaire ».

AJOUT DE LAIT LIQUIDE D'AUTRES ESPÈCES ANIMALES

Dans l'aire de distribution géographique du dromadaire, les troupeaux de chèvres, de brebis, voire de zébus et buffles sont fréquents. Le lait de ces animaux possède, en raison de sa composition en caséine et en calcium, une bonne aptitude fromagère ; leur mélange peut être envisagé pour améliorer la fromageabilité du lait de dromadaire.

Une expérimentation conduite en Arabie Saoudite (RAMET, 1990) a montré que la supplémentation du lait de dromadaire par du lait de brebis dans une proportion de 10 à 50 % a des conséquences extrêmement positives sur la coagulation et l'égouttage :
– le temps de coagulation est réduit très sensiblement ; ainsi, le gain de temps est amélioré de près de 70 % après ajout de 10 % de lait de brebis ;
– la fermeté du gel mesurée par une méthode instrumentale est accrue d'une manière très marquée ; celle-ci est doublée après apport de 10 % de lait de brebis ;
– l'égouttage est plus rapide ; après une addition de 10 % de lait de brebis, la réduction de temps nécessaire pour recueillir un volume de sérum égal à 50 % du poids de lait mis en œuvre est de l'ordre de 20 % par rapport au coagulum de lait de dromadaire ;
– l'acidification est légèrement plus rapide après ajout de lait de brebis, vraisemblablement par atténuation du pouvoir tampon élevé du lait de dromadaire ;
– le taux de matière sèche récupérée dans le fromage, rapporté à la matière sèche du lait mis en œuvre, est augmenté d'une manière très significative ; il passe de 37 % pour le témoin à 44 % pour le lait supplémenté avec 10 % de lait de brebis et à 56 % pour le lait enrichi avec 50 % de lait de brebis (tableau VII).

L'ensemble des effets favorables constatés au cours de la coagulation et de l'égouttage s'expliquent par une meilleure structuration du coagulum consécutive à l'apport par le lait de brebis d'un extrait sec important composé de constituants réputés hautement coagulables.

Il convient de remarquer que, même en cas de disponibilité réduite de lait de brebis, son mélange au lait de dromadaire apporte des bénéfices considérables pour la transformation du lait de dromadaire en fromage. La simplicité du procédé le rend très facilement applicable pour les fabrications familiales et artisanales.

Correction des équilibres salins

APPORT D'UN SEL DE CALCIUM

On sait que la présence de calcium ionisé est indispensable à l'accomplissement de la phase secondaire de la coagulation qui conduit, après protéolyse spécifique de la caséine kappa par l'enzyme coagulante, à l'agrégation des micelles pour former un réseau constituant le coagulum (RAMET, 1985*a* ; WEBB *et al.*, 1974). En raison de l'existence dans le lait de dromadaire d'un équilibre salin particulier, l'ajout d'un sel de calcium apporté sous forme de chlorure ou de phosphate monocalcique entraîne un raccourcissement très marqué des temps de coagulation et renforce la fermeté des gels (RAMET, 1985*b* ; RAMET, 1987*b* ; RAMET, 1990). L'action bénéfique de ces sels est liée, d'une part, à un abaissement de pH (figures 5, 6 et 7) qui favorise l'activité enzymatique de la protéase coagulante, et, d'autre part, à l'enrichissement du milieu en ions calciques qui créent des pontages renforçant la cohésion et la réticulation intermicellaires.

Tableau VII. Evolution des bilans fromagers en fonction du taux de supplémentation en lait de brebis.

	Lait de brebis (%)					
	0	10	20	30	40	50
Lait de dromadaire						
Lait :						
Extrait sec	11,4	11,9	12,2	12,6	13,2	14,1
Fromage :						
Rendement poids humide (%)	14,0	12,9	13,7	14,5	15,3	15,8
Extrait sec (%)	30,1	41,1	45,0	47,0	48,1	50,5
Rendement poids sec (%)	4,2	5,3	6,2	6,8	7,3	8,0
Taux de récupération en matière sèche (%)	37,2	44,5	50,5	54,0	55,6	56,6
Lait de vache						
Lait :						
Extrait sec	12,1	12,5	13,1	13,6	14,3	15,1
Fromage :						
Rendement poids humide (%)	12,9	13,5	14,5	15,4	17,0	17,9
Extrait sec (%)	48,0	51,5	51,6	51,7	52,5	53,0
Rendement poids sec (%)	6,2	6,7	7,5	7,9	8,9	9,5
Taux de récupération en matière sèche (%)	51,1	53,5	57,1	58,5	62,4	62,8

EST (extrait sec total) lait de brebis ajouté au lait de dromadaire : 16,9 % ; au lait de vache : 19,0 % [n (nombre d'essais) = 2 ; CV (coefficient de variation) = 2,9-3,6 %.]

Au plan de la pratique fromagère, il convient de limiter l'ajout de sels de calcium à une concentration de 10 à 15 g pour 100 litres de lait, ce qui entraîne une réduction du temps de coagulation de 20 à 25 %, par rapport à un lait non supplémenté (FARAH et BACHMANN, 1987 ; RAMET, 1985*b* ; RAMET, 1987*b* ; RAMET, 1990).

Pour permettre une répartition homogène du sel de calcium dans toute la masse du lait et pour assurer la modification souhaitée de l'équilibre salin, il est nécessaire d'ajouter le sel de calcium, au minimum 30 minutes avant l'apport d'enzyme coagulante. Dans le cas contraire, l'ajout de sels de calcium a peu d'influence sur le temps de floculation (MOHAMED *et al.*,1990).

Lorsqu'un chauffage du lait est assuré en début de fabrication pour améliorer la qualité des produits, il convient d'effectuer l'apport des sels de calcium après traitement thermique et refroidissement du lait à la température de coagulation ; dans le cas contraire, les sels de calcium ajoutés seraient insolubilisés et perdraient leur efficacité.

Des taux en sels de calcium supérieurs au seuil précité provoquent fréquemment l'apparition de goût amer dans le fromage (RAMET, 1987). Il convient également de n'utiliser que des sels purifiés de qualité alimentaire. Le chlorure de calcium est disponible sur le marché sous forme sèche (poudre - granulés) ou liquide (concentré à 510 g/l) ; son coût est faible. Le phosphate monocalcique est plus rare et son prix supérieur ; il se présente sous forme pulvérulente.

APPORT DE CHLORURE DE SODIUM

Le salage du lait à l'aide de chlorure de sodium est parfois utilisé pour protéger le milieu des altérations par

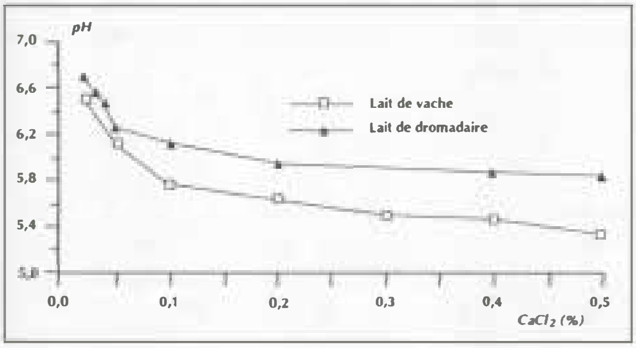

Figure 5. Influence de l'apport de chlorure de calcium sur le pH du lait de dromadaire et du lait de vache.

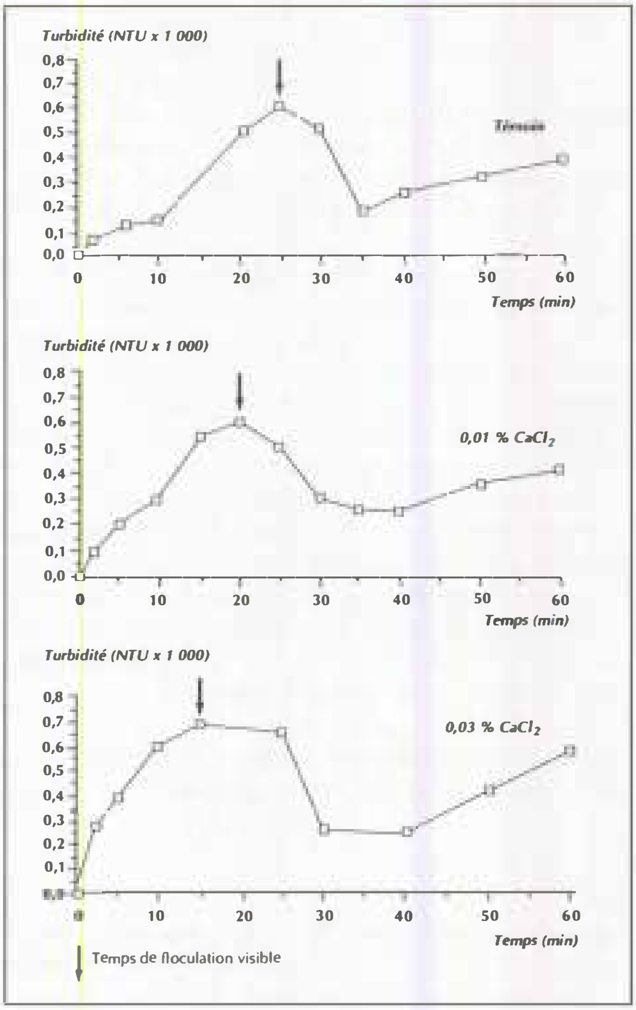

Figure 7. Influence de l'ajout de chlorure de calcium (%) sur l'évolution de la turbidité du lait de dromadaire en fonction du temps (conditions de coagulation : enzyme : 0,25 ml/l ; T : 37° C ; n : 3 ; CV : 1,6-2,5 %).

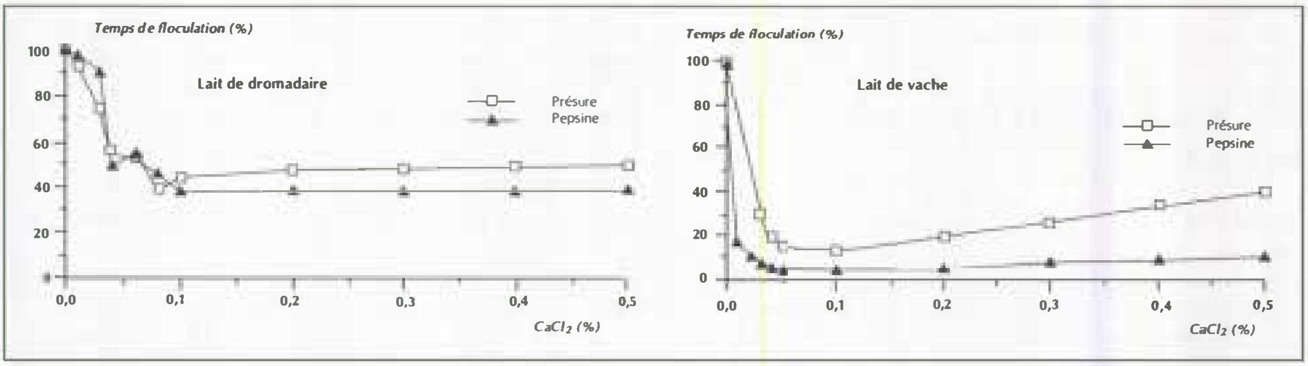

Figure 6. Influence de l'ajout de chlorure de calcium sur le temps de floculation du lait de dromadaire et du lait de vache (conditions de coagulation : enzyme : 0,25 ml/l ; température : 37° C ; n : 5 ; CV : 1,4-2,1 %).

voie microbienne ; le taux de sel nécessaire pour abaisser suffisamment l'activité de l'eau et interdire la prolifération des germes est de l'ordre de 4 à 6 % (RAMET, 1985*a*).

L'effet du chlorure de sodium sur l'aptitude à la coagulation est différent selon la concentration utilisée ; pour des teneurs très faibles comprises entre 0 et 0,3 %, on note une faible activation de la coagulation, d'environ 15 %, à l'aide de la présure de veau et de la pepsine bovine. Lorsque les taux de sels sont plus élevés, les temps de coagulation augmentent. Ils deviennent supérieurs aux temps témoins observés sur le lait non salé lorsque le salage dépasse 0,6 % (RAMET *et al.*, 1982). L'incidence favorable du chlorure de sodium, constatée pour les faibles teneurs en sel, paraît être liée à l'effet activateur induit par effet pH et par la force ionique sur l'activité enzymatique. Aux concentrations supérieures, le rôle dissociant du sodium sur les protéines micellaires et sur l'enzyme coagulante devient dominant et contribue à retarder la formation du gel (figure 8). Selon la nature de l'enzyme coagulante employée, l'effet du chlorure de sodium sur la coagulation du lait de vache n'est pas identique (HAMDY et EDELSTEN, 1970 ; RAMET et EL MAYDA, 1984). On retrouve un phénomène similaire pour le lait de dromadaire ; la pepsine bovine apparaît moins sensible que la présure de veau, à la présence de sel dans le milieu, notamment aux concentrations élevées.

Les propriétés rhéologiques des gels formés sont également modifiées par la présence de sel ; l'évolution

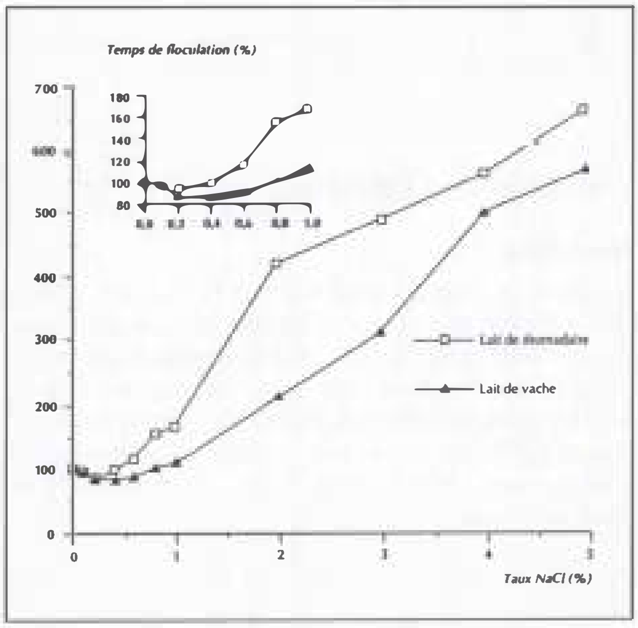

Figure 8. *Evolution du temps de floculation par la présure en fonction du taux de salage du lait (conditions de coagulation : T : 37 °C ; présure : 0,25 ml/l ; temps de floculation (100 %) du lait de vache : 10 min, du lait de dromadaire : 23 min ; n : 4 ; CV : 1,6-2,4 %).*

est parallèle à celle des temps de floculation. Aux faibles teneurs en chlorure de sodium de 0 à 0,3 %, la fermeté est améliorée et la friabilité réduite ; au-delà, l'effet est inversé, il se traduit par une chute de fermeté et un accroissement de friabilité qui, par ailleurs, est plus marqué avec la présure de veau qu'avec la pepsine bovine (RAMET, 1990).

Ces observations permettent de conclure qu'un salage faible du lait au taux de 0,3 % peut être préconisé pour améliorer la coagulation du lait de dromadaire. Il apparaît toutefois que ce traitement doit être utilisé avec discernement et être réservé à la production de fromage à humidité élevée, le chlorure de sodium accroît en effet la rétention d'eau dans le coagulum en cours d'égouttage et ne permet pas d'obtenir des fromages à taux de matière sèche élevés (RAMET, 1985*a* ; RAMET *et al.*, 1982 ; RAMET et EL MAYDA, 1984). Il faut noter que le lactosérum issu de ces fabrications est lui-même salé à environ 3 g/l, ce qui ne semble pas devoir limiter ses valorisations potentielles.

Conduite de la coagulation

Choix de l'enzyme coagulante

Plusieurs expérimentations menées en Arabie Saoudite (RAMET, 1985*a*, 1990) et en Tunisie (RAMET, 1987*a*) ont permis de montrer que les affinités des différentes préparations coagulantes disponibles sur le marché pour coaguler le lait de dromadaire n'étaient pas identiques (figure 1). Parmi celles-ci, la pepsine bovine a été identifiée comme la plus apte à la coagulation ; la présure de veau et l'enzyme coagulante de *Mucor miehei* présentent une aptitude à la coagulation un peu inférieure, mais acceptable. D'autres observations (GAST *et al.*, 1989 ; YAGIL, 1982) apparaissent confirmer le statut privilégié des pepsines pour coaguler le lait de dromadaire.

Une des caractéristiques communes à toutes les pepsines est d'être plus actives en milieu acide que la chymosine et la présure ; l'activité coagulante décroît fortement au-dessus de pH 6,3 ; au pH du lait frais (6,65-6,75), la coagulation n'apparaît pas. Une évolution comparable a été mesurée dans le lait de dromadaire ; les résultats indiquent que pour bénéficier au mieux de l'effet pH, il y a bien lieu d'acidifier le lait avant coagulation jusqu'à pH 6,2-6,4. Toutefois, cette pratique ne peut pas être utilisée pour tous les types de fromages, car l'acidification entraîne une déminéralisation corrélative des micelles qui induit une friabilité accrue du gel et une baisse de l'aptitude à l'égouttage. De ce fait, seuls les laits destinés à la fabrication de fromages à pâtes fraîches et à pâtes molles, pourraient être traités dans les conditions précitées. Pour les pâtes pressées, il conviendra de limiter l'acidification à des pH supérieurs et en fonction du taux de matière sèche recherché dans le fromage, soit 6,4-6,5 pour les pâtes pressées non cuites et 6,5-6,6 pour les pâtes pressées cuites.

Ajustement du pH de coagulation

Toutes les enzymes coagulantes de fromagerie sont des protéases à caractère acide dont l'activité optimale est généralement proche de pH 5,5 (RAMET, 1984). Le lait frais de dromadaire possède, d'après différentes sources bibliographiques, un pH pouvant, selon ses origines très diverses, varier dans une fourchette assez large comprise entre pH 6,55 et 6,85 ; ces valeurs ne sont pas très favorables à une bonne activité coagulante, d'où l'intérêt, en pratique, d'acidifier légèrement le lait au moment de l'emprésurage.

On montre en particulier qu'en acidifiant le lait de dromadaire de pH 6,66 à pH 6,40 on diminue le temps de coagulation par la présure de 28 % et de 70 % pour la pepsine.

Plusieurs techniques peuvent être proposées pour réaliser cet ajustement dirigé du pH :
– la méthode la plus simple consiste à inoculer le lait avec 1 à 2 % de ferments lactiques ayant une acidité titrable de l'ordre de 0,8 % ; l'abaissement de pH du lait consécutif à cet apport est alors d'environ 0,10 à 0,15. Si cet abaissement est jugé insuffisant, il y a lieu de laisser maturer le lait à une température de 28 à 35 °C, pour permettre une production supplémentaire d'acide lactique par les bactéries précédemment ensemencées. Cette période de maturation peut être maintenue pendant 30 à 90 minutes selon l'acidité souhaitée lors de la coagulation ;
– la seconde méthode, la plus usitée, réalise l'abaissement de pH par apport d'un sel de calcium ou de sodium. Les limites pratiques de cet ajout ont été précisées ci-dessus ;
– un troisième procédé est d'apporter dans le milieu un acide organique. Les acides ayant des goûts très caractéristiques (acide citrique, acide acétique) ne peuvent pas être utilisés ; l'acide lactique commercial de qualité alimentaire est le plus adapté.

On peut également citer pour mémoire deux méthodes proposées récemment dans les pays industrialisés. La première réalise une acidification par de l'acide gluconique. Cet acide est libéré progressivement dans le lait par hydrolyse spontanée en présence d'eau de glucono-delta-lactone ou GDL. La seconde utilise une injection de gaz carbonique dans le lait ; ce gaz étant très soluble dans l'eau, l'ajustement du pH est quasi instantané.

Il faut rappeler que toute acidification entraîne une déminéralisation de la caséine qui conduit lors de la coagulation à une friabilisation du gel et à une diminution de l'aptitude à l'égouttage. L'ajustement du pH doit être conduit de manière définie dans des limites strictes pour chaque type de fromage.

Augmentation de la température de coagulation

La température optimale d'activité des enzymes coagulantes se situe pour la plupart au voisinage de 40-50 °C. Au-dessus de cette valeur, se produit une dénaturation progressive de l'enzyme qui devient complète vers 65 °C.

Augmentation de la concentration en enzyme coagulante

Pour la plupart des enzymes coagulantes, il existe une relation pseudolinéaire entre le temps de coagulation et l'inverse de la concentration en enzyme ; un doublement de la dose d'enzyme réduit de moitié le temps de floculation (RAMET, 1985*a*).

En pratique, l'application de cette règle doit rester très limitée car elle bouleverse l'équilibre précis qui existe dans une fabrication donnée entre caractère acide et caractère enzymatique. De plus, un surdosage d'enzyme coagulante conduit fréquemment à une texture granuleuse de la pâte, à un affinage plus rapide avec, de plus, apparition possible d'amertume due à l'accumulation de peptides amers.

En raison de l'aptitude réduite à la coagulation du lait de dromadaire qui nécessite de majorer la dose de coagulant, il n'apparaît pas judicieux de surdoser une nouvelle fois le milieu en enzyme coagulante.

Conduite de l'égouttage

Modalités

L'égouttage reste conditionné par la fragilité relative des gels. De ce fait, les différents traitements mécaniques intervenant en début d'égouttage doivent être appliqués avec grande précaution de manière à éviter tout bris incontrôlé du gel. Pour cela, le tranchage doit être fait d'une manière très douce, sur un coagulum suffisamment raffermi pour éviter sa pulvérisation en fines particules.

Pour les fromages à pâte molle et à pâte pressée, il y a lieu, pour obtenir un grain plus ferme au moulage, qui ne se brisera pas au contact des supports d'égouttage (toiles, moules, plateaux), d'accroître le degré de tranchage par rapport aux normes existantes pour les fromages homologues au lait de vache (RAMET, 1985*a*), puis de prolonger la durée de l'égouttage statique en cuve ; il se produit alors un raffermissement important du gel consécutif à l'augmentation du taux de matière sèche lié à la séparation du lactosérum.

Pour les fromages présentant un caractère acide et une humidité élevée, supérieure à 65 %, le moulage direct en moules est très délicat en raison des pertes très importantes de caillé pouvant se produire par les trous des moules ; il est alors préférable de réaliser un pré-égouttage en sacs textiles qui assurent une rétention et une filtration efficace du caillé ; la mise en moules du caillé partiellement égoutté peut alors être effectuée sans pertes excessives.

Cette adaptation des modalités de début d'égouttage s'avère surtout nécessaire lorsque le lait traité est pauvre en matière sèche et est, en particulier, collecté en saison chaude auprès d'animaux rarement abreuvés (RAMET, 1987*a* ; RAMET, 1991 ; YAGIL et ETZION, 1980).

La synérèse des coagulums de lait de dromadaire est rapide, comparativement à celle des gels du lait de vache ; la forte teneur en eau du lait et la capacité d'hydratation limitée de la caséine sont vraisemblablement responsables de ce phénomène.

Différents procédés énoncés précédemment pour corriger l'aptitude à la coagulation (traitement thermique, enrichissement en protéines) ont pour effet d'accroître l'hydratation du gel et de ralentir son égouttage.

Pour les fromages à humidité plus faible de type chèvre, de type pâte pressée non cuite et de type pâte persillée, quelques dégustateurs ont noté une texture légèrement rugueuse qui peut s'expliquer par la faible teneur en matière grasse de la pâte et par le dessèchement plus accentué.

D'une manière très ponctuelle, certains lots de fromage à pâte pressée non cuite présentent en bouche lors de la mastication un texture collante et graisseuse voisine de celle mentionnée précédemment. L'origine du défaut n'a pas été déterminée (RAMET, 1990 ; RAMET et KAMOUN, 1988).

L'odeur des fromages est faible sans dominante caractéristique.

Le goût des différents types de pâtes a été jugé bon et assez comparable à celui d'un fromage de chèvre non affiné dépourvu de saveur caprine typique. Contrairement à une opinion préconçue souvent rencontrée, la flaveur du fromage de dromadaire est assez neutre et sans rapport avec l'odeur souvent très typée de l'animal !

Une amertume momentanée en début d'affinage et d'intensité faible à modérée a été trouvée pour des fromages à pâte pressée non cuite ; elle a été attribuée à l'utilisation de doses élevées de chlorure de calcium destinée à faciliter la coagulation (RAMET, 1987*a*), ainsi qu'à une acidification excessive en cours d'égouttage déterminant un pH bas favorable à l'accumulation de peptides amers (RAMET et KAMOUN, 1988).

La saveur amère et légèrement salée présentée par certains lots de lait provenant d'animaux élevés en élevage extensif traditionnel n'est plus détectable dans les fromages correspondants (RAMET, 1987*a*). Il n'est pas déterminé si les substances responsables sont hydrosolubles et éliminées avec le lactosérum ou si leur goût est masqué par les autres composants du fromage.

En Somalie, le lait est recueilli dans des récipients désinfectés à l'aide de charbon de bois (RAMET, 1989). Cette pratique communique au lait une saveur fumée et une couleur très légèrement grise ; ces caractéristiques donnent au fromage de type *Grana* une saveur typique et une couleur sombre originale (MOHAMED *et al.*, 1990).

Conduite de l'affinage

Modalités

Les données relatives à la caractérisation de l'affinage des fromages au lait de dromadaire sont très rares ; il n'existe en particulier aucune information sur l'évolution dans le temps des principaux facteurs liés au substrat (pH, activité de l'eau) qui régulent les équilibres microbiens et l'activité du potentiel enzymatique responsables de la protéolyse et de la lipolyse (RAMET, 1985*b*).

Seules quelques observations d'ordre général faites lors de fabrications expérimentales sont disponibles (MOHAMED *et al.*, 1990 ; RAMET, 1987*a* ; RAMET, 1990 ; RAMET et KAMOUN, 1988).

L'évolution apparente des fromages a été jugée satisfaisante pour les différentes catégories de fromages ; pour les fromages à pâte molle de type Camembert et comportant une moisissure superficielle de *Penicillium camembertii*, la croissance du mycelium s'est faite dans les délais habituels et de manière homogène. Pour les fromages plus humides correspondant au type « chèvre », aucune différence visible n'a été également relevée ; il en est de même pour les fromages de type pâte persillée, caractérisés par le développement interne de la moisissure bleue *Penicillium requefortii*.

Pour les fromages à pâte pressée non cuite de type *Baby Gouda* et de type *Gibneh*, l'évolution a été, elle aussi, relevée conforme au comportement habituel de ces produits en phase d'affinage.

Pour l'ensemble des fromages, une perte de poids assez accentuée a été notée ; celle-ci résulte d'une évaporation de l'eau plus intense que celle observée pour les fromages au lait de vache ; il est difficile de préciser si cette perte est consécutive à des fluctuations d'hygrométrie dans les enceintes d'affinage ou à un moindre degré de liaison de l'eau contenue dans la pâte du fromage dû au caractère moins hydrophile de la caséine du lait de dromadaire.

Caractéristiques organoleptiques

Au plan organoleptique, les analyses sensorielles pratiquées à différents moments de l'affinage ont révélé une qualité globalement satisfaisante des produits fabriqués :

– l'aspect des fromages a été jugé conforme aux critères spécifiques de qualité des catégories concernées ;

– la texture onctueuse et très fine a été appréciée pour les fromages frais.

Rendements fromagers

Les rendements fromagers obtenus avec le lait de dromadaire se caractérisent par un taux de recouvrement très faible de l'ordre de 30 % dans le fromage, de la matière sèche du lait mis en œuvre. L'analyse comparée des résultats obtenus lors de fabrications homologues de fromages à pâte pressée non cuite (tableau VIII) montre qu'après thermisation préalable du lait, ajout de chlorure de calcium et adaptation des paramètres d'égouttage dans les conditions précitées, le taux de recouvrement de matière sèche était sensiblement amélioré ; le gain observé peut être estimé à environ 2 % en traitant un lait très pauvre en matière sèche (9,4 %) et à près de 10 % avec un lait plus riche en extrait sec (10,2 %). La perte en matière grasse dans le lactosérum est très sensiblement réduite de 1,3 à 0,63 % (RAMET, 1987*a* ; RAMET et KAMOUN, 1988).

Conclusion

Les recherches effectuées au cours des dernières années ont permis d'expliquer l'aptitude fromagère limitée du lait de dromadaire et d'apporter des moyens de correction adaptés à la fabrication de différents types de fromages.

A terme, ces procédés permettront de différer la consommation du lait de la période de haute production vers la période de basse production et d'assurer une plus grande régularité dans l'approvisionnement des ressources alimentaires des populations concernées.

Il est également probable que le développement de ces produits nouveaux entraîne la création de nouveaux échanges entre zones rurales et urbaines et/ou entre pays producteurs et pays consommateurs.

Tableau VIII. Caractéristiques de fabrication des fromages à pâte pressée non cuite obtenue à partir de lait de dromadaire.

Origine du lait	Dromadaire		Vache
Type d'élevage	Extensif*	Intensif**	Intensif*
Lait			
Matière sèche (%)	9,46	10,10	12,21
Matière grasse (%)	2,04	2,75	3,20
Coagulation			
pH	6,21	6,61	6,50
Temps floculation (min)	12,45	7,96	11,50
Fromage			
Matière sèche (%)	31,70	45,79	49,96
Rendement frais (%)	6,88	10,74	12,13
Rendement sec (%)	3,00	4,60	6,06
Récupération matière sèche (%)	31,70	45,79	49,96
Lactosérum			
Matière sèche (‰)	69,95	65,52	64,53
Matière grasse (‰)	13,21	6,29	5,06

* D'après RAMET, 1987*a*.
** RAMET et KAMOUN, 1988.

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Camel's milk processing and its consumption patterns in Mongolia

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Abstract. This communication aims to describe the basic forms of utilisation of camels in Mongolia with high emphasis on the camel's milk processing in particular. The Bactrian camels (*Camelus bactrianus*) valued as an important domestic animal because of its hardiness and various productive capabilities. The ability of camels to survive in a harsh environment where other large species are not well adapted makes them highly preferred and valued. Camels are utilised in Mongolia as multi-purpose animals for their milk, wool, meat and excellent working capacity. Female camels are milked for a lactation period of about 450-480 days and the average milk yield for such a lactation period is estimated to be 800-1,000 litres. This includes the amount suckled by the calf. A good half of the total milk produced by a she-camel is used for making different dairy products for household consumption and trade. Camel's milk is completely processed in household using techniques based on indigenous know-how which have very unique rules and technological steps that are taken from other places in Mongolia. The wasteless technological steps in making different dairy products are described in order to illustrate the patterns of camel's milk processing in Mongolia. Other goals for further increased milk yield of Bactrian camel and processing methods are discussed.

Key words. Camel, *Camelus bactrianus*, milk, milk products, processing, Mongolia.

Résumé. Cette communication a pour but de décrire les formes traditionnelles de l'utilisation des chameaux en Mongolie, en insistant en particulier sur le traitement du lait de chamelle. Le chameau de Bactriane (*Camelus bactrianus*) est considéré comme un animal domestique primordial en raison de sa résistance et de sa capacité de production variée. L'aptitude des chameaux à survivre dans des environnements difficiles auxquels beaucoup d'autres espèces ne sont pas bien adaptées a fait d'eux l'espèce préférée et la plus valorisée de Mongolie. Les chameaux y sont utilisés comme animaux à usages multiples, pour leur production de lait, laine, viande et leur excellente capacité au travail. Les chamelles sont traites pendant une période de lactation d'environ 450 à 480 jours et la production moyenne pour cette période est estimée à 800 à 1 000 litres, cette quantité incluant la portion réservée au chamelon. Une bonne moitié de la totalité du lait produit par une chamelle est utilisée pour fabriquer divers produits laitiers pour la consommation des ménages et le commerce. Le lait de chamelle est complètement transformé chez les éleveurs, en utilisant des techniques basées sur le savoir-faire local aux règles spécifiques, ainsi que des étapes techniques empruntées à d'autres lieux de Mongolie. Les étapes technologiques utiles pour l'élaboration des différents produits laitiers sont décrites dans le but d'illustrer les modèles spécifiques de transformation du lait de chamelle en Mongolie. D'autres objectifs pour augmenter la production de lait de chamelle, ainsi que des méthodes de fabrication, sont discutés.

Mots clés. Chameau, *Camelus bactrianus*, lait, produit laitier, traitement, Mongolie.

Introduction

Mongolia, a land-locked country, covers a total area of 1,555,600 sq. km and ranges in altitude between 560 m and 4,374 m a.s.l. with an average altitude of 1,580 m. About 43% of the total human population live in rural areas. The population density is 1.3 persons per sq. km, one of the lowest in the world (ALTANSUKH and ERDENEBAATAR, 1994).

Materials and Methods

Climate and geography

Mongolia essentially comprises three broad ecological zones: the forest-steppe and mountains to the north and north-west (27%), the vast eastern and central steppe (31%) and the Gobi desert to the south (42%). The provinces of Mongolia are shown in figure 1.

Figure 1. Provinces and provincial capitals of Mongolia.

Mongolia has an extreme continental climate with high monthly and daily changes. The continental climate, with a short growing season, sharply defined seasons and mean temperatures of between – 6 and + 4°C, and high fluctuations ranging from + 45 to – 40°C in some places, is the overriding constraint to Mongolian livestock production and a major factor contributing to its fragile ecosystems. The length of the growing period ranges between 70 and 130 days in various parts of the country. There are only 80-90 frost free days in the year in the mountains and forest-steppe, and up to 130 in Gobi, thus severely constraining the plant growth season throughout the country. Annual precipitation is low, from 300 mm in mountains and 200-300 mm in steppes, to less than 150 mm in Gobi. Rainfall is mono-modal, with 70-80% falling in summer and autumn.

Land resources

About 81% of the total land is agricultural land, 10% is forest and 1% is covered by water (SHOMBODON, 1993). Natural pastures, as the basis for livestock production occupy 125.0 million hectares (98,9% of total agricultural land) and supply more than 96% of the annual livestock fodder requirement.

In accordance with the geographical and meteorological conditions, Mongolian territory is divided into 6 vegetation zones: high mountains, mountain taiga, mountainous steppe and forest steppe, dry steppe, desert steppe and desert. There are more than 2,500 plant species, including hundreds (about 600) that are valuable for forage in Mongolia.

Camel herding in Mongolia

Two-humped camel (Bactrian camel) is one of the major domestic animals among those that Mongolians call the "Five kinds of Livestock". Mongolia is considered the homeland of Bactrian camels, because a wild two-humped camel species locally known as *Khavtgai* can be found in the Mongolian Gobi. The camel is an essential part of a mixed herd consisting of other large and small livestock species. The multi-species herding strategy among Mongolian herders may be regarded as a strategy to cope with high natural risk as well as satisfying various household labour and consumption needs. By keeping different animals in the Gobi and steppe area where camel herding is common, the camels are utilized as both basic and supplementary means of subsistence. The Bactrian camel is well able to survive in a harsh environment with poor grass and very little water. For the last four years the number of camels in Mongolia has decreased quite sharply. The total decrease estimated to be 31.6% from 1990 to 1993.

The Mongolian two-humped camel is utilized for milk, wool, meat and excellent working capacity. The improvement of the draught performance was the main goal of traditional camel breeding in Mongolia. Consequently, it is considered that the improved body comformation of the Mongolian camel is a result of common use of camels for packing and riding as well as some degree of selective breeding aimed to improve the draught capability.

Camel's milk and its processing in Mongolia

Camel milk is a major source of milk supply for people living in the Gobi and desert steppe area. Camel's milk consumption in these areas makes up about 35% of the total food ration. The main goal of camel milking is household consumption. The female camel is milked on calf suckling-milking principles twice daily. So much of the milk produced is suckled by their calves. The productive milking of the female camel starts from late

May or early June when the calves are big enough to graze on their own. The lactation period lasts about 15-16 months. Milk yield usually decreases in summer when it is extreme hot and increases again in autumn. The productive yield of milk of she camel does not exceed 500 liters. Camel's milk is highly appreciated by the Mongolians. It is considered better than milk from other species. The value placed on camel's milk could be due both to the composition and to the year-round availability.

Camel's milk is very white, foamy and rich tasting. The average dry matter content is 15.5%, fat 5.4%, lactose 4.8%, protein 4.4% and minerals 0.9%. The composition of milk of the Mongolian female camel is given in table I.

Table I. Composition of milk of Mongolian female camel.

	Months of lactation							
	2	4	6	8	10	12	14	16
Fat (%)	5.2	4.9	5.0	5.7	6.0	6.2	6.0	6.4
Protein (%)	4.6	4.1	4.7	4.2	4.8	4.9	4.8	4.8
Sugar (%)	4.8	4.8	5.6	5.1	5.1	4.7	4.8	4.7
Ash (%)	0.8	0.8	0.8	0.9	0.9	0.8	0.8	0.8

Source: INDRA R, 1983. Milk and milk products. Ulaanbaatar, Mongolia, SPH.

Camel's milk contains more casein and some amount of albumin and globulin, 1.5-2 times more than in cow milk. It is rich in amino acids such as leucine, isoleucine, valine, phenylalanine, threonine, arginine, methionine and tryptophan. The portion of unsaturated fatty acids in total fatty acid composition in camel's milk appears to be 39.1%. One of the specific traits of camel's milk is low (trace) content of butanidieous, caprylic, caproic and capric acids. The content of these fatty acids in goat milk reaches 16.8%, which distinguishes it from camel's milk (INDRA, 1983). However, camel's milk is as rich in most vitamins: A, D, C and B and minerals: Ca, P, K, Na, Mg, Zn, Fe and Cu. Therefore, the rich composition of camel's milk makes it preferred. It has a better shelf life than cow's and goat's milk due to its composition mosaic that enables it to be more resistant to high temperature environment. The acidity of camel's milk is 22T, pH 6.6 and natural buffer 3.8 in terms of acids and 3.3 in terms of bases (BATSUKH, 1994). Proteins in camel's milk are less coagulative than other milk due to the high natural buffering action. But BERLIN and FORSELL (1990) argue that this property depends on the shortage of H-casein in camel's milk. Nevertheless, Mongolians do not use camel's milk for making yoghurt.

Because of the above-mentioned properties, camel's milk is used for making cultured, fat and protein-based dairy products by using the different constitutes. Instead of making yoghurt from camel's milk, it is used for producing fermented milk (*airag*), a product obtained by fermentation of milk using a special yeast (culture) composed of *Str. thermophilus, Lactobacillus bulgaricus* and *Saccharomyces* (INDRA *et al.*, 1988).

The basic technological operations in obtaining the above-mentioned products are different according to the type of finished products required. The main steps in camel's milk processing in Mongolia are given in figure 2.

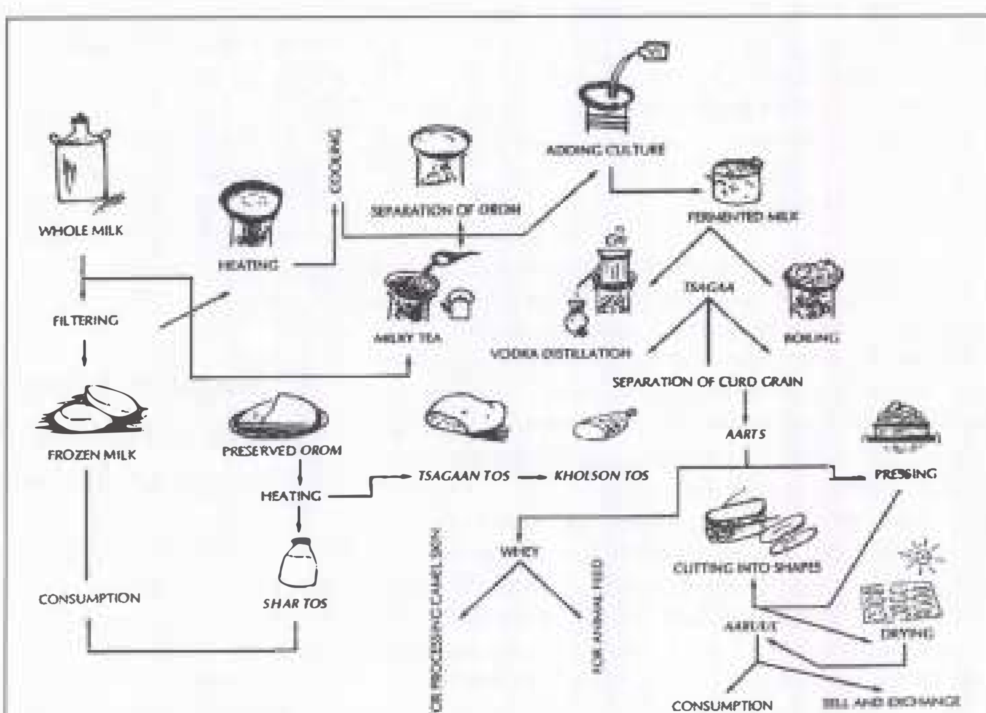

Figure 2. Camel's milk processing steps.

Camel's fermented milk

The advantage of producing *airag* with the help of cultures of bacteria is based on the fact that it has uniform taste and longer durability.

The following are the steps in making camel fermented milk :
- milking and filtering,
- heating (35-40°C),
- cooling (25-30°C),
- adding cultures,
- stirring for a few minutes,
- ripening (10-16 hours).

No specific manufactured equipment is required to make fermented milk. Fermented milk is consumed directly or used for making a low alcohol drink through a special distillation technique. Mongolian people also use fermented camel's milk to make *butsalgaa*, a mix of airag and boiled hot camel milk. This kind of drink is less sour and more tasty. It has a curative character against intestinal and kidney diseases and reduces swellings (ZAGSUREN *et al*., 1990).

Protein-based products

Because of low coagulation of camel's milk, to obtain curd grains for making cheese-type products, Mongolian herders have developed indigenous technology for making protein-based dairy products through re-processing the *airag* residue. These products are called *aarts* (cottage cheese) and *aaruul* (dried curd).

The following are the steps in making protein-based dairy products:
- distillation or boiling fermented milk,
- separation of curd grains and whey,
- pressing (3-5 hours),
- shaping,
- drying in the sun.

Fermented milk is reprocessed into protein-based products in one of two ways depending on the initial purpose. It can be boiled to obtain low alcohol vodka (*arkhi*) or it can be boiled directly to facilitate separation of curd grains from whey. In both cases the fermented milk is naturally boiled to stop further fermentation and improve the collection of curd grains. The newly boiled fermented milk is called *tsagaa*. It can be consumed hot, or cooled to treat some simple symptoms of fatigue and heighten the digestive functions. Separation of grain curds and whey is achieved through filtering the *tsagaa*. In doing so, *tsagaa* is packed in less porous matter and pressed for a period of 3 to 5 hours. During this operation part of the whey is drawn off and curd grains become more dense and more compact. The average harvesting of *aarts* is about 25% of the total amount of *tsagaa*. The dregs or *aarts* are cut into different shapes and processed into dried curds (*aaruul*) in the sun. Dried curd is softer and tastier than non-dried curd. It is used for home consumption and the surplus is sold or traded.

Fat-based products

Based on the high fat content of camel's milk, Mongolian people have developed special techniques for making a limited number of fat-based products from camel's milk. By farming and specific processing of milk, *orom* (soured cream) is obtained. The average yield of *orom* is 4-5 kg per 100 liters of whole milk. *Orom* is consumed directly and used for making different fat-based products.

The following are the steps in making fat-based products:
- warming (75-85°C),
- foaming by mixing,
- cooling (18-20°C),
- leaving the fat globules to float up (10-15 hours),
- collecting or skimming *orom*,
- making *shar tos* and *tsagaan tos*.

Usually, *orom* is consumed fresh, mixed with bread or other milk products. It can be preserved for consecutive processing or dried for later use. In preserved *orom*, lactoacid bacteria reproduce and microbiological processes take place. Microbiologically, processed *orom* is rich in various vitamins and protein and is a source of valuable and easily digestible food products. When processed *orom* is melted, *shar tos* is obtained. When *shar tos* is separated, the remaining part is called *tsagaan tos*.

Camel milk is utilized also for making a milky tea. Surprisingly, Mongolians never consume liquid camel milk. To make milky tea some amount of camel milk mixed with water (approximately 1:3) and pieces of green tea and little salt is added.

Major achievements and specific patterns in camel dairying

From ancient time, Mongolians have been processing camel milk which has resulted in the development of a unique technology for making different types of products from camel's milk. Also, there are valuable achievements and progressive approaches in camel milking in Mongolia. Mongolian camel keepers have developed a "domesticated" culture for making fermented camel milk. As was mentioned earlier, the culture is composed of three types of local microorganisms in the best symbiosis. It is interesting to note that highly purified cultures have been obtained under nomadic living conditions. The secret of this is that from ancient times onward, the nomads have used "their" cultures not only for one product. It has been used for making various products, which led to the preparation of the best possible mixture of highly symbiotic microorganisms. This suggests that under Mongolian conditions the herders are used for monitoring the technological steps of milk processing rather than the microbes. The basic technological steps and processing techniques appear simple, even "primitive" as some researchers have expressed, but actually they are unique and can be considered a wasteless producing system. The various steps are interconnected; each step is followed by the next one, so that the product is ready for the next step of processing. Mongolian techniques of camel milk processing, thus, can be called as classical, for the following reasons:

- ability to be used both for large scale and household level processing;
- diversity of products of different taste and nutritive value;
- small amount of milk is required for serial processing;
- high utilization rate of basic milk components;
- different techniques for different products;
- long conservation of products.

Major constraints in camel milk utilization

Despite these achievements, there are serious constraints that limit wide processing and improved consumption of camel milk in Mongolia, for example:

- the camel population, in particular, the number of female stock has decreased for the last four years following nationwide livestock privatisation. This leads to likely decreases of camel's milk production and consumption;
- the Mongolian Bactrian camel has been bred mostly for other types of products and for a working capacity that has led to low milk performance. This has probably enhanced the high labour requirement for the time consuming milking activity, and the difficulties in training camels for milking;
- there is no experience in camel dairy farming. In other words, collection and centralised processing of camel's milk in Mongolia has not yet been developed in a proper way;
- there is a series of difficulties in marketing of camel dairy products mostly due to the distance between the Gobi and the desert-steppe area, and the centralized urban markets.

Important goals for further development of camel dairying would be the following:

- improving the milk yields of female camels through purposive selection among the existing high producing local races;
- developing a national technology for camel dairy processing plants based on efficient use of traditional knowledge and achievements without changing the types of finished products;
- mproving the taste and quality of products through value-added processing in order to increase the profitability of the milk processing;
- improving the utilization rate of milk and its components by producing different products;
- adoption of basic elements for marketing of camel's dairy production by increasing the production of milk products.

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La transformation laitière et le nomadisme : exemple du Niger

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Résumé. L'auteur décrit un processus d'amélioration de la qualité dans une chaîne traditionnelle de transformation laitière, en vue de l'élaboration de fromage *tchoukou* au Niger, fromage fabriqué à partir de laits de diverses origines animales, au sein d'une filière bien organisée.

Mots clés. Lait de chamelle, lait de chèvre, lait de vache, produit laitier, fromage, traitement, nomadisme, Niger.

Abstract. The author describes how the quality of *tchoukou* cheese —maked from various animals' milks—has been improved in Niger. By mean of simple innovations that have been introduced in the traditional dairy process, the quality of the product and the income of the producers have been considerably improved, in the midst of the dairy subsector.

Key words. Camels' milk, goat's mild, cow's milk, milk products, cheese, processing, nomadism, Niger.

Introduction

La transformation laitière est une série d'étapes qui permet aux producteurs de lait d'avoir un débouché commercial pour leur lait et de fournir aux consommateurs urbains du lait et des produits laitiers.

Les étapes de la filière laitière sont les suivantes :
- collecte journalière du lait ;
- réception et standardisation du lait à l'usine laitière ;
- transformation du lait en produits sains pouvant être distribués pendant un temps plus long (lait pasteurisé, yoghourt, beurre, fromage) ;
- distribution et commercialisation du lait et des produits laitiers auprès des consommateurs.

Toutes ces tâches sont entreprises par l'usine laitière qui, de plus, dans certains pays, joue également le rôle de conseiller technique auprès des producteurs de lait et également de fournisseurs de produits pour l'élevage (sous-produits agricoles pour la nourriture des bovins, médicaments vétérinaires, etc.).

Dans les pays en développement, la collecte laitière entreprise par la laiterie est très souvent une opération onéreuse en raison du mauvais état des routes, de la dispersion des éleveurs et de leur faible volume de production. Pour les petits éleveurs très éloignés des centres de commercialisation et, *a fortiori*, pour les peuples semi-nomades ou nomades, la collecte laitière du surplus familial est impossible. Depuis fort longtemps, il existe pour ces populations une alternative pour la commercialisation du lait : la fabrication d'un produit laitier susceptible d'être conservé sur une longue période. Cette tradition de fabrication d'un fromage existe dans de nombreux pays, et est pris ici l'exemple du Niger où la FAO est intervenue pour améliorer la technologie du fromage *tchoukou*.

Amélioration de la technologie du fromage *tchoukou* au Niger

Apporter une amélioration dans la technologie fromagère d'un produit laitier traditionnel est déjà une opération délicate en soi. Divulguer cette amélioration auprès d'un public exclusivement féminin, illettré et strictement confiné à la sphère ménagère, appartenant à plusieurs ethnies de langues différentes, semi-sédentaires ou nomades, qui connaissent des conditions de vie très difficiles en zone aride ou semi-aride et, de surcroît, soumises depuis plusieurs années à une instabilité politique chronique, est un véritable pari qu'a fait la FAO, dans la zone de Tabalak, en y lançant le projet « *Tchoukou* ».

La transformation traditionnelle du lait — opération importante pour la préservation d'un produit de grande valeur, mais hautement périssable — est une activité exclusivement féminine. Il s'agit de la fabrication de beurre, par barattage dans une coloquinte, ou d'un fromage sec local présenté en feuilles.

Ce fromage traditionnel, appelé *tchoukou* en langue haoussa, et *tikomart* en touareg, est un fromage des zones désertiques ou semi-désertiques (voir cahier hors texte, figure N1). Il est fabriqué de longue date par les femmes (voir cahier hors texte, figures D1, D2, D3) qui, par ce moyen, valorisent l'importante production laitière en saison d'hivernage en stockant des réserves alimentaires pour la période sèche. La vente des surplus de *tchoukou* permet aussi d'acheter des denrées indispensables pour la famille. Il est consommé soit en l'état, trempé dans le thé brûlant, soit pilé et incorporé à la bouillie de mil (farine de mil humectée et modelée en boule, au sein de laquelle s'opère une fermentation lactique, et qu'on délaie pour la consommation dans le babeurre ou le lactosérum).

Sur le plan technique, c'est un fromage sec, obtenu à partir de lait de vache, de chèvre ou d'un mélange des deux, selon la saison, emprésuré à chaud juste après la traite, donnant un caillé fortement présuré. On évite l'acidification par la flore microbienne indésirable en procédant rapidement à son séchage, grâce à sa faible épaisseur. Il n'y a donc pas d'affinage, mais seulement une maturation enzymatique due à la présure.

Il faut environ 1,5 litre de lait pour fabriquer un *tchoukou.*

Le projet de la FAO avait pour but d'améliorer la qualité du fromage traditionnel *tchoukou* pour augmenter le revenu des productrices. Les principaux défauts de la technologie traditionnelle étaient les suivants :
– le lait utilisé contenait souvent des impuretés physiques (poils, fèces, paille) et n'était pas filtré ;
– la présure utilisée constituait la principale source de contamination au moment de l'emprésurage. Conservée à température ambiante, il s'y développait des germes entraînant une putréfaction et donnant une odeur désagréable au fromage. Son pouvoir coagulant était très variable ;
– le lait était caillé dans des calebasses ou des récipients divers, exposé aux mouches et à la poussière. Le nettoyage des récipients était très sommaire ;
– le découpage et la répartition du caillé se faisaient avec les doigts, et le pressage avec la paume de la main ;
– la mise en forme, le pressage et l'égouttage du caillé se faisaient dans une natte de panicum (*Assabar*) qui, n'étant pas nettoyée, constituait une importante source de contamination, notamment en moisissures, et favorisait les pertes de caillé à travers les tiges ; il en allait de même pour la natte de panicum servant au séchage (*adabara*) ;
– lors du séchage, les fromages étaient exposés aux insectes, à la poussière, aux oiseaux ;
– la forme (grossièrement rectangulaire) et le poids étaient très disparates ; les rainures laissées par les nattes de panicum donnaient un aspect inesthétique ;
— enfin, les fromages vendus sur les marchés contenaient souvent des impuretés visibles, du sable ; ils étaient présentés dans des emballages malpropres.

Afin d'apporter une aide dans l'amélioration de la fabrication traditionnelle du *tchoukou* (meilleur rendement, plus grande régularité dans la forme et la qualité du fromage, réduction du temps de fabrication), il fallait organiser et former les productrices de *tchoukou* et intégrer leur production dans un système commercial organisé qui puisse améliorer leur revenu.

Afin de remédier aux défauts précédemment recensés, une série de travaux d'expérimentation ont été menés ; des matériaux présents sur le marché local ont été utilisés, afin de constituer des micro-fromageries transportables (des kits de fromagerie) obéissant aux principes suivants : ustensiles simples pouvant être adoptés facilement par les productrices, efficaces quant à l'amélioration technologique, de faible coût et facilement transportables par une personne.

Après plusieurs tentatives, un kit de fromagerie a été mis au point, permettant, avec un litre de lait, de faire un *tchoukou.* Ses caractéristiques sont les suivantes :
– il est composé de 18 éléments, dont 5 fabriqués localement (voir annexe 1) ;
– il permet de fabriquer 10 fromages par jour (10 litres de lait), soit 6 avec la traite du matin et 4 avec la traite du soir ;
– tout le matériel est emballé dans un sac de jute ;
– il pèse environ 8 kg ;
– il coûte 13 500 F CFA, soit 46 dollars EU (avant la dévaluation).

Le kit, qui constitue en quelque sorte une « micro-fromagerie » portable, couvre l'ensemble du processus technologique de la fabrication fromagère.

Le choix de cet équipement ainsi que les paramètres technologiques de fabrication qui en découlaient ont permis l'obtention de fromages de qualité nettement améliorée, notamment sur le plan de l'hygiène (pas d'impuretés physiques, protection contre les mouches et la poussière, aucune manipulation directe) et de la qualité commerciale (fromages de poids et de dimensions constants, de forme plus esthétique, plus faciles à transporter et à manipuler).

Le matériel proposé devait pouvoir être trouvé ou fabriqué sur place et permettre une nette amélioration du *tchoukou* traditionnel en simplifiant au maximum les manipulations, et donc le travail des femmes. L'élément principal de changement a été la forme du *tchoukou*, traditionnellement rectangulaire. Lorsqu'on a introduit un moule rond, une petite révolution s'est produite, mais productrices et consommateurs ont rapidement adopté cette nouvelle forme.

Cette technologie a également eu des conséquences socio-économiques positives, en assurant un meilleur rendement fromager (moins de perte en caillé) ; en permettant la récupération complète du sérum, plus propre et utilisable dans la bouillie de mil et en facilitant et en réduisant le travail des femmes.

Il est à signaler, par ailleurs, que les articles composant le kit de fromagerie sont polyvalents ; la productrice peut les utiliser pour d'autres activités domestiques pendant la période sèche.

Tous ces facteurs ont ainsi contribué à la diffusion rapide de cette technologie et à la réussite de l'inovation.

A la fin du projet, 406 productrices organisées en association ont bénéficié de la nouvelle technologie et ont reçu chacune un kit de fromagerie. L'essentiel du procédé technologique a été assimilé, ce qui s'est traduit par une amélioration spectaculaire de la qualité des fromages.

Les productrices de *tchoukou* ont très rapidement apprécié l'avantage économique de ce nouveau système. En effet, au lieu de vendre de façon aléatoire et risquée, sur le bord de la route Agadez-Tahoua, des fromages à 100 F CFA pièce (en utilisant un litre et demi de lait), il leur est maintenant possible, sans se déplacer, de vendre, au début au même prix et très bientôt à 125 F CFA, un fromage nécessitant seulement un litre de lait. Quant au prix du lait servant à sa fabrication, il est passé, pour les productrices, de 70 F CFA le litre avant le projet à 100 FCFA, pour atteindre 125 F CFA en phase de croisière.

La transformation du lait de chamelle par les nomades

L'élevage du chameau et de la chamelle revêt un caractère essentiellement extensif et transhumant, caractéristique de la zone sahélienne en Afrique. Pour ces peuplades nomades, il est reconnu que, pendant la période de lactation des chamelles, une partie importante du lait produit après consommation familiale est perdue, faute de débouchés commerciaux, en raison du manque de moyens permettant de transformer le lait en un produit laitier qui puisse se conserver. La FAO, grâce aux études entreprises par le Professeur RAMET (1985*a* ; 1985*b* ; 1987*a* ; 1987*b* ; 1990 ; 1991), a permis de mettre au point une technologie qui peut transformer le lait de chamelle en fromage. Grâce à cette nouvelle technologie et à la mise au point d'un kit de fromagerie transportable, il est maintenant possible de transformer le lait de chamelle des nomades en un produit laitier qui puisse se conserver et se commercialiser après un temps relativement long. Cette source de profit additionnel représentera pour ces familles une amélioration importante de leurs conditions de vie.

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Annexe 1

ÉLÉMENTS CONSTITUANT LA MICRO-FROMAGERIE.

Epuration du lait

Entonnoir-filtre en matière plastique.

Coagulation

– Bidon plastique avec couvercle de protection ;
– flacon de 250 cm^3 pour le stockage de la présure ;
– compte-gouttes pour le dosage de la présure ;
– fourchette-écumoire pour le mélange lors de l'emprésurage.

Moulage, pressage, égouttage

– Récipient métallique couvert d'une tôle rigide métallique perforée et toiles plastiques. Ce récipient sert également à récupérer le sérum ;
– moule rond en PVC de 20 cm de diamètre et 4 cm de hauteur ;
– taloche de pressage en bois, servant également pour le retournement ;
– louche en aluminium de 200 cm^3 pour le moulage ;
– couteau-racleur pour démoulage.

Séchage

– Deux cadres de séchage de 75 x 50 cm, dont l'un sert de couvercle ;
– film plastique transparent servant de couture « en sandwich » des cadres pour la protection contre la pluie ou la poussière ; ce film accélère le séchage grâce à l'effet de serre.

Nettoyage

– Bidon d'eau de 20 litres ;
– éponge synthétique.

Stockage

Calebasse perforée, avec couvercle, pour le stockage hebdomadaire des fromages séchés (fournie par la productrice).

BONNET P. (éditeur), 1998.
Dromadaires et chameaux, animaux laitiers /
Dromedaries and camels, milking animals.
Actes du colloque, 24-26 octobre 1994,
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Montpellier, France, Cirad, 304 p. + X p. hors texte.
(collection Colloques)

Camel's milk economics in pastoral Somalia

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Abstract. The authors describe, based on a group analysis of Somalian pastoralists economical practices, how the camel is a cornerstone of the local economy, whether for large scale herds or for small scale herds. Its is shown why and how the camel's milk trade is so reliable to markedly fulfill a complete annual economical and nutritional cycle. In this field, it is also demonstrated, how the role of the women and the men are well distributed in the Somalian camel's milk economy.

Key words. Dromedary, *Camelus dromedarius*, camel's milk, economics, trade, socioeconomic organization, pastoralism, Somalia.

Résumé. Cette étude socio-économique démontre le rôle important joué par les dromadaires en Somalie, en particulier à travers les pratiques de l'économie laitière. Après avoir décrit le fonctionnement normal de deux types de troupeaux mixtes de différentes tailles, et les variations annuelles et saisonnières du commerce du lait, l'auteur insiste sur les rôles complémentaires joués par la femme et par l'homme au sein d'un foyer d'éleveurs somaliens. Il précise enfin les enjeux locaux et régionaux d'un développement de cette activité ainsi que du commerce des animaux vivants.

Mots clés. Dromadaire, *Camelus dromedarius*, lait de chamelle, économie, commerce, organisation socioéconomique, pastoralisme, Somalie.

I Background and Objectives

Camels (one-humped camel, dromedary) are a neglected domestic species in the promotion of livestock development by international donor agencies. Only recently they have become the subject of more intensive and systematic interest in the context of increasing the development potential of drylands in Africa, Asia and Arabia.

Somalia is a key camel country which has one of the world's largest camel population, estimated 5.8 million (FAO, 1988). Over 50% of the Africa's 14.5 million camels are kept and raised in Somalia. For the human population of Somalia, about 50% of whom live as nomadic pastoralists in the extensive dry regions of the country, the camel is of exceptional importance. Camels in Somalia account for approximately half of the national livestock herd calculated in Tropical Livestock Units (TLU), with 63% for the northern regions, 40% for the central regions and 47% for the southern parts of Somalia, respectively (SCHWARTZ, 1979). The ratio of man to camel in Somalia is almost one to one. This means on average there is more than one camel per person in the country. Above all, the camel plays a major economic role in the subsistence sector, particularly by the provision of milk, and it is a cornerstone of the social organisation of pastoral life.

Until recently, pastoral groups of Somalia had a viable pastoral system of livestock management and production, with traditional control over land and water, and strategies to utilise the natural resources in an harmonious and balanced way. They had been to a great extent self-sufficient by producing most of their food and even surplus of certain items (like milk and milk products) which enabled them, through bartering or direct sale, to acquire household goods that could not be produced in the locality.

The livestock sector will remain the mainstay of the Somali economy since 45% of the country's total land surface (623,840 sq.km) must be considered exclusively as rangeland (figure 1). Nearly 90% falls into the category of potential rangeland. At present the opportunity costs of this land are nearly null since the soil is not suited for any use other than extensive grazing.

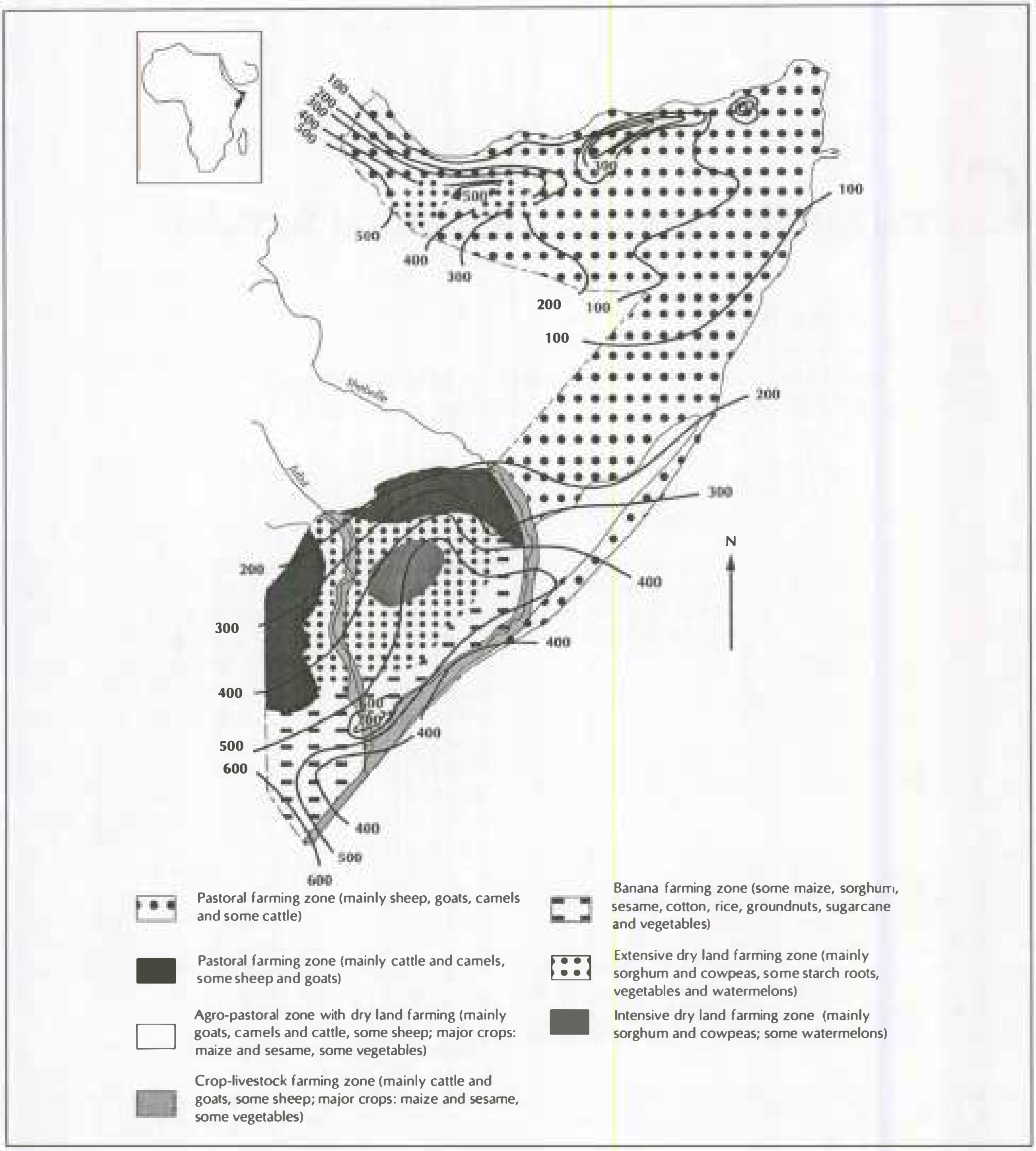

Figure 1. Generalized farming systems within rainfall distribution in Somalia.

Information on camel's milk production economics in pastoral Somalia is limited and sparse. Particularly are lacking data on household milk production, consumption, processing and marketing.

The paper's main objective is to provide general information and to contribute to the general understanding on camel's milk economics, production, consumption and marketing within the subsistence-oriented pastoral household systems in Somalia. Specifically, the communication examines whether the camel's milk still has to fulfill a significant role and function in the pastoral household's economy, and describes the seasonality of camel and camel's milk marketing. The communication also underlines that the role of livestock and in particular camels is by no means limited to the production of animal foods.

The approach and methodology used here is diagnostic in nature and mainly based on participant observation, open-ended interviews, etc. The design of the approach reflects on the argument that a through understanding of why people do and understanding of why they do what they do is the most relevant basis for formulating rural development activities. Therefore, the interest is not so much to establish percentages and averages or statistical tables. In this communication two pastoral household groups are defined, i.e. small and large household. Small household is household which has a herd of 10 camels and 80 sheep and goats. Large household accordingly has a herd of 30 camels and 200 sheep and goats. Analysis has consequently been limited to the above mentioned herds, i.e. small and large household.

Role and function of camel

Camel as a source of asset and as a social security

Livestock in traditional pastoral production systems rarely serve only as single purpose such as the provision of milk. It is common to rear livestock for multiple uses which —apart from milk, meat and skins — include the provision of transport, dung for fuel and manure. Primarily, camels are more valued by Somalis than cattle, goats, and sheep. A man's prestige and influence are proportional to the number of livestock, in particular the number of camels, he owns. Camels as the main subsistence and reserve stock, and to a lesser extent cattle, are hardly ever sold in the Somali traditional economy.

Despite this importance, its use for security and investment is beyond doubt. Livestock in general have a savings account function by being recognised as private property, by being a relatively safe and durable form of storing wealth, by earning interest in form of offspring, and by being readily disposable and convertible into cash or other valued things. Livestock are better than a saving account because they are unaffected by inflation and remain under complete control of his investor (JAHNKE, 1984).

The appreciation of the camel in the Somali pastoral society in general is depicted by the Somali Proverb (ABOKAR, 1982): *"Never give camels away but seek to get them from other men."*

This statement should not lead to the suggestion that camel accumulation as a capital stock and herder's unwillingness to sell, lead to the so-called "camel complex" in analogy with the "cattle complex" theory expounded by HERSKOVITS (1926).

In all of the pastoral areas of Somalia, savings and credit facilities are either sparse, completely absent or are not accepted. Lack of saving is understandable, because the inflation rates encountered by pastoralists for livestock inputs and for non-pastoral foods are well above the interest rate offered/paid by banks, which does not even account for the costs of acquisition such as travel expenses and time involved. Consequently, investment in livestock is a rational decision even though in the rural areas there are no other investment opportunities with which pastoralists may compare their investment decision. Despite the low productivity of camels in traditional systems, livestock (camel) investment is a sound one (ABDULLAHI, 1989).

Model calculations give an annual rate of return on investment for herd camels of 9.99% (table I). This rate of return is attractive and pastoralists will invest any surplus cash for purchase of animals. The model calculation is based on the methodology first developed by UPTON (1985). The model was modified to allow to use camels.

Table I. Mean annual rate of return on camel enterprise in Central Somalia.

A. Calving interval	650.0	days
B. Annual reproductive rate (365/A)	56	%
C. Survival rate from 0 to 6 months	50	%
D. Survival rate from 6 to 12 months	70	%
E. Survival rate from 0 to 24 months (C x D)	30	%
F. Effective calving rate	65	%
G. Liveweight at 24 months	150	kg
H. Liveweight production per stud	164	kg
I. Number of studs per sire	85	%
J. Mortality per breeding stock	23	%
K. Mean price per kg liveweight	8,500	SoSh.
L. Price per male-camel	5,000	SoSh.
M. Price per female-camel	6,000	SoSh.
N. Gross meat output per stud	5,489	SoSh.
O. Gross milk production per stud	1,100	kg
P. Annual milk production (O x F)	710	kg
Q. Milk price per litre	60	SoSh.
R. Gross value of milk output	66,000	SoSh.
S. Total gross output	71,489	SoSh.
T. Cost of stud mortality (J x L)	1,150	SoSh.
U. Cost per sire mortality (JxM)	1,380	SoSh.
V. Breeding stock depreciation (T x S/I)	18,670	SoSh.
W. Cost of veterinary drugs and water	2,143	SoSh.
X. Net output per stud per year (S-T-V)	50,675	SoSh.
Y. Capital investment per stud (L+M/I)	5,070	SoSh.
Z. Annual rate of return (X/Y x 100)	9.99%	

Source: ABDULLAHI, 1989

In addition to their subsistence, security, and other uses, camels are regarded primarily as a medium for regulating most aspects of social, political and religious life. Bride price, DIA-payment —blood money (is a collective security against other groups, i.e. livestock paid by one clan-family to another as compensation for a member of a family murdered or injured by a member of another family), prestige and honour are regulated through livestock species and in particular through camels.

Camel's milk subsistence

From a global perspective the economic significance of camel production is minimal. It is, however, beyond doubt that camel production makes a significant contribution to various national economies in African and Asian countries. So for example approximately 14 million camels are estimated to produce 2 million tons of milk and 200,000 tons of meat annually in Africa.

Within the context of the Somali subsistence pastoralism, camels are not primarily export animals as are goats and sheep and to a lesser extent cattle. Their value lies in the material (subsistence) and social survival capacity that they offer to the families that keep them. Its greatest advantage as food producer, particularly milk, is as a more reliable milk producer than cattle. Camel's milk as a source of food is a most precious and valuable product to the Somali people; camel's milk is superior to all other kinds of milk, it tastes better and stays fresh for longer time. Fresh milk is the only appropriate food to serve honourable guests whereby goat's milk is regarded as children's food. The pastoralists believe that a person who habitually drinks camel's milk has more physical strength and stamina than one who is fed on cattle milk. Cattle milk tends to make people fat and plump. This theory is supported by the following Somali saying (Abokar, 1982): *"A gulp of camel's milk keeps you going for half a day."*

Camel's milk is a mere subsistence product and is estimated to contribute between 7.1% to 18.4% to the mean annual caloric intake of the poor and rich pastoral household members respectively (figures 2, 3).

A family's food consumption is balanced between the need for sufficient caloric energy and the prices of the commodities during the annual price cycle. The above figures make it quite clear that it would be difficult for pastoralists to subsist without grains, sugar/tea. Even household with a sufficiently large number of animals do not abstain from using non-pastoral products to cover the main parts of their protein and energy requirements.

Camel's milk is regarded as foremost food and it is a product that is strongly associated with femaleness although camels are strongly associated with men and believed to be their property. It provides cash income from sales contributing up to 20% to of the whole total household cash income.

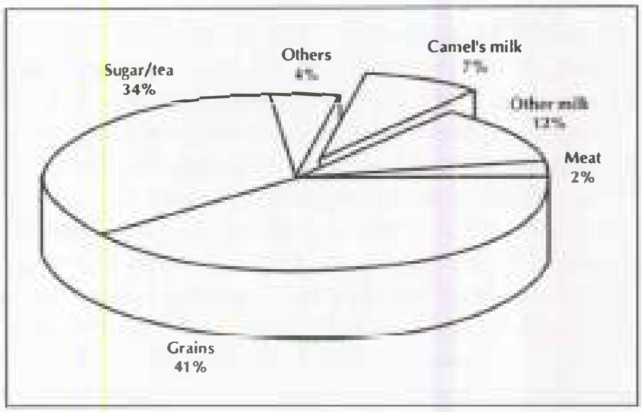

Figure 2. *Mean annual caloric-energy supply by food sources in small pastoral household.*

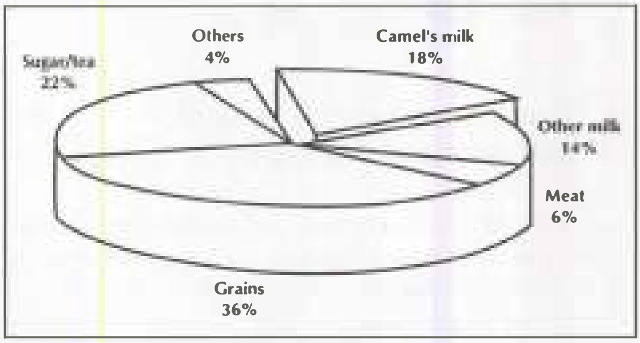

Figure 3. *Mean annual caloric-energy supply by food sources in large pastoral household.*

Apart from the total value of milk production, one question of interest is to what extent milk is consumed by the household itself or used to generate cash. Estimated total milk yields were about 5,796 litres/year in small and 13,615 litres in large scale herds during 1988/1989. In small households, it is estimated that 30% of the total milk yield is given to the calves remaining 4,057.2 litres for household consumption and sales. By assuming that 35% of this amount is sold, an average of 2,840.0 litres per household per year is reached. In rich households the respective figures are 9,530.5 and 3,335.6 litres per household per year. All this milk is sold at local villages and larger agglomerations close to the camp sites of the mobile household. During the years 1988/1989, average milk consumption in smaller households was 1,217.2 litres per year, compared to 6,194.8 litres in larger herds. It is interesting in this context to note that the relative amounts of subsistence, are high indicating a situation of increased commercialisation of herds to meet a household's cash requirements and subsistence requirements.

Camel's milk marketing

The economic enterprising of camel's products, in particular of milk trading is undoubtedly a means of obtaining cash and thus increases economic security. The milk supply, however, displays a strong seasonal pattern; the availability of milk for markets or for sale depends heavily on rainfall and pasture conditions and varies accordingly. There is also indeed an outspoken shortage in the supply of camel's milk to the rural markets toward at the end of the dry season, when pastoralists may give to their calves all four teats of milk or keep the remainder for household consumption. Moreover, the availability to sell camel's milk also depends on whether the household keeps other livestock species such as cattle and goats and/or has available alternative sources of cash income. These seasonal shortages and surpluses of milk, therefore, form the axes around which livestock exchange and sale-tactics revolve (KERVEN, 1987).

It is clear that from the point of view of the pastoralists, the sale of milk would have its advantages, as it would allow the potentially fine tuned sale of a replenishable commodity in a way that does not cut into the herd. Moreover, dairy products tend to be in highest demand and to fetch highest price in dry seasons, when prices of livestock are low (ABDULLAHI, 1989, KERVEN, 1987). Among the camel herdsmen, selling milk plays an important role and is partially an important survival strategy. Thus camel's milk marketing is not only a way of disposing of wet season surpluses, but an integral part of the way by which households earn the necessary cash for buying other non-pastoral products such as cereals, sugar/tea and other goods, especially in the dry season. For small households their milk production is rarely sufficient to cover consumption requirements so that they tend to sell milk throughout the whole year. The market for camel's milk thus allows poor households to sell milk rather than animals in order to maintain the herd, but they do so with a potentially deleterious impact on their nutrition. In recent decades non-pastoral food items, have been consumed in increasing amounts in Somalia and elsewhere in East Africa. This trend is claimed, at least in Somalia, to encourage a decrease in overall livestock productivity, in terms of milk and meat, due to a shift from a subsistence milk-surplus-system to a sale or commercial live animal system, both for domestic and for international markets (ABDULLAHI, 1989; BEHNKE, 1985). Recent studies on household income expenditure indicated that in average, all households cover between 60% and 80% of their annual caloric intake by non-pastoral products. In terms of calories the conversion of milk to grain is, however, still rather favourable to pastoralists. In the dry seasons, when necessity to buy grains is highest, 1 kcal of milk bought up to 8 kcal of grains, and in the wet season before the harvest, the rate is still favourable and better than 1:3,5.

The main buyer of camel's milk from the market are district and village residents for their home consumption. Another category of buyers are the small teashops/restaurants in the areas. Here the main buyers are often the teashops catering for transit traffic on the main road.

With regard to the household's milk sales and redistribution, it is the women who are in charge of the trade in camel's milk and of its organisation, even though camels are associated with men and recognised to be their animals. Milk trade in Somalia is almost fully in the hands of pastoral women whether they bring (collectively) their milk or groupwise directly to the bigger villages, or they rent truck on a daily basis or twice according of milk's availability every two days to the cities, where there is always high demand of milk.

Recalling the traditional division of labour, it can be noted that it is the men who are involved to a large extent in milk production within the context of the household. They milk the camels and bring the milk to the women for storage and sale. In other groups, women do also milking of camels, and sometimes a portion of the herd is set aside particularly for them to milk and trade with. The deep involvement of women in the camel's milk trade might also lead to some readjustment in division of labour within the household system and also to heavier burden of labour to women (ABDULLAHI and TALLE, 1993). The camel's milk trade has given women some new and enlarged responsibilities as far as household production is concerned.

Camel's milk prices

Camel's milk plays an important role in the daily diet of the Somali population. Milk prices, like livestock prices display a seasonal pattern, as milk is plentiful during the rainy season and scarce in the dry one. The seasonality of milk production is reflected in the camel's milk price pattern obtained from rural markets. During the two rainy seasons, being the calving seasons for all domestic animals with resultant high milk production, prices showed a downward trend. Between the rainy seasons, milk prices increased progressively, and indeed more dramatically during the long dry period from January to March. It is thus noted that there is a 40% price increase from some rural markets for camel's milk. The margin, consequently, increased dramatically during the dry seasons of high milk supply as prices in the producing areas dropped sharply (figure 4). It is obvious that this variation is driven by fluctuating supply and not in demand. However, average seasonal prices have to be treated with caution, since they may not reflect the seasonal fluctuation in any given place. Moreover, the decision to sell camel's milk is influenced by the availability of other species milk for the household consumption, and by the availability of alternative sources of cash income. The disadvantage for camels is seen in the need to stay closer to villages (HERREN, 1990), where pasture is less abundant due to fields, charcoal clearing and high livestock densities. In terms of productivity, the results are that camels are being weaker and thus more susceptible to diseases, mainly in dry season. Accordingly, it can be assumed that in this period mortality is higher and fertility is lower.

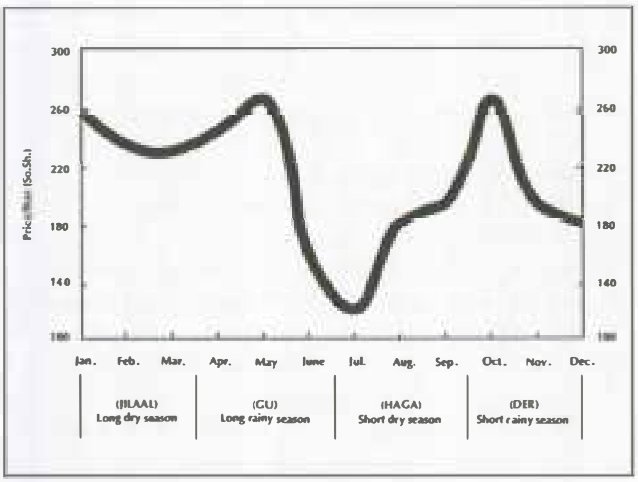

Figure 4. *Theoretical pattern of camel's milk price in rural markets, in the North Eastern regions of Somalia.*

Camel supply and demand

The sale of an animal is not a sign of progressiveness as it is commonly assumed, but rather a reaction created by necessity and scarcity. Camels are used in the Somali pastoral way of life mainly for milk and transport and to a lesser extent for meat. Camel symbolism in the Somali pastoral culture plays an important role both in socio-economic and cultural terms. Camels are the most valuable animals of all. Consequently their commercialisation is very low in comparison with other species. Their full value does not adequately reflect the amount of cash they bring as a source for food. One may conclude that social factors rather than economic factors influence the pastoralist's camel selling behaviour. Unfortunately most of these factors are yet poorly understood and almost none have been rigorously quantified.

As mentioned elsewhere, Somali camel's herders do not willingly dispose of productive camels. The number of animals brought to the market is lower than all other species and overwhelmingly consist of male animals. This fact can be linked to the camel herder's reluctance to sell breeding stock and can lead to the notion that camel herd sizes are maintained and expanded not for prestige but for security and precautionary motives.

The domestic and export marketing of camels and other animals are subject to seasonal export demand from Saudi Arabia and the Golf States. Consequently one sees marked seasonal variations in demand, supply and prices. Beyond foreign demand, seasonal climatic variability, affecting herd production risks, as well as pastoral mobility may further explain some fluctuations in demand and supply. Camels play a dominant role both in socio-economic relations and subsistence. Consequently, commercialisation of camels is very low in comparison to that of other species and can partially be explained by the unwillingness of the Somali camel's owners to sell camels. As repeatedly mentioned earlier, supply and demand for camels cannot solely be explained in economic terms. Socio-cultural and socio-economic factors play a dominant role.

While seasonal variations and flexibilities in the supply of animals from herds to markets can be noted, depending on the condition of stock and the particular needs and aspirations of herding households, the general market mechanism indicates that there are the same prevalent interdependencies/interrelationships between demand and supply as in any other so-called free market system.

Concluding remarks

From a socio-economical and technical point of view, pastoral exploitation of the huge vast areas of Somalia can only be achieved through camel keeping. At present the opportunity costs for this land are nearly nil since the soil is not suited for any use other than extensive camel production. These areas support an extensive camel pastoral system and are suitable for browsing by camels only, and cannot be utilised efficiently by any other species by present conditions. Camels assist in the control of plant species unpalatable to other livestock that may become undesired weeds on the range.

The future role of camels would probably lie in their capacity to produce milk and meat products and to some extent transport. If the camel do retain this unique position, then its capacity to produce milk, to utilise low quality feed and to convert it into animal protein, power and other products must not be lost. It is possible that commercial offtake of camel's milk could be increased, mainly in the wet season by providing a better milk preservation and distribution links and making camel's milk available to a wider range of consumers resolving thus the problem of substantial seasonal overproduction. It seeks improvements in present preservation techniques and viability in introducing new techniques. With improved knowledge about milk preservation follows the question of how to reach urban and pre-urban markets. In view of the present available resources and insufficient level of infrastructure development, traditional camel and camel's milk marketing system is working reasonably well because it is both flexible and reliable at the same time. Profit margins of marketing intermediaries do not appear exorbitant , but are still marginally attractive.

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Séance de clôture
Closing session

Les 11 recommandations proposées par le Comité

Recommendations to improve camel's dairy production

1. Poursuivre les coordinations existantes.
To continue and strengthen the scientific coordinations.

2. Encourager le développement de méthodes de contrôle laitier dans le monde agro-pastoral, basées sur des définitions strictes de la terminologie.
To encourage the development of milk control methods in agro pastoralist fields, based on strict terminology definitions.

3. Encourager la recherche sur les contraintes pathologiques liées à la production laitière (par exemple par les indicateurs hormonaux de la reproduction utilisant les standards camelins).
To encourage research on pathological constraints linked to milk production. For this aim, hormonal indicators of lactation could be used, and hormonal variation measured.

4. Encourager la caractérisation des races camelines dans le cadre de la recherche sur la biodiversité.
To encourage breeds characterisation within the framework of research on biodiversity .

5. Œuvrer pour une meilleure connaissance des qualités du lait de chamelle (sanitaires, nutritionnelles,...).
To improve the knowledge on milk qualities, in order to specify the rules of quality control .

6. Rechercher les effets des différents niveaux nutritionnels sur la production laitière, dans des environnements comparables.
To research the effects of different levels of nutrition on milk production in similar environments.

7. Encourager le développement et la fabrication de produits de transformation laitière adaptés aux besoins locaux.
To encourage the development of appropriate dairy technology and products adapted to the local consumers.

8. Encourager et aider les services nationaux de vulgarisation, y compris dans un objectif de santé humaine (liée à la consommation du lait).
To encourage and help the national extension services in different aims such as human health linked to milk consumption.

9. Renforcer les études socio-économiques, législatives et les études de marché sur les produits laitiers.
To encourage as priorities socio economic, marketing, and legislative studies.

10. Soutenir les publications et organes de liaison dans le domaine camelin.
To encourage and support publications and documentation in this topic.

11. Développer et encourager les formations concernant les camelins (et notamment dans des pays où la filière laitière est potentiellement importante).
To develop and encourage the training courses specially in countries with high potential of camel's milk production.

Motions

Soutien des éleveurs, des chercheurs et des participants
Support from breeders, researchers and participants

Considérant l'importance de cet atelier international sur le dromadaire et son apport incontestable à l'approfondissement de nos connaissances de cet animal, élément essentiel de notre cheptel et par delà de notre économie nationale.

Considérant les conclusions et recommandations issues de cet atelier qui a mis en évidence les retombées économiques et sociales de l'élevage du dromadaire et les énormes possibilités qu'offre son développement.

Nous, éleveurs, chercheurs, participants à cet atelier international singulier par son genre, adressons nos vifs remerciements et félicitons l'Etat mauritanien et à sa tête son président, Son Excellence Maaouya Ould Sid'Ahmed Taya, le gouvernement mauritanien sous la conduite de M. le Premier ministre Sidi Mohamed Ould Boubacar, pour avoir accueilli ce forum international qui honore la République islamique de Mauritanie.

Nos remerciements vont aussi à M. le Ministre du développement rural et de l'environnement pour la parfaite organisation de cet atelier.

Remerciements des participants
Acknowledgements from participants

A l'occasion de la tenue à Nouakchott de l'atelier « Dromadaires et chameaux, animaux laitiers » du 24 au 26 octobre 1994, les participants remercient le peuple et le gouvernement mauritaniens et à leur tête le président de la République, Son Excellence Maaouya Ould Sid'Ahmed Taya, pour l'accueil cordial et fraternel qu'ils leur ont réservé durant leur séjour, et pour les conditions excellentes qui ont permis le bon déroulement des travaux de cet atelier.

Discours de clôture de Monsieur Sidi Ould Cheikh

Closing speech by Mr Sidi Ould Cheikh

Secrétaire général du ministère du développement rural et de l'environnement de Mauritanie
Secretary-General of Ministry for Rural Development and Environment of Mauritania

Messieurs les Secrétaires généraux,

Excellences Messieurs les Ambassadeurs,

Messieurs les Représentants des organisations internationales,

Chers participants,

Mesdames, Messieurs.

VOUS AVEZ PROCÉDÉ au cours des trois derniers jours à un examen approfondi des différents thèmes inscrits à l'ordre du jour du présent colloque portant sur les « Dromadaires et chameaux, animaux laitiers ».

Vos travaux se sont déroulé dans un climat marqué par la volonté d'aboutir aux meilleurs résultats.

En effet, les conclusions auxquelles vous êtes parvenues, sont, je puis l'affirmer, à la mesure des aspirations que nous fondions sur cette importante rencontre. Ce résultat appelle la satisfaction et laisse augurer favorablement de l'introduction des nouvelles techniques allant dans le sens de l'amélioration de la production et de la productivité de l'une des principales composantes de nos ressources animales : le dromadaire.

Mesdames, Messieurs,

les décisions et recommandations, quelles que soient leur pertinence et leur objectivité, restent sans effet si elles ne sont pas traduites dans les faits. C'est pourquoi je tiens à vous préciser que notre pays ne ménagera aucun effort, conformément aux directives de Son Excellence M. Maaouya Ould Sid'Ahmed Taya, président de la République, pour mettre en application les propositions contenues dans les documents finaux du présent atelier.

Chers participants,

les résultats encourageants auxquels vous avez abouti, ne seraient pas ce qu'ils sont sans le soutien significatif apporté à cette initiative par nos partenaires en coopération, notamment la Coopération française et le Cirad-emvt. Que les uns et les autres trouvent ici, en votre nom à tous, l'expression de nos remerciements et de notre gratitude.

Mes remerciements vont également à tous ceux qui ont participé de près ou de loin à l'organisation et à la réussite de ce colloque. Je pense notamment au personnel d'appui, interprètes, secrétaires, j'en oublie peut-être, pour les efforts louables qu'ils ont déployés afin que vos travaux se déroulent dans les meilleures conditions.

Mesdames, Messieurs,

avant de terminer la présente allocution, je tiens à vous renouveler nos remerciements pour les peines de voyage que vous avez endurées afin d'assister mais aussi de participer efficacement aux travaux de cet important forum scientifique.

Tout en vous souhaitant un bon retour dans vos pays et familles respectifs, je déclare clos les travaux du colloque « Dromadaires et chameaux, animaux laitiers ».

Je vous remercie.

Dromadaires et chameaux, animaux laitiers

Dromedaries and camels, milking animals

Planches

Plates

1. Au Maroc, ici à El Laâyoune, on assiste depuis peu de temps à la mise à disposition de femelles laitières près des villes, dans des ateliers laitiers de type hors sol. Les femelles suitées sont mises en production pour la vente de lait environ un mois après la mise bas, sur la base d'un régime alimentaire amélioré par l'apport de sous-produits agricoles tels que les pulpes de betterave. (Photo P. Bonnet)

In Morocco (here the city of El Laâyoune southern part of the country), we are currently observing the emergence and the development of new dairy farming systems using she-camels from the extensive herds for periurban milk production. They are gathered with their calves in the outskirts of the city to implement dairy production in zero grazing farming systems. Females with their young at heel are being used generally one month after calving to produce milk devoted to local urban markets. They are fed through a special diet including by-products such as beetroot pulps. (Photograph P. Bonnet)

2. Au Kazakhstan, l'allotement des animaux fait partie de la logique de gestion, et l'on compte environ 250 animaux dans chaque ferme, permettant aujourd'hui une traite quotidienne d'au minimum une quarantaine de laitières. La traite de ces femelles nécessite environ 1 heure pour 4 personnes, chaque animal produisant de 2 à 4 litres de lait par jour, en plus du lait destiné aux jeunes. (Photo P. Bonnet)

In Kazakhstan the habits to divide animals into feedlots is a part of the management practices. We can account about 250 animals in every dairy farm. A daily milking is made for at least forty she-camels within the farm. The daily milking time is almost one hour for four persons acting, each animal producing 2 to 4 litres of milk per day in addition to the milk that feeds the calf. (Photograph P. Bonnet)

3. L'éleveur doit arbitrer les parts respectives du lait de chamelle allouées au chamelon et au marché ou à l'autoconsommation. Lors de la traite, la présence du chamelon est souvent nécessaire pour assurer la descente du lait. Parfois, le chamelon amorce la production de lait de la mère, puis il est attaché à un des membres de celle-ci et tète le lait résiduel à la fin de la traite (ici, un jeune sous sa mère entravée, au Soudan). (Photo G. Saint-Martin)

The farmer acts as a decision maker to allocate the quantity of milk devoted to the young calf, to the market, or to the intra-household self-consumption. During the milking period the presence of the young is often necessary to allow the milk-down. Sometimes the calf initiate the milk-down and after being fasten to his mother's leg he is allowed to milk her and make use of the residual milk (here a young calf and his mother in Sudan). (Photograph G. Saint-Martin)

4. L'activité de succion du jeune favorise la production laitière. En milieu traditionnel, la production totale de lait peut être 2,9 fois plus importante quand le petit survit jusqu'au sevrage que lorsqu'il meurt avant (ici, allaitement d'un chamelon à Gedaref, Soudan). (Photo G. Saint-Martin)

The sucking activity of the young do act in favour of an increased milk yield. In traditional farming systems the total milk yield could be 2 to 3 times more important when the young reaches the post-weaning period, in comparison with the average lactation yield if he dies before the weaning time (here a suckling calf in the city of Gedaref, Sudan). (Photograph G. Saint-Martin)

5. L'activation de la descente du lait par le jeune posté passif à proximité de la mère ou actif avant la traite participe à la performance de la production laitière. Les pratiques de gestion quotidienne du couple mère-jeune constituent donc un des déterminants de la performance et du rendement laitier (ici, un jeune sous sa mère au marché de Shuwak au Soudan). (Photo P. Bonnet)

Activation of milk-down is obtained by the presence of the calf during or before the hand milking, and thus is a factor which participates to the milk yield. Day to day management practices of the pair calf plus mother are acting as major determinants of the dairy herd performance (here a young calf in Shuwak market, Sudan). (Photograph P. Bonnet)

6. L'étude de la conformation de la mamelle a été conduite dans le cadre de l'adaptation à la traite mécanique, afin d'optimiser par la sélection la conformation des trayons naturels et d'obtenir les gobelets trayeurs artificiels les plus adaptés. Des critères morphologiques de la conformation mammaire peuvent être utilisés pour la sélection des mères meilleures laitières, en analysant certaines mesures morphométriques de la mamelle. (Ici, un cliché effectué au National Research Centre on Camel (NRCC) de Bikaner (Rajhastan, Inde).) (Photo G. Saint-Martin)

The study of the udder anatomy has given some patterns to adapt and optimise milking machine to the natural teats conformation. Morphological criteria of the udder could be used also for selection of she-camels with the best ability to be adapted to milking machines. (Photograph by G. Saint-Martin: NRCC National Research Centre on Camel, Bikaner, Rajasthan, India.)

1. Femelles dromadaires des systèmes laitiers périurbains au Maroc.
She-camels from periurban dairy systems in Morocco.

2. Chameaux de Bactriane au Kazakhstan.
Bactrian camels in Kazakhstan.

3. Jeune chamelon sous sa mère entravée au Soudan.
Young calf and his mother in Sudan.

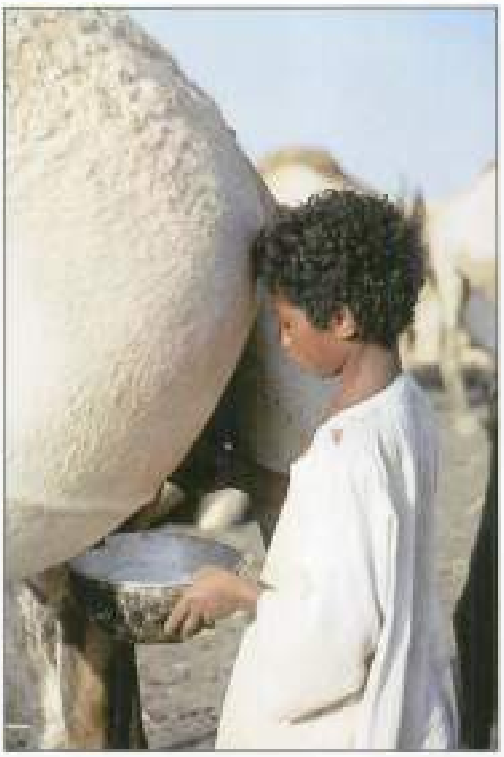
4. Jeune chamelon tétant sous sa mère dans la région de Gedaref au Soudan.
Young calf suckling his mother in Gedaref area, Sudan.

5. Jeune chamelon sous sa mère au marché de Shuwak au Soudan.
Young calf in Shuwak market, Sudan.

6. Jeune chamelon tétant sous sa mère à la station du NRCC de Bikaner (Rajhastan, Inde). *Young calf suckling his mother at NRCC camel research centre, Bikaner, Rajasthan, India.*

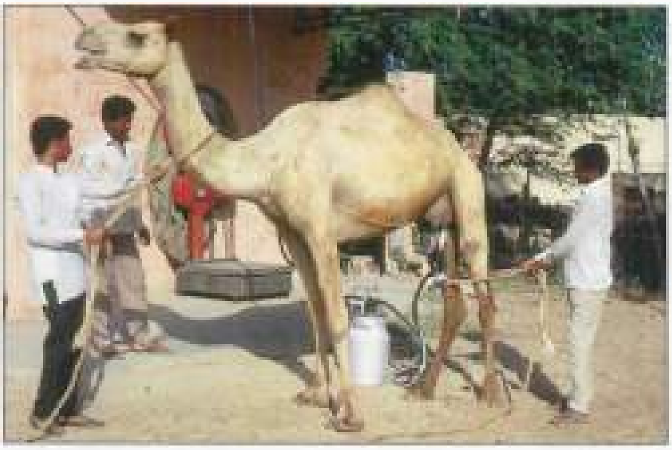
Traite et collecte du lait / *Milking and milk collection*

1. Le lait de chamelle, nourriture des enfants du Soudan pastoral.
The camel's milk as a common food for children in pastoral Sudan.



2. Traite à la main de chamelles au Kazakhstan.
Hand milking camels in Kazakhstan.

3 et **4.**
Traite mécanique de chamelles de Bactriane au Kazakstan.
Machine milking of Bactrian camels in Kazakhstan.



5. Traite mécanique à la station du NRCC de Bikaner (Rajasthan, Inde).
Machine milking at NRCC camel research centre, Bikaner, Rajasthan, India.

6. Récipients de collecte à la laiterie de Nouakchott (Mauritanie).
Containers and equipment used for milk collection by dairy plant in Nouakchott, Mauritania.

1. Le lait camelin est encore majoritairement un aliment primaire consommé dès son expulsion à la traite, et il constitue un aliment riche. Il est aussi notablement utilisé comme aliment diététique et thérapeutique sur de nombreux continents, à destination des enfants (ici au Soudan) et des malades. Sa composition reste cependant dépendante de nombreux facteurs d'environnement notamment alimentaires, ou liés à l'animal (stade de la lactation), et il sera nécessaire de le standardiser dans le cadre d'une consommation citadine plus exigeante. (Photo G. Saint-Martin)

The camel's milk is still mainly a primary food consumed from the direct milking of the animal. It represents a rich nutriment and is also utilised in different continents as a dietetic food for children (here in Sudan) and as therapeutic food for sick persons (against diabetes). Therefore the composition of camel's milk is always closely related to environmental factors, such as feeding practices, animal factors (lactation rank and lactation period) and we assume that it would be very necessary to try to standardise the quality and composition of the milk in order to match the increasing urban demand and its new quality standards. (Photograph G. Saint-Martin)

2. Ici dans une ferme près d'Almaty au Kazakhstan, la traite manuelle est effectuée par deux trayeurs face à face, la femelle étant entravée au jarret, le membre tiré en arrière le long des barres de contention. Le jeune n'est pas présent dans le bâtiment et l'usage d'ocytocine est systématique, bien qu'il soit probable que le réflexe de descente de lait soit provoqué assez rapidement par le simple geste lié à l'usage de la seringue et de son aiguille. (Photo P. Bonnet)

Here in Kazakhstan in a camel's farm near Almaty, the hand milking is made by two hand milkers standing face to face, the she-camel being hobbled at the hock, the leg stretched back along the handling equipment. The young calf is not present in the stable and thus there is a systematic use of oxytocin. It is therefore likely that after a certain period the milk-down reflex would be induced by gesture more than the hormonal injection itself. (Photograph P. Bonnet)

3 et **4.** Des filières organisées à partir des systèmes pastoraux ont été réalisées dans certaines zones d'élevage du chameau de Bactriane, en particulier au Kazakhstan. La traite mécanique, telle que celle pratiquée sur ces deux photos à la ferme d'application de l'Institut d'élevage ovin de Minbaevo au Kazakhstan, reste basée sur des principes simples adaptés au chameau. Les procédés de contention sont ad hoc, et la descente de lait est amorcée par l'injection systématique d'hormone post-hypophysaire de fabrication locale. (Photos Moussaiev et P. Bonnet)

Dairy commodity chains have been experienced with good success using Bactrian camels in pastoral areas like Kazakhstan. Machine milking such as presented in these two pictures made at the Minbaevo Sheep Breeding Institute farm, Kazakhstan, are based on simple principles adapted to the camel. Ad hoc handling equipment is required and the use of locally-made post hypophyse hormonal injection is generally systematic. (Photographs Moussaiev and P. Bonnet)

5. La pratique de la traite mécanique chez le dromadaire et le chameau se heurte à des difficultés anatomiques, psycho-physiologiques, techniques ou logistiques qui n'ont pas empêché certains centres de recherches de développer ces techniques, en particulier en Inde (ici à la station du National Research Centre on Camel (NRCC) de Bikaner au Rajasthan) et en Asie centrale (au Kazakhstan). (Photo G. Saint-Martin)

Current management of machine milking in camels is facing anatomical, psycho-physiological, technical or logistic constraints. Therefore it has been possible for some research centres to develop and experience practical solutions particularly in India (here NRCC National Research Centre on Camel, Bikaner, Rajasthan) and Central Asia (Kazakhstan). (Photograph G. Saint-Martin)

6. La collecte du lait est une étape délicate dans la chaîne industrielle menant à un lait pasteurisé. La saisonnalité des apports lactés dans les systèmes de production laitiers camelins périurbains implique la présence temporaire des animaux dans l'espace de recrutement industriel. La collecte est donc souvent mixte et concerne des laits de différents systèmes d'élevage et de diverses espèces. Le lait de chamelle, de par ses qualités liées à ses défenses naturelles, résiste mieux que les autres laits aux altérations bactériennes consécutives à des délais de collecte plus longs. L'usage de contenants de diverses sortes (ici des conteneurs plastiques de faible coût et réutilisables après lavage et désinfection en laiterie à Nouakchott en Mauritanie) doit cependant se plier à des règles d'hygiène communes à tous les fluides alimentaires d'origine animale. (Photo P. Bonnet)

The milk collection is an important and sensitive step in an industrial chain producing pasteurised milk delivered to the urban consumer. One particular characteristic of the camel dairy farming systems is the seasonal patterns of the supply.. The temporary presence of animals in the urban milkshed supplying the dairy industrial plant has to be compatible with the means used for collection and storage in order to limit the producing costs and produce with a competitive price. The milk collection thus often involves milks from different farming systems and from diverse animal species. Generally quality problems are often encountered with milk from outer circles of the milkshed. Therefore the camel's milk is more resistant than other milks to the microbial alterations due to its natural defences and thus its relatively good ability to be collected from remote areas. The use of diverse intermediate packaging means is possible (here plastic buckets and containers in Nouakchott, Mauritania). They are reusable after simple washing and implementation of disinfecting procedures within the dairy plant compound. (Photo P. Bonnet)

1, 2 et **3.** Fabrication d'un fromage traditionnel en milieu pastoral au Niger : le *tchoukou* ou *tikormat* des Touaregs est fait de laits de mélanges où la part du lait de chamelle peut être variable, liée à la disponibilité des diverses espèces animales présentes dans les systèmes d'élevage. Produit par les populations pastorales, le *tchoukou* est utilisé pour l'autocommation ou vendu. Des améliorations simples comme l'usage de contenants de meilleure qualité sanitaire et technologique, ont permis de faire évoluer à la fois le rendement du procédé et le revenu de l'éleveur. (Photos reproduites avec l'aimable autorisation de G. Duhard, Orion)

The processing of a traditional cheese in a pastoral environment in Niger: the tchoukou *or* tikormat*-called cheese is made by Tuareggs from diverse species milk. It is sold or used for self consumption. The percentage of camel's milk is changeable depending on the availability of the different animal species within the diversity of dairy farming systems in an area. Some simple improvements such as the use of better sanitary and technical qualities containers have allowed to improve both the yield and the income of the farmer. (Photograph reproduced with kind authorisation of Guy Duhard, Orion)*

4. Des recherches sur des procédés de transformation améliorée ont permis de mettre sur le marché des ferments stabilisés et de qualité homogène tels que le Camifloc® de la société Bio Serae (France). Ces ferments expérimentés sur le terrain pastoral ont révélé une bonne efficacité pour la production de *tchoukou* (voir figures 1,2, et 3). (Photo P. Bonnet et G. Duhard).

Research on improved processing methods have leaded to the availability of stabilised ferments (starters) having homogeneous quality such as the Camifloc® from Bio Serae Company Ltd, France. These starters have been experienced in pastoral areas in Niger and have demonstrated a good ability to serve the local practices in order to produce camel's milk-made tchoukou *cheese (see figures 1, 2, 3). (Photograph P. Bonnet et G. Duhard)*

5. Des tests d'affinage de fromages présentés ici sur des lots de diverses fabrications de la laiterie de Nouakchott (Mauritanie) montrent qu'une veille technologique constante est à élaborer afin de suivre ou même de précéder les évolutions du marché. Il faut alors tester de nouveaux procédés de fabrication en fonction de marchés locaux ou d'exportation. (Photo P. Bonnet)

Some cheese maturing tests are undertaken with different batches of cheeses produced by the dairy plant in Nouakchott, Mauritania. It shows that a current lookout work in technological research and development has to be brought into operation in order to investigate daily new products and process. To precede or to follow changes in the urban market consumption patterns it could be necessary to experience new dairy products process for local or international markets. (Photograph P. Bonnet)

6. Au Kazakhstan le *shubat* est le produit d'acidification du lait de chamelle. Il s'agit d'un produit liquide fermenté au goût acide, très différent du lait cru et ayant des vertus thérapeutiques reconnues et étudiées ; c'est un aliment recommandé en particulier pour les problèmes digestifs et le diabète. On voit ici des éléments d'une ancienne chaîne servant à battre le lait en fûts de bois fumé, après pasteurisation du lait ou sans pasteurisation. L'acidification et la fermentation en font un produit sûr au plan sanitaire. (Photo Moussaiev et P. Bonnet)

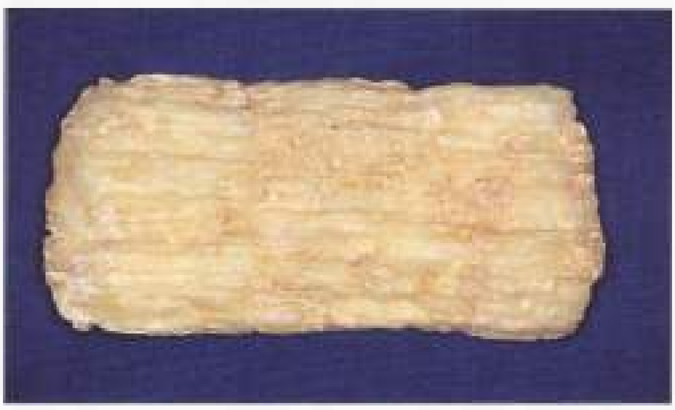
In Kazakhstan the most famous dairy product is the shubat *processed by acidification of the camel's milk. It is a fermented liquid dairy product with an acid taste, very different from raw milk. Its therapeutic properties have been studied and it is recommended for digestive disorders and diabetes. Here on the photography we can see some parts of an old processing chain used to churn the milk in woody smoked barrel generally after the milk is being pasteurised. Acidification and fermentation process lead to the safe product with regards to food security. (Photograph Moussaiev and P. Bonnet)*

7. Au Kazakhstan, le lait de chamelle est transformé en « fromage » séché appelé *kourt* issu du *shubat* (voir figure 6). Ce dernier est séché de manière artisanale (séchage solaire) et mis en forme en petites unités. Une fois délayé dans de l'eau, il peut permettre de relancer la transformation du lait brut. Ces « fromages » secs, blocs de lait fermenté en poudre, sont aussi utilisés pour la consommation directe. (Photo P. Bonnet)

In this picture made in Kazakhstan the camel's milk has been processed into kurt*, a traditional dry cheese made from* shubat *(see figure 6). After being sun dried the* shubat *is formed into small balls of cheese, which after being rehydrated will act as a starter in the raw milk in order to copy the production of the* shubat*. These small dry cheeses, sorts of blocks of powder fermented milk, are used also for final consumption by customers. (Photograph P. Bonnet)*



1, 2 et **3.** Fabrication d'un fromage traditionnel, le *tchoukou*, en milieu pastoral au Niger.
The processing of the traditional tchoukou*-called cheese in a pastoral environment in Niger.*



4. Des ferments stabilisés expérimentés sur le terrain pastoral ont révélé une bonne efficacité pour la production de fromage de chamelle (ici, le *tchoukou*).
Some stabilised ferments experienced in pastoral areas in Niger have demonstrated a good ability to serve the local practices in order to produce camel's milk-made cheese (here the tchoukou*).*

5. Tests d'affinage de fromages présentés sur des lots de diverses fabrications de la laiterie de Nouakchott (Mauritanie).
Some cheese maturing tests are undertaken with different batches of cheeses produced by the dairy plant in Nouakchott, Mauritania.

6. Eléments d'une ancienne chaîne de traitement du *shubat* au Kazakhstan, matériel servant à battre le lait en fûts de bois fumé.
Some parts of an old processing chain used to churn the milk in woody smoked barrel in order to process the shubat *in Kazakhstan.*

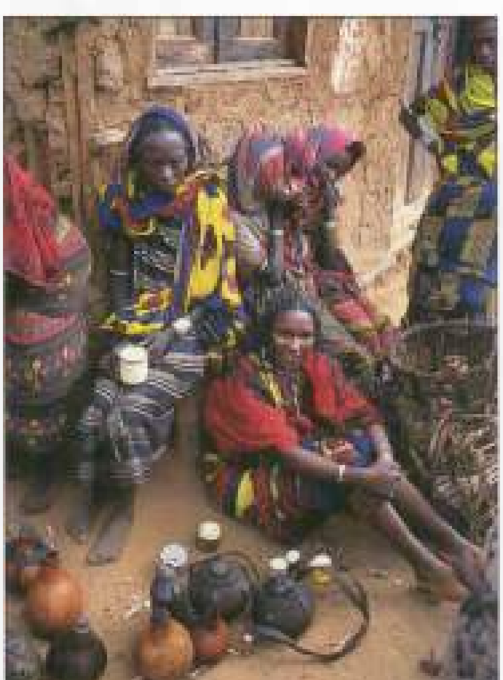
7. Au Kazakhstan, le lait de chamelle est transformé en « fromage » séché appelé *kourt*.
In Kazakhstan the camel's milk is being processed into kurt*, a traditional dry cheese.*

1. En Mauritanie, solutions spécifiques pour le respect des exigences sanitaires.
Use in Mauritania of specific solutions aiming at respecting sanitary rules.

2. Les équipements nécessaires à la mise en place d'un outil industriel sont le plus souvent réunis dans les villes des marchés comme ici à Nouakchott (Mauritanie).
Good equipment and assets are generally available in an urban environment like Nouakchott, Mauritania.

3. En Mauritanie, un projet industriel de dimension modeste, mais modulaire et adaptable. *In Mauritania, a modest but efficient mid size industrial project achieved with modularity and good adaptability to the market dynamics and scope.*

4. Usage de charrettes de transport du lait faisant office de supports publicitaires.
Use of small carts for milk transport which are also used for advertising purpose.



5 et **6.**
Au marché de Yabelo, Borana, Sud de l'Ethiopie, les femmes s'occupent de la vente sur le marché local.
At the Yabelo market (Borana Region South Ethiopia) women are in charge of the sale in the local markets.

1. En Mauritanie, les contraintes sanitaires et de salubrité alliées à des traditions vestimentaires locales conduisent à des solutions spécifiques pour le respect des exigences de moyens (ici vêtements et matériels) requises pour l'obtention de produits de qualité sanitaire reconnue. (Photo P. Bonnet)

The sanitary and healthiness constraints for processing milk in Mauritania are reaching the local clothing habits. That leads to the use of specific solutions aiming at respecting sanitary rules (here garments and equipment are adapted) to gain and convey a good and recognised sanitary status for the products and the process. (Photograph P. Bonnet)

2. Le stockage au froid préalablement à la livraison des litres et demi-litres de lait pasteurisé de chamelle et de vache nécessite l'équipement de base en matière d'énergie, d'eau courante et de locaux. Ces équipements sont le plus souvent réunis dans les villes des marchés comme ici à Nouakchott (Mauritanie). (Photo P. Bonnet)

Cold storage preliminary to the delivery of pasteurised camel's or cow's milk in half litre or one litre packaging requires availability of basic equipment and materials such as electric power, clean water supply, good shaped building in order to achieve an industrial and entrepreneurial project. These equipment and assets are generally available in an urban environment like Nouakchott, Mauritania. (Photograph P. Bonnet)

3. L'usage de salles aérées peintes de couleurs claires, utilisant du matériel d'occasion de bonne qualité, permet la naissance d'un projet industriel de dimension modeste mais qui peut être modulaire et adaptable. (Photo P. Bonnet)

The use of large halls well aired and painted with clear colours, using second-hand equipment of good maintenance and quality has allowed to start a modest but efficient mid size industrial project. This flexibility is achieved through modularity and could provide good adaptability to the market dynamics and scope. (Photograph P. Bonnet)

4. A Nouakchott, en Mauritanie, la commercialisation des unités de lait conditionné passe par un réseau de distribution qui, de la laiterie, touche les quatre coins de la ville, du fait d'une part des habitudes de la consommation à heures fixes et d'autre part de l'éclatement géographique des détaillants et de la clientèle. Ici les charrettes utilisées font office de supports publicitaires. (Photo P. Bonnet)

The delivery of packaged milk units in Nouakchott, Mauritania, is using different pathways from the dairy factory to the four corners of the town. It is due to the consuming habits at fixed hours and to the geographical spread of retailers and consumers. Here the picture demonstrate the use of small carts which are also used for advertising purpose. (Photograph P. Bonnet)

5 et **6.** Le commerce des produits laitiers camelins est une activité introduite récemment, comme par exemple par les commerçants à Djibouti. Dans tous les cas, l'opérateur qui vend le premier dans la chaîne de la filière utilise ses excédents pour fournir un produit frais ou transformé. Cela nécessite souvent l'existence de lieux d'échanges et de produits divers sur ces marchés afin de couvrir la variété des besoins des opérateurs. Dans le cas de ces deux photos (marché de Yabelo, Borana, Sud de l'Ethiopie), les femmes s'occupent de la traite, de la transformation éventuelle et de la vente sur le marché local, ce qui nécessite un équipement en outils spécifiques de récolte et de transport. Il s'agit en général de lait de bovin et de beurre, mais aussi de lait de chamelle. (Photos P. Bonnet)

The trade of camel's dairy products is sometimes a very recent activity that can be seen as an innovation introduced by local merchants (like in Djibouti) due to the high demand for milk in urban markets. In most of the cases the first operator in the dairy commodity chain, i.e. the milk producer, utilises milk surplus of the periurban production to finally supply the consumer with a fresh or a processed product. The marketing activity always necessitates trading places, village markets where all kinds of inputs and products are available in order to supply these specific livestock production systems and the related commodity chains agents. Here in the market at Yabelo (Borana Region South Ethiopia) women have multiple duties: to milk the she-camels, to process the dairy products and also the sale of the milk and the butter in the local markets. They are using specific containers and tools to collect, transport and process the milk. The milk originates mainly from cattle but also somehow from camels which is now used in large areas despite tenacious taboos. (Photographs P. Bonnet)

Annexes

Visite d'une unité de transformation du lait Présentation d'un ferment fromager spécifique

Visit of a milk processing unit Demonstration of a specific cheese making starter

Une visite de l'entreprise « Laitière de Mauritanie » (voir illustrations p. 287) a permis aux participants de mieux comprendre comment un procédé industriel peut influer sur les habitudes de consommation du lait de chamelle. Elle a fourni aussi l'occasion de présenter des innovations dans le mode de traitement, et de mesurer certaines contraintes dans l'activité de transformation de lait de chamelle. Dans cette optique, a été également présenté un produit industriel, le ferment fromager Camifloc® (voir p. 288).

A visit of the company "Laitière de Mauritanie" (see pictures p. 287) has provided the participants the opportunity to better understand how an industrial process can introduce changes in camel's milk consumption patterns. It also provided an opportunity to demonstrate the use of new technologies and products for milk processing, as well as assessed constraints and limitations in the camel's milk processing activity. In this regard, it has also been given a demonstration of an industrial product, Camifloc® starter (see p. 288), in order to illustrate such a topic.

Deux exemples de projets de conditionnement attractif pour un fromage de type camembert à base de lait de chamelle pasteurisé sont reproduits ci-contre (en haut). Les appellations « Caravane » et « Sahara » sont dans la droite ligne du marketing utilisé en Europe, se servant des images exotiques associées à la défense de l'environnement, mais aussi proches des valeurs traditionnelles des marchés musulmans d'Afrique du Nord et du Moyen-Orient.

Tiviski, la marque du lait pasteurisé de chamelle en vente en Mauritanie, et produit par la *Laitière de Mauritanie*, est commercialisée dans un conditionnement moderne (ci-contre, en bas) utilisant l'imagerie traditionnelle pour les marchés urbains.

Two examples of packaging proposals are presented at the top of the p. 287. They have been designed for a camembert type cheese made from pasteurised camel's milk. The designations " Caravane " and " Sahara " are referring to exotic symbols and marketing patterns currently used in Europe and associated to environmental values. They are meanwhile referring to traditional values of word of Muslims in Northern Africa and Middle East region.

Tiviski the trade mark for pasteurized camel's milk sold in Mauritania, and produced by Laitière de Mauritanie, *is commercialised in urban markets in a modern type of packaging using traditional imagery (see at the bottom of the p. 287).*

Des travaux ont abouti à la mise au point d'un procédé de fabrication de fromages de différents types à partir du lait de camélidé et d'un agent de coagulation spécifique, Camifloc® (voir p. 288), dont la préparation associe plusieurs activités : acidification précoce et progressive, correction de la balance minérale du lait, coagulation par une enzyme adaptée, fermentation par apport d'un inoculum de ferments lactiques mésophiles et thermophiles aux caractères acidifiants et aromatiques.

Research has leaded to propose processes for different types of cheese making from camel's milk and using a specific starter for coagulation (Camifloc®: see p. 288). The process is combining different activities : early and progressive acidification, correction of unbalanced mineral contents of the camel's milk, coagulation with an adapted enzyme, fermentation through use of a lactic starter inoculum acting as acidifying agent and having aromatic characteristics.

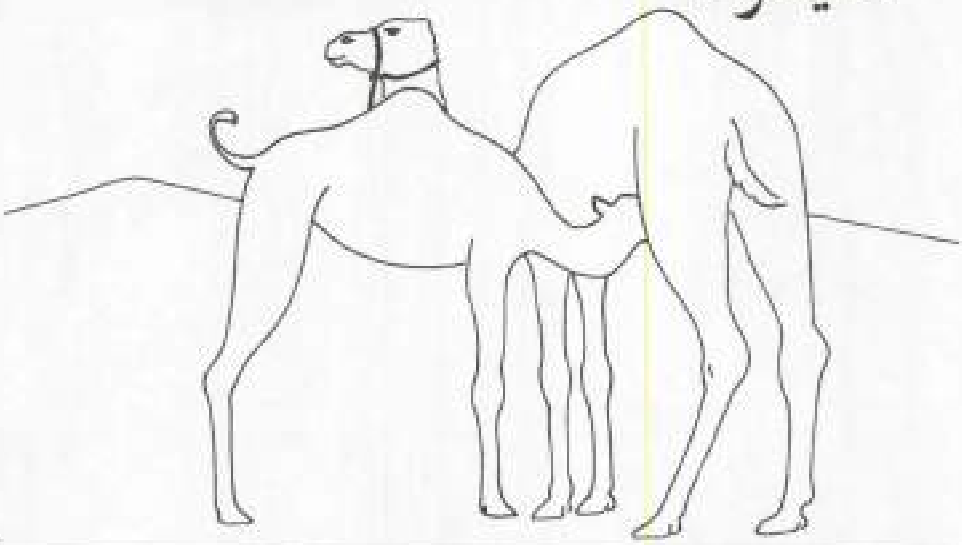
Projets de conditionnement (ci-dessus) et conditionnement utilisé (ci-dessous), reproduits avec l'aimable autorisation de la *Laitière de Mauritanie.*

Packaging proposals (above) and available packaging (below) reproduced with kind authorisation of Laitière de Mauritanie.

مستحضر أنزيمي مخثّر خاص لتخثير حليب النوق

PRÉPARATION ENZYMATIQUE COAGULANTE
MILK CLOTTING PREPARATION

CAMIFLOC كاميفلوك



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PRÉPARATION ENZYMATIQUE COAGULANTE
CAMIFLOC

DESCRIPTION

CAMIFLOC est une préparation enzymatique coagulante spécialement adaptée à la coagulation du lait de chamelle; elle est obtenue après fermentation d'une souche pure d'un champignon microscopique (Mucor miehei). Le produit est conforme aux normes internationales exigées pour les préparations enzymatiques de qualité alimentaire.

CARACTÉRISTIQUES

CAMIFLOC se présente sous forme d'une poudre blanchâtre homogène finement cristallisée; tous ses composants sont facilement solubles dans l'eau pure et le lait aux concentrations utilisées pour la production des fromages.
CAMIFLOC est conditionné en sachet-dose de deux types
- Type I ..... pour coaguler 50 L de lait
- Type II .. pour coaguler 1000 L de lait

RECOMMANDATIONS

CAMIFLOC est une préparation pour usage alimentaire; toutefois, en cas de projection sur les yeux et la peau du produit pur ou concentré, il faudra bien rincer avec de l'eau.
Il est souhaitable de conserver le produit dans les sachets fermés d'origine, à basse température (0 à 4°C), jusqu'à utilisation, pour réduire les pertes d'activité coagulante.

INFLUENCE DE L'ACIDITÉ ET DE LA TEMPÉRATURE DU LAIT SUR L'ACTIVITÉ ENZYMATIQUE

L'acidité et la température du lait influencent fortement l'activité coagulante. Pour obtenir des conditions de coagulation reproductibles, il est indispensable que ces deux facteurs possèdent des valeurs constantes lors de chaque fabrication.
L'acidification du lait accroît l'activité enzymatique et diminue le temps de coagulation (Fig. 1).

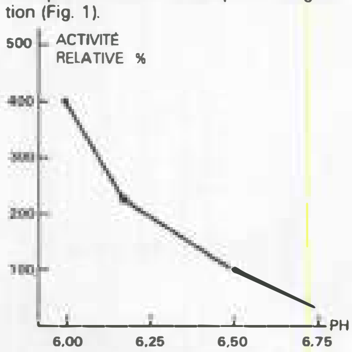

Fig 1 INFLUENCE DE L'ACIDITÉ DU LAIT SUR L'ACTIVITÉ ENZYMATIQUE

L'élévation de température du lait entre 10 et 42°C entraîne également une activation de la coagulation, mais au-delà de cette température limite, l'enzyme est progressivement détruite (Fig. 2).

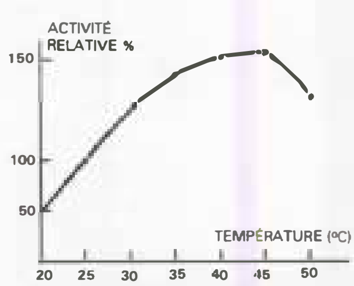

Fig. 2 INFLUENCE DE LA TEMPÉRATURE SUR L'ACTIVITÉ ENZYMATIQUE

MODE D'EMPLOI

— Choisir un lait frais et peu acide.
— Ajuster sa température à 33-36°C.
— Ensemencer le lait éventuellement avec des ferments lactiques acidifiants.
— Dissoudre CAMIFLOC dans de l'eau pure de 20 à 35°C
Pour coaguler 50 litres de lait : 1 sachet dose type I dans 50 ml d'eau.
Pour coaguler 1000 litres de lait : 1 sachet dose type II dans 1 litre d'eau.
— Agiter soigneusement jusqu'à complète dissolution.
— Ajouter immédiatement la solution de CAMIFLOC dans le lait sous agitation modérée pendant 1 à 2 mn.
— Arrêter ensuite tout mouvement du lait et laisser au repos complet. La coagulation apparaît alors après 10 à 30 mn selon l'acidité du lait.

Plaquette partiellement reproduite avec l'aimable autorisation de *Bio Serae*.
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Lexique français-anglais /*French-english glossary*

A

Acides gras saturés	*Saturated fatty acid*
Acides gras non saturés	*Unsaturated fatty acid*
Acidification	*Souring*
Acidification (maturation) de la crème	*Acidifying, souring, ripening (about cream)*
Acidifier	*To acidify, acidulate, to sour*
Acier inoxydable	*Stainless steel*
Affiné	*Matured*
Agglutination (groupement, rassemblement) des globules gras	*Clumping, clustering (of fat globules)*
Agitateur	*Agitator, stirrer*
Amas de grains de beurre	*Cluster of butter granules*
Appareil pour la culture des levains	*Butter culture apparatus*
Appareil de préparation des levains purs	*Starter heater*
Appréciation du degré de qualité du lait	*Grading of milk*
Aptitude au barattage	*Churnability*
Aptitude à la coagulation	*Coagulation ability*
Aspect et consistance du beurre	*Texture and body of butter*
Assiette d'écrémeuse	*Separating dishes*
Autoclave	*Autoclave, vat under pressure*

B

Bacille du foin (*B. subtilis*)	*Hay bacillus*
Bacille de la tuberculose	*Tuberculosis bacillus*
Bacilles butyriques	*Butyric acid bacteria*
Bactéries productrices d'arôme	*Aroma-forming bacteria*
Bactéries propioniques	*Propionic acid bacteria*
Bain-marie	*Water bath*
Barattage	*Butter making, churning*
Baratte	*Churn(er), buttering machine*
Baratte à batteurs	*Plunge-dash churn, dasher*
Baratter	*To churn*
Bassin (tank, réservoir) à eau glacée	*Cooling tank (containing ice water)*
Beurre acidifié (beurre maturé)	*Soured butter (ripened butter)*
Beurre amer	*Salt-bitter butter*
Beurre cassant	*Brittle butter*
Beurre collant	*Sticky butter*
Beurre de coloration irrégulière	*Uneven-coloured butter*
Beurre doux	*Sweet butter*
Beurre dur	*Firm butter*
Beurre de fabrique (beurre fabriqué dans une beurrerie)	*Creamery butter*
Beurre de ferme (beurre fabriqué dans les fermes)	*Farm butter, dairy butter* (Can.)
Beurre laitier	*Dairy butter*
Beurre marbré	*Butter with marblelike colour*
Beurre maturé (acidifié)	*Soured (ripened) butter*
Beurre plat, beurre insipide	*Butter flat in flavour*
Beurre de printemps	*Grassbutter*
Beurre rayé (tacheté)	*Streaky butter*
Beurre de sérum (ou beurre de petit lait) = beurre fabriqué avec la matière grasse récupérée du lait	Whey butter
Beurrerie	*Butter factory*
Bichromate de potassium	*Potassium bichromate*
Bidon (pot) à lait	*Milk pot, milk can*
Boîte de Pétri	*Petri dish*
Bol	*Bowl*
Bonnet	*Second stomach*
Boue d'écrémeuse	*Separator slime*
Butyromètre à godet ou cupule (pour crème ou fromage)	*Butyrometer for cream*

C

Cageot	*Crate*
Caillage, coagulation	*Curdling, renneting*
Caillé (ensemble des grains de caillé)	*Curd (groups of cheese granules)*
Caillebotte (caséine acide)	*Soured casein*
Cailler, coaguler	*To curdle, to coagulate*
Carbonate de sodium	*Soda ash, sodium carbonate*
Carbonate de sodium cristallisé	*Washing soda, crystallized sodium carbonate*
Caséeux (ayant l'aspect du fromage)	*Cheesey, like cheese*
Caséine acide	*Acid casein*
Caséine acide (caillebotte)	*Soured casein*
Caséine à la présure	*Rennet casein*
Cave à fromages	*Cheese storing room, curing-room*
Cercle à fromage	*Cheese girdle*
Chambrage (pasteurisation prolongée)	*Holding pasteurization*
Chambre de maturation	*Ripening room*
Chambreur	*Holder*
Chancre (du fromage)	*(Cheese) cancer*
Chaudière à fromages	*Cheese kettle*
Chauffage sous vide	*Vacuum heating*
Cire à fromage	*Cheese wax*
Citerne de transport	*Transporting container*
Clous de girofle	*Cloves*
Coagulation, caillage	*Curdling, renneting*
Coaguler, emprésurer, cailler	*To coagulate, to curdle, to clot*
Congélation	*Freezing, congelation*
Conservation	*Storage*

Consommateur — *Consumer*
Crème — *Cream*
Crème à café — *Coffee-cream*
Crème fouettée — *Whipped cream*
Crème glacée — *Ice cream*
Croûte (d'un fromage) — *Rind (of cheese)*
Culture bactérienne — *Bacterial culture*
Culture mère (levain) — *Mother starter, mother culture*
Culture pure, levain — *(Pure) culture, starter*
Cuve à crème, cuve à maturation — *Cream vat*
Cuve à fromage — *Cheese vat*
Cuve à levain — *(Starter) jar, (butter culture) jar*
Cuve de maturation — *Ripening vat, cream ripener*

D

Débit — *Hour-capacity, turnover, output*
Découpage du caillé, décaillage — *Cutting of curd*
Défaut d'aspect, de présentation (du fromage) — *Defect in appearance (of cheese)*
Défaut d'oxydation (saveur oxydée) — *Oxidized defect (oxidized flavour)*
Degré (taux) d'écrémage — *Skimming degree*
Dépenses d'exploitation — *Operating expenses*
Dessèchement — *Dessication*
Détermination de la force de la présure — *Curd test*
Dispositif de déferrisation — *Deferrization aggregate*
Division du caillé — *Cutting of the curd*
Dosage de la matière grasse — *Fat determination*
Durée de coagulation — *Renneting time*

E

Eau de lavage — *Washing water*
Eau de refroidissement — *Cooling water*
Eau oxygénée — *Hydrogen peroxide*
Eau salée, saumure — *Salt water, brine*
Echangeur de chaleur (récupérateur) — *Regenerative*
Echantillon — *Sample*
Eclisse, moule à fromage — *Hoop, cheesel*
Ecrémage — *Skimming, separation (mechanical)*
Ecrémer — *To skim, to separate, to cream*
Ecrémeuse, écrémeuse centrifuge — *Separator, centrifugal separator*
Egoutter — *To drain*
Emmagasiner — *To stock, to store*
Ensilage — *Ensilage*
Entrepôt de fromages — *Store-room, curing-room*
Epreuve à l'alcool — *Alcohol test*
Epreuve à l'alizarol — *Alizarol test, alizarin-alcohol-test*
Epreuve au bromothymol — *Brom-thymole test*
Epreuve combinée de réductas et de fermentation — Combined methylene-blue and fermentation test
Epreuve de coagulation à la présure — *Coagulating test (by renneting), renneting test*
Epreuve de fermentation — *Fermentation test*
Epreuve de la catalase — *Catalase test*
Epreuve de l'acidité (détermination de l'acidité) — *Acidity test (determination of acidity)*
Epreuve de la créatine — *Creatin test*
Epreuve de la phosphatase — *Phosphatase test*
Epreuve de la réductase — *Methylene-blue reduction test, reductase test*
Epreuve de l'ébullition — *Boiling test, experimental cooking*
Epreuve de propreté (épreuve du sédiment) — *Dirt test, sediment test* (Am.)
Epreuve de Storch, épreuve de la peroxydase — *Storch's test, peroxidase test*
Epreuve du sédiment *(épreuve de propreté)* — *Dirt test, sediment test* (Am.)
Epurateur centrifuge — *Clarifier, clarifying centrifuge*
Extrait sec dégraissé (solides non gras) — *Solids-not-fat*
Extrait sec du lait — *Milk solids*

F

Fabrication continue de beurre — *Continuous buttermaking*
Falsification — *Adulteration*
Ferment, levain — *Starter*
Fermentation — *Fermenting, fermentation*
Fermentation des fromages — *(Cheese) fermentation*
Ferments lactiques — *Lactic-acid bacteria*
Feuillet — *Third stomach*
Fièvre aphteuse — *Foot-and-mouth disease*
Filtre (tamis, passoire) à lait — *Milk strainer, sieve*
Filtre d'ouate — *Cotton-wool strainer*
Filtrer, tamiser — *To strain, to filter*
Flacon à échantillon — *Sample bottle*
Formation d'yeux (de trous) (dans le fromage) — *Eye formation*
Forme du fromage — *Shape of the cheese*
Fourrage — *Fodder, feeding stuff*
Frais d'entretien — *Upkeep costs*
Frais d'exploitation — *Working expenses*
Fromage à caillé brassé ou granulé — *Stirred or granular curd cheese*
Fromage à caillé lavé — *Washed curd cheese*
Fromage à la crème — *Cream cheese*
Fromage à la présure — *Rennet cheese*
Fromage à tartiner — *Spread cheese*
Fromage au cumin — *Cumin-seed-cheese*
Fromage aux clous de girofle — *Frisian clove cheese*
Fromage blanc — *Cottage cheese*
Fromage de ferme — *Farmer's cheese*
Fromage de laiterie — *Dairy cheese*
Fromage de sérum — *Whey cheese*
Fromage émulsifié (fondu) — *Emulsified (process) cheese*

Fromage fondu, fromage en pains, fromage en boîte, fromage sans croûte = produit alimentaire résultant de la pulvérisation et du mélange d'un ou plusieurs lots de fromages en une masse homogène, à l'aide de chaleur et d'agents émulsifiants	*Loaf cheese, blended, package, process, crustless cheese = food product obtained by comminuting and mixing one or more lots of cheese with the aid of heat and emulsifying agents into a homogeneous mass*
Fromage gonflé	*Bloated cheese*
Fromage gras	*Whole milk cheese, full cream cheese*
Fromage maigre	*Skim-milk cheese*
Fromage sans ouverture	*Blind glass cheese*
Fromage sans trous (sans ouverture)	*Blind cheese, cheese without eyes*
Fromager	*Cheesemaker*
Fromagerie (fabrique de fromage)	*Cheese dairy, cheese factory*

G

Globule gras	*Fat globule*
Gonflement (des fromages)	*Bloating (of cheese)*
Goût de cuit	*Cooked flavour*
Goût de moisi	*Mouldy flavour, musty flavour*
Goût de poisson	*Fishy taste*
Goût de rance	*Rancid taste, rancid flavour*
Goût de savon	*Soap taste*
Goût levuré	*Yeasty flavour*
Goût métallique	*Metal flavour*
Grain de caillé	*Curd granule*
Grains de beurre	*Butter-granules*
Graisse de beurre	*Butterfat*
Grange	*Barn*

I

Indice de réfraction	*Refractive index, refractometer reading*
Indice de saponification	*Saponification number*
Indice d'iode	*Iodine number*
Inspection officielle du lait de consommation, contrôle du lait	*Official inspection of milk for human consumption* (Am.), *milk control*
Iode	*Iodine*

L

Lactose (sucre de lait)	*Lactose (milk sugar)*
Lait aigre	*Sour milk*
Lait caillé (coagulé)	*Coagulated milk*
Lait coagulé (caillé)	*Coagulated milk*
Lait concentré, lait condensé	*Condensed milk*
Lait condensé non sucré	*Unsweetened condensed milk*
Lait condensé stérilisé	*Evaporated milk*
Lait condensé sucré	*Sweetened condensed milk*
Lait de chaudière	*Kettle milk*
Lait de consommation	*Market milk*
Lait de fin de lactation	*Milk given towards the end of lactation*
Lait de laiterie	*Dairy milk*
Lait dysgénésique	*Dysgenic milk (slow development of acidity in milk)*
Lait écrémé	*Skim (skimmed) milk*
Lait écrémé acidifié	*Sour skim milk*
Lait écrémé en poudre	*Powdered skimmed milk, dry skimmed milk, skimmed milk powder*
Lait en poudre (poudre de lait)	*Powdered milk, milk powder, dry milk, dried milk*
Lait entier en poudre	*Whole milkpowder*
Lait entier, lait non écrémé	*Whole milk, unskimmed milk*
Lait évaporé	*Evaporated milk*
Lait frais	*Fresh milk*
Laiterie (usine)	*Dairy, dairy factory, milk plant*
Laitier (homme s'occupant de la laiterie)	*Dairy man*
Lessive	*Lye (caustic lye), lixiviated ashes*
Levain (culture mère)	*Mother starter, mother culture*
Levain, culture pure	*(Pure) culture, starter*
Levain, ferment	*Starter*
Ligne de crème	*Cream line*
Livre généalogique	*Herdbook*

M

Machine à capsuler	*Bottle capper*
Machine à laver les bidons (pots)	*Milk can washer*
Machine à laver les bouteilles	*Bottle-washing machine*
Machine à remplir les bouteilles	*Milk bottling machine, bottle filler*
Machine à traire	*Milking machine*
Machine à vider (basculer) les bidons	*Milk elevator*
Malaxage	*Butter working*
Malaxeur	*Butter working-machine, working-churn, butter worker*
Mamelle	*Udder*
Marque	*Mark, brand*
Marque de contrôle du Gouvernement	*Government control mark*
Marque de fabrique	*Trade-mark*
Mastite, mammite	*Garget, mastitis*
Matière grasse du beurre	*Butterfat, butyrin*
Matière sèche	*Dry matter (solids)*
Maturation de la crème	*Cream ripening*
Maturation du fromage	*Curing, ripening of cheese*
Maturation du lait (avant caillage)	*Ripening of milk before curdling*
Méthode acidobutyrométrique	*Acid using butyrometric method of testing milk for butter fat*
Mite de fromage (Acarien)	*Cheese mite*
Moisi	*Mouldy*
Moisir, devenir moisi	*To mould, to grow mouldy, to turn musty*

Moisissure	*Mould, mildew, white film, mustiness mould fungus*
Morge (croûte glaireuse)	*Coating, scap*
Moulage (découpage) du beurre	*Butter cutting*
Moule à fromage (éclisse à fromage)	*Hoop, cheesel, cheese-mould, cheese-form*
Mouleuse	*Printer*
Moulin à caillé	*Curd-mill*
Mousse, écume	*Foam, scum*
Mousseline à fromages	*Cloth gauze*

N

Nettoyeur centrifuge	*Clarifier*
Numération microbienne	*Plate count*

O

Odeur	*Scent, smell, flavour*
Odeur impure	*Unclean smell, unclean odour*
Overrun (excédent de beurre pour cent de matière grasse pure)	*Butter overrun per cent*
Oxydant	*Oxidant, oxidizing agent, oxygenizer*

P

Panse	*Paunch*
Papier kraft	*Kraft paper*
Papier parchemin, papier sulfurisé	*Perchment paper*
Paraffiner	*To coat*
Passoire (tamis, filtre) à lait	*Milk strainer*
Pasteurisateur, réchauffeur	*Pasteurizer, pasteurizing apparatus* (Am.), *heater*
Pasteurisateur à cloche	*Bell pasteurizer, bell heater* (Am.)
Pasteurisateur à plaques (ou réchauffeur à plaques)	*Plate pasteurizer, plate heater*
Pasteurisateur à tube	*Tube pasteurizer*
Pasteurisation haute	*High-temperature short-time pasteurization (H.T.S.T.)*
Pasteurisation haute instantanée	*High-temperature short-time pasteurization (H.T.S.T.), flash pasteurization*
Pasteurisation prolongée (chambrage)	*Holding pasteurization*
Poids spécifique	*Specific gravity*
Point de fusion	*Melting point*
Pompe à lait	*Milk pump*
Pot (bidon) à lait	*Milk pot*
Potentiel redox	*Redox potential*
Poudre de babeurre	*Buttermilk powder*
Poudre de lait (lait en poudre)	*Powdered milk, powder milk, dry milk, dried milk*
Poudre de lait écrémé (lait écrémé en poudre)	*Dry skimmed milk, skimmed milk powder (powdered skimmed milk)*
Pourcentage de matière grasse dans la matière sèche	*Content of fat in the dry matter*
Précipité, dépôt	*Precipitate, deposit*
Précipiter, déposer	*To precipitate, to deposit*
Prélèvement d'échantillon(s)	*Sampling*
Pressage (des fromages)	*Pressing (of cheese)*
Presse à fromages	*Cheese press*
Présure	*Rennet, rennin, runnet, rennet extract*
Procédé Alfa	*Alfa method*
Procédé de la pulvérisation	*Spray process*
Procédé du cylindre	*Roller process*
Procédé du tambour sous vide	*Vacuum drum process*
Production de lait	*Milk yield, production of milk*
Produit dérivé du sérum	*Whey product*

Q

Quai (plate-forme) de réception	*Receiving platform*

R

Raccord de canalisation	*Pipe fitting*
Race pure (de), pur sang	*Through bred, pure bred*
Rance	*Rancid*
Rancidité	*Rancidity, rancidness*
Rayons à fromages	*Cheese shelf*
Réactif	*Reagent*
Réchauffage du caillé	*Heating of the curd*
Réchauffage du lait à la température d'emprésurage	*Preheating, heating to the setting temperature (at cheese making)*
Récolte du lait	*Collect of milk*
Réfraction, pouvoir réfringeant	*Refractive power, refractivity*
Réfrigérateur, refroidisseur	*Cooler, refrigerator*
Réfrigérateur à surface	*Surface cooler*
Réfrigération, refroidissement	*Cooling down, cooling, refrigeration*
Réfrigérer, refroidir complètement	*To cool down, to refrigerate*
Refroidissement par saumure	*Brine-cooling*
Régulateur à lait (régulateur de débit)	*Milk regulator*
Robinet	*Tap*
Rouleau-malaxeur, cylindre	*Roller, working roller*

S

Salle de fabrication des fromages	*Cheese making room*
Salle de fermentation, salle chaude	*Curing room, warm room*
Salle de pressage	*Pressing room*
Salle de salage	*Salting room, brine cellar*
Salle (chambre) de stockage	*Storage room*
Saumure	*Brine*
Saveur d'ail	*Garlic flavour*
Saveur d'étable	*Stable flavour*
Saveur de brûlé	*Burnt flavour*
Saveur de fourrage	*Food flavour, feed flavour* (Am.)

Saveur de malt	*Malty flavour*
Saveur de poisson	*Fishy flavour*
Saveur défectueuse	*Off-flavour*
Saveur huileuse	*Oily flavour*
Saveur impure	*Unclean taste*
Saveur oxydée (défaut d'oxydation)	*Oxidized defect, oxidized flavour*
Saveur suiffée (de suif)	*Tallowy flavour*
Sels du lait	*Milk salts*
Sérum, petit lait de fromagerie	*Whey*
Solidifier (se), se figer, congeler	*To solidify, to congeal*
Solution tampon	*Buffer solution*
Sonde à beurre	*Butter trier, butter grader*
Souche	*Strain*
Sous-produits laitiers	*Dairy by-products*
Sperme	*Sperm, semen*
Spore, sporule	*Spore*
Stabilisateur	*Stabilizer*
Stassanisateur	*Stassanisator*
Structure, texture	*Texture, composition, structure*
Sucre de lait (lactose)	*Milk sugar, lactose*
Sur (acide)	*Acid, sour*

T

Table d'égouttage	*Strainer board*
Table de malaxage	*Butter working table*
Tamis (passoire, filtre) à lait	*Milk strainer, sieve*
Tank de maturation	*Ripening tank*
Température de coagulation	*Renneting temperature*
Test de sédimentation	*Sediment test*
Texture friable	*Grumbly texture*
Titrer	*To titrate*
Toile à fromages	*Cheese cloth*
Tournesol	*Litmus*
Traite manuelle	*Hand milking*
Traite mécanique	*Machine milking*
Tranche-caillé	*Cheese harp, curd-knife*
Transporteur à rouleaux	*Roller way*
Trayon, mamelon, tétine	*Dug, teat, nipple*
Trous dans le fromage	*Holes in cheese*
Tuyauteries	*Tubes*

V

Vache pleine	*In-calf*
Vêler	*To calve*
Ver de fromage	*Cheese maggot*
Verrerie graduée	*Measuring glass, graduated glass vessel*

Y

Yaourt	*Yogurt*
Yoghourt (yaourt)	*Yoghurt*

Lexique anglais-français / *English-french glossary*

A

Acid, sour	*Sur (acide)*
Acid casein	*Caséine acide*
Acid using butyrometric method of testing milk for butter fat	*Méthode acidobutyrométrique*
Acidify (to), acidulate, to sour	*Acidifier*
Acidifying, souring, ripening (about cream)	*Acidification (maturation) de la crème*
Acidity test (determination of acidity)	*Epreuve de l'acidité (détermination de l'acidité)*
Adulteration	*Falsification*
Agitator, stirrer	*Agitateur*
Alcohol test	*Epreuve à l'alcool*
Alfa method	*Procédé Alfa*
Alizarol test, alizarin-alcohol-testzarol	*Epreuve à l'alizarol*
Aroma-forming bacteria	*Bactéries productrices d'arôme*
Autoclave, vat under pressure	*Autoclave*

B

Bacterial culture	*Culture bactérienne*
Barn	*Grange*
Bell pasteurizer, bell heater *(Am.)*	*Pasteurisateur à cloche*
Blind cheese, cheese without eyes	*Fromage sans trous (sans ouverture)*
Blind glass cheese	*Fromage sans ouverture*
Bloated cheese	*Fromage gonflé*
Bloating (of cheese)	Gonflement (des fromages)
Boiling test, experimental cooking	*Epreuve de l'ébullition*
Bottle capper	*Machine à capsuler*
Bottle-washing machine	*Machine à laver les bouteilles*
Bowl	*Bol*
Brine	*Saumure*
Brine-cooling	*Refroidissement par saumure*
Brittle butter	*Beurre cassant*
Brom-thymole test	*Epreuve au bromothymol*
Buffer solution	*Solution tampon*
Burnt flavour	*Saveur de brûlé*
Butter culture apparatus	*Appareil pour la culture des levains*
Butter cutting	*Moulage (découpage) du beurre*
Butter factory	*Beurrerie*
Butter flat in flavour	*Beurre plat, beurre insipide*
Butter-granules	*Grains de beurre*
Butter making, churning	*Barattage*
Butter overrun per cent	*Overrun (excédent de beurre pour cent de matière grasse pure)*
Butter trier, butter grader	*Sonde à beurre*
Butter with marblelike colour	*Beurre marbré*
Butter working	*Malaxage*
Butter working machine, working-churn, butter worker	*Malaxeur*
Butter working table	*Table de malaxage*
Butterfat	*Graisse de beurre*
Butterfat, butyrin	*Matière grasse du beurre*
Buttermilk powder	*Poudre de babeurre*
Butyric acid bacteria	*Bacilles butyriques*
Butyrometer for cream	*Butyromètre à godet ou cupule (pour crème ou fromage)*

C

Calve (to)	*Vêler*
Catalase test	*Epreuve de la catalase*
(Cheese) cancer	*Chancre (du fromage)*
Cheese cloth	*Toile à fromages*
Cheese dairy, cheese factory	*Fromagerie (fabrique de fromage)*
(Cheese) fermentation	*Fermentation des fromages*
Cheese girdle	*Cercle à fromage*
Cheese harp, curd-knife	*Tranche-caillé*
Cheese kettle	*Chaudière à fromages*
Cheese maggot	*Ver de fromage*
Cheese making room	*Salle de fabrication des fromages*
Cheese mite	*Mite de fromage (Acarien)*
Cheese press	*Presse à fromages*
Cheese shelf	*Rayons à fromages*
Cheese storing room, curing-room	*Cave à fromage*
Cheese vat	*Cuve à fromage*
Cheese wax	*Cire à fromage*
Cheesemaker	*Fromager*
Cheesey (like cheese)	*Caséeux (ayant l'aspect du fromage)*
Churn (to)	*Baratter*
Churnability	*Aptitude au barattage*
Churn(er), buttering machine	*Baratte*
Clarifier	*Nettoyeur centrifuge*
Clarifier, clarifying centrifuge	*Epurateur centrifuge*
Cloth gauze	*Mousseline à fromages*
Cloves	*Clous de girofle*
Clumping, clustering (of fat globules)	*Agglutination (groupement, rassemblement) des globules gras*
Cluster of butter granules	*Amas de grains de beurre*
Coagulated milk	*Lait caillé (coagulé)*
Coagulating test (by renneting), renetting test	*Epreuve de coagulation à la présure*
Coagulation ability	*Aptitude à la coagulation*
Coat (to)	*Paraffiner*

Coating, scap	*Morge (croûte glaireuse)*
Coffee-cream	*Crème à café*
Collect of milk	*Récolte du lait*
Combined methylene-blue and fermentation test	*Epreuve combinée de réductase et de fermentation*
Condensed milk	*Lait concentré, lait condensé*
Consumer	*Consommateur*
Content of fat in the dry matter	*Pourcentage de matière grasse dans la matière sèche*
Continuous buttermaking	*Fabrication continue de beurre*
Cooked flavour	*Goût de cuit*
Cool down (to), to refrigerate	*Réfrigérer, refroidir complètement*
Cooler, refrigerator	*Réfrigérateur, refroidisseur*
Cooling down, cooling, refrigeration	Réfrigération, refroidissement
Cooling tank (containing ice water)	*Bassin (tank, réservoir) à eau glacée*
Cooling water	*Eau de refroidissement*
Cottage cheese	*Fromage blanc*
Cotton-wool strainer	*Filtre d'ouate*
Crate	*Cageot*
Cream	*Crème*
Cream cheese	*Fromage à la crème*
Cream line	*Ligne de crème*
Cream ripening	*Maturation de la crème*
Cream vat	*Cuve à crème, cuve à maturation*
Creamery butter	*Beurre de fabrique (beurre fabriqué dans une beurrerie)*
Creatin test	*Epreuve de la créatine*
Cumin-seed-cheese	*Fromage au cumin*
Curd granule	*Grain de caillé*
Curd-mill	*Moulin à caillé*
Curd test	*Détermination de la force de la présure*
Curdle (to), to coagulate	*Cailler, coaguler*
Curdling, renneting	*Caillage, coagulation*
Curds (groups of cheese granules)	*Caillé (ensemble de grains de caillé)*
Curing, ripening of cheese	*Maturation du fromage*
Curing room, warm room	*Salle de fermentation, salle chaude*
Cutting of curd	*Découpage du caillé, décaillage*

D

Dairy butter	*Beurre laitier*
Dairy by-products	*Sous-produits laitiers*
Dairy cheese	*Fromage de laiterie*
Dairy, dairy factory, milk plant	*Laiterie (usine)*
Dairy man	*Laitier (homme s'occupant de la laiterie)*
Dairy milk	*Lait de laiterie*
Defect in appearance (of cheese)	*Défaut d'aspect, de présentation (du fromage)*
Deferrization aggregate	*Dispositif de déferrisation*
Dessication	*Dessèchement*
Dirt test, sediment test (*Am.*)	*Epreuve de propreté (épreuve du sédiment)*
Drain (to)	*Egoutter*
Dry matter (solids)	*Matière sèche*
Dry skimmed milk, skimmed milk powder (powdered skimmed milk)	*Poudre de lait écrémé (lait écrémé en poudre)*
Dug, teat, nipple	*Trayon, mamelon, tétine*
Dysgenic milk (slow development of acidity in milk)	*Lait dysgénésique*

E

Emulsified (process) cheese	*Fromage émulsifié (fondu)*
Ensilage	*Ensilage*
Evaporated milk	*Lait condensé stérilisé, évaporé*
Eye formation	*Formation d'yeux (de trous) (dans le fromage)*

F

Farm butter, dairy butter (*Can.*)	*Beurre de ferme (beurre fabriqué dans les fermes)*
Farmer's cheese	*Fromage de ferme*
Fat determination	*Dosage de la matière grasse*
Fat globule	*Globule gras*
Fermentation test	*Epreuve de fermentation*
Fermenting, fermentation	*Fermentation*
Firm butter	*Beurre dur*
Fishy flavour	*Saveur de poisson*
Fishy taste	*Goût de poisson*
Foam, scum	*Mousse, écume*
Fodder, feeding stuff	*Fourrage*
Food flavour, feed flavour (*Am.*)	*Saveur de fourrage*
Foot-and-mouth disease	*Fièvre aphteuse*
Freezing, congelation	*Congélation*
Fresh milk	*Lait frais*
Frisian clove cheese	*Fromage aux clous de girofle*

G

Garget, mastitis	*Mastite, mammite*
Garlic flavour	*Saveur d'ail*
Government control mark	*Marque de contrôle du Gouvernement*
Grading of milk	*Appréciation du degré de qualité du lait*
Grassbutter	*Beurre de printemps*
Grumbly texture	*Texture friable*

H

Hand milking	*Traite manuelle*
Hay bacillus	*Bacille du foin* (B. subtilis)
Heating of the curd	*Réchauffage du caillé*
Herdbook	*Livre généalogique*

High-temperature short-time pasteurization (H.T.S.T.) — *Pasteurisation haute*

High-temperature short-time pasteurization (H.T.S.T.), flash pasteurization — *Pasteurisation haute instantanée*

Holder — *Chambreur*

Holding pasteurization — *Chambrage (pasteurisation prolongée)*

Holes in cheese — *Trous dans le fromage*

Hoop, chessel — *Eclisse, moule à fromage*

Hoop, cheesel, cheese-mould, cheese-form — *Moule à fromage (éclisse à fromage)*

Hour-capacity, turnover, output — *Débit*

Hydrogen peroxide — *Eau oxygénée*

I

Ice cream — *Crème glacée*

In-calf — *Vache pleine*

Iodine — *Iode*

Iodine number — *Indice d'iode*

K

Kettle milk — *Lait de chaudière*

Kraft paper — *Papier kraft*

L

Lactic-acid bacteria — *Ferments lactiques*

Lactose (milk sugar) — *Lactose (sucre de lait)*

Litmus — *Tournesol*

Loaf cheese, blended, package, process, crustless cheese = food product obtained by comminuting and mixing one or more lots of cheese with the aid of heat and emulsifying agents into a homogeneous mass — *Fromage fondu, fromage en pains, fromage en boîte, fromage sans croûte = produit alimentaire résultant de la pulvérisation et du mélange d'un ou plusieurs lots de fromages en une masse homogène, à l'aide de chaleur et d'agents émulsifiants*

Lye (caustic lye), lixiviated ashes — *Lessive*

M

Machine milking — *Traite mécanique*

Malty flavour — *Saveur de malt*

Mark, brand — *Marque*

Market milk — *Lait de consommation*

Matured — *Affiné*

Measuring glass, graduated glass vessel — *Verrerie graduée*

Melting point — *Point de fusion*

Metal flavour — *Goût métallique*

Methylene-blue reduction test, reductase test — *Epreuve de la réductase*

Milk bottling machine, bottle filler — *Machine à remplir les bouteilles*

Milk can washer — *Machine à laver les bidons (pots)*

Milk elevator — *Machine à vider (basculer) les bidons*

Milk given towards the end of lactation — *Lait de fin de lactation*

Milk pot — *Pot (bidon) à lait*

Milk pot, milk can — *Bidon (pot) à lait*

Milk pump — *Pompe à lait*

Milk regulator — *Régulateur à lait (régulateur de débit)*

Milk salts — *Sels du lait*

Milk solids — *Extrait sec du lait*

Milk strainer, sieve — *Filtre (tamis, passoire) à lait*

Milk sugar, lactose — *Sucre de lait (lactose)*

Milk yield, production of milk — *Production de lait*

Milking machine — *Machine à traire*

Mother starter, mother culture — *Culture mère (levain)*

Mould, mildew, white film, mustiness mould fungus — *Moisissure*

Mould (to), to grow mouldy, to turn musty — *Moisir, devenir moisi*

Mouldy — *Moisi*

Mouldy flavour, musty flavour — *Goût de moisi*

O

Off-flavour — *Saveur défectueuse*

Official inspection of milk for human consumption (*Am.*), milk control — *Inspection officielle du lait de consommation, contrôle du lait*

Oily flavour — *Saveur huileuse*

Operating expenses — *Dépenses d'exploitation*

Oxidant, oxidizing agent, oxygenizer — *Oxydant*

Oxidized defect, oxidized flavour — *Saveur oxydée (défaut d'oxydation)*

P

Pasteurizer, pasteurizing apparatus (*Am.*), heater — *Pasteurisateur, réchauffeur*

Paunch — *Panse*

Perchment paper — *Papier parchemin, papier sulfurisé*

Petri dish — *Boîte de Pétri*

Phosphatase test — *Epreuve de la phosphatase*

Pipe fitting — *Raccord de canalisation*

Plate count — *Numération microbienne*

Plate pasteurizer, plate heater — *Pasteurisateur à plaques (ou réchauffeur à plaques)*

Plunge-dash churn, dasher — *Baratte à batteurs*

Potassium bichromate — *Bichromate de potassium*

Powdered milk, milk powder, dry milk, dried milk — *Lait en poudre (poudre de lait)*

Powdered skimmed milk, dry skimmed milk, skimmed milk powder — *Lait écrémé en poudre*

Precipitate, deposit — *Précipité, dépôt*

Precipitate (to), to deposit — *Précipiter, déposer*

Preheating, heating to the setting temperature (at cheese making)	*Réchauffage du lait à la température d'emprésurage*
Pressing (of cheese)	*Pressage (des fromages)*
Pressing room	*Salle de pressage*
Printer	*Mouleuse*
Propionic acid bacteria	*Bactéries propioniques*
(Pure) culture, starter	*Culture pure, levain*

R

Rancid	*Rance*
Rancid taste, rancid flavour	*Goût de rance*
Rancidity, rancidness	*Rancidité*
Reagent	*Réactif*
Receiving platform	*Quai (plate-forme) de réception*
Redox potential	*Potentiel redox*
Refractive index, refractometer reading	*Indice de réfraction*
Refractive power, refractivity	*Réfraction, pouvoir réfringeant*
Regenerative	*Echangeur de chaleur (récupérateur)*
Rennet casein	*Caséine à la présure*
Rennet cheese	*Fromage à la présure*
Rennet, rennin, runnet, rennet extract	*Présure*
Renneting temperature	*Température de coagulation*
Reneneting time	*Durée de coagulation*
Rind (of cheese)	*Croûte (d'un fromage)*
Ripening of milk before curdling	*Maturation du lait (avant caillage)*
Ripening room	*Chambre de maturation*
Ripening tank	*Tank de maturation*
Ripening vat, cream ripener	*Cuve de maturation*
Roller process	*Procédé du cylindre*
Roller way	*Transporteur à rouleaux*
Roller, working roller	*Rouleau-malaxeur, cylindre*

S

Salt-bitter butter	*Beurre amer*
Salt water, brine	*Eau salée, saumure*
Salting room, brine cellar	*Salle de salage*
Sample	*Echantillon*
Sample bottle	*Flacon à échantillon*
Sampling	*Prélèvement d'échantillon(s)*
Saponification number	*Indice de saponification*
Saturated fatty acid	*Acides gras saturés*
Scent, smell, flavour	*Odeur*
Second stomach	*Bonnet*
Sediment test	*Test de sédimentation*
Separating dishes	*Assiette d'écrémeuse*
Separator, centrifugal seperator	*Ecrémeuse, écrémeuse centrifuge*
Separator slime	*Boue d'écrémeuse*
Shape of the cheese	*Forme du fromage*
Skim (to), to separate, to cream	*Ecrémer*
Skim (skimmed) milk	*Lait écrémé*
Skim-milk cheese	*Fromage maigre*
Skimming degree	*Degré (taux) d'écrémage*
Skimming, separation (mechanical)	*Ecrémage*
Soap taste	*Goût de savon*
Soda ash, sodium carbonate	*Carbonate de sodium*
Solidify (to), to congeal	*Se solidifier, se figer, congeler*
Solids-no-fat	*Extrait sec dégraissé (solides non gras)*
Sour milk	*Lait aigre*
Sour skim milk	*Lait écrémé acidifié*
Soured butter (rupened butter)	*Beurre acidifié (beurre maturé)*
Soured casein	*Caillebotte (caséine acide)*
Souring	*Acidification*
Specific gravity	*Poids spécifique*
Sperm, semen	*Sperme*
Spore	*Spore, sporule*
Spray process	*Procédé de la pulvérisation*
Spread cheese	*Fromage à tartiner*
Stabilizer	*Stabilisateur*
Stable flavour	*Saveur d'étable*
Stainless steel	*Acier inoxydable*
Starter	*Ferment, levain*
Starter heater	*Appareil de préparation des levains purs*
(Starter) jar, (butter culture) jar	*Cuve à levain*
Stassanisator	*Stassaniteur*
Sticky butter	*Beurre collant*
Stirred or granular curd cheese	*Fromage à caillé brassé ou granulé*
Stock (to), to store	*Emmagasiner*
Storage	*Conservation*
Storage room	*Salle (chambre) de stockage*
Storch's test, peroxidase test	*Epreuve de Storch, épreuve de la peroxydase*
Store-room, curing-room	*Entrepôt de fromages*
Strain	*Souche*
Strain (to), to filter	*Filtrer, tamiser*
Strainer board	*Table d'égouttage*
Streaky butter	*Beurre rayé (tacheté)*
Surface cooler	*Réfrigérateur à surface*
Sweet butter	*Beurre doux*
Sweetened condensed milk	*Lait condensé sucré*

T

Tallowy flavour	*Saveur suiffée (de suif)*
Tap	*Robinet*
Texture and body of butter	*Aspect et consistance du beurre*
Texture, composition, structure	*Structure, texture*
Third stomach	*Feuillet*
Through bred, pure bred	*De race pure, pur sang*
Titrate (to)	*Titrer*

Trade-mark	*Marque de fabrique*
Transporting container	*Citerne de transport*
Tube pasteurizer	*Pasteurisateur à tube*
Tuberculosis bacillus	*Bacille de la tuberculose*
Tubes	*Tuyauteries*

U

Udder	*Mamelle*
Unclean smell, unclean odour	*Odeur impure*
Unclean taste	*Saveur impure*
Uneven-coloured butter	*Beurre de coloration irrégulière*
Unsaturated fatty acid	*Acides gras non saturés*
Unsweetened condensed milk	*Lait condensé non sucré*
Upkeep costs	*Frais d'entretien*

V

Vacuum drum process	*Procédé du tambour sous vide*
Vacuum heating	*Chauffage sous vide*

W

Washed curd cheese	*Fromage à caillé lavé*
Washing soda, crystallized sodium carbonate	*Carbonate de sodium cristallisé*
Washing water	*Eau de lavage*
Water bath	*Bain-marie*
Whey	*Sérum, petit lait de fromagerie*
Whey butter	*Beurre de sérum (ou beurre de petit lait) = beurre fabriqué avec de la matière grasse récupérée du lait*
Whey cheese	*Fromage de sérum*
Whey product	*Produit dérivé du sérum*
Whipped cream	*Crème fouettée*
Whole milk, unskimmed milk	*Lait entier, lait non écrémé*
Whole milk cheese, full cream cheese	*Fromage gras*
Whole milkpowder	*Lait entier en poudre*
Working expenses	*Frais d'exploitation*

Y

Yeasty flavour	*Goût levuré*
Yoghurt	*Yoghourt (yaourt)*
Yogurt	*Yaourt*

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