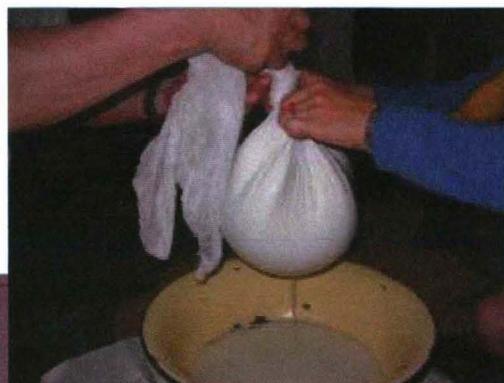


## MISSION ECONET 2007

# Impact de la pollution sur la qualité du lait de chamelle au Kazakhstan

*du 22 mai au 6 juin 2007*



**Bernard FAYE**



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CIRAD-ES 2007

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au Kazakhstan**

**Du 22 mai au 6 juin 2007**

**Bernard FAYE**



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**RÉSUMÉ :**

Cette mission s'inscrit dans les activités de recherches financées dans le cadre du programme ECONET. Deux missions sont programmées cette année au Kazakhstan. Cette mission avait plusieurs objectifs : (1) participer au jury de la soutenance de thèse en cotutelle de G. Konuspayeva à l'université Al-Farabi d'Almaty après la soutenance à l'université de Montpellier II le 22 mars dernier, (2) Etablir les contacts pour le stage d'Emilie Diacono, étudiante du master PARC, notamment dans la région d'Atyrau (stage sur l'impact de la pollution sur la qualité du lait) et mettre en place le contenu du stage sur place, (3), préparer le stage d'A. Meldebekova à Montpellier début septembre (4) Préparer la programmation 2008, (5) Préparer le séminaire d'octobre sur pollution et qualité des produits animaux (demande formulée à l'OTAN), (6) Valoriser la thèse de G. Konuspayeva (rédaction de 2 articles, un troisième en cours).

Pour l'avenir, le SCAC d'Almaty est prêt à prolonger son soutien pour une thèse en cotutelle. Il est proposé d'ailleurs de faire une thèse en binôme (franco-kazakhe) sur le thème des polluants résiduels dans les produits laitiers. Enfin, un séminaire régional sur l'élevage des grands camélidés pourrait être organisé en 2008 avec l'université agraire.



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## RESUME

Cette mission s'inscrit dans les activités de recherches financées dans le cadre du programme ECONET. Deux missions sont programmées cette année au Kazakhstan.

Cette mission avait plusieurs objectifs :

1. Participer au jury de la soutenance de thèse en cotutelle de G. KONUSPAYEVA à l'Université Al-Farabi d'Almaty après la soutenance à l'Université de Montpellier II le 22 mars dernier,
2. Etablir les contacts pour le stage d'Emilie DIACONO, étudiante du master PARC, notamment dans la région d'Atyrau (stage sur l'impact de la pollution sur la qualité du lait) et mettre en place le contenu du stage sur place,
3. Préparer le stage d'A. MELDEBEKOVA à Montpellier début septembre
4. Préparer la programmation 2008,
5. Préparer le séminaire d'octobre sur pollution et qualité des produits animaux (demande formulée à l'OTAN),
6. Valoriser la thèse de G. KONUSPAYEVA (rédaction de 2 articles, un troisième en cours).

Pour l'avenir, le SCAC d'Almaty est prêt à prolonger son soutien pour une thèse en cotutelle. Il est proposé d'ailleurs de faire une thèse en binôme (franco-kazakhe) sur le thème des polluants résiduels dans les produits laitiers. Enfin, un séminaire régional sur l'élevage des grands camélidés pourrait être organisé en 2008 avec l'Université agraire.



## Introduction

En 2006, un projet ECONET sur le thème de l'impact des pollutions sur la qualité du lait a été introduit dans le cadre des appels d'offres ECONET (Ministère des Affaires Etrangères). Ce projet a été retenu pour deux ans, pour un total de 32 000 euros auxquels s'ajoutent des appuis directs de l'Ambassade de France à Almaty (20 000 euros sur 2 ans). Cette collaboration entre le CIRAD et les partenaires Kazakhs (Université Al-Farabi, Université agraire, Académie de nutrition) s'est construite patiemment depuis 1998 au travers de nombreux échanges et missions de recherche qui ont abouti en premier lieu à la première soutenance de thèse d'une étudiante kazakhe en France (thèse de Mlle KONUSPAYEVA) en 2007, et à un nombre appréciable de publications.

Ce rapport de mission relatera donc les principaux enseignements à tirer de la thèse soutenue, puis les actions en cours ainsi que les perspectives à court et plus long terme. Pour les actions antérieures on se reportera aux précédents rapports<sup>1</sup>.

### 1. Thèse de G. Konuspayeva

La thèse de Gaukhar KONUSPAYEVA, intitulée « **Variabilité physico-chimique et biochimique du lait des grands camélidés (*Camelus bactrianus*, *Camelus dromedarius* et hybrides) au Kazakhstan** » a été soutenue publiquement à l'Université de Montpellier II le 22 mars 2007. Le jury comprenait outre moi-même et G. LOISEAU (respectivement directeur et co-directeur de thèse), Mme Eliane DUMAY (Université de Montpellier), Frédéric GAUCHERON (INRA-Rennes), J.P. RAMET (ENSAIA-Nancy), Zacharia FARAH (Institut polytechnique de Zurich) et Anatoly IVASHCHENKO (Université Al-Farabi). La soutenance a été brillante et la plus haute distinction a été attribuée par le jury à l'unanimité. Au-delà des résultats et des aspects formels de la soutenance, il faut souligner la qualité du partenariat que ce travail de thèse a pu susciter à bien des égards. On peut considérer que Mlle KONUSPAYEVA est la pierre angulaire de toute prolongation de notre collaboration, du fait de sa maîtrise désormais du français et surtout des conditions de recherche en France. A l'évidence, son rôle est désormais moteur pour la poursuite de nos actions et le montage de projets.

Au cours de mon séjour, la thèse a été présentée (en russe) au collège des professeurs de la Faculté, en présence de M. MANSUROV, Recteur de l'Université Al-Farabi, et de L. GIRIAT, Attaché de coopération à l'Ambassade de France. S'agissant de la première thèse franco-kazakhe à l'Université Al-Farabi, cette manifestation était d'importance.

Il faut souligner toutefois les difficultés administratives auxquelles est confrontée G. KONUSPAYEVA pour faire reconnaître le diplôme français dans la mesure où sa soutenance en France doit faire jurisprudence. Il semble que ce soit en cours de résolution, mais il a fallu des interventions au plus haut niveau et l'insistance de l'Ambassade de France.

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<sup>1</sup> FAYE B., TOURRAND J.F., 2006. *Mission ECONET 2006. Turkménistan-Kazakhstan*. Rapport de mission CIRAD-EMVT n°2006-17, Montpellier, 59 p.

FAYE B., LOISEAU G., 2006. *Atelier de restitution : les résultats des recherches sur le lait de chamelle au Kazakhstan*. Rapport de mission CIRAD-EMVT n°06-19, Montpellier, 58 p.

J'ai été sollicité également au cours de cette présentation de la thèse, pour resituer le contexte de la thèse et celui de la coopération en cours sur le thème de la « démarche qualité dans la filière lait ». J'ai insisté au cours de ma présentation sur la place du CIRAD dans les dispositifs de recherche en coopération, la place spécifique du réseau que j'anime sur les camélidés (notamment avec la création de l'ISOCARD – *International Society of camelid Research and Development*), et sur le budget correspondant à cette coopération en soulignant l'appui du MAE français, de l'Ambassade de France et du CIRAD (bourses DESI) dans ce budget qui représente en moyenne 28 k€ par an. La part du Kazakhstan dans ce budget demeure anecdotique, mais pourrait s'accroître rapidement dans les prochaines années, les autorités prenant conscience de la pérennité de nos actions, de la qualité de notre coopération et de l'efficacité de cette collaboration en termes de publications et d'échanges scientifiques. A ce titre, la parution d'un article<sup>2</sup> dans *Journal of Dairy Sciences*, revue la plus cotée dans notre domaine, avec un facteur d'impact très important, témoigne du dynamisme scientifique de nos échanges.

Il reste à valoriser encore le travail de thèse et au moins trois articles sont en cours de rédaction (notamment au cours de cette mission) dont certains en annexe :

- un article sur les différences entre les laits de dromadaire des laits de Bactriane sur la base d'une analyse discriminante bayésienne
- un article sur la méta-analyse des références bibliographiques sur la composition du lait de chamelle et le positionnement de nos résultats
- un article sur la composition en acides gras du lait de chamelle.

Un autre travail réalisé par une étudiante de master sur la même base d'échantillonnage et portant sur la microbiologie du *shubat* a été valorisé par un poster<sup>3</sup> mais pourrait faire l'objet d'une nouvelle publication.

## 2. Actions en cours

### 2-1. Stage d'Emilie DIACONO

Dans le cadre du master PARC (Productions Animales en Régions Chaudes) auquel contribue le CIRAD, Emilie DIACONO réalise un stage sur l'impact des métaux lourds sur la composition du lait de chamelle. Ce stage se focalise sur quelques éléments minéraux (plomb, cadmium, arsenic, mercure, zinc) présents dans l'environnement. Ces éléments seront déterminés dans les fourrages consommés par les animaux et le lait des chamelles en lactation dans différentes régions plus ou moins polluées du Kazakhstan.

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<sup>2</sup> KONUSPAYEVA G., FAYE B., LOISEAU G., LEVIEUX D., 2006. *Lactoferrin and Immunoglobulin content in camel milk from Kazakhstan*. J. Dairy Sci., 90, 38-46.

<sup>3</sup> N.Grillet, G.Konuspayeva, B.Faye, D.Montet, G.Loiseau. 2006. Analysis of lactic acid bacteria in raw camel milk and traditional fermented camel milk (Shubat) in Kazakhstan. The 20th International ICFMH Symposium food safety and food biotechnology: diversity and global impact 29 Aug - 02 Sept 2006 Alma Mater Studiorum, Bologna, Italy, p.322.

Les analyses pourront être réalisées sur place (probablement à l'Académie de nutrition), mais le nombre sera forcément limité par le budget opérationnel (les fonds EGIDE ne finançant que des échanges et des réunions, il est impossible de mener ce type de travail sur le seul budget ECONET). L'analyse de chaque échantillon revient au minimum à 2 000 tengues (12,5 €) pour 4 éléments. Par ailleurs, les distances étant très importantes dans ce pays, les déplacements sont toujours problématiques. Aussi, l'appui de l'Ambassade de France a été décisif pour une bonne mise en route de ce stage.

En dépit de ces contraintes, ce stage se déroule dans de bonnes conditions d'accueil à l'Université et auprès des producteurs. L'intégration d'Emilie DIACONO dans l'équipe du Pr. IVASHCHENKO est excellente et sa présence est appréciée des partenaires. Une prolongation de ce travail est envisagée sous forme d'une thèse (voir plus loin).

## **2-2. Thèse d'Aliya MELDEBEKOVA**

Mlle Aliya MELDEBEKOVA est en fin de thèse à l'Université Al-Farabi. Le titre de sa thèse est «*Protein content of camel milk and shubat* ». Un aspect de ce travail de thèse concerne les xénobiotiques et un important travail de synthèse bibliographique tout particulièrement réalisé à partir des données de la littérature en langue russe (assez abondante mais peu accessible à la communauté scientifique internationale) a été réalisé. Ce travail de synthèse est très important pour mieux spécifier les axes des recherches futures à mettre en œuvre et il est prévu qu'il soit présenté au cours de l'atelier international (sous réserve de l'acquisition des financements) prévu à l'automne 2007 à Almaty (voir ci-dessous).

Dans le cadre du budget ECONET, un stage de 2 semaines est prévu pour Mlle MELDEBEKOVA à Montpellier au début de septembre. Ce stage vise à réaliser diverses analyses de métaux lourds à Montpellier et quelques radionucléides à Sofia-Antipolis sur des échantillons de lait de chamelle en provenance de la région d'Almaty et de Tchimkent.

Au cours de la présente mission, les documents administratifs (demande de préparation de mission, lettres d'accueil), ainsi que le programme du stage ont été préparés.

## **3. Perspectives à court terme**

### **3-1. Projet d'atelier (cf. annexe 3)**

Dans le cadre des dispositifs d'appui scientifique de l'OTAN, j'ai soumis un projet d'organisation d'atelier sur le thème de l'impact de la pollution sur la qualité des produits animaux. Ce dispositif dénommé ARW (*Advanced Research Workshop*) m'avait déjà permis en 2004, d'organiser une rencontre à Achkhabad (Turkménistan) sur la sécurité alimentaire en zone désertique, et qui avait abouti à l'édition d'un ouvrage<sup>4</sup> de bonne tenue. Le projet soumis en début d'année est en cours de discussion et les résultats de l'appel d'offres devraient être donnés en juillet. Si la réponse est positive, l'atelier doit se tenir à l'automne prochain à Almaty. On trouvera en annexe du

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<sup>4</sup> FAYE B., ESENOV P., 2005. *Desertification combat and food safety: the added value of camel producers*. Vol. 362 NATO Sciences Series, Life and Behavioural Sciences. IOS press Publ., Amsterdam (The Netherlands), 240 p.

présent rapport, les justifications, le contenu et le programme de ce projet ainsi que les coordonnées et les titres des participants. Selon les règles de l'OTAN, tous les ressortissants proviennent des pays de l'OTAN, du bassin méditerranéen et des pays partenaires d'Asie Centrale.

L'organisation de cet atelier, sous réserve de l'obtention des crédits, est une étape importante de la coopération, car il devrait permettre de constituer un réseau pour la soumission d'un projet européen. Dans le passé, nous avons en effet proposé à plusieurs reprises un projet INTAS sur le thème de l'atelier, malheureusement sans succès pour l'instant.

Par ailleurs, le thème de l'atelier recouvre complètement les activités en cours (stage d'Emilie DIACONO ou thèse d'A. MELDEBEKOVA).

#### **4. Perspectives à plus long terme (2008)**

##### ***4-1. Thèse en binôme : métaux lourds et pesticides dans le lait***

Ce n'est pas dans le temps imparti et le budget proposé par la programmation ECONET que l'on peut aborder avec très grande efficacité un thème aussi complexe que l'impact de la pollution dans l'environnement sur la qualité des produits offerts aux consommateurs. Il est donc envisagé de prolonger les premières actions menées au cours de ce programme par des travaux plus approfondis et, espérons-le, avec d'autres moyens auxquels le Kazakhstan pourrait contribuer plus fortement que par le passé.

L'une des possibilités serait de proposer une double-thèse, l'une réalisée au Kazakhstan par un ou une étudiante de l'Université Al-Farabi, l'autre par un ou une étudiante française avec des séjours en alternance pour les deux candidat(e)s. L'objectif de réaliser ce binôme en 2008 laisse le temps de trouver les financements nécessaires tant au niveau de l'Ambassade de France, de l'Université Al-Farabi que du côté du CIRAD et des bourses françaises.

L'idée générale de cette thèse en binôme serait de travailler sur le même terrain au Kazakhstan, avec un dispositif identique, mais en se focalisant sur différents aspects qui pourraient être les métaux lourds pour l'un, et les pesticides pour l'autre. Les séjours en France ou au Kazakhstan se feraient aux mêmes périodes.

Sous réserve de convaincre les partenaires, deux candidates sont désormais possibles avec E. DIACONO du côté français, ce qui lui permettrait de prolonger les activités de son stage de master, et l'autre avec C. AKHMETSADYKOVA, étudiante en master à l'Université Al-Farabi, francophone et biologiste. Une bourse en cotutelle sera sollicitée auprès du SCAC dès 2008, ainsi qu'un appui logistique.

##### ***4-2. Séjour post-doc***

Dans les cadres des procédures INTAS de l'Union Européenne, il est possible d'organiser des séjours post-doc. Suite à la thèse de G. KONUSPAYEVA, on pourrait envisager de déposer un dossier en 2008 pour un séjour d'une année en France avec un thème de recherche plus approfondie sur les propriétés médicinales du lait de chamelle, thème récurrent mais peu fondé scientifiquement.

Ce travail s'inscrirait dans un projet plus global en cours d'élaboration avec l'INRA de Rennes (F. GAUCHERON), l'Université de Montpellier II (S. MARCHESSAUX) et l'ENSIA-SIARC (G. LOISEAU) sur les propriétés des laits non conventionnels (chamelle, yak, jument, bufflesse).

#### **4-3. Bourses DESI**

Il est envisagé de proposer au moins une demande de bourse DESI (Développement des échanges scientifiques internationaux) pour des partenaires Kazakhs au travers des appels d'offres du CIRAD. Cette demande pour début 2008, pourrait cibler un travail de laboratoire sur le dosage des protéines dans le lait et la taille des micelles, en collaboration avec l'Université Montpellier II.

#### **4-4. Atelier régional sur les camélidés**

Il existe une demande plusieurs fois formulée par les partenaires pour l'organisation d'une manifestation scientifique ouverte aux producteurs, et à la filière en général, sur l'élevage et les productions camélines en Asie Centrale. Une telle manifestation pourrait se faire en 2008 (sous réserve de trouver les financements) en intégrant des aspects commerciaux (structures agro-alimentaires kazakhes intéressées par les produits laitiers traditionnels) et des aspects culturels (utilisation traditionnelle du chameau de Bactriane). On pourrait envisager de placer cet évènement au centre des activités 2008 dans le cadre du programme ECONET. Une première proposition sera faite en fin d'année auprès de l'Université agraire.

### **5. Conclusion**

La coopération ne doit pas s'arrêter avec la soutenance de thèse de G. KONUSPAYEVA. La demande est présente et le temps nécessaire pour construire un partenariat solide et sérieux est tel, que le pas de temps des appels d'offres est souvent insuffisant pour aller au bout des activités de recherches envisagées.

Dans l'avenir, il faut nous appuyer sur les relais locaux pour tenter une nouvelle fois de décrocher des projets européens aux financements plus efficaces, notamment pour permettre les équipements de laboratoire, ce que n'autorise pas le programme ECONET. On peut espérer aussi, que le relai assuré désormais par G. KONUSPAYEVA, porte ses fruits en termes de « lobbying » auprès des correspondants des projets européens au Kazakhstan.



## **ANNEXES**

- ANNEXE 1 - Calendrier et personnalités rencontrées**
- ANNEXE 2 - Résumé de la thèse de G. KONUSPAYEVA  
soutenue à Montpellier le 22 mars 2007**
- ANNEXE 3 - Projet d'atelier international à Almaty  
(octobre 2007)**
- ANNEXE 4 - Projet de thèse en binôme**
- ANNEXE 5 - Articles soumis**



## **ANNEXE 1**

### **Calendrier et personnalités rencontrées**



## Calendrier et personnalités rencontrées

### Mardi 22 mai

- Départ de Montpellier, via Paris et Amsterdam

### Mercredi 23 mai

- Accueil par G. KONUSPAYEVA
- Entretien avec le Pr. IVASHCHENKO
- Entretien avec E. DIACONO (en stage master PARC à Almaty)
- Entretien avec M. NARMURATOVA (en fin de thèse à l'Université agraire)
- Préparation de ma présentation pour la soutenance de thèse de G. KONUSPAYEVA (thèse en co-tutelle)

### Jeudi 24 mai

- Séance de travail à l'Université (discussion sur le projet de thèse d'E. DIACONO)
- Entretien avec A. MELDEBEKOVA (prévue en stage à Montpellier en septembre 2007)
- Pré-soutenance de thèse de G. KONUSPAYEVA (présentation à blanc)

### Vendredi 25 mai

- Préparation de ma présentation Powerpoint
- Soutenance de thèse de G. KONUSPAYEVA à l'Université Al-Farabi

### Samedi 26 mai

- Visite de la vallée d'Ile et du lac Issik avec le Pr. IVASHCHENKO
- Rédaction du projet de thèse

### Dimanche 27 mai

- Entretien avec N. AKHMETASADYKOV
- Visite de Turgen
- Départ pour Atyrau en avion
- Accueil par Dr KOSYBEK IRZAGALIEV (Chef des services vétérinaires de la région d'Atyrau)

### Lundi 28 mai

- Départ pour la ferme de Birinshi Mamyr (Directeur : ESKARIYEV AMANJOL).
- Présentation des résultats du travail de thèse–Essai de fabrication fromagère.

### Mardi 29 mai

- Visite de la ferme de Bibaris
- Départ pour Almaty

### Mercredi 30 mai

- Arrivée à Almaty
- Séance de travail à l'université (rédaction de l'article sur les paramètres discriminants les laits de dromadaire et Bactriane).

- Entretien avec le Pr. M. PRASAD (Université d'Hyderabad –Inde), spécialiste des pollutions dans les plantes, en mission à Almaty.

#### **Jeudi 31 mai**

- Séance de travail à l'Université – Organisation du calendrier des sorties terrain (stage d'Emilie DIACONO).
- Rédaction d'article.
- Entretien avec le Pr. IVASHCHENKO

#### **Vendredi 1er juin**

- Départ pour Koulsai

#### **Samedi 2 juin**

- Fin de la rédaction de l'article sur analyse discriminante (revue visée : Journal of Dairy Sciences)

#### **Dimanche 3 juin**

- Rédaction de l'article sur les acides gras du lait (revue visée : Le lait)
- Début de rédaction de l'article sur la méta-analyse des références bibliographiques sur le lait de chamelle (revue visée : Journal of Dairy Research)

#### **Lundi 4 juin**

- Retour sur Almaty
  - Entretien avec F.O. SEYS et L. GIRIAT (SCAC Ambassade de France)
  - Entretien avec le Pr. SINIAVSKI (Académie de nutrition)
  - Rédaction de l'article sur les lipides

#### **Mardi 5 juin**

- Entretien avec A. NAMIE TOV (Université agraire d'Almaty)
- Rédaction du rapport de mission
- Bilan de la mission avec G. KONUSPAYEVA et budget prévisionnel

#### **Mercredi 6 juin**

- Départ pour Montpellier via Amsterdam et Paris

**ANNEXE 2**

**Résumé de la thèse de G. KONUSPAYEVA  
soutenue à Montpellier le 22 mars 2007**



**Titre : Variabilité physico-chimique et biochimique  
du lait des grands camélidés  
(*Camelus bactrianus*, *Camelus dromedarius* et hybrides) au Kazakhstan.**

Globalement, le lait de chamelle au Kazakhstan est plus riche que ceux décrits dans la littérature, indépendamment de l'origine génétique, géographique ou saisonnière. Il est en particulier riche en matières grasses (5,96%), en matières protéiques (5,02%) et en vitamine C (154 mg/L). Ces valeurs situent en moyenne les laits du Kazakhstan très différemment des autres laits (résultat d'une méta-analyse quasi-exhaustive des publications sur le lait de chamelle).

Par analyse discriminante, il a été possible de distinguer le lait de Bactriane de celui du dromadaire, avec une prédiction à 71%. Les paramètres discriminants sont la teneur en matières grasses, le pH, la concentration en vitamine C, l'indice d'iode, la concentration en calcium et phosphore. La typologie réalisée sur 176 échantillons de lait cru en tenant compte des principaux paramètres physico-chimiques, a permis d'identifier trois types de lait. Ces types de lait peuvent être qualifiés de « lait de chamelle supérieur », « lait de chamelle normale » et « lait de chamelle acceptable pour la fabrication de shubat ». Ces appellations sont basées sur les paramètres physico-chimiques pour lesquels au final, les effets « région » et « saison » ont peu d'influence. En revanche, il est nécessaire de tenir compte de l'effet « espèce ».

Pour les échantillons de shubat, quatre classes de produit ont été identifiées. On observe :

- des shubats les moins acides, mais pauvres en minéraux majeurs essentiellement en hiver et dans les régions de Chymkent et d'Aralsk ;
- les shubats pauvres en vitamine C mais riches en protéines proviennent surtout d'Almaty au printemps ;
- Les shubats les plus riches en fer et phosphore sont des shubats de printemps en provenance de Chimkent et d'Atyraou.
- Enfin, les shubats riches en vitamine C sont les shubats d'été en provenance d'Atyraou et de Chimkent dans une moindre mesure.

Les concentrations en lactoferrine et immunoglobulines G dans le lait cru et fermenté, mais aussi dans le colostrum de chamelle ont été également déterminés et les variations spécifiques, régionales et saisonnières ont été évaluées. Le lait cru de chamelle contient en moyenne  $0,229 \pm 0,135$  mg/mL de lactoferrine et  $0,718 \pm 0,330$  mg/mL d'immunoglobulines G. Dans le colostrum dans la 1<sup>er</sup> semaine de post-partum la lactoferrine varie de 1,422 à 0,586 mg/mL, l'immunoglobuline G – de 132 à 4,75 mg/mL.

Ainsi, « les allégations santé » attribuées au lait de chamelle ne peuvent s'appuyer sur l'affirmation selon laquelle cela serait dû en partie à une plus grande quantité en lactoferrine, ces valeurs étant peu différentes que celles observées dans le lait de vache. Les analyses de la composition en acides gras ont été réalisées sur les mêmes échantillons de lait. Le lait de chamelle contient une part un peu plus élevée d'acides gras insaturés par rapport au lait de vache. De plus, la quantité des acides palmitique, stéarique, oléique et miristique est plus importante chez la chamelle que chez la vache. Ces caractéristiques incitent à confirmer l'intérêt diététique du lait de chamelle et probablement son rôle pour la santé.

**Discipline :** Sciences des aliments

**Mots clés :** Lait de chamelle, *C.bactrianus*, *C.dromedarius*, lactoferrine, immunoglobuline G, acide gras, composition physico-chimique, Kazakhstan

**Laboratoire d'accueil :**

CIRAD TA C-DIR / B Campus International de Baillarguet  
34398 Montpellier cedex 5, France

**Title : Physico-chemical and biochemical variability  
of big Camelidae's milk**

***(Camelus bactrianus, Camelus dromedarius and hybrids) at Kazakhstan***

On average, the camel's milk is richer than it is described in literature not depending on the region, species or season. It is particularly rich on fat matter (5.96%), proteins (5.02%) and on vitamin C (154 mg/l). These values put the camel's milk in very different position than the other types of milk (this is the result of meta-analysis quasi-exhaustive of the publications dedicated to camel's milk).

By the discriminating analysis it was possible to distinguish the milk of Bactrian from the milk of dromedary camels with a prediction of 71%. The discriminative parameters were content of fat, pH, vitamin C concentration, iodine index and Calcium and Phosphorus concentration. The typology realized on 176 samples of the raw milk taking into account the main physico-chemical parameters has permitted to identify three types of milk. Those types may be described as "high quality camel's milk", "normal camel's milk" and "camel's milk suitable for shubat production". These types are based on the physico-chemical parameters for which the effect of "region" and "season" were not remarkable. Otherwise, it is necessary to take into consideration the influence of the "species".

For shubat samples, there were identified four classes. We have :

- the shubat less acid but poor for major minerals, especially in winter and in the regions of Chimkent and Aralsk;
- the shubat poor on vitamin C but rich on proteins from Almaty in spring;
- the shubat richest on iron and phosphorus is a spring shubat from Chimkent and Atyrau. Finally, the shubat rich on vitamin C is summer shubat from Atyrau and, in smaller extent, from Chimkent.

There were also studied the concentrations of lactoferrine and immunoglobulines G in fresh milk, fermented milk and colostrums with the variations of species, region and season. The raw milk contains on average  $0.229 \pm 0.135$  mg/mL of lactoferrine and  $0.718 \pm 0.330$  mg/mL of immunoglobulin G. In the colostrums of the first week post-partum the lactoferrine varies from 1.422 to 0.586 mg/mL, the immunoglobulin G – from 132 to 4.75 mg/mL.

Thus, the health properties which are often attributed to camel's milk cannot be described by the higher content of lactoferrine, because its quantity are very close to known quantities of lactoferrine in cow's milk. There were made the analysis of the fatty acids for the same samples of milk. The camel's milk contains a little bit higher quantity of unsaturated fatty acids than the cow's milk. Also, the quantities of palmitic, stearic, oleic and miristic acids are higher for the camels than for the cows. These characteristics must confirm the interest to camel's milk as to the dietetic product and probably to its role for the health.

**Field :** Food science

**Keywords :** Camel milk, *C.bactrianus*, *C.dromedarius*, lactoferrin, immunoglobulin G, fatty acid, physicochemical composition, Kazakhstan

**Laboratoire d'accueil**

CIRAD TA C-DIR / B Campus International de Baillarguet  
34398 Montpellier cedex 5, France



**ANNEXE 3**

**Projet d'atelier international à Almaty (ARW OTAN)**



# Projet d'atelier international à Almaty (ARW OTAN)

**APPLICATION FORM – updated November 2005**



**NATO PROGRAMME SECURITY THROUGH SCIENCE**

**ADVANCED RESEARCH WORKSHOP**

**NATO Public Diplomacy Division, Bd. Leopold III, B-1110 Brussels, Belgium  
fax +32 2 707 4232 : e-mail [science@hq.nato.int](mailto:science@hq.nato.int)**

1. **Enter Priority Research Topic** (please consult the separate Annex and enter a topic from List I, List II and/or List III)

**Food security**

2. **Proposed Advanced Research Workshop** (please select a short title that is comprehensible to the non-specialist)

**Title:**

**IMPACT OF POLLUTION ON ANIMAL PRODUCTS**

**Location (site and country):** **Kazakhstan**

**Dates:** **september 2007**

**Number of working days:** **3 days**

*Objective (concise scientific goal of meeting):*

The main objectives of the ARW are:

- to share the informations on the main risks due to pollutants in Kazakhstan and other countries from Central Asia
- to evaluate the true impact of the pollution on animal products intended for human consumption
- to propose a logical framework to set up a professional training for quality control in animal products

*Type of Workshop (mainly invitation; wide advertising for participants; other – specify)*

Invitation of scientists, professionals (vet services, hygiene control) and students for conferences. Wide advertising for participants from agro-food industries.

2. **Proposed Co-Directors** – (one from a NATO and one from a Partner country)\*

**(i) NATO-country co-director:**

**Surname/First Name(s)/Title** Faye Bernard Dr

**Date of Birth:** 12/06/50

**Institute and Address:** CIRAD-EMVT

Campus International de Baillarguet TA 30/A  
34398 Montpellier cedex France

**Telephone/Fax/E-mail:** Tel: (33) 4 67 59 37 03 fax : (33) 4 67 59 37 95 ou 96

[faye@cirad.fr](mailto:faye@cirad.fr)

**Signature:** \_\_\_\_\_

**(ii) Partner-country co-director:**

**Surname/First Name(s)/Title:** Sinyavskiy Yuri Aleksandrovich /Pr

**Date of Birth:** 11/11/1951

**Institute and Address:**

Nutrition Academy  
Klochkov str 66,  
Almaty, index 480008

**Telephone/Fax/E-mail:** 3272-42-89-50/42-15-29/ [Sinyavskiy@list.ru](mailto:Sinyavskiy@list.ru)

**Signature:** \_\_\_\_\_

*We should be much obliged if in using the Latin alphabet applicants would please use the same spelling throughout the application*

**3. Key Speakers (names, affiliations and indication of the degree of their commitments – i.e. firm +++, tentative ++, not yet contacted +)**

<b>Surname Initials</b>	<b>Title</b>	<b>Institute</b>
1. Aijanov M.M. Dr	Kazakh Academy of nutrition, laboratory of ecology and nutrition, Kazakhstan	
+++		
2. Babaev I.I. Dr	Tajik Ministry of healthcare, hygiene department, Tadjikistan	+++
3. Belonog A.A. Dr	ministry of healthcare of Kazakhstan, Sanitary doctor, Kazakhstan	+++
4. Fayzieva D. Kh.Dr	academy of Sciences, hygiene and environment. Medicine, Uzbkistan	+++
5. Kenesariiev U.I.Pr.	Kazakh national Medical University, head of hygiene and ecology chair	+++
6. Ospanov K.S. Dr.	Station of Sanitary-epidemiology, Kazakhstan	+++
7. Sharmanov T. Sh	Academician, Kazakh Academy of nutrition, president, Kazakhstan	+++
8. Zhakashev N. KH Pr	Kazakh national medical university, Kazakhstan	+++
9. Rychen G., Dr	National Agro-food industry High School, France	+++
10. Jouany J.P., Dr	National Agronomic Research Institute, France	+++
11. Cattaneo D., Pr	Milan University, Food quality department Italy	+++
12. Thomas G. Pr	Lancaster university, department of environmental Sciences, UK	+++
13. During R.A. Pr	Giessen university, Environmental chemistry	+++
14. Ronchi B., Pr	Tuscia university, department of animal production, Italy	+++
15. Focant J.F., Pr	Liege university, Mass spectrometry lab., Belgium	+++
16. Seboussi R. Dr	Saint-Hyacinthe veterinary school, Canada	+++
17. Mebelkova A.	University Al-Farabi, Kazakhstan	+++
18. Konuspayeva G.	University Al-Farabi, Kazakhstan	+++
19. Jargalsaihan L.Pr	Ministry of nature and environment, Mongolia	+++
20 Jones S. Dr	Lancaster university, Institute of biological sciences, UK	++
21. Tuinstra L.G. Dr	Institute of control quality of agricultural products, Netherland	++
22. Tedesco D., Pr	Milan University, Food quality department Italy	+++

**4. Key Words:**

Milk – meat – pollutants – food safety – food security

**6. Grant requested (i.e. costs to be covered by NATO)**

**AMOUNT IN EUR**

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- Please note that names, affiliations and e-mail addresses may be published by NATO in the context of providing information on the Science Programme. Inclusion of these details here implies authorisation for their use for this purpose.

**7. Justification for the proposed Advanced Research Workshop:** need, importance, timeliness, motivation, general approach, etc. (*A detailed programme should be presented at Annex 1*)

**General justification**

In Central Asia, the production and the consumption of meat and traditional fermented milk products (*koumis, shubat, chal, agaran, doïran, kurut*) is a common fact. With a yearly consumption per capita of 210 litres of crude of fermented milk and 43.9 kg of meat, people from Kazakhstan are among the highest animal food protein consumers in the Central Asia. These products are culturally very important and are

typical of these countries. They play a strong role for maintaining rural activities in desert areas zones. The traditional milk products, which come from horse and camel, are highly appreciated because scientists and consumers attribute them probiotic and medicinal properties. Elsewhere, the cow, camel and horse farms are currently settled in polluted zones from the steppe (chemical, heavy metals and radionuclide pollution). Some regions in Kazakhstan and Kyrgyzstan are highly affected by soil and plant contamination. The chronicle contamination of regular milk consumers in Central Asia is not very well documented. Some authors said that a regular camel or horse milk consumption is quite useful to thwart the pollution effect. But, if many scientific publications from these countries affirm that, most of the knowledge is empirical and the experimental procedures to prove these properties could be largely improved. Secondly, the true effect of pollution pressure on milk and meat composition is not studied in the traditional milk from camel and horse.

#### ***Specific justification***

At the Soviet Union time, all the collective farms (*kholkoze, sovkhoze*) could be considered as experimental where the scientific innovations were directly applied according to the objective of the planned economy. They had standardised practices and methods for the production, for processing and marketing the products. After Soviet Union collapse, division of collective structures into small privatised production units, local and individual know-how formerly used for self-consumption became predominant. This leads to a wide type of process and variable quality of the traditional milk products, in the same time highly competed with the industrial products “western type” proposed by modern dairy plants in sub-urban areas. Elsewhere, in some part of the NIS countries the farms are situated in high polluted areas and contaminants as heavy metals and radionuclides could be widely present in the environment. The risk for milk contamination is not well documented. Therefore, the research has to take in account the new deal: how to characterise and manage the diversity of traditional milk product processing? How to reach the market with a safe products answering to the taste and to the needs of the urban consumers? Those new approaches are necessary to propose products with guaranteed standard quality able to fit international market conditions.

A common research on traditional milk characterisation was started between French and Kazakh partners since 1999. Several scientist and student exchanges were achieved between 1999 and 2006 and a PhD is currently achieved in close collaboration between CIRAD and University Al-Farabi at Almaty. The objective of those common researches is to initiate a team for implementing high level research in food hygiene and technology. Secondly, the implementation of a training module for the students in this field will be relevant for the future with the development of the demand in food safety and quality. A TEMPUS project is envisaged in the near future to contribute for this team implementing.

The expected results would be quite operational first to manage updated processed traditional products (for example by using specific strain of lactic bacteria) and second to initiate a new approach for food production in NIS based on the European system of “sign of quality” of those traditional products guarantying their quality (including contaminants due to made-man pollution) and their origin. Elsewhere, the use and the control of new analytic methods for the characterisation of the traditional milk products quality represents a good scientific progress for the NIS partners and agro-food industry in those countries.

According to the main objectives of the ARW, it is expected:

1. To share the informations on the main risks due to pollutants in Kazakhstan and other countries from Central Asia: Numerous informations are available in Central Asia and some researches were achieved, for example to evaluate POP (Permanent Organic Pollutants) in human milk. But the true impact of the polluted area and type of pollutant on animal products is not well documented. To review the current situation in the different regions and countries of former Soviet Union, this ARW will appeal to ecologists, biochemists, zootechnicians working on this aspect.
2. To evaluate the true impact of the pollution on animal products intended for human consumption: the links between soil contamination, plant pollution and human intoxication (chronic or acute) is not very documented. To share the information and evaluate the expected impact on human health through the animal product consumption, the ARW will appeal to human epidemiologist and doctors
3. to propose a logical framework to set up a professional training for quality control in animal products: this aspect is important for operational point of view by setting up of a logical framework in the aim to propose multidisciplinary research project to international community (for example through INTAS project).

**8. Number of Key Speakers (K) and estimated number of Other Participants (P) by country**

	K	P		K	P		K	P
<i>NATO COUNTRIES</i>			<i>ELIGIBLE PARTNER COUNTRIES*</i>			<i>NON-ELIGIBLE PARTNER COUNTRIES*</i>		
Belgium	1		Albania			Austria		
(Bulgaria)**	---	--	Armenia			Finland		
Canada	1		Azerbaijan			Ireland		
Czech Republic			Belarus			Sweden		
Estonia			Bulgaria**			Switzerland		
Denmark			Croatia					
France	3	1	Georgia					
Germany	1		Kazakhstan	9	15	<i>MEDITERRANEAN DIALOGUE COUNTRIES</i>		
Greece			Kyrgyz Republic			Algeria		
Hungary			Moldova			Egypt		
Iceland			Romania **			Israel		
Italy	2	1	Russian Federation			Jordan		
Latvia			Tajikistan	1		Mauritania		
Lithuania			the former Yugoslav Republic of Macedonia <sup>(1)</sup>			Morocco		
Luxembourg			Turkmenistan			Tunisia		
Netherlands	1		Ukraine					
Norway			Uzbekistan	1				
Poland								
Portugal						<i>OTHER COUNTRIES – specify - lecturers only</i>		
(Romania)**	---	--				Mongolia	1	
	-	--						
Slovak Republic								
Slovenia								
Spain								
Turkey								
UK	2							
USA								
<b>SUB-TOTAL</b>	11	2	<b>SUB-TOTAL</b>	11	15	<b>SUB-TOTAL</b>	1	
<b>TOTAL</b>	13		<b>TOTAL</b>	26		<b>TOTAL</b>	1	

<sup>(1)</sup>Turkey recognises the Republic of Macedonia with its constitutional name

PARTICIPANT TOTALS	
From NATO countries**	13
From Eligible Partner *** or Mediterranean Dialogue countries	26
From Non-Eligible Partner or Other countries	1
<b>Total Number Participants</b>	<b>40</b>

- Eligible/Non-eligible Partner countries means those countries which are members of the Euro-Atlantic Partnership Council (EPAC), and are/are not eligible for support under the Security Through Science Programme.

\*\* NATO countries **Bulgaria** and **Romania** may still be considered as ‘Partners’ in this context, in accordance with special provisions in place. See Notes for Applicants.

9. **Estimated Cost** (see section on funding in Notes for Applicants)

	<b>PROPOSED SUBSIDIES TO INDIVIDUALS (1)</b> (No x Amount)	<b>Total Estimated Cost In EUR</b>	<b>Costs to be Covered by NATO In EUR</b>
<b>(a) LIVING EXPENSES</b>			
Director from NATO country	110 x 10 d x 2 missions	2200	1100
Local Key Speakers	5 x 70x 5d	1750	1750
International Key speakers	14 x 70 x 5d	4900	4900
Other Participants (local)	15 x 20 x 5d	1500	1500
International	2 x 70 x 5d	500	500
<b>(b) TRAVEL EXPENSES</b>			
Directors and Key Speakers - from Europe	11 x 1200	13200	12000
- from USA/Canada	1 x 1800	1800	1800
- from elsewhere	3 x 600	1800	1800
Other Participants - from Europe	2 x 1200	2400	2400
- from USA/Canada	x		
- from elsewhere	x		(2)
<b>© RENTALS</b> – if charged separately from (a) (e.g. conference rooms, equipment, transport) specify			
Conference room		600	200
Computer et videoprojector rent		1800	800
Local Transport		1000	500
Bus rent for field day trip		300	300
<b>(d) CLERICAL AND TECHNICAL ASSISTANCE (specify)</b>			
Stationery		500	200
Copy service		500	200
Photo service		200	100
<b>(e) ORGANIZATIONAL EXPENSES (3)</b>			
- publicity		200	100
- mail, fax, telephone charges		1200	600
- lecture notes		600	300
- other (specify)			
Written translation of reports		1500	1000
Synchrony interpretation		1500	1000
<b>(f) DIRECTORS' DISCRETIONARY FUND</b> (covers items not specified above. Up to EUR 1,250 to be used at discretion of directors)			
Employment costs Coordinator and secretary		600	600
Souvenirs 40 x 15		600	600
Farewell supper 40 x 15		600	0
<b>(g) OTHER (specify)</b>			
Contingencies		500	100
<b>ESTIMATED TOTAL COST</b>		<b>42250</b>	<b>34350</b>
<b>ESTIMATED INCOME</b> (break down under item 10)			

Please indicate here the estimated cost of living per person for the full duration of the ARW:  
EUR

(1) For NATO-funded participants only: the resulting amount should correspond to the figures indicated in the right-hand column.

(2) For ARW participants from NATO member countries, Partner countries and Mediterranean Dialogue countries only.

(3) The costs related to the preparation of the manuscript for publication in the NATO Science Series are covered by a separate grant of EUR 2,500 and thus should not be included here.

**10. Breakdown of estimated income (in EUR) -  
from NATO (estimated income from right-hand column of item 9): 34350**

**from other funding institutions (details below):**

**contribution from participants:**

*Total (estimated income from left-hand column of item 9):*

**Details of funding from other institutions:**

amounts already awarded: 10000 €

sources: French Embassy (Cooperation service)

amounts expected: 2000 €

sources: French Ministry of Foreign Affairs

(ECONET programme)

**11. Organizing Committee members, starting with Directors (from at least three countries)**

	Name	Position	Official address
(a)	Pr. A. Sinyavsky	Co-director	Laboratory Biotechnology of Special Products. 050008, 66 Klochkov str., Almaty, Kazakhstan.
(b)	Dr B. Faye	Co-director	CIRAD-EMVT Campus international de Baillarguet 34398 Montpellier Cedex, France
©	Mrs A. Meldebekova	Coordinator	Chair of biotechnology, biochemistry and plant physiology, Biology faculty, University Al-Farabi, Av. Al-Farabi, 71, 050073 Almaty, Kazakhstan
(d)	Mrs G. Konuspayeva	Secretary	Chair of biotechnology, biochemistry and plant physiology, Biology faculty, University Al-Farabi, Av. Al-Farabi, 71, 050073 Almaty, Kazakhstan

*(Enclosure of curriculum vitae is mandatory for Directors and desirable for other members)*

**12. Indicate any previous involvement of Organizing Committee members in NATO programmes, particularly ARWs or ASIs**

LST.ARW 980162: Desertification combat and food security. Ashkabad, Turkménistan, 19-21/04/04

13.

**(a) What is the proposed title of the book to be published in the NATO Science Series as an output of the meeting?**

Impact of pollution on animal products in Europe and Central Asia

**(b) If you do not intend to publish in the NATO Science Series, what type of publication is planned?**

**(c) What are the most recent books on the same subject?**

No book on that specific aspect. There are books on POPs in general.

**14. Are you aware of any other scientific meetings in the proposed subject area planned for the same year?**

*(please indicate title, date and type of the meeting)*

Not at my knowledge

## TENTATIVE PROGRAMME, TIMETABLE AND ORGANIZATION

Set out in as full detail as possible the timetable with key speakers (*names only*), titles of lectures or other activities. Please note that the ARW should last for 2-5 working days.

### 1<sup>st</sup> day

*Under time-tables of airlines*      The meeting of participants of the workshop, their registration and accommodation in hotel  
Cultural program      *Organizing committee*

### 2nd day

**a.m.**

Opening of the workshop:

**Behalf of the ministry of Environment protection**

**Behalf of the Ministry of health**

**Pr Sharmanov:** the greetings of the Nutrition Academy

**Pr Mansurov,** the greetings of the rector of Al-Farabi University

**Pr Siniavsky, Dr B. Faye:** the introduction of the participants

**p.m.**

*The pollution area and pollution origin in Central Asia and in Western countries*

<b>Pr Bigaliev,</b> University Al-Farabi, Kazakhstan	Pollution situation in Kazakhstan
<b>Dr Jargalsaihan,</b> Ministry of Nature and Environment, Mongolia	The POPS situation in Mongolia
<b>Dr Babaiev,</b> Ministry of Healthcare, Tadjikistan	Ecological and hygienic aspects of using pesticides in agriculture in conditions of Tadjikistan
<b>Pr Belonog,</b> Ministry of health, Uzbekistan	The current POP situation in Uzbekistan
<b>Dr Rychen,</b> INRA, France	The pollution origin in Europe
<b>Pr Jones,</b> Lancaster University, UK	??
<b>Pr Tuinstra,</b> Insitute of control quality, Netherland	??

### 3rd day

*Relationships between Soil contamination, plant contamination and animal products status*

**a.m.**

<b>Pr Sharmanov,</b> Nutrition Academy, Kazakhstan	Problems of pollution in Food stuffs
<b>Pr Thomas,</b> Lancaster university, UK	
<b>Pr Ronchi,</b> Tuscia university, Italy	Contamination by persistent chemical pesticides in Livestock production system
<b>Dr Fayzieva,</b> , Academy of Sciences, Uzbekistan	??
<b>Dr Kanesariev,</b> medical university, Kazakhstan	Environment and population health in Oil-Gas regions of RK
<b>Dr Zhakashev,</b> Medical university, Kazakhstan	Environment and population health in nuclear polygon region
<b>A. Meldebekova,</b> Al-Farabi, university, Kazakhstan	Pollution of camel milk in Kazakhstan

**p.m.**

<b>Pr Focant,</b> Liege university, Belgium	POP measurements in food and feed
<b>Dr During,</b> Giessen University, Germany	Transfer of organic and inorganic pollutants from soil to plants and from plants to grazing animals
<b>Pr Cattaneo,</b> Milan University, Italy	Selenium and poultry products
<b>Dr Seboussi,</b> Montreal University, Canada	Selenium toxicity in camels
<b>Dr Faye,</b> CIRAD, France	Heavy metals in camel milk
<b>Dr Konuspayeva,</b> Al-Farabi University,KZ	Variation factors of macro-elements in camel milk

#### 4th day

##### *Relationships between Soil contamination, plant contamination and animal products status (ctd)*

a.m.

**Pr Ospanov**, Station of epidemiology, KZ

**Dr Tedesco**, Milan University, Italy

Strategy of agencies of the Kazakh State

Reduction of mycotoxins in poultry and ruminants by use of natural substances.

**Dr Jouany**, INRA, France

**Pr Focant**, Liege university, Belgium

**Pr Aijanov**, Academy of nutrition, Kazakhstan

Milk contamination by Mycotoxines present in feed

Levels and trends in food-feed-human for dioxins and PCBs.

Nitrosamines and their precursors in some foods in Kazakhstan

##### *Operational plan for the future*

p.m.

Working groups for final recommendations

- **group I: needs for further research and Common project**

- **group II: Strategy for prevention of POPs in animal products**

Synthesis of the recommendations

#### 5th day

All-day field visit

(proposal: Charyn, singing dunes???)

#### List of the key speakers

1. Aijanov M.M. Dr, Kazakh Academy of nutrition, laboratory of ecology and nutrition, Kazakhstan  
[Aidjanov@yahoo.com](mailto:Aidjanov@yahoo.com) Tel/Fax??  
Dr Aijanov is the head of the laboratory
2. Babaev I.I. Dr, Tajik Ministry of healthcare, hygiene department, Tadjikistan Email, tel/fax ??  
Dr Babaev is the head of Hygiene department at the Ministry of Healthcare in Tajikistan
3. Belonog A.A. Dr, Ministry of healthcare of Kazakhstan, Sanitary doctor, Kazakhstan  
Email, Tel, Fax??  
Dr Belonog is vice-minister and the main state sanitary doctor of Kazakhstan at the Ministry of health
5. Kenesariev U.I. Pr., Kazakh national Medical University, hygiene and ecology chair Email, Tel/Fax??  
Pr Kenesariev is the head of hygiene and ecology chair
6. Ospanov K.S. Dr. Station of Sanitary-epidemiology, Kazakhstan  
[rses@netmail.kz](mailto:rses@netmail.kz), tel/fax??  
Dr Ospanov is the main doctor of sanitary-epidemiology station and vice-sanitary doctor of republic of Kazakhstan
7. Sharmanov T. Sh Academician Kazakh Academy of nutrition, president, Kazakhstan  
[Sharmanov.t@mail.ru](mailto:Sharmanov.t@mail.ru), Tel/fax??  
Pr Sharmanov is a well-known academician, president of the Nutrition academy and author of many papers on effect of pollutant on human health (?)
8. Zhakashev N. KH Pr Kazakh national medical university, Kazakhstan  
Email, Tel/Fax??  
Dr Zhakashev is ?? at the chair of common hygiene and ecology. His studies are focused on??

9. Rychen G., Dr USC INRA / INPL / ENSAIA / Univ. Nancy 1 : Animal et Fonctionnalités des Produits Animaux ENSAIA 2 avenue de la Forêt de Haye - BP 17254505 Vandoeuvre-Les-Nancy Cedex, France  
[guido.rychen@ensaia.inpl.nancy.fr](mailto:guido.rychen@ensaia.inpl.nancy.fr)  
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**ANNEXE 4**

**Projet de thèse en binôme**



### **Justification scientifique**

En Asie Centrale, la production et la consommation des produits laitiers sous forme de produits fermentés est très répandue. Avec une consommation *per capita* de 210 litres de lait cru et fermenté, le Kazakhstan apparaît comme un pays de forte tradition laitière.

Les produits laitiers (shubat, fabriqué à partir du lait de chamelle ou koumis, à partir de lait de jument) sont culturellement importants et contribuent à l'identité de la culture des steppes. De plus, la production laitière à partir d'espèces non conventionnelles (chameaux, juments, secondairement yaks) représente un atout essentiel du maintien d'une activité économique dans les zones rurales les plus marginales du pays.

Les produits laitiers de ces espèces sont surtout appréciés pour leurs propriétés (avérées ou supposées) médicinales et probiotiques. Cependant, l'élevage des animaux laitiers, source de ces produits, se pratique souvent dans des régions ayant subi au cours de l'histoire récente, et tout particulièrement pendant la période soviétique, des formes de pollution d'origine diverse dont on a pu décrire dans la littérature les conséquences sur la santé publique. Ces régions steppiques fréquemment polluées par des éléments chimiques, minéraux ou radioactifs sont marquées par des contaminations importantes des sols, des ressources en eau, des plantes et donc indirectement des fourrages destinés aux animaux. Si la recherche s'intéresse aux conséquences humaines des intoxications aiguës, la contamination chronique par des consommateurs réguliers de lait en Asie Centrale est peu documentée. *A contrario*, certains auteurs affirment (sur des bases scientifiques discutables) que la consommation régulière de lait de chamelle ou de jument représente un facteur de protection contre certaines pollutions (notamment par les éléments radioactifs).

En réalité, ni l'impact de la pollution sur la composition de ces laits, ni l'effet bénéfique supposé de ces laits sur la santé des consommateurs en termes de protection contre les effets délétères d'un environnement pollué, ne sont vraiment renseignés dans la littérature scientifique, et des études sérieuses manquent pour étayer ces hypothèses.

### **Contexte de l'étude**

A l'époque soviétique, les structures collectives (*kolkhoze*, *sovkhoze*) pouvaient être considérées comme des stations expérimentales où les chercheurs pouvaient tester leurs innovations appliquées directement en fonction des objectifs du plan. Cela pouvait aboutir à des procédures standardisées pour la production, la transformation et la commercialisation des produits. Après la chute de l'Union Soviétique, les unités de production privatisées, souvent de taille réduite, ont mis en œuvre leurs propres pratiques et leur propre technologie de transformation conduisant à une plus grande diversité des produits souvent utilisés pour l'autoconsommation. La concurrence, dans le domaine laitier, des produits de type « occidentaux », a conduit la filière à chercher à son tour des débouchés commerciaux pour ses produits plus traditionnels et donc plus originaux sur le marché international. Cependant, cette volonté d'exportation se heurte à la nécessité de proposer des produits de qualité connue et reconnue sur la base de données récentes fiables et s'appuyant sur des techniques nouvelles d'analyse.

Par ailleurs, les fermes de production laitière peuvent se situer dans des zones polluées. De plus, les risques de contamination du lait sont mal évalués, hormis de nombreuses

références sur le lait de femme. Aussi, la recherche doit pouvoir répondre à plusieurs questions :

- Comment caractériser et gérer la diversité des processus de transformation des produits laitiers ?
- Comment apprécier l'impact des polluants sur la composition du lait et la présence des résidus ?
- Comment atteindre les marchés nationaux et internationaux avec des produits fiables répondant au goût et aux besoins des consommateurs urbains ?

Ces approches sont nécessaires pour proposer des produits avec une garantie de qualité standard capable d'atteindre les conditions du marché international.

Un programme de coopération scientifique entre le CIRAD/Université de Montpellier et l'Université Al-Farabi à Almaty (Kazakhstan) sur la caractérisation des produits laitiers traditionnels a démarré depuis 1998. Cette coopération s'est traduite par de nombreux échanges de chercheurs et d'étudiants et une thèse en cotutelle a pu être soutenue en 2007. Cette thèse portait sur la caractérisation biochimique et physico-chimique du lait de Bactriane, dromadaire et hybride. Dans la phase suivante du projet, il est proposé une thèse en binôme (une thèse française et une thèse kazakhe) sur le problème des résidus xénobiotiques dans le lait d'animaux élevés dans des zones polluées. Ces travaux visent à proposer une approche nouvelle sur les signes de qualité intégrant le problème des contaminants (métaux lourds, pesticides). Ces travaux peuvent s'inscrire dans la soumission d'un projet INTAS maintes fois proposée, mais jamais gagnée pour l'instant en dépit des bonnes notes scientifiques obtenues.

### **Protocole de la thèse**

#### **Dispositif de terrain**

Quatre régions du Kazakhstan seront choisies pour l'importance des sources de pollution. Ces zones (sous réserve de modification) pourraient être :

- région d'Almaty où il existe plusieurs sources de pollution minérale (*cf. carte*) telles que le Baryum, ainsi que des pesticides



- région de Chymkent, où les sources de pollution chimique et minérales (Arsenic, plomb, métaux rares, argent) sont fréquentes,



- région d'Atyraou située à proximité des zones pétrochimiques,
- région de Semipalatinsk marquée par une importante pollution chimique et nucléaire.

Les 3 premières régions sont des zones d'élevage des grands camélidés, alors que la région de Semipalatinsk est plutôt une zone d'élevage des bovins et chevaux. Le protocole d'étude n'est pas nécessairement centré sur une éventuelle variation saisonnière, mais plutôt sur la variabilité zonale autour des sources primaires de pollution. Il conviendra donc d'établir un zonage si possible concentrique autour des points polluants pour établir le plan d'échantillonnage (choix des fermes et des zones de pâturages). Le diamètre des zones concentriques dépendra des obstacles du relief (montagnes, bassins versants) et des vents dominants. Il y aura donc au préalable, un travail de zonage géographique (avec GPS) permettant d'établir une carte précise servant de base d'échantillonnage.

Au total, il serait souhaitable de disposer d'au moins 5 à 10 fermes par source majeure de pollution identifiée. Dans ces fermes, il faudrait se concentrer sur les animaux producteurs.

### **Protocole de prélèvements**

L'objectif étant de travailler sur la chaîne de contamination allant de la ressource alimentaire au produit final (lait et éventuellement viande), les prélèvements devront concerner la ressource (fourrages, eau qui peuvent être contaminés ou accumuler certains éléments) et les produits finaux fournis par les animaux en fonction de leur utilisation majeure (lait, viande).

Il est suggéré :

- ◆ un prélèvement d'eau dans chaque ferme,
- ◆ des prélèvements des principaux fourrages consommés par les animaux (limiter l'échantillonnage à une seule saison, par exemple le printemps, pour éviter d'éventuels facteurs de variation saisonnière)<sup>5</sup>,
- ◆ des prélèvements de lait sur le lait de mélange dans chacune des fermes aux mêmes périodes que les prélèvements de fourrages,
- ◆ un prélèvement de viande sur un animal par ferme si cela est possible en fonction des objectifs d'abattage des différentes fermes. Le prélèvement de viande sera fait toujours sur le même muscle (par exemple le diaphragme de faible valeur commerciale),
- ◆ un prélèvement de gras dans la zone de stockage adipeux principal, c'est-à-dire la bosse. En cas de non abattage dans une ferme, une biopsie de bosse pourra être pratiquée, sous réserve de la quantité nécessaire pour les analyses. En effet, notamment les pesticides sont généralement stockés dans les tissus adipeux des animaux.

### **Analyses de laboratoire**

Le principe étant de mettre en place un dispositif commun pour des analyses complémentaires, on peut concevoir un lot d'analyses séparées entre les deux thèses.

- Analyse des métaux lourds et des éléments traces potentiellement toxiques : les principaux métaux analysables sont : fer, cuivre, strontium, arsenic, zinc, sélénium, bore, baryum, aluminium, molybdène, chrome, nickel, plomb, manganèse, cobalt et cadmium. Tous ces éléments ne pourront pas être analysés (ne serait-ce que pour des raisons budgétaires). Seront retenus les éléments faciles et peu coûteux à analyser et les éléments dont la présence est attestée dans les sources polluantes.
- Analyse des pesticides : au-delà de la dioxine et des principales molécules disponibles dans l'industrie phytosanitaire (organochlorés et organophosphorés), une « enquête préliminaire » sera nécessaire pour arrêter la liste des produits à analyser. Concernant les champs pétrolifères, il faudra probablement se concentrer sur certains composés de type hydrocarbures polycycliques dont fait partie d'ailleurs la dioxine, mais aussi les polychlorobiphényles (PCB) et les hydrocarbures aromatiques polycycliques (HAP).

### **Partenariat**

Aussi bien le travail de terrain que les analyses de laboratoire, nécessitent un partenariat fort. Au Kazakhstan, le partenariat existe avec l'Université Al-Farabi d'Almaty, mais d'autres partenaires seront indispensables pour réaliser certaines analyses. Un appui des autorités locales sera également nécessaire.

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<sup>5</sup> On se limitera aux éléments principaux de la ration car c'est la quantité ingérée qui importe plus que la diversité des ressources alimentaires.

En France, on s'appuiera sur des laboratoires d'analyse spécialisée. En particulier, certains dispositifs analytiques sont disponibles à l'INRA de Theix (équipe de J.P. JOUANY) et à l'ENSAIA de Nancy (équipe de G. RYCHEN). Les métaux lourds peuvent être dosés en grande partie au CIRAD.

### **Budget**

La thèse kazakhe pourra bénéficier d'une bourse de l'Ambassade de France à Almaty pour les séjours en France, notamment dans le cadre d'une thèse en cotutelle avec l'Université Montpellier II. Une partie des crédits de fonctionnement pourrait être permise par les actions incitatives du CIRAD et un dispositif programmatique d'actions intégrées (programme ECONET). Il reste à trouver une bourse pour la thèse française avec un minimum de fonctionnement qui peut être également permis par les appuis incitatifs du CIRAD en direction des thésards. Au cours de la préparation de la thèse, un budget approximatif doit être précisé en fonction du nombre et du coût des analyses.

### **Calendrier**

En l'état actuel des choses, il est délicat de proposer un calendrier précis, mais on peut aisément prendre accord pour des thèses en alternance de 6 mois en France et 6 mois au Kazakhstan chaque année. Les dispositifs de prélèvements devront plutôt centrer la période « kazakhe » (K) entre mars et septembre et la période « française » (F) entre octobre et février de chaque année. Une première approche pourrait proposer le calendrier suivant :

	An 1				An 2				An 3			
	F	K	K	F	F	K	K	F	F	K	K	FK
Biblio	■	■			■				■			
Pré-enquête		■										
Prélèvements et enquête		■	■			■	■					
Analyses de laboratoire				■	■			■	■			
Traitement des données					■				■	■		
Rédaction											■	■



**ANNEXE 5**

**Article soumis dans « Journal of Dairy Sciences »**



**Discriminant parameters of Bactrian  
(*Camelus bactrianus*)  
and dromedary (*Camelus dromedarius*)  
camel milk in Kazakhstan**

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**ABSTRACT**

The cohabitation of Bactrian camels, dromedary camels and their hybrids is a common feature in Kazakhstan. On 147 milk samples coming from these two species and their hybrids, a discriminant analysis was achieved after discarding the seasonal and regional variability. The retained parameters after a first screening by ANOVA procedure were total proteins, fat matter, iodine index, vitamin C, pH and phosphorus. The most discriminant parameter were phosphorus (linear discriminant coefficient = -1.00), pH (-0.408), vitamin C (-0.377) and fat matter (-0.226), in higher concentration in Bactrian camel milk compared to dromedary. Only iodine index (0.287) was higher in dromedary camel milk. After quadratic discriminant analysis, it was possible to predict the species from their milk composition with a percentage of well-classed at 75.4 %. The milk composition of hybrids was intermediate for most of the parameters, but as the hybridizing level was not well-known, it was not possible to discriminate clearly the hybrid groups.

**Keywords:** Camel milk, dromedary, Bactrian camel, hybrid, discriminant analysis

**Abbreviations:**

Ca: Calcium

Da: Dornic acidity

De: Density

Fe: Iron

FM: fat matter

II: iodine index

La: lactose

P: Phosphorus

SDM : skimmed dry matter

TP: total protein

VitC : vitamin C

PCAIV: principal component analysis with respect to orthogonal instrumental variables

## INTRODUCTION

The camel population in Kazakhstan included two species of camels (*Camelus bactrianus* and *Camelus dromedarius*) and a wide range of hybrids with different level of hybridising (Terenytev, 1975). The Bactrian species was described as the Kazakh Bactrian breed, and the dromedary species was Arvana breed originated from Turkmenistan (Tasov and Alybaev, 2005; Cherezkov and Saparov, 2005). Elsewhere, the gross composition of camel milk was correctly documented in the literature, but, at our knowledge, no paper comparing clearly the milk composition of dromedary and Bactrian camel in similar environmental conditions was available. In Kazakhstan, the both species often cohabit in the same areas or even in the same farms (Konuspayeva and Faye, 2004). This is a high opportunity to identify the physico-chemical parameters discriminating these two species.

## MATERIAL AND METHODS

### *Sampling procedure*

To obtain the maximum variability, the camel's milk was sampled from 4 different regions at extreme points of Kazakhstan: Almaty, Atyrau, Aralsk and Shymkent (the maximum distance between the different points was more than 3,500 km) and at 4 seasons of the year. In total, 147 samples were used for determination of the camel's raw milk gross composition (table 1). Those samples were collected randomly among the lactating she-camel on 2 private farms per region. The raw milk samples were collected at the milking time in Bactrian (n = 57), dromedary (n=70) and Hybrid (n=20) animals. Bactrian camel's milk samples were from different Kazakh types as described according to their geographical distribution: *uralobokeliki*, *kyzylorda* and *ontustik-kazakhstan* (Terenytev, 1975; Konuspayeva and Faye, 2004). Milk samples from dromedary camel were from the Turkmen Arvana breed. Hybrid samples involved F1 or F2 crossbred animals. The F1 crossbred Bactrian male and dromedary female was called *Iner* (M) or *Iner-maya* (F). The F1 crossbred dromedary male and Bactrian female was called *Nar* (M) and *Nar-maya* (F). The F2 crossbred *Iner* x Bactrian was called *Kospak* and the F2 crossbred *Nar* x dromedary, *Kurt*. In all the case, milk was obtained by manual milking and kept frozen at - 20 °C until analysis, except for vitamin C determined on fresh milk.

### *Laboratory analysis*

The biochemical parameters involved to differentiate the two species were the classical milk components, i.e., total protein (TP), fat matter (FM), iodine index (II that expressed the unsaturated part of fat matter), lactose (La), calcium (Ca), phosphorus (P), iron (Fe), vitamin C (VitC). Some physical parameters were included also: Dornic acidity (Da), pH, density (De), and finally skimmed dry matter (SDM).

Total protein was determined by Kjeldahl method (Ref: ISO5983). The density, skimmed dry matter and fat matter were quantified by an apparatus (Lactan-4) based on middle-infra-red spectrophotometric method. The iodine index was measured by Margoshes method (Anonymous, 1969). The lactose was determined by Bertrand's method (reference NF V 04-213, 1971) and by using enzymatic-kit (kit UV-method, Enzymatic BioAnalysis/Food Analysis, Cat. No 10 176 303 035, Boehringer Mannheim). Minerals were determined with a plasma emission spectrometer ICP Varian-Vista after dry way mineralization and silica discarding with fluorhydric acid.

Vitamin C was quantified by colorimetric method using 2,6-dichlorindophenol (2,6-DIPh).

Dornic acidity was determined by Dornic sodium hydroxide after mixing milk sample with phenolphthalein solution. Classical pH-meter was used for determination of pH.

### ***Statistical procedure***

The statistical procedure aimed different objectives:

- to identify the parameters linked to the species effect,
- to eliminate the season and region effect,
- to determine the multiple function discriminating the Bactrian camels and dromedaries milk composition,
- to introduce hybrids in the discriminating model.

To achieve these objectives, the procedure included 5 steps:

1. A linear model was tested, with TP, FM, II, La, Ca, P, Fe, VitC, Da, pH, De and SDM as dependent variables. The tested variation factors were region, species, season, and their interactions. The significance level for the variance analysis was set at 0.05 for region and season effect and 0.15 for species effect for taking in account the possible interactions between parameters in the later multivariate model. The results are presented as mean  $\pm$  standard error. When the variances were not homogeneous, data were log-transformed to attain a normal distribution of values. This step aimed to select variables to be included in the between-species discriminant model after discarding the between-correlated parameters.
2. The main constraint was that the milk samples were collected at much contrasted season and regions inducing an independent variability to species. So, the description by species was conditioned to these two factors. For discarding those effects, a data table including 127 rows (milk samples from Bactrian camels and dromedaries exclusively) and  $y$  columns (parameters linked to species effect in step 1 at  $p < 0.15$ ) was prepared by analyzing the variance's residuals due to the factors season and region. The preparation of such data table was supported by a principal component analysis with respect to orthogonal instrumental variables or PCAIV (Sabatier *et al.*, 1989).
3. The determination of the discriminant parameters was achieved by a simple discriminant analysis applied to the above data table. As the between-correlated parameters were discarded, each parameter could participate to between-species discrimination independently. The discriminant analysis allowed getting coefficients of linear and or quadratic discriminants for each parameter. Those coefficients expressed the multiple discriminating linear or quadratic function (Venables and Ripley, 2002).
4. The discriminant analysis was pursued by the prediction and estimation of the well-classed rate with cross validation (leave-one-out cross validation: one sample was randomly discarded and the analysis achieved after 127 replications) (Ripley, 1996).
5. The similar steps 1 to 4 were applied on the whole data table including hybrids (i.e., 147 camel's milk samples).

The R software was used for all statistical analyses (Ihaka and Gentleman, 1996).

## RESULTS

### *Mean composition of camel's milk according to species*

The Bactrian camel milk was significantly richer in fat matter, vitamin C, calcium and phosphorus compared to dromedary (table 2). Dromedary camel milk had less Dornic acidity than other species. Hybrid camel milk had significant higher iodine index and density than other species. No significant differences were reported for skimmed dry matter, lactose and iron. The differences in total protein content were non significant at 0.05 *P* level.

The homogeneity of variance for each parameter in each sub-population (Bactrian and dromedary) as far as the similarity of co-variance was tested to confirm the ability to use the discriminant analysis.

### *Selection of independent variables for discriminating model*

Six non correlated parameters were selected as variables to discriminate the species: total proteins, fat matter, iodine index, vitamin C, pH and phosphorus. Dornic acidity was highly correlated to pH, and density to the fat matter and total protein, so they were discarded of the subsequent model. Calcium and Phosphorus were significantly correlated ( $P < 0.001$ ). So, calcium was discarded from the subsequent model for discriminating the 2 species, because the *P* value for phosphorus was much higher.

### *Principal component analysis with respect to orthogonal instrumental variables*

This step allowed obtaining a new data table including the milk composition of Bactrian and dromedary camels by discarding the variance's residuals due to season and region effects.

The correlation matrix graphically expressed by the main factorial plan (Fig. 1) confirmed the absence of correlation between the selected parameters. However after discarding season and region effects, the phosphorus concentration and total protein content were correlated ( $r = 0.364$ ;  $P < 0.01$ ). Most of the parameters were mainly correlated with the principal factor of the PCAIV except iodine index, most correlated with factor 2.

### *Descriptive discriminant analysis Bactrian-dromedary*

The most discriminant parameter was phosphorus concentration according to the coefficient of linear discriminants (LD1) reported in table 3. Phosphorus was followed by pH and vitamin C, then iodine index and fat matter. Total protein was weakly discriminant. The Bactrian camel's milk samples are richer in phosphorus whatever the season or region. The other discriminant parameters more important in Bactrian's milk were successively pH, vitamin C, fat matter and total protein. Iodine index only was higher in dromedary's milk (Fig. 2).

As the whole, the percentage of well-classed samples was 70.6 % (fig. 3). The discriminating power was less high for Bactrian (60%) than for dromedary species (78.5%). The quadratic discriminant analysis improved the percentage of well-classed samples up to 75.4 %, mainly by decreasing the error rate in Bactrian (73.7% of well-classed).

### ***Predictive discriminant analysis Bactrian-dromedary***

After cross validation (leave-one-out cross validation), the percentage of well-classed samples decreased to 66.9 %. As the Bactrian population seemed more heterogeneous than dromedary population (fig.4), the prediction was less powerful for Bactrian.

### ***Discriminant analysis including hybrids***

The same non correlated parameters were selected as variables to discriminate the 3 species: total proteins, fat matter, iodine index, vitamin C, pH and phosphorus. The homogeneity of variance in hybrid population as far as the low similarity of co-variance allowed achieving a descriptive discriminant analysis only. In some cases, hybrid's values were between those of Bactrian and dromedary (FM, pH), close to dromedary (vitC) or to Bactrian (P) or out (II and TP) (Fig. 5). On the main factorial plan from PCAIV, the hybrid group was positioned between the 2 other groups on the main factor (discriminant power of F1: 68.2%) but with a better contribution to the second factor (discriminant power of F2: 31.8 %) mainly explained by the parameter iodine index (II) and Vitamin C (Fig.6). This figure expressed the higher values in iodine index and lower values in Vitamin C observed in hybrid's milk samples.

As the whole, the well-classed percentages were 58.5 only, the hybrids being a very heterogeneous group: the respective well-classed percentages were 54.4 for Bactrian, 77.8 for dromedary and 10% only for hybrids. The half of hybrid's samples was closed to dromedary and 40% to Bactrian.

## **DISCUSSION**

The discriminant analysis allowed taking in account all the parameters simultaneously. The between-correlated parameters being discarded and the region\*season effect being deleted, the between-species discrimination could be considered as fully convenient.

### ***Camel milk composition***

Data on camel milk composition were not very common (Ramet, 1991; Farah, 1993). In a meta-analysis achieved in a recent study (Konuspayeva, 2007), international bibliographical data base consulting gave no more than 82 references since 1905 (Barthe, 1905) to 2006 (El-Hatmi, 2006). In most of the case, few milk samples were analyzed, and the origin of sampled animals were not systematically described. The differences between breeds, state of lactation, season, and type of diet were rarely mentioned. Also, the sampling and the analytical procedures were roughly described in most of the cases. The available comparison between Bactrian and dromedary milk samples were issued from literature's review. At our knowledge, no field comparison taking in account common breeding and farming conditions as in the present study was published.

On average, Bactrian camel milk was considered as richer in fat content (Terenytev, 1975; Indra and Erdenebaatar 1998). Indeed, the Asian references where Bactrian camels are originated (mainly Kazakhstan, Mongolia, China and Russia) reported high fat content in Bactrian milk compared to dromedary whatever their origin, Africa or Asia. Two references mentioned a comparison between Bactrian and dromedary: 5.5 vs 4.15 % in China (Zhao, 1998), 5.45 vs 4.47 % in Mongolia (Indra et

al., 2003). In our results, the values of fat matter content in milk appeared very high compared to the calculated mean from literature's data, both for camelids originated from Central Asia (mainly Bactrian but probably not exclusively: 4.94) and dromedary camel (3.82). However, in spite of the higher fat content in Bactrian camel's milk, this parameter contributed for a little part to the discrimination between the two species.

The difference in mean protein content between the two species did not appear remarkably important. For example, Zhao (1998) reported 3.87 % for Bactrian and 3.45% for dromedary while Indra et al. (2003) reported values at 4.43 and 3.53 % respectively. As for fat content, our results were higher compared to the literature. On average, protein content calculated in 82 references (Konuspayeva, 2007) was 3.23 in dromedary and 4.02 % in Central Asia that was lower than in our results. The discriminating power of this parameter was very low.

No difference in lactose was reported in these two comparative references mentioned above: 4.34 and 4.76 (Bactrian), 4.55 and 4.95 % (dromedary) in Zhao (1998) and Indra et al. (2003) references respectively. According to the literature, lactose mean content was 4.40 in dromedary and 4.73 % in the references from Central Asia. Those values were higher than our observations. At any case, lactose content did not allow to distinguish Bactrian milk from dromedary milk.

On average, mineral matters were in higher quantity in dromedary camel milk (0.99%) than in the references from Central Asia (0.79%), but few data are available on specific minerals.

Phosphorus (and correlatively calcium) was the main discriminating parameter. If the calcium content in our milk samples was close to the literature's data (Abu-Lehia, 1987; Farah and Ruegg, 1989; Bengoumi et al., 1998) with values between 1.15 and 1.57 g/L, the phosphorus content in camel milk from Kazakhstan appeared in higher concentration than those of the literature: between 0.63 g/L (Sawaya et al., 1984) and 1.04 g/L (Farah and Rüegg, 1989). The highest phosphorus concentration in Bactrian camel's milk compared to dromedary's one could be linked to their highest quantity of fat matter, especially phospholipids. Unfortunately, the quantity of phospholipids was not determined in our study.

Iron milk content did not discriminate the two camel species. A part of iron is linked to lactoferrin. In a previous publication, no significant difference between species was reported for lactoferrin content in the milk (Konuspayeva et al., 2007). The observed values in our samples (around 2mg/L) were slightly lower (3.0 to 3.4mg/L) than those reported by several authors (Sawaya *et al*, 1984; Abdelrahim, 1987; Bengoumi et al., 1998). In some references, very high iron concentrations were reported: 280 mg/L (Elamin and Wilcox, 1992). The lack of standardized method could explain such differences.

The richness of camel milk in vitamin C was a well-known feature (Farah et al., 1992). It is an important part for the medicinal reputation of camel milk (Konuspayeva et al., 2004). According to Farah (1993), the reported range was 25-60 mg/L that was lower than our results in the both species. Ascorbic acid concentration was significantly different between camel breeds in Sudanese camels (Mohamed et al., 2005). Ascorbic acid presents a high instability (especially with temperature change). In our study, vitamin C was determined on fresh milk, reversely to the other authors (Farah et al., 1992; Mohamed et al., 2005). So, the observed differences in vitamin C milk concentration could be partly explained by this analytical condition difference, and probably also by the used method.

The iodine index was the only parameter in higher concentration in dromedary camel with a discriminating power. This index was related to the fat composition, notably to the quantity of unsaturated links in fatty acids. In a previous publication based on the same sampling material, it has been reported that the proportion of poly-unsaturated fatty acids was in higher percentage in dromedary milk (Narmuratova et al., 2006).

The acidity of camel milk was also a discriminant parameter. The storage and transport conditions of the milk samples were identical for the two species, notably because their cohabitation in the same areas was common. So, the difference in pH should be attributed most probably to the intrinsic property of the milk.

### ***Zootechnical aspect***

On average, the milk production is higher in dromedary than in Bactrian camel (Faye, 2005), especially the Arvana breed, well-known for its high dairy potential (Cherzegov and Saparov, 2005). So, the lower concentrations of most of the parameters in dromedary camel milk could be attributed to a "dilution effect". However, the milk composition in the dromedaries in Kazakhstan was closer to the Bactrian milk composition than to the milk composition of other dromedaries in the world. Probably, there was specific environmental conditions (notably feeding) explaining the particular richness of the camel milk in this country.

The positioning of hybrids and their low well-classed percentage could be attributed to the high heterogeneous of this group. In our study, the hybridizing level was not known. The group "hybrid" included as well F1 animals (*Iner* or *Nar*) as F2 (*Kospak* or *kurt*) or F3. The crossbreeding of F1 animals being achieved with pure breed (dromedary or Bactrian), it was not surprising to find a high part of F2 hybrids close to one or other species.

## **CONCLUSION**

Bactrian and dromedary camel were genetically close but different species (Jianlin, 2000). It was obvious that their milk composition should contribute to this species differentiation. In fact, their milk composition was slightly different whatever their region origin (that reflect the feeding variability) or seasonal effect (that reflect the physiological stage). The most discriminating parameters were on quantitative aspect (main minerals, vitamin C, and fat matter) and qualitative (pH, iodine index). Those results confirm that the establishment of standard for camel milk must take in account the different species.

## **ACKNOWLEDGEMENTS**

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Factors	Almaty	Atyraou	Aralsk	Chymkent	total	
Bactrian	winter	4	7	2	13	
	spring	5	5	5	18	
	summer	4	7	1	14	
	autumn	4	6	1	12	
<b>Total Bactrian</b>	<b>17</b>	<b>25</b>	<b>9</b>	<b>6</b>	<b>57</b>	
Dromedary	winter	5	2	2	11	
	spring	14	2	2	22	
	summer	20	1	1	28	
	autumn	2	1		6	9
<b>Total Dromedary</b>	<b>41</b>	<b>6</b>	<b>5</b>	<b>18</b>	<b>70</b>	
Hybrid	winter			2	2	
	spring		1	4	5	10
	summer			2	5	7
	autumn				1	1
<b>Total Hybrid</b>		<b>1</b>	<b>6</b>	<b>13</b>	<b>20</b>	
<b>Total</b>	<b>58</b>	<b>32</b>	<b>20</b>	<b>37</b>	<b>147</b>	

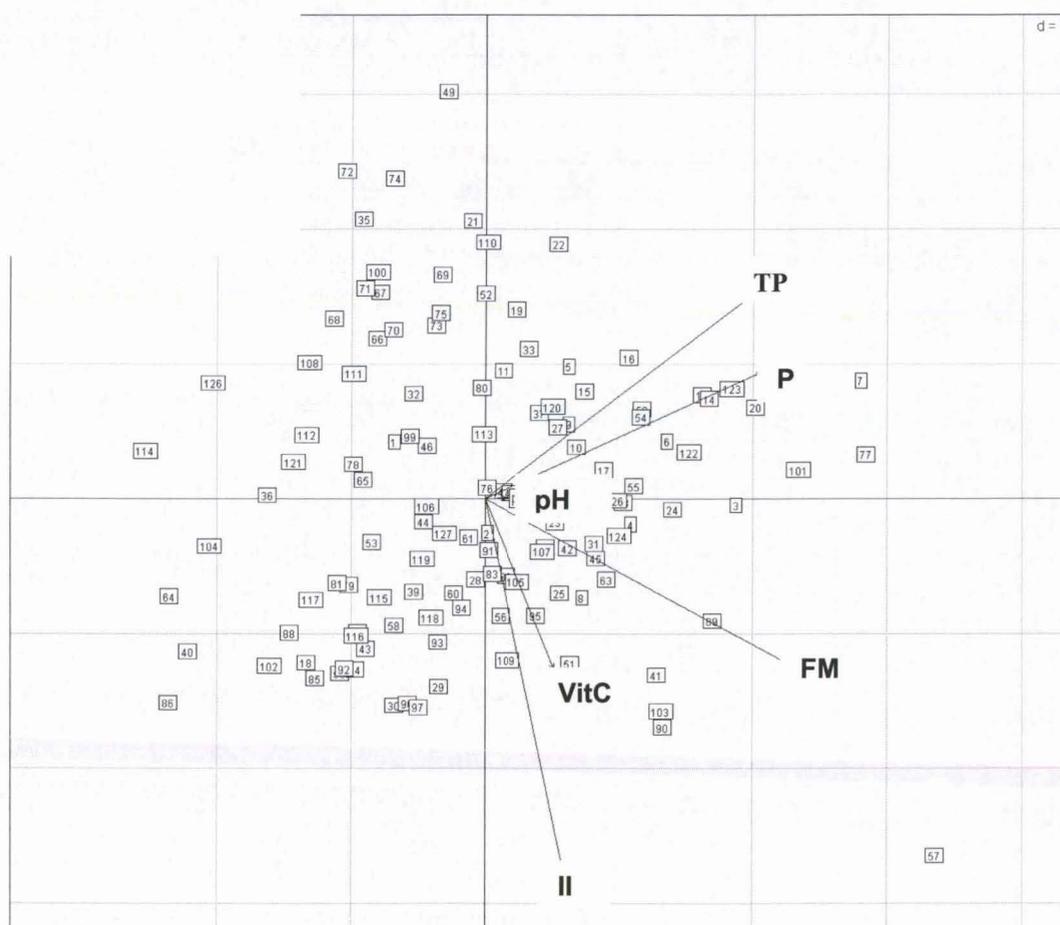
**Table 1.** Camel's raw milk sampling design by species x season x region

Parameters	Bactrian	Dromedary	Hybrid	P value
FM,%	6,67 ± 2,93	5,94 ± 2,26	6,09 ± 1,81	<b>0.04</b>
SDM,%	10,64 ± 3,11	10,87 ± 3,19	11,01 ± 2,66	0.24
De, A°	33,02 ± 6,77	34,66 ± 5,85	37,04 ± 8,54	<b>&lt;0.001</b>
pH	6,55 ± 0,40	6,46 ± 0,51	6,36 ± 0,56	<b>0.05</b>
Do, D°	27,47 ± 12,48	24,04 ± 13,92	27,27 ± 11,47	<b>&lt;0.001</b>
La,%	2,77 ± 0,96	3,12 ± 0,92	3,04 ± 0,60	0.45
Vit C, mg/L	177 ± 109	152 ± 91	133 ± 133	<b>&lt;0.001</b>
II	14,99 ± 6,94	16,62 ± 9,40	22,29 ± 8,53	<b>0.02</b>
TP,%	5,23 ± 1,17	4,76 ± 1,13	5,15 ± 1,59	<b>0.11</b>
Ca, g/L	1,303 ± 0,287	1,163 ± 0,273	1,257 ± 0,268	<b>0.003</b>
P, g/L	1,075 ± 0,177	0,915 ± 0,190	1,067 ± 0,273	<b>&lt;0.001</b>
Fe mg/L	2,11 ± 1,63	1,93 ± 1,06	2,01 ± 0,78	0.55

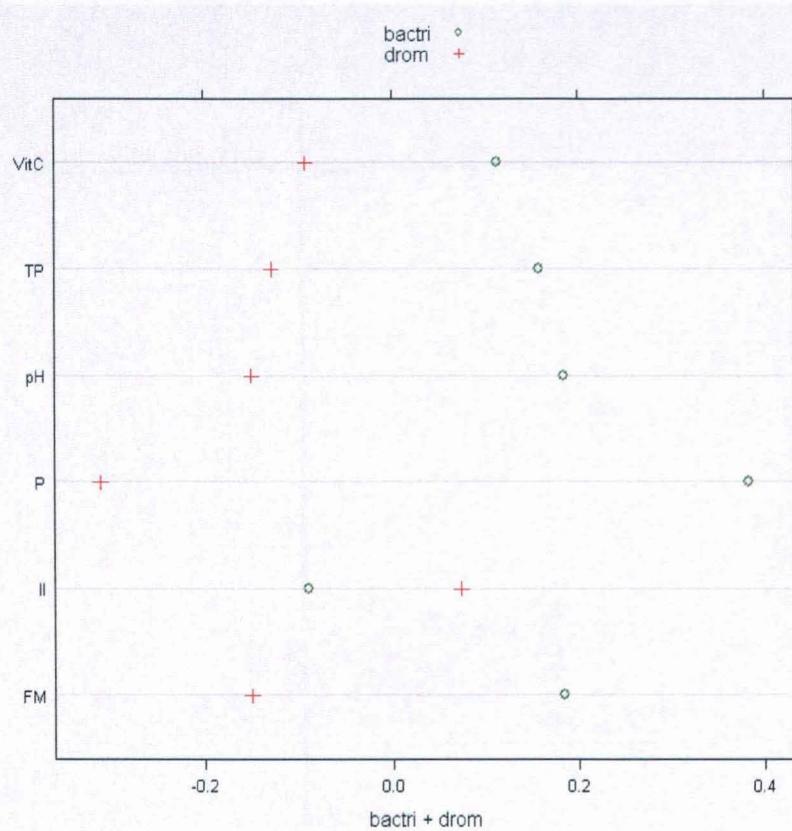
**Table 2.** Mean ± standard error of principal components in camel raw milk in Kazakhstan according to the species (n=147) and probability level from ANOVA. Only significant levels at  $P < 0.15$  for species effect were reported in bold.

Parameters	LD1
Phosphorus	- 1.00076
pH	- 0.40802
vitamin C	- 0.37738
iodine index	0.28723
Fat matter	- 0.22694
Total protein	- 0.00089

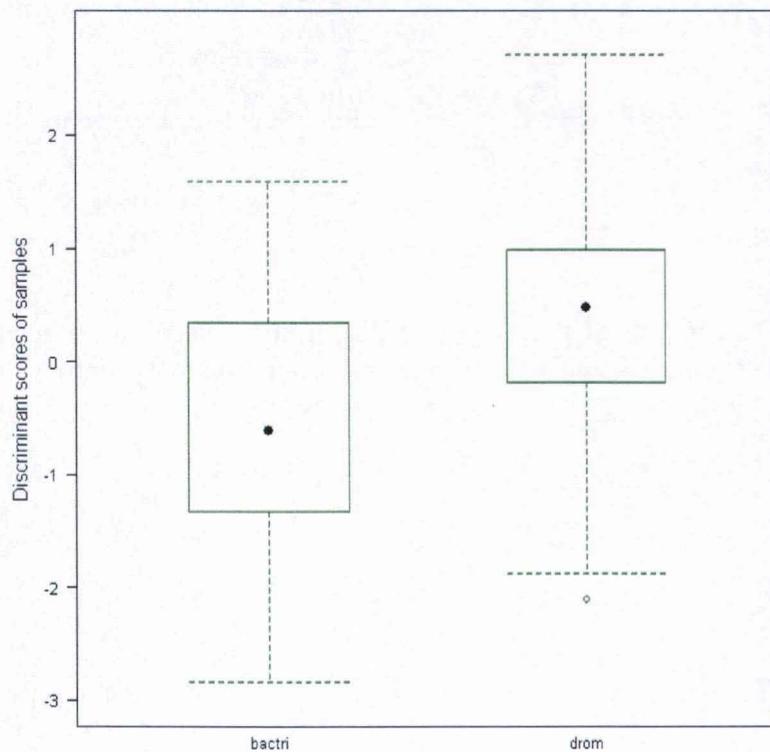
**Table 3.** Coefficients of linear discriminants between Bactrian and dromedary camel's milk issued from simple discriminant analysis.



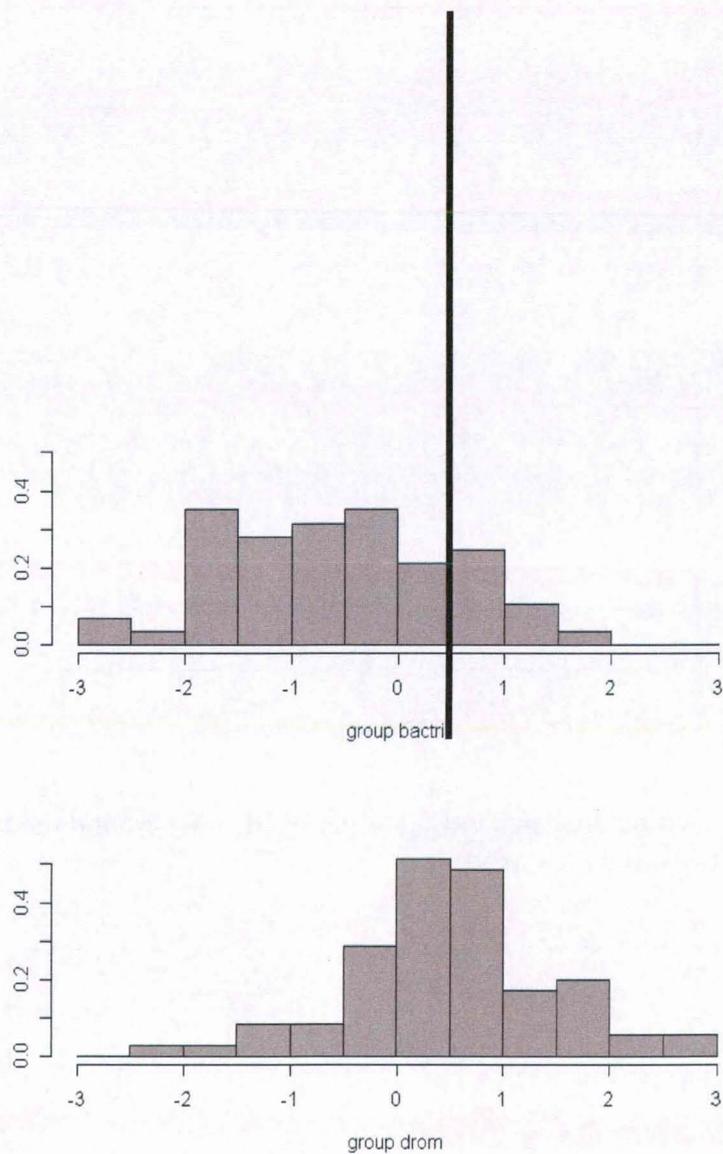
**Figure 1.** Main factorial plan (F1,F2) with the projection of 127 samples and of the six selected parameters for discriminating Bactrian's and dromedary's milk obtained by principal component analysis with respect to orthogonal instrumental variables (Season and region effect excluded)



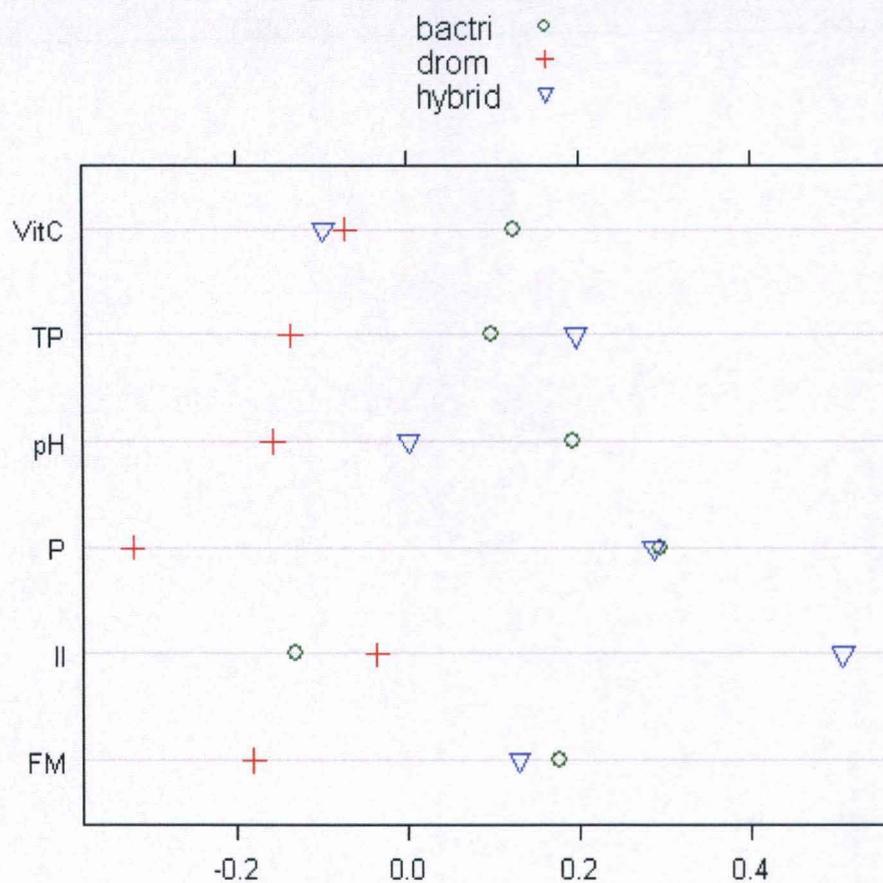
**Figure 2.** Distribution of the mean values for each species (o = Bactrian, + = dromedary) and each parameters (vitC, TP, pH, P, II, FM) around the barycentre of the discriminant analysis (0.0 on x axis)



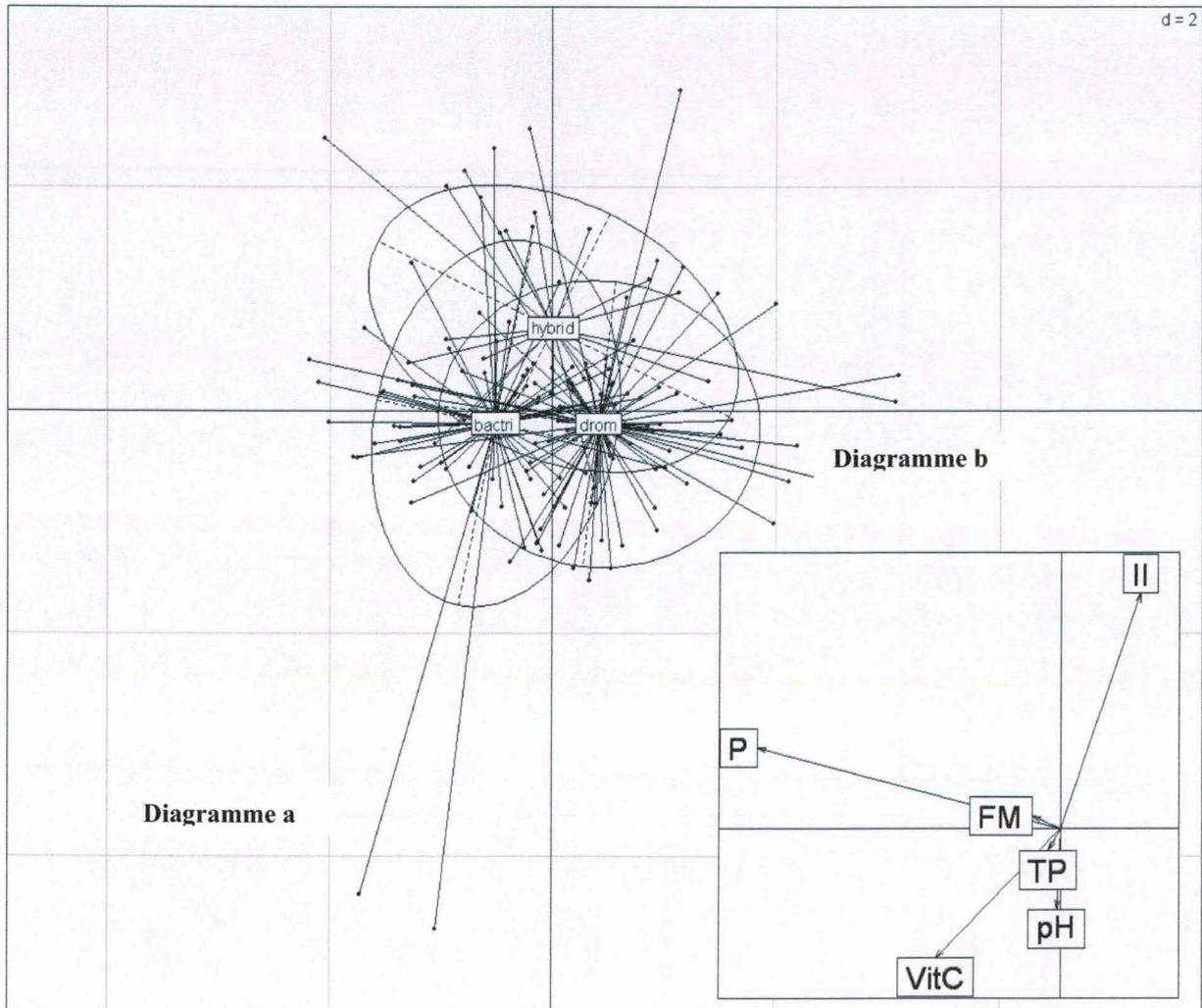
**Figure 3.** Distribution of the linear discriminant scores of Bactrian (bactri) and dromedary milk's samples (drom).



**Figure 4.** Distribution of the quadratic discriminant scores of Bactrian (group bactri) and dromedary milk's samples (group drom) around the barycentre (black line).



**Figure 5.** Distribution of the mean values for each species (o = Bactrian, + = dromedary, ▽ = hybrid) and each parameters (vitC, TP, pH, P, II, FM) around the barycentre of the discriminant analysis (0.0 on x axis)



**Figure 6.** a) Main factorial plan (F1,F2) with the projection of the 147 samples belonging to the 3 species (Bactrian, dromedary and hybrid) obtained by principal component analysis with respect to orthogonal instrumental variables (Season and region effect excluded); b) Main factorial plan (F1,F2) with the projection of the six selected discriminant parameters.

**ANNEXE 6**

**Article soumis dans dans la revue « Le Lait »**



**Lipid composition of camel (*Camelus bactrianus*, *Camelus dromedarius* and hybrids) milk in Kazakhstan.**

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**Short title:** lipid composition of camel milk

**Abstract**

The fatty acid composition and cholesterol content were determined in 22 milk samples from Kazakhstan in different regions, at different season and on different species (Bactrian, dromedary and hybrids). The camel fat milk had major acids C14:0, C16:0, C18:0 and C18:1. The ratio unsaturated/saturated acid was in favour of camel milk compared to cow milk. This composition gave a nutritional advantage to camel milk, but the cholesterol content (37.15 mg/100g) was in higher quantity than in cow's milk. The multivariate analysis allowed identifying four types of fatty acid profiles with a clear opposition between milk rich in low chain fatty acids and milk with long chain fatty acids. These results confirmed that environmental and farming conditions allowed modulating the lipid composition of camel milk.

**Keywords:** camel milk/lipid/fatty acid/cholesterol/Kazakhstan

**Résumé: Composition des lipides du lait de chamelle (*Camelus bactrianus*, *Camelus dromedarius* et hybrides) au Kazakhstan**

La composition en acides gras et la teneur en cholestérol sont déterminés dans 22 échantillons de lait du Kazakhstan, provenant de différentes régions, à différentes saisons et de différentes espèces (chameau de Bactriane, dromadaire et hybrides). La matière grasse du lait de chamelle comprend comme acides majeurs C14 :0, C16:0, C18:0 and C18:1. Le rapport acides insaturés/acides saturés est en faveur du lait de chamelle comparé au lait de vache. Cette composition donne un avantage nutritionnel au lait de chamelle, mais sa teneur en cholestérol (37.15 mg/100g) est plus élevée que dans le lait de vache. L'analyse multivariée a permis d'identifier quatre types de profils d'acides gras avec une claire opposition entre les laits riches en acides à courtes chaînes et les laits riches en acides à longues chaînes. Ces résultats confirment que l'environnement et les conditions d'élevage permettent de moduler la composition des lipides du lait de chamelle.

**Mots-clefs :** lait de chamelle/lipides/acides gras/cholestérol/Kazakhstan

## **1. Introduction**

In Kazakhstan the genus *Camelus* including two species cohabit in the same areas and even in the same farms: the one-humped camel (*Camelus dromedarius*) and the Bactrian two-humped camel (*Camelus bactrianus*) [13]. This particularity allows comparing the milk composition of those animals reared in similar environment. Elsewhere, crude camel milk and fermented product (named *shubat*) were always an important food of Kazakh peoples. Especially *shubat* was renowned and used for some medicinal purpose [6], [14]. The fatty acid composition of milk is one of the aspects linked to the discussion on the health effect of milk and milk products [18]. However, the fatty acid composition of camel milk is not well documented [8], especially in Bactrian camel [19].

## **2. Materials and Methods**

### **2.1 Sampling procedure**

Twenty-two camel milk samples were used for the present study. Those samples came from 7 Bactrian, 10 dromedaries, 3 hybrids and 2 from mixed milk. They are originated from four regions of Kazakhstan (Almaty, Atyrau, Aralsk and Shymkent) and the milk was collected at four different seasons. The samples were collected after the milking, stored at 4°C up to the laboratory, then frozen and stored at -18°C until the analyse.

### **2.2. Laboratory analysis**

#### ***2.2.1. Extraction of total milk lipids***

The extraction of total lipids in camel milk was based on the Rose-Gottlieb method [5] with modification by IDF 172:1995. As the method was never described formerly on camel milk, samples of cow milk UHT Lactel® at 3.4 % fat matter and half skimmed UHT Lactel® at 1.5 % fat matter were used to test the analyze protocol and to have control samples.

#### ***2.2.2. Extraction protocole of lipids***

The milk sample heated up to 40°C then put 10 minutes in ultrasonic bath. 10 mL of sample was mixed with 2 mL ammonia and 10 mL ethanol for 10 minutes. In decantation ampoule 10 mL of milk were mixed with 1 mL 30 % ammonia and 10 mL 95% (v/v) ethanol. Then 20 mL ethylic ether was added and mixed for 1 minute. 20 mL hexane was added and shaken. After separating in two phases, water phase was got back and organic phase was decanted in another decantation ampoule. Extraction was repeated two times with 20 mL hexane with water phase. Organic phase was filtrated by cotton soaked in hexane and covered with anhydrous sodium sulphate.

The filtrate was got back in a balloon put formerly 30 min. in stove (100°C) and 30 min. in desiccator. Hexane was evaporated by rotavapor at 50°C, and then the balloon was stove 30 min. at 100°C and 45 min. in desiccator before weighing.

Extracted fat matters were stored in hexane at 4°C up to analyse.

#### ***2.2.3. Fatty acid analyses***

Fatty acids were determined after methylation by gas chromatography and were confirmed by mass spectrometry for each milk samples.

Varian 3400 gas chromatograph was used with capillary colon DB-Wax type non polar (molten silica) with 60 mm length, 0.32 mm diameter and 0.25 µm thickness. All other conditions were those described by Collomb and Bühler, 2000 [4]. Agilent 6890 Series GC System was used for mass spectrometry with soft gcms 5973 Data analysis.

#### **2.2.4. Cholesterol analyses**

On 10 samples, determination of cholesterol was achieved by enzymatic kit of R-Biopharm (Ref. : 10 139050 035).

#### **2.2.5. Statistical Analysis**

As the objective is to have an idea of the variability of fatty acid composition with only at least one sample in each cell region\*species\*season, the variance analysis was not applicable. The analysis of the fatty acid profiles was achieved with multivariate analysis. In order to take in account each fatty acid with the same weight, the values were divided into 3 modalities with balanced number of samples in each modality: 1 for the lower values (modality l), 2 for the mean values (modality m), 3 for the higher values (modality h). Finally, the obtained qualitative data table was analyzed with multiple correspondence factorial analysis (MCFA) followed by a cluster analysis to identify types of samples according to their fatty acid composition. The software Winstat © was used for multivariate analysis.

### **3. Results**

#### **3.1. Mean composition**

Globally mean composition of camel fatty acids of milk fat had major acids C14:0, C16:0, C18:0 and C18:1 (Tab. I).

Fatty acid composition by regions show that C6:0, C14:0 dm, C16:1, C18:3 varied significantly (Tab. II). Hexanoic (C6:0), 13, 13-dimethyltetradecanoic (C14:0 dm), palmitic (C16:1) acids were higher at Shymkent region and lower at Aralsk region. Linolenic acid (C18:3) was lower at Almaty region.

Fatty acid composition by seasons show that C8:0, C10:0, C10:1, C20:0 varied significantly (Tab. III). Octanoic (C8:0), decanoic (C10:0) and 2-decylenoic acids was presented higher at spring. Quantity of arachidic acid (C20:0) was higher at winter than all others.

Fatty acid composition by species show that C14:0, C17:0iso, C18:1 varied significantly (Tab. IV). Myristic acid (C14:0) was lower at dromedary milk samples than in mixed samples, contrary to iso-heptadecanoic (C17:0iso) and oleic (C18:1) acids.

To facilitate the interpretation of the factorial plan, only the main fatty acids (C14:0, C16:0, C18:0 and C18:1) were represented (Fig. 1 and 2)

#### **3.2. Multivariate analysis**

The multiple correspondence factorial analysis allowed to identify a main factorial plan representing 35% of the total variance. By regarding the main fatty acid, the first factor (F1) corresponded to a gradient of medium chain fatty acid (Fig. 1) from the right side of the plan (modalities "low") to the left side (modalities "high") as shown in figure 1 (C14:0 and C16:0). This gradient was reverse to long fatty acids (C18:0 and C18:1) as the modalities "high" are at the right side of the main factor and modalities "low" at the left side (Fig. 2).

The ascending hierarchical classification applied on the transformed data table allowed to get 4 classes well distributed all along the first factor (Fig. 3).

The description of these four classes (Tab. V) confirmed the observed gradients. From the left side to the right side of the main factor, the milk samples were richer in long chain fatty acids: for example percentage of C18:0 was 12.3 in class1, 13.05 in class2, 18.3 in class 4 and 20.9 in class 3. At reverse, the medium fatty acids were in higher proportion in class 1: for example, percentage of C14 was 17.4 in class 1, 14.9 in class 2, 10.1 in class 4 and 9.5 in class 3.

So, the class 1 included milk samples rich in short and medium chain fatty acids but poor in long chain fatty acids. Those samples were mainly from Bactrian in Shymkent region and collected in spring and summer time. The class 2 (richer in C10:1, C14iso and C15:0), was characteristic of dromedary living in Atyrau region on spring milk. The class 4 (richer in C15iso, C17:0 and C17:1) was linked to the dromedary from Aralsk and Almaty regions in winter milk only. Finally, class 3, the richest milk in long fatty acids came from dromedary and hybrid from all Kazakhstan (except Aralsk region), especially in summer milk.

### 3.3. Cholesterol content

In camel milk samples from Kazakhstan, cholesterol concentration was  $37.15 \pm 7.73$  mg/100 g of milk, with min and max value at 25.61 and 50.42 mg/100g respectively.

## 4. Discussion

Fatty acids were determined after methylation by gas chromatography as in most of the literature references [9]. In our case, the results were confirmed by mass spectrometry for each milk samples.

The fatty acid composition of camel milk fat from Kazakhstan are comparable to results of the literature, in particular the highest content of unsaturated fatty acids compared to cow milk [9]. In most of the literature data [10], [1], [7] [15], [2], [12], the fatty acid composition was given without taking in account the variability due to environmental or physiological conditions. Yet, a high variability was observed between the animals, even if the variation factors like genetic (dromedary, Bactrian and hybrids), season or region seem to have a low effect in the context of the present study, especially because the low number of samples for each variation factor. Especially, types of milk were identified according to their fatty acids profiles. It was remarkable that there was a clear opposition between milk rich in long chain fatty acids and milk rich in short and medium chain fatty acids.

The milk fatty acid composition was of a peculiar importance for human consumers both for nutritional and health point of view. It was admitted that milk products furnished 15 to 25% of the fat matter consumed by human and 25 to 35% of the saturated fat [3]. Some saturated fatty acids are well known for their risk to coronary heart disease. The risk due to fatty acid composition could be evaluated with the index of atherogenicity [17]. This index was calculated by the formula:

$$C12:0 + 4 * C14:0 + C16:0 / \text{sum of unsaturated fatty acid.}$$

The index of atherogenicity was between 3.3 and 3.5 in cow milk with standard feeding [3]. In case of camel milk, this index was generally lower: 2.6 on average in our sample, but with high variation between species (2.02 for dromedary, 3.18 for Bactrian and 2.76 for hybrid), season (from 1.79 in winter to 2.85 in spring) and regions (from 2.12 at Almaty to 3.38 at Shimkent). So, on average, the camel milk appeared healthier for the milk consumers. It was of a peculiar importance in a country as Kazakhstan where the milk annual consumption per inhabitant was high (more than 250 kg).

The ratio unsaturated fatty acids/saturated fatty acids was a good indicator of the nutritional quality of milk. This ratio was 0.45 for Bactrian and 0.43 for dromedary in our sample, compared to 0.30 for cow and 0.32 for goat [2]. The higher content of medium chain fatty acids was useful from a nutritional point of view as they are more easily absorbed and metabolized than long chain fatty acids

Cholesterol content in camel milk appeared higher than in cow milk: 12mg/100g of milk approximately according to Sieber, 2005 [16]. In their comparative study, Gorban and Izzeldin, 1999 [11] confirmed that camel milk had a higher content of total cholesterol (31.32 mg/100mg) compared to cow's milk (25.63 mg/100g). The free cholesterol content in milk from lactating

camel was 21.34 mg/100g vs 17.25 in lactating cow milk. So, the nutritional advantage of camel milk due to fatty acid composition could be reduced by the higher content of cholesterol.

## **5. Conclusion**

Fatty acid composition of camel milk from Kazakhstan confirmed the nutritional and health interest of this product in spite of a higher content in cholesterol compared to the cow's milk. However, a more important number of milk samples would be necessary for a better understanding of the variability in the lipid composition. Indeed, it was possible to identify some types of milk according to their fatty acids profiles, but the high number of variation factors (species, season and region) in our study compared to the limited number of samples did not allow to affirm a statistical link with such or such factor.

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**Figure 1.** Main factorial plan issued from Multiple correspondence factorial analysis showing the positioning of the modalities high (h), mean (m) and low (l) of C14:0 and C16:0

**Figure 2.** Main factorial plan issued from Multiple correspondence factorial analysis showing the positioning of the modalities high (h), mean (m) and low (l) of C18:0 and C18:1.

**Figure 3.** Representation of the four classes issued from classification analysis on the main factorial plan showing the distribution of the four groups of samples all along the main factor.

**Table I.** Total mean fatty acid composition of camel milk fat of Kazakhstan

#	Acids	Mean and SD	#	Acids	Mean and SD
1	<b>C4:0</b>	0.375 ± 0.410	14	<b>C16:0 iso</b>	0.277 ± 0.176
2	<b>C6:0</b>	0.381 ± 0.285	15	<b>C16:0</b>	31.344 ± 4.192
3	<b>C8:0</b>	0.403 ± 0.321	16	<b>C16:1</b>	6.934 ± 1.537
4	<b>C10:0</b>	0.346 ± 0.398	17	<b>C16:0 dm</b>	0.399 ± 0.237
5	<b>C10:1</b>	0.853 ± 1.152	18	<b>C17:0 iso</b>	0.635 ± 0.303
6	<b>C12:0</b>	1.015 ± 0.464	19	<b>C17:0</b>	0.685 ± 0.222
7	<b>C13:0</b>	0.074 ± 0.216	20	<b>C17:1</b>	0.349 ± 0.168
8	<b>C14:0 iso</b>	0.163 ± 0.140	21	<b>C18:0</b>	16.329 ± 4.611
9	<b>C14:0</b>	12.831 ± 4.113	22	<b>C18:1</b>	21.404 ± 5.396
10	<b>C14:1</b>	0.731 ± 0.350	23	<b>C18:2</b>	1.372 ± 0.485
11	<b>C14:0 dm</b>	0.385 ± 0.267	24	<b>C18:3</b>	0.596 ± 0.558
12	<b>C15:0 iso</b>	0.793 ± 0.205	25	<b>C20:0</b>	0.023 ± 0.068
13	<b>C15:0</b>	1.297 ± 0.338	26	<b>C20:1</b>	0.012 ± 0.037

**Table II.** Fatty acid composition of camel milk fat by 4 regions of Kazakhstan

Acids	Almaty (n=6)	Atyrau (n=6)	Aralsk (n=2)	Shymkent (n=8)	<i>p</i> value
<b>C4:0</b>	0.375 ± 0.368	0.356 ± 0.139	0.093 ± 0.012	0.461 ± 0.603	0.44
<b>C6:0</b>	0.214 ± 0.157	0.344 ± 0.160	0.145 ± 0.010	0.592 ± 0.340	0.01
<b>C8:0</b>	0.228 ± 0.234	0.361 ± 0.209	0.173 ± 0.008	0.623 ± 0.374	0.08
<b>C10:0</b>	0.331 ± 0.517	0.231 ± 0.134	0.111 ± 0.015	0.503 ± 0.465	0.15
<b>C10:1</b>	1.008 ± 1.599	0.651 ± 0.269	0.270 ± 0.020	1.033 ± 1.383	0.53
<b>C12:0</b>	0.758 ± 0.215	1.018 ± 0.176	0.597 ± 0.080	1.311 ± 0.620	0.02
<b>C13:0</b>	0.049 ± 0.071	0.034 ± 0.039	0.007 ± 0.009	0.140 ± 0.357	0.49
<b>C14:0iso</b>	0.239 ± 0.120	0.151 ± 0.112	0.101 ± 0.067	0.130 ± 0.178	0.72
<b>C14:0</b>	11.051 ± 3.527	12.194 ± 2.926	10.604 ± 0.845	15.200 ± 4.975	0.21
<b>C14:1</b>	0.703 ± 0.382	0.567 ± 0.101	0.408 ± 0.102	0.956 ± 0.378	0.03
<b>C14:0 dm</b>	0.654 ± 0.308	0.410 ± 0.084	0.492 ± 0.037	0.138 ± 0.075	<0.001
<b>C15:0iso</b>	0.840 ± 0.271	0.899 ± 0.080	0.714 ± 0.046	0.699 ± 0.214	0.54
<b>C15:0</b>	1.312 ± 0.214	1.501 ± 0.422	1.195 ± 0.004	1.159 ± 0.349	0.07
<b>C16:0iso</b>	0.438 ± 0.220	0.276 ± 0.103	0.263 ± 0.018	0.160 ± 0.114	0.03
<b>C16:0</b>	30.606 ± 5.113	27.925 ± 3.051	31.784 ± 1.339	34.352 ± 2.501	0.02
<b>C16:1</b>	7.651 ± 2.109	5.674 ± 0.664	5.498 ± 0.260	7.701 ± 0.727	<0.001
<b>C16:0dm</b>	0.543 ± 0.316	0.446 ± 0.158	0.562 ± 0.037	0.216 ± 0.116	0.02
<b>C17:0iso</b>	0.913 ± 0.222	0.639 ± 0.293	0.610 ± 0.077	0.431 ± 0.254	0.22
<b>C17:0</b>	0.702 ± 0.150	0.834 ± 0.188	0.784 ± 0.078	0.535 ± 0.240	0.01
<b>C17:1</b>	0.445 ± 0.085	0.366 ± 0.209	0.417 ± 0.040	0.247 ± 0.163	0.03
<b>C18:0</b>	15.135 ± 4.946	18.758 ± 3.252	22.299 ± 0.767	13.910 ± 3.941	0.003
<b>C18:1</b>	23.907 ± 5.911	24.566 ± 4.547	20.343 ± 1.275	17.420 ± 3.872	0.03
<b>C18:2</b>	1.650 ± 0.667	1.381 ± 0.274	1.576 ± 0.081	1.106 ± 0.417	0.35
<b>C18:3</b>	0.176 ± 0.131	0.413 ± 0.249	0.955 ± 0.241	0.959 ± 0.710	0.01
<b>C20:0</b>	0.076 ± 0.120	0.008 ± 0.019	0	0	0.14
<b>C20:1</b>	0.022 ± 0.040	0	0	0.018 ± 0.051	0.77

**Table III.** Fatty acid composition of camel milk fat by 4 seasons

Acids	Winter (n=3)	Spring (n=8)	Summer (n=8)	Autumn (n=3)	p value
C4:0	0.284 ± 0.238	0.576 ± 0.637	0.258 ± 0.091	0.247 ± 0.094	0.04
C6:0	0.140 ± 0.073	0.500 ± 0.320	0.403 ± 0.293	0.242 ± 0.118	0.08
C8:0	0.100 ± 0.074	0.596 ± 0.341	0.395 ± 0.305	0.214 ± 0.075	<0.001
C10:0	0.114 ± 0.075	0.607 ± 0.555	0.259 ± 0.182	0.118 ± 0.044	0.001
C10:1	0.379 ± 0.288	1.539 ± 1.745	0.540 ± 0.215	0.332 ± 0.110	0.01
C12:0	0.719 ± 0.301	1.239 ± 0.607	0.968 ± 0.365	0.844 ± 0.184	0.03
C13:0	0.033 ± 0.018	0.163 ± 0.353	0.015 ± 0.025	0.034 ± 0.045	0.26
C14:0iso	0.163 ± 0.029	0.184 ± 0.203	0.135 ± 0.111	0.180 ± 0.110	0.66
C14:0	10.267 ± 2.277	14.235 ± 4.633	12.487 ± 3.974	12.565 ± 4.866	0.45
C14:1	0.472 ± 0.162	0.860 ± 0.454	0.683 ± 0.117	0.774 ± 0.560	0.22
C14:0 dm	0.457 ± 0.138	0.360 ± 0.190	0.398 ± 0.401	0.343 ± 0.168	0.38
C15:0iso	0.757 ± 0.136	0.670 ± 0.188	0.881 ± 0.213	0.924 ± 0.151	0.02
C15:0	1.304 ± 0.217	1.177 ± 0.314	1.283 ± 0.266	1.647 ± 0.562	0.12
C16:0iso	0.284 ± 0.149	0.294 ± 0.184	0.260 ± 0.223	0.268 ± 0.093	0.35
C16:0	26.200 ± 0.682	30.690 ± 3.136	33.546 ± 3.718	32.358 ± 6.234	0.09
C16:1	5.694 ± 0.360	6.630 ± 1.610	7.261 ± 0.988	8.116 ± 2.645	0.13
C16:0dm	0.454 ± 0.210	0.366 ± 0.174	0.439 ± 0.332	0.328 ± 0.179	0.57
C17:0iso	0.798 ± 0.205	0.511 ± 0.206	0.628 ± 0.389	0.824 ± 0.298	0.38
C17:0	0.681 ± 0.048	0.623 ± 0.214	0.663 ± 0.237	0.913 ± 0.248	0.003
C17:1	0.322 ± 0.093	0.312 ± 0.158	0.316 ± 0.162	0.562 ± 0.172	0.004
C18:0	19.019 ± 2.265	16.028 ± 6.263	16.166 ± 3.131	14.874 ± 5.663	0.64
C18:1	29.332 ± 1.377	19.723 ± 4.735	20.159 ± 4.691	21.275 ± 6.044	0.20
C18:2	1.741 ± 0.696	1.416 ± 0.496	1.230 ± 0.384	1.266 ± 0.546	0.89
C18:3	0.093 ± 0.091	0.700 ± 0.476	0.622 ± 0.664	0.751 ± 0.682	0.69
C20:0	0.152 ± 0.136	0	0.006 ± 0.017	0	0.001
C20:1	0.043 ± 0.051	0.018 ± 0.051	0	0	0.21

**Table IV.** Fatty acid composition of camel milk fat by species of Kazakhstan

Acids	Bactriane (n=7)	Dromedary (n=10)	Hybrids (n=3)	Mix (n=2)	p value
C4:0	0.536 ± 0.627	0.341 ± 0.293	0.198 ± 0.197	0.253 ± 0.088	0.52
C6:0	0.463 ± 0.392	0.288 ± 0.157	0.350 ± 0.342	0.602 ± 0.304	0.20
C8:0	0.527 ± 0.408	0.266 ± 0.193	0.407 ± 0.439	0.647 ± 0.167	0.02
C10:0	0.460 ± 0.507	0.272 ± 0.395	0.304 ± 0.337	0.383 ± 0.012	0.66
C10:1	1.149 ± 1.444	0.806 ± 1.224	0.543 ± 0.602	0.512 ± 0.040	0.78
C12:0	1.241 ± 0.585	0.798 ± 0.199	1.003 ± 0.695	1.331 ± 0.348	0.03
C13:0	0.172 ± 0.376	0.033 ± 0.059	0.013 ± 0.012	0.031 ± 0.043	0.56
C14:0iso	0.196 ± 0.189	0.186 ± 0.116	0.055 ± 0.023	0.093 ± 0.131	0.49
C14:0	15.434 ± 4.094	10.100 ± 1.325	12.951 ± 5.708	17.192 ± 3.682	0.001
C14:1	0.797 ± 0.416	0.571 ± 0.150	0.856 ± 0.520	1.114 ± 0.401	0.04
C14:0 dm	0.324 ± 0.167	0.497 ± 0.328	0.278 ± 0.209	0.197 ± 0.130	0.06
C15:0iso	0.772 ± 0.215	0.881 ± 0.204	0.601 ± 0.127	0.719 ± 0.002	0.07
C15:0	1.412 ± 0.503	1.240 ± 0.179	1.068 ± 0.165	1.526 ± 0.384	0.19
C16:0iso	0.222 ± 0.140	0.343 ± 0.214	0.205 ± 0.048	0.243 ± 0.191	0.31
C16:0	32.051 ± 3.834	29.738 ± 4.617	32.564 ± 2.660	35.070 ± 3.637	0.12
C16:1	7.008 ± 2.014	6.599 ± 1.314	6.735 ± 1.011	8.651 ± 0.732	0.11
C16:0dm	0.380 ± 0.203	0.441 ± 0.300	0.340 ± 0.209	0.344 ± 0.013	0.86
C17:0iso	0.548 ± 0.268	0.823 ± 0.237	0.487 ± 0.207	0.230 ± 0.325	0.003
C17:0	0.646 ± 0.318	0.756 ± 0.173	0.610 ± 0.119	0.575 ± 0.153	0.23
C17:1	0.332 ± 0.248	0.376 ± 0.130	0.329 ± 0.169	0.304 ± 0.008	0.83
C18:0	14.752 ± 5.553	17.824 ± 3.702	17.689 ± 5.351	12.330 ± 1.919	0.12
C18:1	18.779 ± 4.680	24.661 ± 4.629	20.641 ± 5.378	15.446 ± 1.492	0.002
C18:2	1.186 ± 0.446	1.606 ± 0.507	1.101 ± 0.406	1.260 ± 0.270	0.24
C18:3	0.604 ± 0.406	0.511 ± 0.710	0.673 ± 0.357	0.875 ± 0.723	0.81
C20:0	0.007 ± 0.018	0.045 ± 0.097	0	0	0.31
C20:1	0	0.013 ± 0.032	0	0.072 ± 0.102	0.05

**Table V.** Percentage of fatty acids (short chain C4:0 to C8:0, mean chain C10:0 to C16:0, and long chain C17:0 to C20:0) in the different classes issued from the classification analysis.

Fatty acid's group	Class number			
	1	2	4	3
C4:0 - C8:0	2.15	1.28	0.81	0.37
C10:0 - C16:0	66.82	60.36	53.65	49.19
C17:0 - C20:0	31.03	38.49	45.52	50.48



