Vol 16 No 2, p 245-251

PHYSIOCHEMICAL PROPERTIES AND AMINO-ACID COMPOSITION OF ALXA BACTRIAN CAMEL MILK AND SHUBAT

Yan-hong Bai[1], Dian-bo Zhao[1] and He-ping Zhang[2]

[1]College of Food and Biological Engineering, Zhengzhou University of Light Industry, Dongfeng Road, Zhengzhou, Henan, P.R., China

[2]College of Food Science and Engineering, Inner Mongolia Agriculture University, Hohhot, P.R., China

ABSTRACT

The milk of Alxa bactrian camels reared in Inner Mongolia during different lactation stage were analysed for specific gravity, pH, titrable acidity, electrical conductivity and the composition of amino acids. Meanwhile, the composition of shubat prepared from camel milk was also determined. The values of specific gravity, pH and titrable acidity were 1.055 to 1.034, 6.31 to 6.53 and 0.17 to 0.24 of colostrums from 2h to 7d post partum (PP), respectively, and the respective mean values of regular milk were 1.032 to 1.034, 6.31 to 6.57 and 0.17 to 0.20%. The total content of Na^+, $K^+$and Cl^- was responsible for most of electrical conductivity in Alxa bactrian camel milk. The values content of histidine, arginine, threonine, valine, methionine, isoleucine, leucine, phenylalanine and lysine at the first milking were 2.50, 4.94, 6.50, 6.52, 2.10, 4.05, 7.94, 4.38 and 7.40 g/100 g, respectively, and the respective mean values of milk (90d PP) were 2.64, 4.11, 4.52, 6.20, 3.16, 5.61, 9.48, 4.73 and 7.75 g/100 g. The ratio of essential to non- essential amino acids, cystine to methionine and phenylalanine to tyrosine in Alxa bactrian camel milk (90d PP) were 0.97, 0.34 and 1.19, respectively, and the respective mean values of shubat were 1.11, 0.28 and 1.86.

Key words: Alxa bactrian camel, amino acid composition, camel milk, physical parameters, shubat

The bactrian camels more prevalent in desert and semi-desert areas of northwestern China and Mongolia, are mainly used for working and wool production. There are also some bactrian camels in Afghanistan and Tajikistan, where camel milk is mainly used for feeding young calf. Milk-producing camels can be divided into 3 categories, i.e. high milk yield (more than 3000 l/yr), medium milk yield (1500 to 3000 l/yr) and low milk yield (less than 1500 l/yr) (Zhang *et al*, 2005).

There are 3 fine breeds of bactrian camels in China, namely Xinjiang, Alxa and Sunite (Zhang *et al*, 2005). Alxa camels can further be divided into Gobi and Desert camels based on their stature, physical features, and breeding distinctions. Alxa camels are reared mainly by natural grazing in different herd sizes ranging from 10 to 100 camels with a grazing radius of 40 to 50 km. Pregnancy lasts 395 to 405 days and lactation takes place during February–August. Alxa camel belong to low milk yield category and produce 0.25 to 1.5 l of milk daily in addition to the amount consumed by the calf.

Camel milk can be used for making various dairy products such as butter, shubat, cheese and milk tea. Fermented camel milk is traditional product and has various names in different parts of the world, which strongly contributes to the cultural identity of those countries. In Kazakhstan, it is called shubat (Stefan Kappeler, 1998), kefir (Caucasus), dahi (India), yoghurt (Bulgaria), lehben (Syria, Israel and Egypt) and Tarag (Mongolia).

Camel milk is not only nutritious for local people, but also had therapeutic properties. It had been proved that camel milk was benificial for patients. In India, camel milk was used therapeutically against dropsy, jaundice, tuberculosis, asthma, anaemia, and piles (Yagil, 1982). Lozovich (1995) reported that camel milk was used to treat patients suffering from gastrointestinal ulcers, the complete healing was seen in 57.5% cases. Agrawal *et al* (2003) reported that camel milk was also useful for the treatment of Type 1 diabetes patients as the insulin demand decreased by consumption of 0.5 l of camel milk per day. Shubat was a kind of camel milk product that was used to cure certain ailments (Yagil, 1982). Sukhov *et al* (1986) revealed that shubat was sucessfully used in the treament of peptic ulcers in Russia.

SEND REPRINT REQUEST TO DIAN-BO ZHAO email: zhaodb212@163.com

It is well known that the best nutritional option for new-borns is their mother's milk, however, some infants may not be exclusively breast fed during the first month of life. Therefore, there is a need for another substitute of close composition and properties as human milk. Modified cow milk preparations are the most used as substitutes for human milk. However, many nutritional problems were reported from its use for infant feeding due to cows milk allergy. Other types of milk has been proposed as substitute of human milk such as goat (Park and Haenlein, 2006), sheep (Haenlein and Wendorff, 2006), buffalo (Shamsia, 2005), but little information are available on the use of camel milk for this purpose.

The chemical composition of Alxa bactrian camel milk, in particular, protein, fat, lactose, ash, total solids, fatty acids, major minerals, vitamins and fraction of proteins has been published (Zhang *et al*, 2005). However, the information about physico-chemical properties of Alxa bactrian camel milk such as specific gravity, pH, acidity and electrical conductivity was limited in China. The biological value of camel milk and shubat were determined to a large extent by their amino-acid composition. The amino-acid composition of dromedary camel milk had been investigated (Yagil, 1982; Sawaya *et al*, 1984; Mehaia and Al-Kahnal, 1989; Park and Haenlein, 2006; Shamsia, 2005). However, the amino-acid composition of Alxa bactrian camel milk and shubat had been insufficiently studied in China.

The objectives of this work was to study the physico-chemical properties and the amino-acids composition of Alxa bactrian camel milk and shubat in Inner Mongolia.

Materials and Methods

Animals

Ten 5-year old Alxa bactrian female camels close to giving birth for the first time were randomly selected from different herds that depended on natural grazing. The camels, which all belonged to the Alxa nomads in Inner Mongolia, were kept under muster management before giving birth and fed with hay supplemented with corn after parturition.

Collection of Samples

Sampling collection started immediately following parturition at 2h, 1d, 3d, 7d, 15d, 30d, and 90d post partum (PP). All the samples collected were stored at -40°C until analysis. During testing, samples taken at the same stage of lactation were thawed, pooled and portions taken for analysis. Samples taken during the first 7d of lactation were considered as colostrum, after which the secretion were considered regular milk (Gorban and Izzeldin, 1997).

The shubat were collected from TaLingAiLi pasturage in Alxa Prefecture in Inner Mongolia. The shubat was prepared from Alxa bactrian camel milk that had been naturally fermented for 3 days.

Physical parameters analysis

Titrable acidity (TA) and specific gravity were determined according to the method of Association of Official Analytical Chemists (AOAC, 1990a,b). pH values were determined using pH meter (Model pHS-3C, Lei-Ci Instruments, Shanghai, China). Electric conductivity and EC, were determined using conductivity meter (Model DDS-11C, Lei-Ci Instruments, Shanghai, China) according to the instruction.

Amino Acids Composition Analysis

Thawed milk samples were thoroughly mixed and hydrolysed using 6N HCl in sealed glass ampule for 24h at 110°C (Ozols, 1990). The hydrolysate was centrifuged and the supernatant was used for analysis after filtering through a 0.22 μm syringe filter. The analysis of amino acids were achieved by automatic amino acid analyser (Hitachi 835-50, Tokyo, Japan).

Data were analysed by a general linear model procedure of the Fisher's PLSD test using SAS (SAS Institute Inc., Cary, NC). This test combines ANOVA with comparison of differences between the means of the treatments.

Results and Discussion

Physical parameters analysis

The data of physical parameters for Alxa bactrian camel milk was shown in Table 1. The titrable acidity (TA) was denoted in terms of lactic acid content (g/100g). At the first milking (2h PP), the TA content and pH of Alxa bactrian camel colostrum (0.24±0.01% and 6.31±0.046, respectively) were lower and higher, respectively than those of Indian camel colostrum (0.38% and 5.6, respectively) as reported by Ohri and Joshi (1961). As lactation progressed, the pH and TA value did show any variation, which could be attributed mainly to the buffering properties of milk. The pH values ranged from 6.31 to 6.53 for Alxa bactrian camel colostrum, which were similar to those reported for dromedary camel colostrum by Gorban and Izzeldin (1997). The pH values ranged from 6.31 to 6.57 for Alxa bactrian camel regular milk, the data were congruent with similar results of dromedary camel milk as reported by Mehaia *et al* (1995), Gorban and Izzeldin (1997) and Farah (1993), however, the pH values were lower than Majaheim, Wadah and Hamra breeds of camel as reported by Mehaia *et al* (1995). The TA values ranged from 0.17 to 0.20% for Alxa bactrian camel regular milk, and higher than that of dromedary camel (Table 2).

The specific gravity of colostrum obtained from the first milking (1.055±0.008) was slightly lower than that of Indian camel colostrum (1.079) reported by Ohri and Joshi (1961). Within the first day of lactation there was a significant change ($p < 0.05$) in the specific gravity value. As lactation progressed, the specific gravity value did not show any noticeable variation up to 90 days.

Results presented in Table 3 and Fig 1 revealed that there was the same variation trendline between EC and the total concentration of Na^+, K^+ and Cl^- and with the increase of the total concentration of Na^+, $K^+$and Cl^-, the electrical conductivity value also increased. Any ion content changes, did not affect the electrical conductivity (Table 1, Table 3). Therefore, Na^+, K^+ and Cl^- are responsible for most of electrical conductivity in Alxa bactrian camel milk. The results were similar to cow milk reported by Fox and Mcsweeney (1998).

Changes in amino acid composition of Alxa bactrian camel colostrum and regular milk protein during from 2h to 3-month lactation period were shown in Table 4.

There was a sharp decline in threonine content from 6.50 g/100 g to 5.50 g/100 g from the first milking to 1d postpartum. It continued decreasing

Table 1. Changes of physical parameters of Alxa bactrian camel milk during the lactation period (mean values ±sd).

Lactation stage (h/d)	Specific Gravity	pH	Titrable Acidity (%)	EC (10^4µS/cm)
2h	1.055±0.008[a]	6.31±0.05[c]	0.24±0.01[a]	0.380±0.006[e]
1d	1.034±0.002[b]	6.45±0.10[abc]	0.18±0.02[d]	0.450±0.003[b]
3d	1.037±0.003[b]	6.53±0.07[a]	0.22±0.01[b]	0.430±0.004[c]
7d	1.035±0.003[b]	6.48±0.13[ab]	0.18±0.02[d]	0.408±0.004[d]
15d	1.036±0.003[b]	6.57±0.08[a]	0.18±0.02[d]	0.380±0.004[e]
30d	1.034±0.003[b]	6.45±0.11[abc]	0.20±0.02[c]	0.400±0.010[d]
90d	1.032±0.001[b]	6.31±0.02[bc]	0.17±0.01[d]	0.547±0.011[a]

Data are means of triplicate determinations.

[a,b,c,d,e]The same letters in a column denote treatments that are not significantly different ($P > 0.05$) based on Fisher's PLSD multiple comparisons.

Table 2. Physical parameters for dormedary camel regular milk.

Reference	pH	Titrable Acidity (%)	Specific Gravity
Wangoh (1997)	–	0.13-0.16	1.028-1.033
Mehaia (1994)	6.61	0.14	–
Sawaya *et al* (1984)	6.49	0.13	–
Abu-Lehia (1987)	–	0.15	–
Mehaia and Al-Kanhal (1989)	6.50	0.13	–
Elamin and Wilcox (1992)	–	0.15	–
Farah (1993)	6.56-6.70	–	1.025-1.032
Gorban and Izzeldin (1997)			
Colostrum	6.00-6.79	–	–
Mature milk	6.23-6.85	–	–
Mehaia *et al* (1995)[1]			
Majaheim	6.61-6.68	0.14-0.15	–
Wadah	6.61-6.68	0.13-0.15	–
Hamra	6.61-6.68	0.13-0.15	–
Shamsia (2009)	6.59-6.69	0.16-0.17	1.033

1. Majaheim, Wadah and Hamra were 3 different breeds.

Table 3. Contents of Na^+, K^+ and Cl^- in Alxa bactrian camel milk during the lactation period (mg/100g).

Lactation stage (h/d)	Na^+	K^+	Cl^-	Total (Na^+, K^+ and Cl^-)
2h	65.0	136.5	141.2	342.7
1d	92.5	124.0	194.7	411.2
3d	79.5	150.0	133.5	363.0
7d	63.0	152.5	91.3	306.8
15d	57.5	151.5	80.9	289.9
30d	60.5	154.0	86.3	300.8
90d	72.0	191.0	152.0	415.0

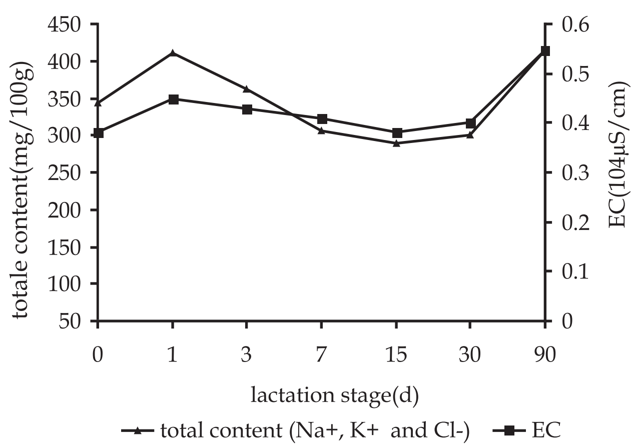

Fig 1. Relation between the total content of Na^+, K^+ and Cl^- and EC changes in amino-acid composition of Alxa bactrian camel milk.

gradually to reach 4.54 g/100 g on 7d of lactation, thereafter stabilised on regular milk. The valine content of Alxa bactrian camel colostrum milk at the first milking was higher (6.52 g/100 g) than that of regular milk. There was no significant variation from 1d to 90d (PP), and the value of valine content was 6.20 g/100 g on 90d. This study also showed that the contents of methionine, isoleucine and leucine increased gradually from the first milking to 7d lactation in Alxa bactrian camel colostrum milk, thereafter the contents remained relatively stable on regular milk. The values contents of methionine, isoleucine and leucine were 2.10, 4.05 and 7.94 g/100 g at the first milking, respectively, and the respective values were 3.16, 5.61 and 9.48 g/100 g for regular milk on day 90. The content of phenylalanine remained relatively stable, the value ranged from 4.31 to 4.73 g/100 g during the study period lactation. It suggested that the composition of phenylalanine was not influenced by stage of lactation. There was no obvious difference in contents of lysine for Alxa camel milk from day 1 to 90. The lysine concentration of Alxa bactrian camel colostrum at 2h after parturition was as low as 7.40 g/100g, then reached its highest levels (7.89 g/100 g) after about a week and then decreased to its average value thereafter. Lysine was present at lower level in Alxa bactrian camel regular milk than that of cow, human, buffalo, sheep and goat milk reported by Park and Haenlein (2006) but higher than the dromedary camel milk as reported by Sawaya *et al* (1984), Mehaia and Al-Kahnal (1989), Park and Haenlein (2006) and Shamsia (2009).

In present study arginine and histidine were considered as essential amino acids (Park and Haenlein, 2006). The values of histidine content in milk exhibited less marked changes in test period. The present histidine values fell well within the range of values (2.50 to 2.90) as shown in Table 5. The content of arginine was higher in Alxa bactrian camel colostrum than that in regular milk. The value of arginine content was 4.94 g/100 g at the first milking, thereafter it decreased to 4.27 g/100 g on day 7 with the progress of lactation. The present value of arginine content in regular milk was congruent with similar results reported by Sawaya *et al* (1984), Mehaia and Al-Kahnal (1989), Park and Haenlein (2006) and Shamsia (2009).

Glutamic acid is the major amino acid in Alxa bactrian camel milk, similar to other species reported by Farah (1993) and Park and Haenlein (2006). Glutamic content was as low as 17.66 g/100 g at the first milking, thereafter the contents exhibited less marked changes, and the values ranged from 21.27 to 22.26 g/100 g during the test period from d 3 to 90. The present values of glutamic content in Alxa bactrian camel regular milk was congruent with similar results reported by Sawaya *et al* (1984), Mehaia and Al-Kahnal (1989), Park and Haenlein (2006) and Shamsia (2009).

The content of aspartic, serine, glycine and alanine were higher in Alxa bactrian camel colostrum than that in regular milk. Their values at the first milking (2h PP) were 8.39, 6.01, 3.48 and 3.76 g/100 g, respectively, thereafter they decreased gradually, and the respective values were 7.16, 4.72, 1.49 and 2.51 g/100 g at 7d PP, then remained relatively stable of regular milk. The content of aspartic, serine and glycine in Alxa camel regular milk were similar to that of dromedary camel milk reported by Sawaya *et al* (1984), Mehaia and Al-Kahnal (1989), Park and Haenlein (2006) and Shamsia (2009).

The content of cystine, proline, and tyrosine was 0.40, 7.64 and 4.75/100 g at 2h, respectively, and the perspective values were 1.08, 7.68 and 3.90/100 g at 90d PP. However, the content of proline, tyrosine and alanine in Alxa bactrian camel regular milk were lower than that of dromedary camel milk reported by authors Sawaya *et al* (1984), Mehaia and Al-Kahnal (1989) and Park and Haenlein (2006).

The amino acid composition of Alxa bactrian camel regular milk appeared to be similar to that of wild bactrian camel, Gobi Red bactrian camel (JiRiMuTu, 2006), dromedary camel, cow, buffalo, sheep and goat milk that reported by Sawaya *et al* (1984), Mehaia and Al-Kahnal (1989), Park and Haenlein (2006) and Shamsia (2009).

There was difference between datum of amino acid of composition for camel milk that had been published (Table 5). The difference in the amino acid composition may be attributed to factors such as breed, age, the number of calving, nutrition, management, the stage of lactation and the sampling techniques used. In general, the essential amino acids of composition for Alxa camel milk were well within the range of dromedary camel.

The ratio of essential to non-essential amino acids in Alxa bactrian camel milk (90d PP) was 0.97, which was quite close in milk of other species, being 0.94, 0.92, 0.93, 1.00, 0.95 and 1.07 for wild bactrian camel, Gobi Red bactrian camel, dromedary, cow, sheep and human, respectively (JiRiMuTu, 2006; Park and Haenlein, 2006).

The ratio of cystine to methionine in Alxa bactrian camel milk (90d PP) was 0.34, which seemed to be similar in wild bactrian camel (0.24) and Gobi Red bactrian camel (0.25), and it was quite close to that of dromedary (0.38), however, it was lower than that of cow (0.50) and human milk (0.60) (JiRiMuTu, 2006; Park and Haenlein, 2006). It was perhaps due to the high content of methionine in Alxa bactrian camel milk. The ratio of phenylalanine to tyrosine in Alxa bactrian camel milk (90d PP) was 1.19, which was quite close to that of Wild bactrian camel (1.19), Gobi Red bactrian camel (1.19), and it seemed to be similar to that of dromedary (1.10) and cow milk (0.91), however, it was lower than that of human milk (1.34) (JiRiMuTu, 2006; Park and Haenlein, 2006).

Amino-Acid Composition of Shubat

Amino acid composition of shubat protein was shown in Table 6. The percentage of essential amino acids to total amnio acids was 52.70%, which was quite close to that of human milk (51.80%), however, it was higher than that of Alxa bactrian camel milk on 90 day of lactation (49.21%) (Park and Haenlein, 2006).

Table 4. Changes of amino-acid composition of Alxa bactrian camel milk during the lactation period. (g/100g Protein).

Lactation stage (h/d)	2h	1d	3d	7d	15d	30d	90d
Essential							
Histidine	2.50	2.65	2.75	2.73	2.65	2.63	2.64
Arginine	4.94	4.77	4.35	4.27	3.99	4.00	4.11
Threonine	6.50	5.50	4.81	4.54	4.41	4.45	4.52
Valine	6.52	6.37	6.11	6.17	6.25	6.19	6.20
Methionine	2.10	2.27	2.74	2.86	2.85	2.94	3.16
Isoleucine	4.05	4.73	5.31	5.50	5.56	5.55	5.61
Leucine	7.94	8.72	9.29	9.46	9.41	9.60	9.48
Phenylalanine	4.38	4.35	4.31	4.40	4.37	4.42	4.73
Lysine	7.40	7.77	7.81	7.89	7.65	7.65	7.75
Tryptophan	----	----	----	----	----	----	----
Nonessential							
Aspartic	8.39	8.05	7.57	7.16	6.83	6.55	7.15
Serine	6.01	5.24	4.87	4.72	4.36	4.65	4.65
Glutamic	17.66	19.46	21.82	21.76	22.26	22.23	21.27
Glycine	3.48	2.57	1.69	1.49	1.35	1.32	1.50
Alanine	3.76	3.24	2.68	2.51	2.35	2.37	2.46
Cystine	0.40	0.59	0.65	0.74	0.70	0.68	1.08
Proline	7.64	7.76	7.62	8.09	9.59	9.27	7.68
Tyrosine	4.75	4.23	3.82	3.93	3.68	3.78	3.96

---- Not detected,Values are means of triplicate determinations.

The ratio of essential to non-essential amino acid in shubat was 1.11, which was quite close to that of human milk (1.07), and higher than that of Alxa bactrian camel, Wild bactrian camel, GobiRed bactrian, dromedary, cow and sheep milk (JiRiMuTu, 2006; Young and George, 2006). The ratios of phenylalanine to tyrosine in shubat was 1.86, which seemed to be similar to that of human milk (1.34) (Park and Haenlein, 2006). It was similar to that of other species milk, that glutamic acid was the major amino acid in shubat and its content was 17.84 g/100 g.

Reassessed the essential amino acid for Alxa camel milk

The suggested patterns of amino acid requirements in g/100 g of protein were compared with the composition of Alxa camel milk (90d PP). The results were shown in Table 7. The content of tryptophan was not determined at the present study. The contents of phenylalanine, tyrosine, valine,

Table 5. Comparison of the composition of amino acid in Alxa bactrian camel milk (90d) with dormedary camel milk. (g/100g Protein).

	This work (90d PP)	Camel[1]	Camel[2]	Camel[3]	Camel[4]
Essential					
Histidine	2.64	2.50	2.70	2.70	2.9
Arginine	4.11	3.90	3.80	4.03	5.1
Threonine	4.52	5.20	4.30	5.73	5.3
Valine	6.20	6.10	6.90	6.65	4.80
Methionine	3.16	2.50	3.60	3.15	2.6
Isoleucine	5.61	5.40	5.00	5.10	4.9
Leucine	9.48	10.40	9.50	9.70	9.00
Phenylalanine	4.73	4.60	5.60	5.00	3.70
Lysine	7.75	7.00	7.10	7.20	6.60
Tryptophan	----	1.20	----	1.20	1.80
Nonessential					
Aspartic	7.15	7.60	6.40	6.98	7.20
Serine	4.65	5.80	4.20	5.20	3.00
Glutamic	21.27	23.90	19.50	21.70	21.10
Glycine	1.50	1.70	1.30	1.50	1.20
Alanine	2.46	2.80	2.70	3.00	3.30
Cystine	1.08	1.00	0.60	1.20	1.50
Proline	7.68	11.10	11.10	12.00	13.00
Tyrosine	3.96	4.50	4.00	4.55	3.00

Values for dromedary camel from different source:
1. Originated from Sawaya *et al* (1984)
2. Originated from Mehaia andAl-Kahnal (1989)
3. Originated from Park and Haenlein (2006)
4. Originated from Shamsia (2009)

isoleucine and lysine were higher in Alxa camel milk proteins than that of the suggested patterns of amino acid requirements for infants. The composition of leucine, methionine, cystine, threonine and histidine were similar to the patterns of amino acid requirements as suggested by FAO/WHO/UNU (1985). The composition of essential amino acids were higher in Alxa camel milk proteins than the patterns of amino acid requirements for adults suggested by FAO/WHO/UNU (1985). The Alxa camel milk proteins with an essential amino acid content and pattern (Table 7) that effectively met the needs of infants and young children will also be adequate for elder children and adults. It was evident that the amino acid composition of Alxa camel milk proteins more than requirements for all other age groups suggested by FAO/WHO/UNU (1985).

Table 6. Amino acid composition of Shubat (g/100g Protein).

Essential amino acids		Nonessential amino acids	
Histidine	2.40	Aspartic	5.89
Arginine	3.59	Serine	4.56
Threonine	4.47	Glutamic	17.84
Valine	6.22	Glycine	1.33
Methionine	2.76	Alanine	2.73
Isoleucine	5.34	Cystine	0.78
Leucine	9.71	Proline	5.63
Phenylalanine	4.28	Tyrosine	2.30
Lysine	6.98		
Tryptophan	–		

Table 7. Comparison of the composition of amino acid in Alxa camel milk (90d) with the suggested patterns of requirement by FAO/WHO/UNU.

Amino acid (g/100g Protein)	Suggested patterns of requirement			
	Alxa camel milk	Infant	Schoolchild	Adult
Isoleucine	5.61	4.60	2.80	1.30
Leucine	9.48	9.30	4.40	1.90
Lysine	7.75	6.60	4.40	1.60
Methionine + Cystine	4.24	4.20	2.20	1.70
Phenylalanine+ Tyrosine	8.69	7.20	2.20	1.90
Tryptophan	–	1.70	0.90	0.50
Valine	6.20	5.50	2.50	1.30
Threonine	4.52	4.30	2.80	0.90
Histidine	2.63	2.60	1.90	1.60
Total				
Including Histidine	49.12	46.00	24.10	12.70
Minus Histidine	46.49	43.40	22.20	11.10

The present study data revealed that Alxa camel milk proteins had the satisfactory quality balance of essential amino acids for human diets, or exceeding the FAO/WHO/UNU (1985) requirement for amino acids. Alxa camel milk could meet at least or better significant proteins of daily nutrient need of human, especially the essential amino acids, a relatively small amounts of camel milk could supply human needs.

References

Abu-Lehia (1987). Composition of camel milk. Milchwissenchaft 42:368-371.

Agrawal RP, Swami SC, Beniwal R, Kochar DK, Sahani MS, Tuteja FC and Ghouri SK (2003). Effect of camel milk on glycaemic control, risk factors and diabetes quality of life in type-1 diabetes: a randomised prospective controlled study. Journal of Camel Practice and Research 10:45-50.

AOAC (1990a). Acidity of milk (Titrimetric method). In: Official Methods of Analysis, No. 947.05. Association of Official Analytical Chemists Inc. Virginia, USA.

AOAC (1990b). Specific gravity of milk (Pycnometer method). In: Official Methods of Analysis, No.925.22. Association of Official Analytical Chemists Inc. Virginia, USA.

El-Amin FM and Wilcox CJ (1992). Milk composition of Majaheim camels. Journal of Dairy Science 75:3155-3157.

Farah Z (1993). Composition and characteristics of camel milk. Journal of Dairy Research 60:603-626

FAO/WHO/UNU (1985). Energy and protein requirements. WHO Technical Reports Series Nr. 724, WHO, Geneva.

Fox PF and Mcsweeney PLH (1998). Dairy Chemistry and Biochemistry. Great Britain: St Edmundsbury Press Ltd, Bury St Edmunds, Suffolk.

Gorban AMS and Izzeldin OM (1997). Mineral content of camel milk and colostrum. Journal of Dairy Research 64:471-474.

Haenlein G, Wendorff WL (2006). Sheep milk. In: Handbook of Milk of Non-Bovine Mammals. Park YW, Haenlein GF (Eds), Blackwell Publishing, Iowa, USA. pp 137-194.

JiRiMuTu (2006). Studies on Molecular Evolution of Domestic and Wild Bactrian and the Physical-chemical Properties of Camel Milk. Diss. ETH No 219208, China.

Lozovich S (1995). Medical use of whole and fermented mare milk in Russia. Cultured Dairy Products Journal 30:18-21.

Mehaia MA and Al-Kahnal MA (1989). Studies on camel and goat milk proteins: Nitrogen distribution and amino acid composition. Nutrition Reports International 39(2):351-357.

Mehaia MA (1994). Effect of milk and calcium concentration and pH on rennet coagulation time of UF camel milk. Egyptian Journal of Dairy Science 22:297-306.

Mehaia MA, Hablas MA, Abdel-Rahman KM and El-Mougy SA (1995). Milk-Composition of Majaheim, Wadah and Hamra Camels in Saudi-Arabia. Food Chemistry 52:115-122.

Ohri SP and Joshi BK (1961). Composition of camel milk. Indian Veterinary Journal 38:604-608.

Ozols J (1990). Amino acid analysis. In: Guide to protein purification; (Ed. Murray, PD). Methods in Enzymology. 182:587-601, Academic Press, London.

Park Young W and Haenlein George FW (2006). Handbook of Milk of Non-Bovine Mammals. Australia: Blackwell Publishing Ltd, First edition.

Sawaya WN, Khalil JK, Al-Shalhat A and Al-Mohammad H (1984). Chemical composition and nutritional quality of camel milk. Journal of Food Science 49:744-747.

Shamsia S (2005). Biochemical, Molecular and Immunological studies on buffalo milk protein in relation to human health and nutrition Ph.D. Thesis, Alexandria University, Egypt.

Shamsia SM (2009). Nutritional and therapeutic properties of camel and human milks. International Journal of Genetics and Molecular Biology 2:052-058.

Stefan Kappeler (1998). Compositional and Structural Analysis of Camel Milk Proteins with Emphasis on Protective Proteins, Diss. ETH No. 12947, Zurich.

Sukhov SV, kalamkarova LI, Il'chenko LA and Zhangabylov AK (1986). Changes in the microflora of the small and large intestine in patients with chronic enteritis after dietary treatment with cultured milk products. Voprosy Pitaniya 4:14-17.

Yagil R (1982). Camels and camel milk. Animal Production and Health Paper FAO. Rome, No. 26.

Wangoh J (1997). In: Chemical and technological properties of camel (*Camelus dromedarius*) milk. Diss. ETH No 12295, Zurich.

Zhang H, Yao J, Zhao D, Liu, H Li J and Guo M (2005). Changes in chemical composition of Alxa Bactrian camel milk during lactation. Journal of Dairy Science 88:3402-3410.