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# Camel milk and milk products

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**Abstract**

Camel milk and camel milk products have always been highly esteemed playing even today an important role in the diet of the population in the rural areas of Africa, Asia and the Middle East, with scarce agricultural areas, high temperatures and small amount of precipitation. In aggravated environmental circumstances, camels may produce more milk than any other species, while their demand for food is very modest. A camel produces between 1000 and 2000 L of milk during the lactation period of 8 to 18 months, while the daily production of milk is between 3 and 10 L. The goal of the overview is to present the chemical composition of camel milk, and products made from camel milk. On average camel milk contains 81.4-87 % water, 10.4 % dry matter, 1.2-6.4 % milk fat, 2.15-4.90 % protein, 1.63-2.76 % casein, 0.65-0.80 % whey protein, 2.90-5.80 % lactose and 0.60-0.90 % ash. Variations in the contents of camel milk may be attributed to several factors such as analytical methods, geographical area, nutrition conditions, breed, lactation stage, age and number of calvings. Camel milk is becoming an increasingly interesting product in the world, not only for its good nutritive properties, but also for its interesting and tasteful products.

*Key words:* camel milk, chemical composition, camel's milk products

## Introduction

In only few centuries, camels have inhabited several areas playing an important role in the production of milk, dairy products, production of meat and other products such as chocolate, soaps, etc. Camels are raised in areas with small amount of precipitation and long dry periods. Bactrian camels are mostly raised in areas where annual temperatures do not exceed 21 °C. It is assumed that taming of camels began 2000-4000 years before Christ. Most camel breeds are classified on the basis of clan (family) name as well as according to geographical areas where camels have been raised. One exception is Somalia, where there are three camel breeds classified according to phenotype (*Hour*, *Siifdaar* and *Eyddimo*). Camels belong to the family *Camelidae* and suborder *Tylopoda*. The family *Camelidae* contains the genera *Camelus* (Old World Camelids) and *Lama* (New World Camelids). There are two distinct camel genera, one-humped camels and two-humped camels.

One-humped and two-humped Bactrian camel belong to the one-humped camel genus. The title "Bactrian" for two-humped camels refers to the area of "Bactria" in Northern Afghanistan, where this camel is believed to have originated from. One-humped camel is thinner and taller, with a thinner coat and it dwells in warmer semi-dry areas. The two-humped camel is smaller and has a thicker and

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longer coat; it dwells in cold mountainous areas. According to the FAO data (2008), there are about 18 million of camels in the world, 14 million of which are located in Africa and 4 million in Asia. In the total number of camels, one-humped camels are dominant (16 million). In global perspective, the economic significance of camel breeding is minimal in comparison with breeding of other domestic animals. The reason being higher costs of camel milk production as opposed to e.g. cow milk.

**Physiological adaptation to desert environment**

Camels live in habitat with high temperature differences and scarce precipitation. In the course of evolution, camels have adapted to conditions of such environment. They can store in their humps up to 36 kg of fat which serves as a source of water and energy when nutrients are not available. These humps enable the camel to travel up to 160 km without consuming water. Camels rarely sweat, even at a temperature up to 49 °C. During winter, desert plants may hold enough water to enable camels to survive without water for a few weeks. A camel may endure considerable dehydration. In warm surroundings it may tolerate a loss of water of at least 27 % of its body weight, which is twice as much as in other mammals. In warm periods, the animal coat plays an important role (a camel with a thicker coat consumes less water). Camels do not breathe hard, but they sweat. Sweat is excreted in moderate quantities and the coat remains dry. Camels may produce concentrated urine. Camels have the ability to develop mechanisms of resistance to mineral, energetic and protein malnutrition. One of these mechanisms is the nitrogen recycling (Faye et al., 2010).

Desert sand may present a problem to humans, but camels have developed special adaptations such as a thin membrane on the eye and an internal eyelid, which protects the eyes from sand storms, but still lets enough light through enabling camels to see. Double rows of long eyelashes also keep sand away from the eyes. Camels may close their nostrils and thus prevent sand from entering the nasal cavity.

**Lactation**

According to statistical data (FAO, 2008), camel milk production in the world amounts to about 5.3 million tons annually, with a mere 1.3 million tons consumed by people, while the remaining quantity is for calves. In aggravated environmental conditions, camels may produce more milk than any other species (Farah et al., 2007), while their demand for food is modest. A camel produces between 1000 and 2000 L of milk during 8 to 18 month of lactation (FAO, 2006). The average daily production of milk ranges from 3-10 L during the lactation (Farah et al., 2007). The daily production of milk may be increased to 20 L provided better animal feed, availability of water and veterinary care (FAO, 2006).

Camels become sexually mature at the age of 4 to 5 years. On average camels have their first calving when they are 6 or 7 years old. Under normal conditions (partus every second year), camels have 8-10 calves during their life, with an average life expectancy being 25 to 30 years. Pregnancy period lasts on average 13 months. After delivery, the young are not separated from the mother, if that happens, the mother stops secreting milk. Depending on management and environmental conditions the average lactation length in camel is 12 months with a range from 9 to 18 months (Khan and Iqbal, 2001).

**Chemical composition of camel milk**

Variations in the composition of camel milk may be attributed to several factors such as analytical methods, geographical area, nutritive conditions, breed, stage of lactation, age and number of calvings (Khaskheli et al., 2005). Geographical origin and seasonal variations are factors which influence most changes in composition of camel milk. Konuspayeva et al., (2009) studied the effect of geographical origin on the composition of camel milk and the study showed that camel milk from camels located in east Africa has more fat than milk from camels in Africa and western Asia. Seasonal variations also play a significant role in the composition of camel milk, even with camels of the same breed and from the same region (Bakheit et al., 2008).

**Water**

The amount of water in camel milk varies from 81.4-87 % (Bhakat and Sahani, 2006). Animal feed and consumption of water have the greatest influence on the content of water in camel milk. In the dry period the production of camel milk is reduced and increases in the rainy period. The milk of one-humped

Table 1. Water in milk of various animal species

| Species | Water (%) | Source |
|---|---|---|
| Camel | 81.4 - 87 | Bhakat and Sahani (2006) |
| Cow | 77 - 91 | Bosnić (2003) |
| Sheep | 75 - 87 | Anifantakis (1985) |
| Goat | 84 - 88 | Gazibara (2007) |
| Mare | 89 | Tratnik (2008) |
| Donkey | 90 - 92 | Ivanković et al. (2009) |

Table 2. Dry matter in milk of various dairy species

| Species | Dry matter (%) | Source |
|---|---|---|
| Camel | 8 - 15 | Bengoumi et al. (2005) |
| Cow | 12.8 | Tratnik and Božanić (2012) |
| Sheep | 13 - 25 | Anifantakis (1985) |
| Goat | 12 - 16 | Gazibara (2007) |
| Mare | 11 | Tratnik (2008) |
| Donkey | 8 - 10 | Ivanković et al. (2009) |

Table 3. Chemical composition of milk of various species of camel

| Species | Fat (%) | Protein (%) | Dry matter (%) | Lactose (%) |
|---|---|---|---|---|
| Bactrian camel | 6.67 | 3.33 | 13.07 | 2.77 |
| One-humped camel | 5.94 | 3.03 | 12.39 | 3.12 |
| Krossbreds | 6.09 | 3.28 | 11.91 | 3.04 |

Source: Konuspayeva (2007)

camels which dwell in warmer climate zones have less fat and more water (Wernery, 2006). The water in the milk is in greater part as free water, while the remaining part is in form of bound water. Milk ingredients soluble in water are lactose, α-lactalbumin and a part of salt, while the insoluble ingredients are milk fat, casein and β-lactoglobuline. Table 1 clearly shows that the amount of water in camel milk (81.4-87 %) is similar to that of goat milk (84-88 %).

**Dry matter in milk**

The dry matter in milk, in average of 10.4 %, consists of fat, lactose, proteins, ash (Kouniba et al., 2005). Stage of lactation and season have a significant influence on the daily production of milk, composition of fat, protein and dry matter (Zeleke, 2007).

The share of dry matter in camel milk is similar to that in goat, mare and donkey milk (Table 2). In dry matter (average 15.06 %) of camel milk, the main ingredients in camel milk are protein (4.9 %), milk fat (5.60 %), lactose (5.85 %), mineral substances (0.99 %).

The Bactrian camel milk has the greatest content of fat and dry matter, while the milk of hybrids has the greatest amount of proteins; the one-humped camel milk has the highest lactose content (Table 3).

**Milk fat**

Milk fat is emulgated in milk, which means that it is found in the form of fat globules dispersed in milk serum. The diameter of fat globules varies between 1.2-4.2 micron. The amount of fat in camel milk ranges between 1.8 and 5.0 per 100 g (Khaskheli et al., 2005), with an average of 2.63±0.40 g per 100 g, and is composed of triacylglycerole, which represents about 96 % of the total amount of lipides (Gorban and Izzeldin, 2001).

The composition of fatty acids is influenced by the environment and physiological factors such as nutrition, stage of lactation and genetic differences within the species (Farah et al., 1989). Dominant fatty acids in camel milk are palmitic and oleic acid (Attila et al., 2000). In comparison with cow milk, camel milk fat contains less short-chain fatty acids (Abu-Lehia, 1989) and a lower concentration of carotene (Stahl et al., 2006). Due to the lower concentration of carotene, camel milk is prominently white. Camel milk also contains a higher concentration of long-chain fatty acids compared to cow milk (Konuspayeva et al., 2008). Similarly, average values of unsaturated fatty acids (43 %) are higher in camel milk, especially essential fatty acids (Haddadin et al., 2008). The amount of saturated fatty acids (Konuspayeva et al., 2008) is higher in cow milk (69.9 %) than in camel milk (67.7 %). The cholesterole concentration (Konuspayeva et al., 2008) in camel milk (37.15 mg/100 g) is higher than in cow milk (25.63 mg/100 g). Studies of the physical constants such as melting, temperature and temperature of crystallisation showed that the values are higher in camel milk (41.9 °C and 30.5 °C), than in cow milk (32.6 °C and 22.8 °C) (Rüegg and Farah, 1991). The reason being lower amount of short-chain fatty acids ($C_4$-$C_{12}$) and a greater amount of long-chain fatty acids ($C_{14}$-$C_{22}$) in camel milk than in cow milk (Haddadin et al., 2008).

Camel milk has a higher concentration of caprylic, palmitoleic, oleic and α-linoleic acid in compared to cow milk. The concentration of myristic, palmitic and stearic acid is also higher in camel milk than in with mare milk (Salamon et al., 2009; Khalil et al., 2011; ).

**Milk proteins**

Camel milk contains two main fractions of proteins: casein and whey protein. The total amount of proteins varies from 2.15 to 4.90 % (Konuspayeva et al., 2009), resp. 3.1 % in average. The content of proteins in camel milk is influenced by the breed and season. The breed Majaheim produces milk with higher protein content compared with other breeds (Wadah and Hamra). The protein content is lowest in August (2.48 %) and highest in December and January (2.9 %) (Haddadin et al., 2008).

*Casein*

Casein (CN) is the main camel milk protein and its share in the milk of one-humped camels is 1.63-2.76 %, which represents about 52-87 % of total protein (Khaskheli et al., 2005). The share of casein differs within the breeds, i.e. the Safrah breed contains more casein in comparison to the breeds Majaheim and Wadah. Casein fractions in camel milk are $\alpha_{s1}$-casein (22 %), $\alpha_{s2}$-casein (9.5 %), β-casein (65 %) and κ-casein (3.5 %). $\alpha_{s2}$-casein contains 11 phosphoserine residue which provides casein with a strong affinity towards calcium, magnesium and oligo elements. κ-casein differs from other caseins with its sensitivity to chymosin, low affinity to calcium and the presence of carbohydrates within the structure. Camel milk hydrolysis κ-CN takes place on peptide connection $Phe_{97}$-$Ile_{98}$ by cymosine action, while in the cow milk it takes place on $Phe_{105}$-$Met_{106}$ (Kappeler et al., 1998). Camel milk κ-CN contains an additional proline residue in its sequence (Pro 95). An additional proline residue has an important role in the stability of camel milk κ-CN.

The average diameter of casein micelles in camel milk is 260-300 nm, which is compared with 130 nm in cow milk twice as much (Farah et al., 2004). Camel milk is similar to human milk because it contains a high concentration of β-casein, which might be the reason for its better digestibility and decreased frequency of allergies in infants.

Camel milk has a higher concentration of β-casein and lower concentrations of κ- and α-casein than cow milk. Caseins are easily digestible in the host intestine and are an excellent source of amino acids for growth and development of the young.

Amino acid composition of camel milk is very similar to cow milk. Concentrations of essential and non-essential amino acids are higher in the cow milk casein in comparison with dairy camel breeds, except the concentration of arginine which is higher in the milk of Safrah breeds. Concentration of essential amino acids is higher in cow β-casein in comparison with β-casein in dairy camel breeds, with exceptions like lysine, threonine, methionine and isoleucine (Salmen et al., 2012).

Concentration of nonessential amino acids in κ-casein in cow milk is higher in comparison with camel milk, except arginin the concentration of which is higher in camel milk κ-casein. Cow milk κ-casein contains a higher concentration of essential amino acids in comparison of camel milk, except for lysine whose concentration is higher in the camel κ-casein (Salmen et al., 2012).

*Whey proteins*

Whey proteins found in camel milk are α-lactalbumin, serum albumin, lysozyme, lactoferrin, peptidoglycan recognition proteins, lactoperoxidase and immunoglobulins. Camel milk whey proteins constitute 20-25 % of all proteins. The amount of whey proteins in the milk of one-humped camels varies between 0.63 and 0.80 % (Khaskheli et al., 2005). Camel milk contains a smaller amount of β-lactoglobuline in comparison with cow milk. The basic whey protein in cow milk is β-lactoglobuline (50 %), while in the camel milk it is α-lactalbumin. Lactoferrin in camel milk at pH 3-4 loses iron at its N-terminal end, and at pH 6-7 on its C-terminal end, while lactoferrin in the milk of other animal species retains iron at pH 3-4 (Khan et al., 2001). Whey obtained after camel milk coagulation is white (El-Zubeir and Jabreel, 2008) in comparison with the greenish whey obtained from cow milk. This is because whey from camel milk contains a higher concentration of smaller casein micelles and fat globules, as well as low concentration of riboflavin. Camel milk proteins are less stable at high temperatures (140 °C) in comparison with cow milk due to the absence or lack of β-lactoglobulin and κ-casein. The addition of urea or formaldehyde does not influences thermal stability of camel milk. However, camel milk whey is thermally more stable in comparison with cow milk whey (Wernery, 2006). At 80 °C/30 minutes, the denaturation of camel milk whey proteins is lower (32-35 %) in comparison with cow milk whey (70-75 %). During thermal processing of camel milk whey at pH bellow 5, aggregation of whey proteins occurs because of the high content of α-lactalbumin. Consequently, whey proteins in camel milk are more sensitive to acidity than whey proteins in cow milk (Laleye et al., 2008).

**Lactose**

The amount of lactose in camel milk varies from 2.91 g to 4.12 g per 100 g, which is less when compared to 4.4-5.8 % in cow milk (Khaskheli et al., 2005). Large differences in lactose content may be conditioned by animal nutrition. i.e. dependent on the kinds of plants with which animals are fed (Khaskheli et al., 2005).

**Ash**

The amount of ash in camel milk varies from 0.60 % to 0.90 % (Konuspayeva et al., 2009), and the ash in camel milk is subject to breed, analytical procedures, nutrition, and water consumption (Haddadin et al., 2008). Camel milk is a rich source of chloride (Khaskheli et al., 2005) because of feed consumed by camels, such as *Atriplex* and locust tree, which usually contain a high content of salt (Yagil, 1982).

**Vitamins**

Camel milk contains vitamins C, A, E, D and B group (Haddadin et al., 2008). It is well known that camel milk is a rich source of vitamin C (34.16 mg/L) and is 3-5 fold greater compared with cow milk (Stahl et al., 2006). Moreover, camel milk contains more niacin ($B_3$), folic acid, pantothenic acid, vitamin $B_{12}$, but less vitamin A and riboflavin (Stahl et al., 2006).

**Camel milk products**

Camel milk products have an important role in the diet of the population in rural areas of Africa, Asia and the Middle East. This specially refers to those who live in dry areas where raw milk and fermented products are important source of energy and nutrients.

**Fermented products**

*Shubat (Chal)*

This is a traditional sparkling white fermented milk product in Turkey, Kazakhstan and Turkmenistan with an extremely sour taste. It is made from raw milk or milk diluted with warm water in the ratio 1:1. Milk is then stored in goat skin or ceramic containers and inoculated with 1/3 or 1/5 of previously fermented milk. Incubation takes 3 to 4 hours at 25-30 °C, but is usually left for 8 hours at the same temperature to obtain its typical taste. It is also possible to add lactic cultures like *Lactobacillus casei* and *Streptoccoccus thermophilus* as well as yeasts, in which case the incubation would last 8 hours at 25 °C and another 16 hours at 20 °C (Kuliev, 1959).

*Suusac (Susa)*

This is a traditional fermented milk in Eastern Africa, Kenya and Somalia. The product has a low viscosity, smoky aroma and astringent taste. Fresh milk is placed into previously smoked pumpkin vessels and left for 2 days at a temperature of 25 to 30 °C in order to ferment (Lore et al., 2005). The obtained product is variable in taste and aroma, and often hygienically improper. The ember of specific wood such as *Olea Africana* or *Acacia busia* is used for smoking. It was found that the smoke improves colour and taste and prolongues the shelf-life by up to 20 days.

Farah et al., (1990) have studied the possibility of improving the traditional Suusac by adding mesophilic dairy culture. In that case, milk is heated to 85 °C/30 min, cooled to 22-25 °C, inoculated with 2-3 % dairy cultures and incubated at 27-30 °C for 24 hours.

*Gariss*

It is traditionally produced and consumed in Sudan and Somalia. Raw milk is placed into goat skin bag which is hung on camel's saddle. The bags are usually covered with green grass or dry grass moistened with water and wrapped in a firm net made of palm leaves. Owing to a specifically rough camel walk, during the journey the milk is shaken and stirred and resulting in oxygen enrichment of the milk influencing significantly the fermentation. In addition, the fermentation is stimulated by adding few seeds of black cumin (*Nigellica sativa*) and an onion into the milk. Incubation lasts one day at a temperature of 25 to 30 °C.

*Isolated dairy cultures*

48 species of lactic acid bacteria were isolated and identified in Shubat. Dominant were *Lactobacillus* (44 %), then *Enterococcus* (19 %), *Kluyveromyces* (14 %) and *Leuconostoc* (10 %) (Rahman et al., 2009). Lore et al., (2005) isolated 45 different lactic acid bacteria from traditional samples of Suusac, mostly *Leuconostoc mesenteroides* subsp. *mesenteroides* (24 %) and *Lactobacillus plantarum* (16 %). Smoking and acacia wood burning the pumpkin containers seems to create a favourable environment for the development of bacteria found in plant fermentations. *Lactobacillus fermentum*, *Lactobacillus plantarum*, *Lactococcus lactis*, *Enterococcus* spp. and *Leuconostoc* spp. together with the dominant species *Lactobacillus paracasei* subsp. *paracasei* were isolated and characterised in the microbial flora of Gariss. Adding onion and black cumin seeds create favourable environment for the development of *L. plantarum* and probably inhibit the growth of other bacteria.

*Butter*

Butter is not a traditional product from camel milk and is difficult to produce by using the same technology of production as for butter from cow milk. The high melting point of camel milk fat (41-42 °C) makes it difficult to churn the cream at temperatures used for churning cow milk (8-12 °C). In comparison with butter made from cow milk. Camel milk butter is prominently white with a more buttery and viscous consistency while the taste and the aroma are neutral (Farah et al., 1989).

Nomads produce butter from camel milk in several ways. The butter is used for medical purposes or cooking. In the area of north-eastern Kenya they use methods by which only small amount of camel milk fat is obtained. On a fire, few rocks are heated and put the vessel with raw milk. Drops of fat are formed and appear on the surface. After cooling, milk is churned until fat drops turn into butter grains. According to Yagil (1982), in Sahara butter is being produced by leaving camel milk in goatskin at room temperature for 12 hours in order to ferment. Subsequently the goatskin is inflated with air and closed, hung on a tent pole and swung fast forth and back. At the end of churning, some cold water is added which helps in forming butter.

Farah et al., (1989) conducted an experiment in industrial production of butter in the rural part of north-eastern Kenya. Milk was heated to 65 °C and then centrifuged. The percentage of fat in cream was standardized to 20-30 %. Afterwards, it was churned at temperatures between 15 and 36 °C. After churning, butter was flushed with water at room temperature of 27 °C. Best results were obtained by churning cream with 22.5 % fat and 25 °C. Churning time was 11 minutes.

*Cheese*

Processing camel milk into cheese is difficult, even considered as impossible (Yagil, 1982). It is surprising that although most nomad communities produced at least one type of cheese, there is no traditional method for producing cheese from camel milk. This can be explained by the fact that in their culture camel milk is consumed exclusively as a drink which excludes the possibility of cheese trade. Moreover, the highly perishable nature of cheese in the hot desert climate is not favourable for trade among isolated communities. Just like butter, cheese was made exclusively from goat, sheep and cow milk. Coagulation properties of camel milk are not suitable for the production of cheese.

*Fresh cheese*

Fresh whole or semi-skimmed milk is thermally treated by thermisation at 62-65 °C/1 min or pasteurisation at 72-75 °C/1 min. It is cooled to 20-30 °C after which calcium chloride is added in the amount of 10-15 g/100 kg of milk. Mesophilic culture is added to milk in the ratio of 1-3 g/100 kg of milk. After pre-ripening of milk, 0.4-1.0 g of clotting agent is added to 100 kg of milk. Curdling takes 7-20 hours, after which the curd is cut into irregular grains 1-10 cm in size. The curd is then placed in cheese cloth, whey is drained of and pressed under its own weight for 10 to 24 hours at a temperature of 20 to 28 °C. Cheese is dry-salted by rubbing salt into the surface. At the end of pressing, the cheese is characterized by low dry matter content and a low pH of (4.3-4.5). As a result, the cheese lacks cohesion and looks like soft watery dough. For further keeping, the product must be packed into hard, airtight vessels in order to prevent further draining of whey and external contamination.

Mehaia (1992) in his study produced and analyzed fresh cheese Domiati type of camel milk. Raw milk samples were standardized to various degrees of milk fat (0, 1, 2 and 3 %) and various amount of salt added (0, 1, 2 and 3 %). Milk was pasteurized at 71 °C/15 s, cooled to 40 °C or 22 °C, $CaCl_2$ and lactic cultures like yoghurt culture (40 °C), mesophilic culture (at 22 °C) added. After adding of clotting agent the milk was incubated. The milk was left to coagulate for 2 to 3 hours. The curd was transferred into moulds and left to drain for the next 24 hours before cutting into blocks. The highest yield of cheese (10 and 12 kg/100 L) was obtained from milk with 1.5 % of lactic acid and 3 % of salt added.

*Soft cheese*

After preparing milk by skimming and thermal processing, calcium chloride (10-15 g/100 kg) were added. This was followed by adding mesophilic starter and clotting agent after the temperature of milk decreased to 35 °C and pH to 6.2-6.8. Curdling took 10 to 30 minutes. The curd was cut to grain of 1-4 cm and left in the whey for 30 to 90 minutes. Cheese grains are slowly stirred for 60 seconds every 10 minutes. The curd was placed manually into the moulds where it first remains for 6 hours at 26-28 °C, and for another 18-20 hours at 16-22 °C. The cheese in the moulds should be turned 3 to 5 times during that time. It is salted by dry-salting on the surface or by brining for 10 to 30 minutes. Maturation takes 2 to 8 weeks depending on the water content and development of microflora on the surface or inside the cheese. The temperature in the ripening room should be 12-14 °C and the humidity 90-95 %. Considering the dominant kind of cheese microflora during ripening, three soft cheese types can be distinguished: soft cheeses with surface mould *Penicillium camemberti*, soft cheeses with surface bacteria flora *Brevibacterium linens* and soft cheeses with internal mould *Penicillium roqueforti*.

*Semi-hard cheese*

Whole or semi-skimmed milk is thermally processed by thermisation or low-heat pasteurisation before adding calcium chloride. Mesophilic culture is used in the amount of 0.5-1.5 g/100 kg of milk. The temperature of milk must be decreased to 30-33 °C, and pH 6.4-6.8 before adding the clotting agent (4-8 g/100 kg of milk). Curdling time takes 10 to 30 minutes. The curd is cut into grains of 0.5-1.0 cm in size and during half hour is slowly stirred for 60 seconds every 10 minutes. Between 20-60 % of whey is replaced with the same amount of potable water of 30-33 °C. Pre-pressing is performed in wooden or metal moulds for 10 to 20 minutes and then pressed for 2 to 6 hours at 22-26 °C. It is salted by brining or dry salting on the surface. Ripening lasts for 15 to 45 days at 12-16 °C and 90-95 % humidity. Cheese yield amounts to 6-10 kg/100 kg of milk (Ramet, 2001).

Vikas and Farah (1991) during research in Kenya produced a semi-hard cheese from camel milk with the following production technology. The milk was thermally processed at 65 °C/30 min on open fire and then cooled to 35 °C. After adding 5 % of mesophilic culture and 0.25 g/L of citric acid a pH of 5.6-5.7 was reached, clotting agent was added, the curd cut after 40 minutes. The curd-whey mixture was stirred for 20-30 min at 45 °C. The curd was placed into cheese cloth, pressed and put into a 10 % NaCl brine. Subsequently, the cheese ripened at 18 °C and relative humidity of 95 %. The cheese had a satisfactory cross-section and taste was comparable with Blue Cheese or Limburger. After 3 weeks of storage at room temperature the taste became bitter.

## Conclusion

Camel milk could soon become the new superfood due to its high nutritional value, easy digestibility (suitable for people with lactose intolerance) and low share of fat. Due to the less daily milk production than in cows, price of milk is higher, what is the only obstacle to the introduction of this food in everyday eating habits. According to its chemical composition, camel milk is most similar to human milk. It is a rich source of vitamins and mineral substances, especially B group vitamins, vitamin C and iron. Camel milk is a good source of proteins and is often referred to as a "complete meal" because it contains enough nutrients for maintaining life and is often given to children suffering from malnutrition. Camel milk lactic acid contains a smaller concentration of short-chain fatty acids and a higher concentration of volatile acids, especially linoleic acid and polyunsaturated fatty acids. To extend the limited storage life of camel milk, it is being processed in certain products as: fermented milk, butter and cheese. Products of camel milk are a good source of energy and nutrients.

## *Devino mlijeko i proizvodi od devinog mlijeka*

**Sažetak**

Devino mlijeko i proizvodi od devinog mlijeka oduvijek su bili cijenjeni, a i danas imaju vrlo važnu ulogu u prehrani stanovništva ruralnih područja Afrike, Azije i Srednjeg Istoka, u kojima prevladavaju oskudne poljoprivredne površine, te visoke temperature i male količine oborina. U otežanim okolišnim uvjetima deve mogu proizvesti više mlijeka nego bilo koja druga vrsta, dok su njezini zahtjevi za hranom skromni. Deva proizvodi između 1000 i 2000 L mlijeka u razdoblju od 8. do 18. mjeseca laktacije. Prosječna dnevna proizvodnja mlijeka iznosi između 3 L i 10 L između 12. i 18. mjeseca laktacije. Cilj istraživanja je prikazati pregled kemijskog sastava devinog mlijeka, mliječnih proizvoda, te drugih proizvoda koji se proizvode od devinog mlijeka. Devino mlijeko u prosjeku sadrži 81,4-87 % vode, 10,4 % suhe tvari, 1,2-6,4 % mliječne masti, 2,15-4,90 % proteina, 1,63-2,76 % kazeina, 0,65-0,80 % proteina sirutke, 2,90-5,80 % laktoze i 0,60-0,90 % mliječnog pepela. Varijacije u sastavu devinog mlijeka mogu se pripisati nekolicini čimbenika kao što su: analitički postupci mjerenja, geografsko područje, hranidbeni uvjeti, pasmina, stadij laktacije, dob i broj teljenja. Devino mlijeko postaje sve interesantniji proizvod u svijetu, ne samo zbog svojih dobrih kemijskih osobina već i zbog svojih zanimljivih i ukusnih proizvoda.

*Ključne riječi*: devino mlijeko, kemijski sastav, proizvodi od devinog mlijeka

## References

1. Abu-Lehia, I.H. (1989): Physical and chemical characteristics of camel milk fat and its fractions, *Food Chemistry 34*, 261-271.

   doi: dx.doi.org/10.1016/0308-8146(89)90103-9
2. Anifantakis, E.M. (1985): Comparison of the physico-chemical properties of ewes and cows milk, *Bulletin International Dairy Federation 202*, 42-53.
3. Attila, H., Kherouatou, N., Fakhfakh, N., Khorchani, T., Trigui, N. (2000): Dromedary milk fat: Biochemical. microscopic and rheological characteristics, *Journal of Food Lipids 7*, 95-112.

   doi: dx.doi.org/10.1111/j.1745-4522.2000.tb00164.x
4. Bakheit, S.A., Majid, A.M.A., Nikhala, A.M. (2008): Camels (Camelus dromedarius) under pastoral systems in North Kordofan. Sudan: seasonal and parity effects on milk composition, *Journal of Camelid Sciences 1*, 32-36.
5. Bengoumi, M., Vias, M.G., Faye, B. (2005): Camel milk production and transformation in Sub-Saharan Africa in: Dessertification combat and food safety. B. Faye and P. Esenov (Ed). IOS. 200-208.
6. Bhakat, C., Sahani, M.S. (2006): A unique species in hot arid desert ecosystem, *Everyman's Science 6*, 426-429.
7. Bosnić, P. (2003): Svjetska proizvodnja i kvaliteta kravljeg mlijeka, *Mljekarstvo 53* (1), 37-50.
8. El-Zubeir, I.E.M., Jabreel, M.S.O. (2008): Fresh cheese from camel milk coagulated with Camifloc, *International Journal of Dairy Technology 61*, 90-95.

   doi: dx.doi.org/10.1111/j.1471-0307.2008.00360.x
9. FAO (2008): Camel milk. Retrieved from www.fao.org/ag/againfo/themes/en/dairy/camel.html.
10. FAO (2006): The next thing: Camel milk. Retrieved from www.fao.org/newsroom/en/news/2006/1000275.
11. Farah, Z., Streiff, T., Bachmann, M.R. (1989): Manufacture and characterisation of camel milk butter, *Milchwissenschaft 44* (7), 412-414.
12. Farah, Z., Streiff, T., Bachmann, M.R. (1990): Preparation and consumer acceptability tests of fermented camel milk in Kenya, *Journal of Dairy Research 57*, 281-283.

    doi: dx.doi.org/10.1017/S002202990002690X
13. Farah, Z., Fisher, A. (2004): Milk and Meat from the Camel: Handbook on Products and Processing. Vdf Hochschulverlag AG an der ETH Zürich. Zürich/Singen.
14. Farah, Z., Mollet, M., Younan, M., Dahir, R. (2007): Camel dairy in Somalia: limiting factors and development potential, *Livestock Science 110*, 187-191.

    doi: dx.doi.org/10.1016/j.livsci.2006.12.010
15. Faye, B., Konuspayeva, G., Loisean, G. (2010): Variability of urea concentration in camel milk in Kazakhstan, *Dairy Science and Technology 90*, 707-713.

    doi: dx.doi.org/10.1051/dst/2010025
16. Gazibara, D. (2007): Uvođenje u proizvodnju kozjeg sira u mljekarskoj industriji "Zdenka". Diplomski rad. Prehrambeno-tehnološki fakultet. Osijek.
17. Gorban, A.M.S., Izzeldin, O.M. (2001): Fatty acids and lipids of camel milk and colostrums, *International Journal of Food Sciences and Nutrition 52*, 283-287.

    doi: dx.doi.org/10.1080/713671778
18. Haddadin, M.S.Y., Gammoh, S.I., Robinson, R.K. (2008): Seasonal variations in the chemical composition of camel milk in Jordan, *Journal of Dairy Research 75*, 8-12.

    doi: dx.doi.org/10.1017/S0022029907002750
19. Ibtisam, E.M., Marowa, I.I. (2009): Effect of pasteurization of milk on the keeping quality of fermented camel milk (Gariss) in Sudan, *Livestock Research for Rural Development 21* (2), http://www.lrrd.org/lrrd21/2/zube21019.htm
20. Ivanković, A., Ramljak, J., Štulina, I., Antunac, N., Bašić, I., Kelava, N., Konjačić, M. (2009): Odlike laktacije, kemijskog sastava i higijenske kvalitete mlijeka primorsko-dinarskih magarica, *Mljekarstvo 59* (2), 107-113.
21. Kappeler, S., Farah, Z., Puhan, Z. (1998): Sequence analysis of Camelus dromedaries milk caseins, *Journal of Dairy Research 65*, 209-222.

    doi: dx.doi.org/10.1017/S0022029997002847
22. Ereifej, K., Alu'datt, M., AlKhalidy, H., Rababah, T. (2011): Comparison and characterisation of fat and protein composition for camel milk from eight Jordanian locations, *Food Chemistry 127*, 282-289.

    doi: dx.doi.org/10.1016/j.foodchem.2010.12.112
23. Khan, J.A., Kumar, P., Paramasivam, M., Yadav, R.S., Sahani, M.S., Sharma, S. (2001): Camel lactoferrin - a transferrincum - lactoferrin: crystal structure of camel apolactoferrin at 2.6 A resolution and structural basis of its dual role, *Journal of Molecular Biology 309*, 751-761.

    doi: dx.doi.org/10.1006/jmbi.2001.4692
24. Khan, B.B., Iqbal, A. (2001): Production and composition of camel milk. Review, *Pakistan 1 Agricultural Science 38*, 64-68.
25. Khaskheli, M., Arain, M.A., Chaudhry, S., Soomro, A.H., Qureshi, T.A. (2005): Physico-chemical quality of camel milk, *Journal of Agriculture and Social Sciences 2*, 164-166.
26. Konuspayeva, G. (2007): Variabilite physico-chimique et biochimique du lait des grands camelide's (*Camelus bactrianus, Camelus dromedarius* et hybrides) au Kazakhstan. Universite Montpellier II, France, 255.
27. Konuspayeva, G., Lemarie, E., Faye, B., Loiseau, G., Montet, D. (2008): Fatty acid and cholesterol composition of camel's (*Camelus bactrianus, Camelus dromedarius* and hybrids) milk in Kazakhstan, *Dairy Science and Technology 88*, 327-340.

    doi: dx.doi.org/10.1051/dst:2008005

28. Konuspayeva, G., Faye, B., Loiseau, G. (2009): The composition of camel milk: a meta-analysis of the literature dana, *Journal of Food Composition and Analysis 22*, 95-101.

doi: dx.doi.org/10.1016/j.jfca.2008.09.008

29. Kouniba, A., Berrada, M., Zahar, M., Bengoumi, M. (2005): Composition and heat stability of Moroccan camel milk, *Journal of Camel Practice and Research 12*, 105-110.

30. Kuliev, K. (1959): 'The utilisation of camels' milk'. Mol. Promyslenn 20 (28). cited in R. Yagil, 1982. Camels and Camel milk. FAO animal production and health paper. Rome: Food and Agriculture Organization of the United Nations (FAO).

31. Laleye, L.C., Jobe, B., Wasesa, A.A.H. (2008): Comparative study on heat stability and functionality of camel and bovine whey proteins, *Journal of Dairy Science 91*, 4527-4534.

doi: dx.doi.org/10.3168/jds.2008-1446

32. Lore, A.T., Mbugua, K.S., Wango, H.J. (2005): Enumeration and identification of microflora in suusac, a Kenyan traditional fermented camel milk product. *Lebensm- Wiss. u.- Technol. 38*, 125-130.

33. Mehaia, M.A., Hablas, M.A., Abdel-Rahman, K.M., El-Mougy, S.A. (1995): Milk composition of Majaheim, Wadah and Hamra camels in Saudi Arabia, *Food Chemistry 52*, 115-122.

doi: dx.doi.org/10.1016/0308-8146(94)P4189-M

34. Rahman, I.E., Dirar, H.A., Osman, M.A. (2009): Microbiological and biochemical changes and sensory evaluation of camel milk fermented by selected bacterial starter cultures, *African Journal of Food Science 3* (12), 398-405.

35. Ramet, J.P. (2001): The Technology of Making Cheese from Camel Milk (*Camelus Dromedarius*). FAO Animal production and helath paper *113*, 31-33.

36. Rüegg, M.W., Farah, Z. (1991): Melting curves of camel milk fat, *Milchwissenschaft 46*, 361-362.

37. Salamon, R., Csapo, J., Salamon, Sz., Csapo-Kiss, Zs. (2009): Composition of mare's colostrum and milk. I. Fat content, fatty acid composition and vitamin contents. Acta Universitatis Sapientiae, *Alimentaria 2* (1), 119-131.

38. Salmen, S.H., Abu-Tarboush, H.M., Al-Saleh, A.A., Metwalli, A.A. (2012): Amino acids content and electrophoretic profile of camel milk casein from different camel breeds in Saudi Arabia, *Saudi Journal of Biological Science 19*, 177-183.

39. Stahl, T., Sallmann, H.P., Duehlmeier, R., Wernery, U. (2006): Selected vitamins and fatty acid patterns in dromedary milk and colostrums, *Journal of Camel Practice and Research 13*, 53-57.

40. Tratnik, Lj. (2008): Kemija i tehnologija mlijeka i mliječnih proizvoda. Sveučilište u Zagrebu, Prehrambeno-biotehnološki fakultet.

41. Tratnik, Lj., Božanić, R. (2012): Mlijeko i mliječni proizvodi. Sveučilišni udžbenik. Hrvatska mljekarska udruga, Zagreb.

42. Vikas, M., Farah, Z. (1991): Manufacture of cheese from camel milk. Report on field studies in Kenya, ETH Zürich, Switzerland.

43. Wernery, U. (2006): Camel milk, the white gold of the desert, *Journal of Camel Practice and Research 13* (1), 15-26.

44. Yagil, R. (1982): Camels and camel milk. FAO Animal Production and Health. Paper No. 26. *Food and Agriculture Organization*, Rome, Italy.

45. Zeleke, M. (2007): Non-genetic factors affecting milk yield and milk composition of traditionally managed camels (Camelus dromedarius) in Eastern Ethiopia. *Livestock Research for Rural Development 19* (6). Online publication: http://www.utafoundation.org/lrrd1906/zele19085.htmeferences