

Camelids' Milk

Subjects: [Biochemical Research Methods](#)

Contributor: Paolo Polidori

Camel milk has always represented an important food for nomadic people in the arid parts of the world; recently, camel milk attracted great attention as a possible replacer to dairy cow's milk because of its therapeutic effects. The use of alternative milk for feeding children can be effective in reducing the development of gastrointestinal disorders.

camel milk

dromedary milk

nutraceutical foods

1. Introduction

Human milk represents the best food for newborn children, considering its nutritional and immunological properties, and for these reasons, can be considered very safe for infant nutrition [\[1\]](#). After the infant weaning or early termination of breastfeeding, normally cow milk represents the most common food for infant nutrition but unfortunately can also represent the first allergen in life [\[2\]](#). In fact, in several countries, cow milk, a member of the "Big Eight" food allergens, together with egg, soy, wheat, peanuts, tree nuts, fish, and shellfish, is the most important food allergen in babies and children [\[3\]](#).

Camel milk has always represented an important food for nomadic people in the arid parts of the world; recently, camel milk attracted great attention as a possible replacer to dairy cow's milk because of its therapeutic effects [\[4\]](#). The use of alternative milk for feeding children can be effective in reducing the development of gastrointestinal disorders [\[5\]](#). Initially, goat milk has been investigated [\[6\]](#); later, in the 1990s, donkey milk started to stir great interest in clinical trials [\[7\]\[8\]](#). Recently, the use of camel milk to replace dairy cows and other kinds of milk (goat, donkey, and mare) has attracted interest in the scientific community [\[9\]](#). Allergic symptoms to cow's milk proteins can be treated with camel's milk immunoglobulins (Igs) [\[10\]](#). The antiallergenic properties of camel milk are also due to having a similar protein profile to human mother's milk, with the absence of β -lactoglobulin and a high content of α -lactalbumin [\[11\]](#). Additionally, considering the high content of antioxidant and antimicrobial molecules in camel's milk, it is possible to detect a crucial role of this milk in many health bodies functions. In fact, camel milk is characterized by an insulin content (42 μ U/mL) that is not degraded in the forestomach and bypass to intestines, leading to a reduction in blood glucose levels; therefore, it is effective in diabetes treatment [\[12\]](#). Camel milk also shows antibacterial and antiviral activities due to having bioactive peptides able to perform important physiological properties, enhancing the immune system defense [\[13\]](#). For this reason, camel milk is used as a remedy for diarrhea caused by viruses (*Rotavirus*), and for both B and C hepatitis [\[14\]](#). Camel milk can be considered a highly suitable vehicle in delivering probiotics and can be useful in maintaining gut health [\[15\]](#).

2. Dromedary and Bactrian Camel Milk

Milk is considered a complete food, very important in the human diet both for children and adults [16]. Milk consumption is estimated at around 85 kg/year/per capita, even if there are large differences among different areas: In developed regions, it is estimated at around 214 kg/year/per capita, while in developing regions, it is around 55 kg/year/per capita [17]. Specifically, in East and Southeast Asia, milk consumption is close to 25 kg/year/per capita, in South Asia, close to 52 kg/year/per capita, in sub-Saharan Africa, about 30 kg/year/per capita, in the Middle East and North Africa, about 87 kg/year/per capita, and in Latin America, it is about 113 kg/year/per capita [18].

Malnutrition is responsible in developing regions for about 55% of children's deaths under the age of 5 years [19]. The optimal food for infants is human milk; the World Health Organization (WHO) recommends exclusive breastfeeding for the first 6 months, possibly until the first year of life, while infant formula with a chemical composition similar to human milk is the recommended replacer when breastfeeding is not possible [20]. However, after 6 months of age, breast milk alone does not provide enough nutrients to permit a regular growth of the infant; during the transition period from exclusive breastfeeding to the end of breastfeeding, the risk of lack of nutrition is high [21].

Camels are mammals that ruminate, even if they are considered semi-ruminants because they have a stomach with three compartments with digestive physiology similar to ruminants [22]. They belong to the order *Artiodactyla*, suborder *Tylopoda*, family *Camelidae*. Camels originate and live in arid and semi-arid lands, but due to their special thermal regulation, they do not lose water; in fact, camels regulate body temperature on two levels, with a body temperature of about 40 °C in the heat of the day, while during the night, their body temperature falls to 34 °C [23]. Digestion in camel is more effective, compared with other ruminants; high digestibility of dry matter and fiber is due to the longer retention time and movement of large particles in its fore stomach [24].

Table 1 shows the chemical composition of different mammalian species. Female mammals produce specific milk able to completely fulfill the nutritional requirements of the newborn. Milk is not just a source of nutrients, but it is also able to provide peculiar molecules with bioactive functions and contributes to newborn growth and health [25].

Table 1. Milk chemical composition.

Mammal	Energy (kcal/100 g)	Fat (g/100 g)	Protein (g/100 g)	Lactose (g/100 g)
Human	64.2	3.5	1.2	6.4
Donkey	41.8	0.7	1.6	6.6
Cow	76.2	3.8	3.4	4.8
Sheep	115.7	7.0	5.7	4.7

Mammal	Energy (kcal/100 g)	Fat (g/100 g)	Protein (g/100 g)	Lactose (g/100 g)
Goat	74.5	4.1	3.3	4.5
Dromedary	66.1	3.1	3.5	4.4
Bactrian camel	88.9	5.3	3.9	4.5

Source: [17].

A female camel can produce from 2 to 25 L of milk per day, depending on the quality and the total amount of food she consumes; the gestation period lasts about 13 months, and lactation ranges between 9 and 18 months [26]. In dairy dromedaries, as well as in donkeys, the udder has small cisterns containing about 19.3% of the total milk [27]. Camel's milk color is normally white opaque, and it is characterized by a faint sweetish odor but sharp taste; some consumers consider it salty [28]. Camel's milk acidity has been determined to be 0.144% lactic acid, the mean value of specific gravity has been detected around 1.029, the freezing point has been established at -0.518 °C, and electrical conductivity has been reported to be 6.08 millimhos [29]. However, camel's milk physical and chemical characteristics are highly influenced by the geographical origin, the camel breed, and obviously by the lactation stage [30].

The somatic cell counts level in camel milk is normally low, compared with dairy cow's milk; in a study performed in Saudi Arabia, SCC varied from 11,000 to 298,000 cells/mL in farm A, using a milking machine, and from 14,000 cell/mL to 643,000 in farm B using the hand milking method [31]. Regarding bacterial load, in the same study, intramammary infections were detected in 12% of the 84 milk samples collected in farm A and in 37% of the milk samples examined from camels in farm B [32].

3. Protein Fractions in Camel Milk

The total protein content of camel's milk is represented for about 80% by caseins, while in the remaining 20%, whey contains several soluble proteins and different bioactive peptides generated by camel's milk proteases such as chymotrypsin A and cathepsin D (Table 2) [33].

Table 2. Protein profile (g/L^{-1}) of milk from different mammalian species.

Protein Fraction	Cow	Goat	Sheep	Camel	Donkey	Human
Total caseins	24.6–28	23.3–46.3	41.8–52.6	22.1–26.0	6.4–10.3	2.4–4.2
Total whey proteins	5.5–7.0	3.7–7.0	10.2–16.1	5.9–8.1	4.9–8.0	6.2–8.3
Caseins/whey proteins ratio	82:18	78:22	76:24	73.2:76.2	56:44	29.7:33.7
α S1-Casein	8.0–10.7	0–13.0	2.4–22.1	4.9–5.7	Present	0.77

Protein Fraction	Cow	Goat	Sheep	Camel	Donkey	Human
α S2-Casein	2.8–3.4	2.3–11.6	6.0	2.1–2.5	Present	Absent
β -Casein	8.6–9.3	0–29.6	15.6–39.6	14.4–16.9	Present	3.87
k-Casein	2.3–3.3	2.8–13.4	3.2–12.2	0.8–0.9	Present	0.14
β -Lactoglobulin	3.2–3.3	1.5–5.0	6.5–13.5	Absent	3.3	Absent
α -Lactalbumin	1.2–1.3	0.7–2.3	1–1.9	0.8–3.5	1.9	1.9–3.4

Source: [34].

Amino acid concentrations in milk from different mammalian species are shown in **Table 3**. In milk from buffalos, cows, and horses, cysteine and methionine are the limiting amino acids, while lysine is the limiting amino acid in camel milk; it is interesting to note that camel milk contains more methionine, valine, phenylalanine, arginine, and leucine, compared with cow milk [35].

Table 3. Amino acid concentrations (g/100 g protein) in milk from different mammalian species.

Amino Acid	Cow	Sheep	Goat	Camel	Donkey	Human
Aspartic acid	7.8	n.d.	7.4	6.9	8.9	8.3
Threonine	4.5	4.2–4.4	5.7	4.1	3.6	4.6
Serine	4.8	n.d.	5.2	4.3	6.2	5.1
Glutamic acid	23.2	n.d.	19.3	18.1	22.8	17.8
Proline	9.6	n.d.	14.6	12.0	8.8	8.6
Cysteine	0.6	0.8–0.9	0.6	1.9	0.4	1.7
Glycine	1.8	n.d.	2.1	2.1	1.2	2.6
Alanine	3.0	n.d.	3.6	2.1	3.5	4.0
Valine	4.8	6.2–6.4	5.7	4.1	6.5	6.0
Methionine	1.8	2.7	3.5	2.0	1.8	1.8
Isoleucine	4.2	4.6	7.1	4.9	5.5	5.8
Leucine	8.7	9.7–9.9	8.2	6.1	8.6	10.1
Tyrosine	4.5	3.7–3.8	4.8	3.1	3.7	4.7
Phenylalanine	4.8	4.2–4.3	6.0	4.0	4.3	4.4

Amino Acid	Cow	Sheep	Goat	Camel	Donkey	Human
Histidine	3.0	n.d.	5.0	2.1	2.3	2.3
Lysine	8.1	7.7–7.8	8.2	4.0	7.3	6.2
Arginine	3.3	n.d.	2.9	2.0	4.6	4.0
Tryptophan	1.5	n.d.	n.d.	n.d.	n.d.	1.8
Limiting amino acid	Cysteine Methionine	----	----	Lysine	Cysteine Methionine	----

Source: [35]; n.d.: not detected.

4. Lipid Fractions in Camel Milk

Human milk fat, compared with ruminants' milk, is characterized by lower content of saturated fatty acids (SFAs), higher content of both monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs), a higher ratio ω -6/ ω -3 essential fatty acids, and higher cholesterol content; the conjugated linoleic acid (CLA) content is similar in human and ruminant milk (Table 4).

Table 4. Fatty acid profile (% of total fatty acids) and cholesterol content in milk of different mammalian species.

Fatty Acids	Cow	Sheep	Goat	Camel	Donkey	Human
SFA (%)	55.7–72.8	57.5–74.6	59.9–73.7	47.0–69.9	46.7–67.7	39.4–45.0
MUFA (%)	22.7–30.3	23.0–39.1	21.8–35.9	28.1–31.1	15.3–35.0	33.2–45.1
PUFA (%)	2.4–6.3	2.5–7.3	2.6–5.6	1.8–11.1	14.2–30.5	8.1–19.1
ω 6/ ω 3	2.1–3.7	1.0–3.8	4	n.d.	0.9–6.1	7.4–8.1
CLA (%)	0.2–2.4	0.6–1.1	0.3–1.2	0.4–1.0	n.d.	0.2–1.1
Cholesterol (mg/100 mL milk)	13.1–31.4	14.0–29.0	10.7–18.1	31.3–37.1	n.d.	14.0–20.0

Source: [35]; n.d.: not detected.

5. Minerals and Vitamins in Camel Milk

Calcium, phosphorus, and potassium are the most represented minerals in milk, which are basically designed for bone growth and the proper development of newborns, while iron, zinc, and copper are present in small amounts, except camel milk, which is the richest in these minerals (Table 5).

Table 5. Mineral concentrations in milk from different mammalian species.

Macroelements (mg/100 g)	Cow	Sheep	Goat	Mare	Camel	Human
Calcium	122.0	195–200	132–134	132.7	114–116	33.0
Phosphorus	119.0	124–158	97.7–121	88.4	87.4	43.0
Potassium	152.0	136–140	152–181	66.5	144–156	55.0
Magnesium	12.0	18–21	15.8–16.0	10.2	10.5–12.3	4.0
Sodium	58.0	44–58	41–59.4	19.8	59.0	15.0
Microelements (µg/100 g)						
Zinc	530.0	520–747	56–370	270.0	530–590	380.0
Iron	80.0	72–122	7.0–60	37.0	230–290	200.0
Copper	60.0	40–68	5.0–80.0	64.0	140.0	60.0
Manganese	20.0	5.3–9.0	3.2–6.53	n.d.	80.0	70.0
Iodine	2.1	10.4	2.2	n.d.	n.d.	7.0
Selenium	0.96	3.1	1.33	n.d.	n.d.	1.52

Source: [35]; n.d.: not detected.

Vitamins are organic molecules necessary to the body in small amounts but cannot be synthesized by the body [36]. The dose of vitamins required for growth and body health differs between species. A vitamin necessary in the diet of one species may be regularly synthesized by other species. For example, vitamin C is required only in diets for primates and guinea pigs; other animal species can synthesize ascorbic acid because they have the enzyme gluconolactone oxidase, necessary for vitamin C synthesis. Vitamins may be classified based on their solubility: Water-soluble vitamins are the B group B₁, B₂, B₃, B₅, B₆, B₈, B₉, B₁₂, and ascorbic acid (vitamin C) while the fat-soluble vitamins are retinol (vitamin A), calciferol (vitamin D), tocopherol (and related compounds, vitamin E), and phyloquinone (and related compounds, vitamin K). Vitamin C and vitamin E are primarily antioxidants. Goat milk is rich in vitamin A and some from the vitamin-B group, but it shows a significantly lower amount of vitamin B₁₂ and folic acid, compared with dairy cow's milk (Table 6). Camel milk is characterized by a higher concentration of vitamin C, compared with dairy cows and human milk [37][38]. In fact, in desert areas, fruits and vegetables are scarce, so camel milk represents, in most cases, the main source of vitamin C in the diet of nomadic populations living in those regions [39].

Table 6. Vitamin contents in milk from different mammalian species.

Vitamin	Goat	Sheep	Cow	Camel	Human
Vitamin A (µg/100 g)	185	146	126	26.7	190

Vitamin	Goat	Sheep	Cow	Camel	Human
Vitamin D ($\mu\text{g}/100\text{ g}$)	2.3	1.18	2.0	0.3	1.4
Vitamin B ₁ (mg/100 g)	0.07	0.08	0.05	0.05	0.02
Vitamin B ₂ (mg/100 g)	0.21	0.38	0.16	0.17	0.02
Vitamin B ₃ (mg/100 g)	0.27	0.42	0.08	0.77	0.17
Vitamin B ₅ (mg/100 g)	0.31	0.41	0.32	0.37	0.20
Vitamin B ₆ (mg/100 g)	0.05	0.08	0.04	0.55	0.01
Vitamin B ₈ ($\mu\text{g}/100\text{ g}$)	1	5	5	87	5.5
Vitamin B ₉ ($\mu\text{g}/100\text{ g}$)	1.5	0.93	2	n.d.	0.4
Vitamin B ₁₂ ($\mu\text{g}/100\text{ g}$)	0.07	0.71	0.36	85	0.03
Vitamin C (mg/100 g)	1.29	4.16	0.94	33	5.0

Source: [\[35\]](#); n.d.: not detected.

References

- Nayak, C.M.; Ramachandra, C.T.; Kumar, G.M. A Comprehensive Review on Composition of Donkey Milk in Comparison to Human, Cow, Buffalo, Sheep, Goat, Camel and Horse Milk. *Mysore J. Agric. Sci.* 2020, 54, 42–50.
- Polidori, P.; Vincenzetti, S. Use of Donkey Milk in Children with Cow's Milk Protein Allergy. *Foods* 2013, 2, 151–159.
- Restani, P.; Ballabio, C.; Di Lorenzo, C.; Tripodi, S.; Fiocchi, A. Molecular aspects of milk allergens and their role in clinical events. *Anal. Bioanal. Chem.* 2009, 395, 47–56.
- Zhang, B.Y.; Xu, S.; Villalobos-Santeli, J.A.; Huang, J.-Y. Fouling characterization of camel milk with comparison to bovine milk. *J. Food Eng.* 2020, 285, 110085.
- Izadi, A.; Rahbarimanesh, A.A.; Mojtahedi, Y.; Mojtahedi, S.Y. Prevalence of enterovirus meningitis in children: Report from a tertiary center. *Maedica—J. Clin. Med.* 2018, 13, 213–216.
- El-Agamy, E.I. The challenge of cow milk protein allergy. *Small Rumin. Res.* 2007, 68, 64–72.
- Iacono, G.; Carroccio, A.; Cavataio, F.; Montalto, G.; Soresi, M.; Balsamo, V. Use of ass's milk in multiple food allergy. *J. Pediatr. Gastroent. Nutr.* 1992, 14, 177–181.

8. Monti, G.; Viola, S.; Baro, C.; Cresi, F.; Tovao, P.A.; Moro, G.; Ferrero, M.P.; Conti, A.; Bertino, E. Tolerability of donkey's milk in 92 highly problematic cow's milk allergic children. *J. Biol. Regul. Homeost. Agents* 2012, 26, 75–82.
9. Izadi, A.; Khedmat, L.; Mojtahedi, S.Y. Nutritional and therapeutic perspectives of camel milk and its protein hydrolysates: A review on versatile biofunctional properties. *J. Funct. Foods* 2019, 60, 103441.
10. Shabo, Y.; Barzel, R.; Margoulis, M.; Yagil, R. Camel milk for food allergies in children. *Israel Med. Assoc. J.* 2005, 7, 796–798.
11. Mojtahedi, S.Y.; Izadi, A.; Seirafi, G.; Khedmat, L.; Tavakolizadeh, R. Risk factors associated with neonatal jaundice: A cross-sectional study from Iran. *Macedon. J. Med. Sci.* 2018, 6, 1387–1393.
12. Faraz, A.; Waheed, A.; Tauqir, N.A.; Mirza, R.H.; Ishaq, H.M.; Nabeel, M.S. Characteristics and composition of camel (*Camelus dromedarius*) milk: The white gold of desert. *Adv. Anim. Vet. Sci.* 2020, 8, 766–770.
13. El-Agamy, S.I.; Ruppanner, R.; Ismail, A.; Champagne, C.P.; Assaf, R.J. Antibacterial and Antiviral activity of camel milk protective proteins. *J. Dairy Res.* 1992, 59, 169–175.
14. Kaskous, S. Importance of camel milk for human health. *Emir. J. Food Agric.* 2016, 28, 158–163.
15. Ayyash, M.; Abdalla, A.; Alhammadi, A.; Ranadheera, C.S.; Affan Baig, M.; Al-Ramadi, B.; Chen, G.; Kamal-Eldin, A.; Huppertz, T. Probiotic survival, biological functionality and untargeted metabolomics of the bioaccessible compounds in fermented camel and bovine milk after in vitro digestion. *Food Chem.* 2021, 363, 130243.
16. Faccia, M.; D'Alessandro, A.G.; Summer, A.; Hailu, Y. Milk Products from Minor Dairy Species: A Review. *Animals* 2020, 10, 1260.
17. Fantuz, F.; Salimei, E.; Papademas, P. Macro-and Micronutrients in Non-cow Milk and Products and Their Impact on Human Health. In *Non-Bovine Milk and Milk Products*; Tsakalidou, E., Papadimitriou, K., Eds.; Academic Press: London, UK, 2016; pp. 209–261.
18. Gerosa, S.; Skoet, J. Milk availability: Current production and demand and medium-term outlook. In *Milk and Dairy Products in Human Nutrition*; FAO: Rome, Italy, 2013; pp. 11–40.
19. Black, R.E.; Allen, L.H.; Bhutta, Z.A.; Caufield, L.E.; de Oris, M.; Ezzati, M.; Mathers, C.; Rivera, J. Maternal and child undernutrition: Global and regional exposures and health consequences. *Lancet* 2008, 371, 243–260.
20. Michaelsen, K.F.; Hoppe, C.; Roos, N.; Kaestel, P.; Stougaard, M.; Lauritzen, L.; Molgaard, C.; Girma, T.; Friis, H. Choice of foods and ingredients for moderately malnourished children 6 months to 5 years of age. *Food Nutr. Bull.* 2009, 30, S343–S404.

21. Allen, L.H. Global dietary patterns and diets in childhood: Implications for health outcomes. *Ann. Nutr. Metabol.* 2012, 61 (Suppl. 1), 29–37.
22. Almeida, R.R. Camel Milk: Characteristics and Perspectives for Use in Clinical Practice. *Rev. Chil. Nutr.* 2011, 38, 211–218.
23. Farah, Z. Composition and characteristics of camel milk. *J. Dairy Res.* 1993, 60, 603–626.
24. Faraz, A. Composition of Camel Milk: A Blessing for Health. *Ann. Public Health Epidemiol.* 2020, 1, 1–4.
25. Ballard, O.; Morrow, A.L. Human milk composition: Nutrients and bioactive factors. *Pediatr. Clin. N. Am.* 2013, 60, 49–74.
26. Gorban, M.A.S.; Izzeldin, O.M. Mineral content of camel milk and colostrum. *J. Dairy Res.* 1997, 64, 471–474.
27. Ayadi, M.; Hammadi, M.; Khorchani, T.; Barmat, A.; Atigui, M.; Caja, G. Effects of milking interval and cisternal udder evaluation in Tunisian Maghrebi dairy dromedaries (*Camelus dromedarius* L.). *J. Dairy Sci.* 2009, 92, 1452–1459.
28. Zibae, S.; Hosseini, M.S.; Yousefi, M.; Taghipour, A.; Kiani, M.A.; Noras, M.R. Nutritional and Therapeutic Characteristics of Camel Milk in Children: A Systematic Review. *Electr. Phys.* 2015, 7, 1523–1528.
29. Mehta, B.M.; Aparnathi, K.; Yoganandi, J.; Wadhvani, K.; Darji, V. Comparison of physico-chemical properties of camel milk with cow milk and buffalo milk. *J. Camel Pract. Res.* 2014, 21, 253–258.
30. Yadav, A.K.; Kumar, R.; Priyadarshini, L.; Singh, J. Composition and medicinal properties of camel milk: A Review. *Asian J. Dairy Food Res.* 2015, 34, 83–91.
31. Idrees, E.M.; Ishag, I.A.; Eisa, M.O. Factors Affecting Chemical Properties of Camel Milk. *Sci. Agric.* 2016, 16, 49–53.
32. Saleh, S.K.; Al-Ramadhan, G.; Faye, B. Monitoring of monthly SCC in she-camel in relation to milking practice, udder status and microbiological contamination of milk. *Emir. J. Food Agric.* 2013, 25, 403–408.
33. Mati, A.; Senoussi-Ghezali, C.; Zennia, S.S.A.; Almi-Sebbane, D.; El-Hatmi, H.; Girardet, J.M. Dromedary camel milk proteins, a source of peptides having biological activities—A review. *Int. Dairy J.* 2017, 73, 25–37.
34. Roy, D.; Ye, A.; Moughan, P.J.; Singh, H. Composition, Structure, and Digestive Dynamics of Milk from Different Species—A Review. *Front. Nutr.* 2020, 7, 577759.

35. Barłowska, J.; Sz wajkowska, M.; Litwinczuk, Z.; Król, J. Nutritional Value and Technological Suitability of Milk from Various Animal Species Used for Dairy Production. *Comprehen. Rev. Food Sci. Saf.* 2011, 10, 291–302.
36. Navrátilová, P.; Borkovcová, I.; Kaniová, L.; Dluhošová, S.; Zachovalová, H. The content of selected vitamins and iodine in mare's milk. *Acta Vet. Brno* 2019, 88, 473–480.
37. Polzonetti, V.; Pucciarelli, S.; Vincenzetti, S.; Polidori, P. Dietary Intake of Vitamin D from Dairy Products Reduces the Risk of Osteoporosis. *Nutrients* 2020, 12, 1743.
38. Haddadin, M.S.Y.; Gammoh, S.I.; Robinson, R.K. Seasonal variations in the chemical composition of camel milk in Jordan. *J. Dairy Res.* 2008, 75, 8–12.
39. Bakheit, S.A.; Majid, A.M.A.; Nikhala, A.M. Camels (*Camelus dromedarius*) under pastoral systems in North Kordofan Sudan: Seasonal and parity effects on milk composition. *J. Camelid Sci.* 2008, 1, 32–36.

Retrieved from <https://encyclopedia.pub/entry/history/show/47882>