Camelids Milk Nutritional Properties

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Milk is considered a complete food because all of the nutrients important to fulfill a newborn's daily requirements are present, including vitamins and minerals, ensuring the correct growth rate. A large amount of global milk production is represented by cow, goat, and sheep milks; these species produce about 87% of the milk available all over the world. However, the milk obtained by minor dairy animal species is a basic food and an important family business in several parts of the world. Milk nutritional properties from a wide range of minor dairy animal species have not been totally determined. Hot temperatures and the lack of water and feed in some arid and semi-arid areas negatively affect dairy cows; in these countries, milk supply for local nomadic populations is provided by camels and dromedaries. The nutritional quality in the milk obtained from South American camelids has still not been completely investigated, the possibility of creating an economic resource for the people living in the Andean highlands must be evaluated.

camelids milk functional foods

1. Introduction

Cows are considered the main dairy animal. The term "milk" is normally associated with cow milk in most people's minds, because of the great amount of bovine milk produced worldwide; in 2020 the reported data had risen to around 532 million metric tons [1]. Obviously, considering the financial reasons involved in the dairy industry, most of the studies investigating the milk quality parameters have been performed firstly on bovine's milk, and later on other ruminants' milk, such as ewe, goat and buffalo milk [2].

The milk and dairy products from minor mammalian species, such as camelids, are not important considering the economic point of view, but these animals are crucial in the agricultural systems in several parts of the world, especially in many marginal and poor areas of North Africa, the Middle East, South America and Eastern Europe [3]. Most of the people living in these regions of the world belong to pastoral societies; their main activity consists of breeding livestock using natural pastures as forage [4]. These pastures are normally located in deserts, mountains and steppes, but it is impossible to cultivate or use these lands for agricultural activities; this kind of land represents about 25% of the world's surface [4].

1.1. Camelids Milk

Camelids are in the taxonomic order Artiodactyla (even toed ungulates), the suborder Tylopoda (pad-footed), and the family Camelidae. Camels can be considered important dairy animals for people living in arid and semi-arid areas of the world [5]. In the desert areas of the Middle East, North and East Africa, and Southwest Asia, the

dromedary or Arabian camel (single-humped) is the most common camel species, while in Northwestern China and Mongolia, Southern Russia, Tajikistan and Kazakhstan, the Bactrian camel (two-humped) is the most diffused camel species [6]. The biggest amount of the world camel milk production (more than 87%) is located in sub-Saharan Africa [7]. Somalia is the first country producer of camel milk (53% of world global production), the second one is Ethiopia (12%), and Mali (8%) is the third one [1]. Camelids are herbivores with three stomachs, and their digestive physiology is very similar compared to other ruminants with four stomachs, so they have been defined "pseudo-ruminants" [8].

There are the following four species of South American camelids: vicuña, guanaco, llama, and alpaca; vicuña and guanaco are wild, and llamas and alpacas are domesticated species [9]. These animals provide meat and milk for the local populations living in the Andean highlands, but milk from the alpaca and/or llama is not regularly collected for human feeding.

2. Camel Milk

The camel population in the world accounts about 27,000,000 heads, most of them located in Africa (about 23,000,000), while the remaining 4,000,000 are in Asia; more than 24,000,000 are one-humped dromedary camels (Camelus dromedarius), and 3,000,000 are two-humped (Camelus bactrianus) [10]. Camel milk world production was estimated to be about 2.85 million tons in 2019, which represents 0.35% of the milk consumed in the world [11]; the total amount is increasing year by year [12].

Camel milk is an important food in the human diet in several parts of the word; it represents one of the main sources of proteins for a large part of nomadic populations living in Africa and in Asia, and it can basically be considered the only protein source in infant nutrition for the desert people [13].

Milk production from Indian camel such as Bikaneri, Jaisalmeri, and Kachchhi were reported, respectively, as 3.22 ± 0.15, 2.17 ± 0.16 and 3.94 ± 0.13 L/day. The lactation length is around 14–16 months, the fresh milk represents daily food for the local population [14]. Camel milk has been used for treating infectious diseases such as tuberculosis in humans, and is also administered in Kazakhstan together with drugs in the chemotherapy treatments for cancers of the digestive tract [15].

Camel milk is characterized by an opaque white color, a faint sweetish odor with a sharp salty taste, and the pH value ranges from 6.2 to 6.5. The opaque white color is due to the presence of lipids finely homogenized in the milk [16]. The chemical composition determined in different studies is shown in Table 1.

Table 1. Milk chemical composition and energy in mammalian species (g/100 g).

	Energy (kJ)	Fat	Proteins	Lactose
Dromedary camel	277	3.1	3.5	4.4

	Energy (kJ)	Fat	Proteins	Lactose
Bactrian camel	372	5.3	3.9	4.5
Cow	300	3.7	3.3	4.7
Sheep	470	7.0	6.0	4.9
Goat	270	4.7	3.8	4.3
Human	269	3.0	1.5	6.8

Source: [17]

The lactose, fat and protein content in dromedary milk is not so different compared to bovine milk, but the protein profile of camel and bovine milk is very different. Camel whey proteins, in fact, do not contain β-lactoglubulin, which represents more than 50% of cows' milk whey proteins, while α-lactalbumin (α-la; 27%), serum albumin (SA; 26%) and immunoglobulins (18%) are the most represented protein fractions in camel milk [18].

Camel milk shows antibacterial and antiviral activities due to the bioactive peptides that perform an important physiological activity, enhancing the immune system defense [19]. Camel milk, in fact, has been used from ancient times as a remedy for diarrhea caused by viruses (Rota virus); recently its use has been evaluated in several clinical trials as adjuvant therapy [20].

The camel's immune system, compared to the human one, is stronger; the small immunoglobulins are transferred from the camel milk directly into the human blood [21]. In camel milk immunoglobulins can be detected during the entire lactation, so drinking camel milk can enhance the immune system, representing a treatment for autoimmune diseases. In fact, the small camel's immunoglobulins pass into the milk, and for this reason they are able to be used as a treating agent in human diseases and allergic antigens. Milk yield and composition of autoimmune diseases are caused by immune suppression, a disease that is counteracted by the immunoglobulins because the immune integrity is revitalized [14].

Camel milk shows positive effects in the treatment of tuberculosis (TB), especially in patients suffering from multiple drug-resistant (MDR) tuberculosis [23]. The authors of this clinical trial detected protective proteins in the camel milk, such as particular proteoglycan, lactoferrin, lysozyme, lactoperoxidase, peptidoglycan recognition protein and bacterial permeability increasing protein. Camel milk proteins have significant antibacterial properties, enhancing the body's immune system [24].

3. South American Camelids Milk

In South America, camelids include two wild species, which are the vicuna (Vicugna vicugna) and the guanaco (Lama guanacoe), and two domesticated species, which are the llama (Lama glama) and the alpaca (Lama pacos) [24]. The domestication of the llama and alpaca took place around 6000–7000 years ago in the Andean highlands, where both alpacas and llamas were raised for fiber production. Actually, llamas in South America are estimated to

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be adopted in the future, mainly in the Europe, North America, and Australia, always for fiber production [25]. The alpaca is smaller than the llama; recently also alpacas have been exported to other continents, such as North America, Australia, and Europe, where they are bred for both wool and meat production [26]. The actual Andean alpaca population is estimated to be close to 3 million heads [27].

Milk production, chemical composition, and nutritional aspects of dromedary camel milk. Dairy J. 2010, 20, 811–821.

Milk production in camels shows significant variations, affecting biological and nutritional aspects of the product, with an average of 2 mL/day per animal [28]. Alpaca milk shows higher protein and ash contents with respect to other camelids milk, while llama milk has a very high lactose content; both llama and alpaca milk showed high nutritional quality, and should be considered an alternative food for humans in the semi-arid region of South America. [29]. However, a recent study, in which the milk obtained from llamas and alpacas reared in the same lands was compared, found that the physicochemical composition of milk shows only a few statistical differences between llamas and alpacas [30].

The milk chemical composition in South American camelids is shown in Table 2.

Table 2. Milk chemical composition in South American camelids (g/100 g).

	Alpaca	Llama	Vicugna
Fat	3.8	4.7	4.58
Lactose	6.9	5.93	7.43
Proteins	4.4	4.23	3.7
Ash	1.7	0.74	n.d.
Dry Matter	16.8	15.6	n.d.

Source [25]; n.d.: not detected.

β-lactoglobulin is one of the major milk allergens causing CMPA in children [31]. Therefore, milk from species with a low β-lactoglobulin content or lower β-lactoglobulin-to-α-lactalbumin ratios are very interesting for human nutrition, especially in children affected by CMPA. Camel milk and llama milk do not contain β-lactoglobulin, such as human milk, but scarce data about the complete protein profile of these camelids milk are available [32].

Alpaca milk showed, both at 30 and 60 days of lactation, a higher content of CLA (conjugated linoleic acid, C18:2 cis-9, trans-11), which was, respectively, 1.83 and 1.67 (g/100 g total fatty acids) compared to llama milk (0.70 g/100 g total fatty acids) [26]. The CLA determined in both ruminant meat and milk originates from the incomplete biohydrogenation of linoleic acid in the rumen. Potential health benefits have been associated with CLA dietary consumption; therefore, changes in llama (Lama glama) milk composition during lactation in Dairy do-rumina Sci. 2006, 89, 3484–3493. become an important objective in food research [33].

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