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Physicochemical properties and health benefits of camel milk and its applications in dairy products: A review

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Abstract

Despite the similarity of its components with other milks, camel milk has a considerable attention from both dairy market producers and scientists lately. It is a good substitute for human milk as it contains low αs1-CN, high β-CN, high unsaturated FA, and does not contain β-LG. However, camel milk differs from other ruminants in the proportions of some ingredients with high biological activity. It's low in cholesterol, and high in C & B vitamins, α-hydroxyl acids and minerals. The high concentration of β-CN makes camel milk easier to digest by chymotrypsin than cow's milk, while the lack of β-LG makes it a suitable choice for people who are suffering from allergy to cow's milk. The α-hydroxy acids improve skin smoothness and skin disorders such as dermatitis, and eczema. Camel milk is a rich source of protective proteins; lactoferrin, immunoglobulins, and lysozyme, which have antimicrobial and anti-tumor properties. It contains a large amount of insulin that is not destroyed in the stomach and thus becomes more effective in improving blood sugar in the long term in diabetic patients compared to cow's milk. It's also rich in minerals, especially zinc and magnesium, which have anti-ulcer properties, and iron, which helps treat iron deficiency anemia. Additionally, camel milk composition allows the manufacture of some accepted products, such as those made from cow's milk. It can be used in some dairy products such as fermented milk, soft cheese, butter, and ice cream, by optimization of the processing parameters. So, it could be said that camel milk is a grant from the creator.

Keywords: Camel milk, composition, physical properties, therapeutic impact, dairy products,medical benefits.

1. Introduction

The camel is belonging to Camelidae family which includes two genera: genus Camelus (the old-world camels) and genus lama (the new world camels). The genus Camelus is separated into two species: Dromedary camels (Arabian–Camelusdromedarius) which have one-hump and Bactrian camels (Central Asia–Camelusbactrianus), which have two humps [1]. Dromedary camels adapted to hot arid environments found in the Horn of Africa, the Sahel, Maghreb, Middle East, and South Asia, while Bactrian camels are found in China and Mongolia [2]. Camels can also be used as a multipurpose animal to produce various products such as healthy milk, high-quality meat, wool, and leather products, as well as used in racing, sports, and agricultural works [3, 4].

Camel milk is characterized by many therapeutic effects compared to cow milk such as anti-cancer, hypo-allergic, deal with many spleen problems, asthma, malaria, jaundice, gastrointestinal disorder, pneumonia, tuberculosis, wound healing, and anti-diabetic effects. These influences could be due to its containing of multiple vitamins, minerals, low cholesterol, and high concentration of insulin-like factor [5]. Camel milk antibodies can be an influence against HIV/AIDS, Alzheimer's disease, and hepatitis C [6]. Camel milk can be also a solution for autism disorder, food allergy, and Crohn's problem [7]. Protective milk proteins like like lactoferrin (Lf), lactoperoxidase, lysozymes, immunoglobulin's (Igs), N-acetyl-§-glycosaminidases, and peptidoglycan recognition protein have great importance because they contain the biological peptides which are released from enzymatic reactions. These proteins are highly steady and are present in larger ratios in camel milk compared to cow milk. They have many therapeutic properties such as immune-modulatory, anti-inflammatory, and antimicrobial effects [8, 9].

Bioactive components secreted from camel milk proteins have got many potential impacts if they contribute to various functional foods to make new

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market opportunities. However, manufacturing dairy products from camel milk using the same technology as dairy products of other types of milk can lead to processing difficulties and poor-quality products [8, 9]. Recently, scientific evidence indicates that the possibility of transforming camel milk into various products include fermented milk, soft cheese, yoghurt, butter, and ice cream by optimization of the processing parameters. Also, due to the similarities in the composition of camel milk and human milk, camel milk can be used in infant formulas to alleviate bovine milk allergy in children [10]. This review is an attempt to spotlight the production, unique composition, and physical properties of camel milk compared to cow's milk and human milk. Additionally, it gives an updating record about the importance of camel milk in various modern diseases facing the human body recently. It also looks at dairy products made from camel milk, what has happened lately, and what we must do to activate the markets with these products.

2. Camel distribution and milk production

According to different national estimates and in addition to the number of wild Australian camels, the total number of camels in the world reaches 30 million heads. The dromedary camels represent about 89% of the camels in the world, while 11% belong to the bacterial camels, which are generally found in the cold deserts of Asia [5, 11]. North East African countries like Somalia, Sudan, Ethiopia, and Kenya have contained more than 60% of the dromedary camel population. Ethiopia has got the third position in the world after Somalia and Sudan. Additionally, there are about 159 thousand raised in Egypt and about 92.5 thousand in Nigeria [12]. The growth rate of the camel population is like the buffalo one but lower than the goat population. Each country has a different growth rate, and it could be clarified to 5 types of trends as mentioned by Faye [3]; (i) high recent growth countries (Algeria, Chad, Mali, Mauritania, Oman, Qatar, Syria, UAE, Yemen, Ethiopia, Eritrea), (ii) regular growth countries (Bahrain, Burkina Faso, Djibouti, Egypt, Iran, Kenya, Niger, Nigeria, Pakistan, KSA, Somalia, Sudan, Tunisia, Western Sahara), (iii) stable population countries (Lebanon, Libya, and Senegal), (v) declining population countries (Afghanistan, China, India, Israel, Jordan, Mongolia, Republics of the Soviet Union) and (iv) high rate of decline countries (Iraq, Morocco, Turkey).

About 3.5 million tons of milk is producing from ~30 million heads of camels, representing 0.4% of global milk production [4]. Camels can produce more milk for a longer time than any other milk animal held at the same harsh conditions. The daily production of a camel ranges from 3 to 10 kg while rises to between 12 to 20 kg under the more intensive breeding systems in a lactation period of 12 to 18 months [13]. Camel can survive up to six months without food or water and can live in temperatures ranging from –29 to 49°C. The major difference in the productivity of camel milk is due to the genetic variation between individual camels, the breed, the conditions of feeding and management, the type of work, the frequency of milking, the age of the animal, the continuity of lactation, and stage of lactation [14].

3. Composition of camel milk

Camel milk composition varies due to the difference in breeds, geographical origin, feeding conditions, stage of lactation, seasonal variations, and health status [15]. It is unique from other ruminant's milk in terms of composition as well as functionality; as it contains a high concentration of Igs, vitamins, and minerals but low in protein, and cholesterol [16, 17]. The average components of camel milk are 13.0, 3.4, 3.5, 4.4 and 0.79% for total solids, protein, fat, lactose and ash, respectively [4]. The ingredients of camel milk and their percentage compared to cow milk and human milk are shown in Table 1.

3.1. Proteins

According to a meta-analysis composition of camel milk from both dromedary and Bactrian species performed by Konuspayeva et al. [18], the total protein content of camel milk varying from 2.15 to 4.9%. In India, the average protein content of camel milk was 4.22% for Kachchhi breed, followed by Bikaneri (3.61%) and Jaisalmer (3.37%) breeds [19]. Similar, Hamara and Wadha milk has less protein content as compared to Majaheim milk at the same conditions [20]. With the change in season, protein content of same strain varied. It is found low in August (2.48%) and high in December (2.9%). Other authors reported that the protein content of camel milk ranges between 3.0–3.9%, while ranges between 3.2–3.8% in cow milk. The protein content in human milk, 1.1–1.3%, is lower than both camel milk and cow milk [21].

Proteins of camel milk are divided into two main groups; casein (CN) and whey proteins, as well as a relatively higher amount of immune proteins [22]. Casein is the main protein in camel milk, like all ruminants, as it represents about 52-87% of the total protein compared to 80–82% in cow's milk and 20–45% in human milk [23]. This means that there is a large variation in the casein/protein ratio of camel milk and human milk compared to cow milk. Cow milk has the biggest casein content followed by camel milk, while human milk having particularly low casein content [24]. This may explain why the coagulum of camel milk is softer than that of cow milk. Casein of camel milk contains four main fractions in counterpart to that of cow casein: αs1-CN, αs2-CN, β-CN, and κ-CN [25]. It has high β-CN (65% vs. 34%) and low αs1-CN (22% vs. 45%) and low κ-CN (3.47% vs. 10–12%) content as compared to casein of cow milk [29, 27]. Camel milk and human milk are rich and found the same when compare with the amount of β-CN, but human milk does not contain the αs1-CN which is the predominant factor causing milk protein allergy [5, 15, 22]. On the other hand, casein of camel milk, β-CN, has more digested by chymotrypsin and slowly hydrolyzed by trypsin than cow milk caseins [28]. Also, camel αs1-CN has five phosphoserine (PSer) residues compared to four PSer residues in cow αs1-CN [25].

Whey proteins of camel milk differ markedly from that of cow milk. The main fractions of whey proteins in camel milk are α-LA, serum albumin, Lf, immune proteins and Peptidoglycan Recognition Protein (PGRP) [4, 15, 19]. As in human milk, the whey protein of camel milk does not contain β-LG or found in traces. Therefore, α-LA is the main whey protein in camel milk that contains 4–5 folds more α-LA than cow milk. The α-LA represents only 25%, while β-LG represents 50% of the whey proteins in cow's milk [26, 29]. The α-LA of camel milk consists of 123 residues, which are like to cow milk, and human milk [15]. Camel milk has also a unique immunological system. The Igs concentration was wide and decreased from 132 to 4.75 mg/L throughout the 7 days postpartum, with an important drop after parturition [30]. The concentration of Lf ranged from 4.7–4.9 g/L at 168–192 h postpartum and ranged from 0.9–1.1 g/L in normal milk, which higher than that reported for cow milk, 0.3 g/L [31, 32]. PGRP has been isolated from camel milk, but not found in cow milk. It is also found in higher amounts in camel milk (107 mg/L) than other antibacterial proteins such as Lf, lactoperoxidase, or lysozyme [33, 34]. Lysozyme is a protective protein higher in camel milk (15 μg/100 mL) than milk of cow (7 μg/100 mL) and human milk. It has antibacterial activity gram-positive bacteria like N-acetyl-beta-D-glucosamidase found in similar quantities in human milk [35]. Lactoperoxidase of camel milk, 2.23 U/mL, is resistant to acidic and proteolytic digestion contributes to the non-immune host defense system, exerting bactericidal, growth promotion, and anti-tumor activities as well as it has a close relation (71%) to human thyroid peroxidase, which is involved in iodination and coupling in the formation of the thyroid hormones [36, 37].

3.2. Lipids

The composition and content of lipids in milk fat vary widely among mammalian species. Camel milk has lower amounts of fat and smaller size of fat globules, which do not naturally aggregate due to the absence of agglutinin compared to cow's milk [38, 39]. The fat content of camel milk is ranged between 1.2 and 5.4% with an average of 3.29% and can be reduced to 1.1% in the milk of thirsty camels [4, 18, 19]. The highest fat content was recorded in both the Somali (5.4%) and the Egyptian (5.22%) camel milk, while the lowest was recorded in the Tunisian (1.2%) and the Indian (2.35%) camel milk [19]. Fat globules with the biggest average diameter are found in buffalo milk (5 μm), followed by cow milk (3.5 μm) while the smallest are found in camel milk (2.99 μm) [40, 41]. Camel milk contains higher amounts of long chain FA (96.4%) and unsaturated FA (43%) especially, essential FA as compared to fat of cow's milk (85.3 and 38.8%, respectively). Bai& Zhao [42] reported that unsaturated FA in camel milk (65.02%) is the highest followed by the human milk (58.17%) and cow milk (40.76%). Other authors reported that the concentration of unsaturated FA in human milk was found higher than camel milk and cow milk [18]. Camel milk also has high palmitoleic acid (10.4% vs. 3.6%) and low linoleic acid (2.9% vs. 3.2%) content as compared to cow milk [15]. So, solidification temperature and the melting point of camel milk fat (30.5±2.2°C and 41.9±0.9°C) were higher than that of cow milk (22.8±1.6°C and 32.6±1.5°C), respectively [43]. In addition, camel milk is a natural source of α-hydroxy acids which are known to chubby the skin and smoothies' fine lines [21]. The cholesterol concentration of camel milk fat (345 mg/100 g fat) is higher than that of cow milk fat, 256 mg/100 g, due to the cholesterol is present in the milk fat globule membrane. The small fat globules, which characterizes by a larger surface area of the fat globule membrane, relate to a relatively higher concentration of cholesterol in camel milk [18, 44]. However, due to the higher fat content in cow's milk, serum cholesterol concentration is much higher (227.8±60.5 mg/100 mL) than camel milk (106.4±28.9 mg/100 mL) [3].

3.3. Carbohydrates

The principal sugar of all milk species is the disaccharide lactose, which consisting of glucose and galactose. The lactose content of dromedary camel milk ranges between 2.4–5.8% [18], but it ranges between 4.0–5.0% in cow milk. However, lactose content in human milk is the highest (6.8–7.5%) when compared to both camel milk and cow milk [13,45]. The other significant carbohydrates of human milk are the oligosaccharides, ranging between 0.1–1.0% in normal milk and 1.5–2.3% in colostrums [24]. Fucosylated constitutes approximately 35–50%, sialylated 12–4% and nonfucosylated 42–55% of oligosaccharides in human milk [46].

Table 1.Values of the ingredients of camel milk compared to cow milk and human milk.

Milk ingredients	Camel milk		Cow milk		Human milk	
	(%)	Ref.	(%)	Ref.	(%)	Ref.
Moisture	87.0	[4]	85–87	[4]	88	[4]
	86–88		86–87.1	[54]	88-89.2	[45]
Proteins	2.15–4.9	[18]	3.2–3.8	[4]	1.1–1.3	[4]
	3.0–3.9	[22]	3.48	[45]	1.11	[45]
	3.37-4.22	[19]	3.5–3.7	[55]	0.69-1.72	[55]
Casein	1.63 to 2.76	[23]	2.5-3.0		0.35–44	
CN/TP Ratio	52-87	[23]	80-82	[23]	20–45	[23]
					16.4–38.2	[55]
WP/TP Ratio	20-25	[24]	18–20	[23] [4]	60	[24]
Fat	1.1–4.3	[18]	3.7–4.4	[4]	3.3–4.7	[4]
	1.2–5.4	[9]				
	3.5	[4]				
Lactose	2.4–5.8	[19]	4–5	[45]	6.8–7.5	[13]
	4.4	[4]	4.8–4.9	[13]	6.8–7.0	
Ash	0.6–0.9	[28]	0.7–0.8	[4]	0.2–0.3	[4]
	0.79	[4]				
	0.75	[45]				

TP, Total proteins; CN, Casein; WP, Whey proteins

3.4. Minerals

The total amount of minerals is presented as total ash, which ranges between 0.6 – 0.9% in camel milk [18]. The wide range in mineral concentration was proposed to be due to the differences in feeding, breed, and water intake [47]. Under the similar conditions, Bactrian camel milk has higher minerals content than dromedary camel milk. The concentrations of Ca, P, Na, K, and Mg contents are about 146.8, 134.1, 61.5, 167 and 9.9 mg/100 g in Bactrian camel milk, while was about 123.7, 85.2, 51.6, 143.5 and 12.6 mg/100 g in dromedary camel milk, respectively [48]. Broadly, camel milk is a rich source of chloride, due to some plants eaten by camels such as Atriplex and Acacia [49]. The concentration of Na, K, Fe, Cu, Zn and Mn are higher in camel milk than in cow milk, while Mg, P, and Ca were similar in both types [50]. The mean values of trace minerals are 1.37, 2.19, and 0.44 mg/100 g and 0.05, 0.35, and 0.02 mg/100 g for Fe, Zn, and Cu in camel milk and human milk, respectively [51]. Human milk contained the lowest content of Ca, P, Fe, Zn, Na, K and Mg but contained the highest Mn content compared to both camel and cow milk [14, 36].

3.5. Vitamins

Both water-soluble and fat-soluble vitamins are found in all animals' milk. Camel milk is a kind of exception because of its high concentration of vitamin C. It contains 3 to 5 times more vitamin C (3.0 to 7.5 mg/100 g) than cow's milk (0.8 to 2 mg/100 g), whereas vitamin C concentration is relatively close to that of human milk (1.19 to 7.84 mg/100g) with an average 4.86 mg/100 g [22, 52]. Likewise, camel milk exhibited high levels of vitamin B1, B12, folic acid and pantothenic acid than cow's milk [50]. Zhao et al. [48] reported that vitamin D level (640–692 IU/L) in Bactrian camel milk is higher than that of cow's milk (20–30 IU/L). Other authors reported that vitamin B1, B2, folic acid and pantothenic acid are low in camel milk, while B6 and B12 content is quite like that of cow milk but higher than in human milk [49]. Haddadin et al. [47] reported also the concentration of vitamins E, B6, and B1 in camel milk were similar to those for cow's milk. The concentration of vitamin A, and E were reported to be low in camel milk compared to cow milk [49]. Seman & Altıntaş [53] declared that camel milk has higher amount of vitamin C and B3 but, lower amount of B1, B2, B5, B12 and α-tocopherol than those of cow's milk. Concentration of vitamins A, E and B1 was as 0.02±0.01, 0.033±0.013 and 19.6±6.4 mg% in camel milk as compared to 0.061±0.026, 0.171±0.114l g and 34.7±8.1 mg% in cow's milk, respectively [19].

4. Physical properties of camel milk

4.1. Taste and color

Camel milk is opaque white, normal milky odor, slightly salty, and high acidic nature, which mainly depends on the type of diet and the stage of lactation [15, 51]. The depletion in major milk constituents and elevation in the chloride level of milk obtained from dehydrated camels as well as feed is taken up by camel might be a cause for the salty mouth feel of camel milk [56]. Its taste also may differ according to the habitat of camels. Milk produced from camels on the American continent distinguishes by sweet, slightly salty, and creamy texture. As for camel milk in the Middle East, its flavor is more similar to hazelnuts [57]. Camel whey separated from milk after coagulation has also white color, while cow milk whey has greenish color. This behavior may be due to presence of small fat globules and caseins which cause scattering of light [58]. Sakandar et al. [15] clarified that white color of camel milk is due to lower level of carotene. The values of some physical properties of camel milk compared to cow milk and human milk are presented in Table 2.

4.2. Acidity and pH

The pH of camel milk ranges between 6.5 and 6.75, which is similar to the pH of cow milk, 6.4–6.8, but lower than human milk, which a range of 6.75–7.42 with a mean pH 7.09 [15, 59]. The acidity of camel milk ranges between 0.14–0.15 percent, which is also close to the acidity of cow milk, 0.15% [60–62]. Anonymous [63] reported that acidity content is between 0.13-0.16% in fresh camel milk, which is slightly lower than the mean value of 0.17% for cow milk and seems to depend on the breed. Other authors reported the pH of camel milk, which ranges between pH 6.2–6.5, is lower than cow milk [4]

4.3. Heat stability

At high temperatures, the heat stability of camel milk is much lower than that of cow milk and can't sterilize at natural pH due to the casein micelle size as well as deficiency of β-LG and κ-CN in camel milk [19]. Alhaj et al. [64] reported that κ-CN and Ca are playing a major role in heat stability of camel milk heat stability. At 130°C, cow milk possesses maximum heat stability at pH 6.7 and a minimum at pH 6.9, while camel milk does not show increased stability at pH 6.7 [19]. The main problem of the preserved UHT camel milk is sedimentation of proteins which require selected additive to achieve physical stability. The highest heat stability of sterilized camel milk was in pH ranges between 7.0–7.2, while the lowest heat stability was in pH ranges between 6.5–6.8. Camel milk can also be well pasteurized by Vat or HTST with no evidence of precipitation in proteins [64]. Whey proteins of camel milk were more heat stable than those of cows milk [65]. At 80°C for 30 min, the denaturation of camel milk whey proteins was less (32-35%) than cow milk whey proteins, 70–75% [66]. Felfoula et al. [67] revealed that the denaturation temperature of sweet and acid whey was 73.8 and 60.50 °C for camel milk, and 70.5, and 63.9°C for cow milk, reflecting whey proteins of camel milk are more sensitivity towards acidity than whey protein of cow milk.

Table 2. Values of some physical properties of camel milk compared to cow milk and human milk.

Milk properties	Camel milk		Cow milk		Human milk	
	Value	Ref.	Value	Ref.	Value	Ref.
pH	6.5–6.75	[15]	6.4–6.8	[15]	6.75 – 7.42	[59]
	6.2–6.5	[4]		[69]	7.0-7.4	[77]
	6.4–6.7	[19]	6.6	[54]		
Specific gravity	1.028– 1.033	[69]	1.026–1.034	[69]	1.030	
(g/mL)	1.026–1.035	[4]		[62]		
Viscosity	2.2	[74]	1.8	[74]	1.32 – 1.44	[72]
(mPa.s)	1.72	[75]	2.04	[75]		
	1.765–1.785	[61]				
Freezing point	-0.518	61	-0.53	[61]	-0.531 to -	
(°C)	-0.57 -0.61	62	-0.53 to -0.57		0.586	
Surface tension	58.39	61	42.3-52.1	[72]	47.73	[72]
(dyne/cm)	58.35–58.37	71				

4.4. Freezing point

The freezing point of camel milk is significantly higher (–0.518ºC) than that of cow milk (–0.53ºC) due to it has low MSNF content [68]. Park et al. [62] stated the freezing point of cow milk was between –0.57 to –0.53°C. Inversely, another study found that the freezing point of camel milk is between –0.57°C and –0.61°C, which lower than the freezing point of cow milk. A higher salt or lactose concentration in the camel milk as compared to cow milk may have contributed to low the freezing point [69,]. There aren't many reports available in the literature on the freezing point of camel milk that supports one of these findings. However, when looking at the composition of both camel milk and cow milk, especially soluble components such as lactose and salts, we will find that the freezing point of camel milk can be higher compared to cow milk.

4.5. Specific gravity and surface tension

The mean of specific gravity of camel milk is 1.029 and varied between 1.026–1.035 depending on the breed [4, 15, 61]. These values are similar to those for both cow and human milk, which are between 1.026–1.034 [62]. However, a little information is available about the values of surface tension of camel milk compared to cow milk, except for [61], who found that the mean of surface tension of camel milk was 58.39±0.421 dynes/cm. In the UAE, the surface tension of camel milk samples ranges from 58.35 to 58.37 dynes/cm [70]. Sunarić et al. [71] displayed that the surface tension of camel milk was the highest compared to cow milk (42.3-52.1 dynes/cm) and human milk, 47.73±1.50 dyne/cm, reflecting a higher content of proteins and non-polar molecules results in lower values of the surface tension [72].

4.6. Viscosity

Camel milk viscosity, which ranges between 1.32–1.44 mPa.s, is the highest compared with cow's milk and human milk [71]. The viscosity of Indian camel milk was 1.77 mPa.svs 1.54 mPa.s for cow's milk [61]. In Egypt, the mean value of camel milk viscosity was 2.2 mPa.s, which is higher than the cow milk mean value (1.8 mPa.s) [73]. In UAE, the viscosity of camel milk was found to range between 1.765 and 1.785 mPa.s at 25°C. The high viscosity of camel milk may be attributed to the presence of small floccules like fat globules [61]. Other authors illustrated lower viscosity for camel milk than that cow one milk. Kherouatou et al. [74] found that the viscosity of camel milk is 1.72 mPa.s, which is lower than cow milk at the same dry matter content and the same conditions (2.04 mPa.s). These contradictory results may be explained by the differences in husbandry, mainly in water supply. Milk of heifers deprived from water for several days was reported to be more dilute, probably to protect the calf from dehydration during dry periods. Milk viscosity mainly influenced by concentration of components, pH, temperature and thermal history. Proteins and fats are the principal contributors to the viscosity of milk, which are lower in camel milk compared to cow's milk [70, 75].

5. Therapeutic impact of camel milk

5.1. Anti-microbial effect

Camel milk composition reflects how important it is in fighting bacteria and microbes. It contains Lf with activity ranged from 95-250 mL/dL, lactoperoxidase with activity range from 2.23±0.01 U/mL, and lysozyme, which considered as potent antimicrobial as well as bioactive compounds such as peptide like-insulin [35]. The existence of these components protects against both Gram-positive and Gram-negative bacteria include E. coli, L. monocytogenes, Staph. aureus and S. typhimurium as well as the entry and direct interaction of the hepatitis C virus to hepatocyte-derived carcinoma (Huh7.5) and human hepatoma (HepG2) cells [77–79]. The high ratio of lysosomal enzyme and PGRP is highly effective against pathogenic bacteria because of its ability to conjugate to the bacterial cell wall and act as an antimicrobial action. Moreover, different camel milk peptides such as Lf, casocidin-I and isracidin have also antibacterial activities because they are conjugated and release the liposaccharide molecules located in the outer cell membrane of the Gram-negative bacteria [80]. Wang et al. [81] cleared that the hydrolysis mechanism of camel milk was improving its antimicrobial activity; through releasing bioactive peptides, antimicrobial substances that have high resistance of antibacterial proteins to pepsin and trypsin.Scientists promoted fermented camel milk is high in lactic acid bacteria, which are effective against pathogens; include *Staphylococcus*, *Salmonella*, and *Escherichia* anti-bacillus microorganisms [7]. The few published studies on camel milk have shown that camel milk is considered a niche of lactic acid bacteria producing antimicrobial peptides (bacteriocins, Table 3). Furthermore, it was observed that the pasteurization didn’t influence on antimicrobial activity [4, 82]. Al-Juboori et al. [83] reported that infection by Mycobacterium avium ssp. paratuberculosis lead to a secondary autoimmune response, paving the way for Crohn’s disease. It becomes apparent, that the powerful bactericide properties of camel milk, combined with PGRP have a quick and positive effect on the healing process.

5.2. Immune system effect

Besides the mentioned previous protein content in camel milk, which gives strong natural immunity against infection, the immune system has Igs containing IgM, IgG, IgA, IgD, and subclasses IgG2 and IgG3 only consists of two heavy chains. Light chains (VL) not present [86, 87]. Camel VHH has a long Complementary Determining Region (CDR3) loop, compensating for absence of the VL conventional antibodies rarely show a complete neutralizing activity against enzyme antigens. Camel VHH domains are better suited to enzyme inhibitors than human antibody fragments, thus offering a potential for viral enzymatic neutralization. These Igs have antiviral properties that could prohibit hepatitis

C virus and demonstrated strong signal against its synthetic peptides. As well, it can combat some bacteria such as tuberculosis and especially individuals suffering from multidrug resistance [88]. In India, there is a significant improvement of symptoms observed values through consumption of camel milk by multidrug-resistant tuberculosis ill patients. Moreover, it can save the body from bacterial and viral infections [57, 89].

5.3 Diabetes Mellitus disease

In developed countries, Diabetes Mellitus (DM) is the fourth leading cause of death [90]. The DM ordinary medications such as Biguanides, Sulfonylurea and Thiazolidinedione are linked with annoying side effects like allergic reactions, nausea and vomiting, diarrhea, sexual dysfunction, hemoglobin disorders and lipodystrophy [12]. This is one of the most sought reasons for searching of cheap, natural alternatives from plant or animal extracts. Among these alternatives to classical medicines are camel milk and camel urine, where there are many anecdotal reports but few scientific studies. The insulin of camel milk is 58.67±2.01 U/L, which has hypoglycemic effects versus cow's milk (17.01±0.96 U/L). This is could fluctuate according to lactation stages and insulin-like growth factor-I [36, 91], which are not destroyed in the stomach. Kaskous [6] stated that only camel milk remains unaffected by gastric acid and so passed to the intestine and absorbed. El-Sayed et al. [92] suggested the protection of insulin camel milk from coagulation due to acidity or pepsin in the stomach because the insulin of camel is contained within micelles and protected from proteolysis in the upper gastrointestinal tract. This defense may allow to be absorbed in the micelles, or to be released again to be absorbed by insulin receptors in the small intestine. Mustapha et al. [12] announced that insulin-activated lipoprotein lipase an enzyme that hydrolyses triglyceride leading to low serum lipids, so insulin-like protein in camel milk will lower lipid components in camel milk treated rats. Some studies [93-94] summarized the importance of camel milk in diabetes is due to:

- It has regenerative effects on damaged cells of the pancreas.
- Camel milk insulin does not form coagulum in the acid's environment of the stomach like insulin of other mammals. So, it absorbed into the blood circulation easier than insulin from any other sources or causes resistance to protein degradation.
- Nano-particles encapsulated camel insulin (lipid vesicles) makes it easy to pass through the stomach and enter the blood circulation.
- The antioxidant action of camel milk prevents metabolic syndrome, including hyperglycaemia, hyperlipidaemia, and insulin resistance.
- The sequence of camel insulin and the expected digestion pattern do not indicate the difference to overcome the mucous barriers before decomposing and reaching the bloodstream.

Table 3.Bacteriocin produced by lactic acid bacteria from camel milk and its products.

Genus	Milk sample types	Bacteriocin
Enterococcus faecium	Raw camel milk	Enterocins A, B and P Enterocins L50A and L50B
Lactobacillus casei	Fermented camel milk (Shubat)	Caseicin TN-2
Lactobacillus plantarum		Bacteriocin-like substances
Lactobacillus rhamnosus		
Lactobacillus brevis	Raw and fermented camel milk	
Lactobacillus paracasei		
Lactobacillus fermentum		
Lactobacillus acidophilus	Raw camel milk	Acidophilucin AA105
Leuconostocmesenteroides	Raw camel milk	Leucocin B
Lactobacillus plantarum	Butter made from camel milk	Bacteriocin-like substance

Sources: Vimont et al. [84]; Rahmeh et al. [85].

5.4. Autism

Autism spectrum disorder (ASD) is defined as a lifelong neurodegenerative disorder characterized by poor communication and social interaction before 3 years ago [95]. Besides behavioral impairment, ASD relates to high dispersal of autoimmune disease, gastrointestinal disease and dysbiosis, and mental retardation. Oxidative stress plays a necessary role in the pathology of several neurological diseases such as Alzheimer's disease, Down syndrome, Parkinson's disease, schizophrenia, bipolar disorder, and autism. As reactive oxygen species (ROS) levels override the antioxidant capacity of a cell the oxidative stress take place. It acts as a mediator in brain injury, strokes, and neurodegenerative diseases. Thus, the control of ROS production is needed for physiologic cell function. If the production of ROS both centrally (in the brain) and peripherally (in the plasma) raised, it may result in the decrease of brain cell number leading to autism pathology and apoptosis [35].

Glutathione is considered as one of the most significant intracellular antioxidants, in charge of maintaining the reducing intracellular microenvironment that is essential for normal cellular function, viability and reduction oxidative stress. Ashwood et al. [96] stated that after consuming camel milk, a significant boost in GSH ratio was observed; this could be attributed to the antioxidant nutrients constituents of camel milk such as magnesium, zinc, vitamin E and C. It also has been suggested that high ratios of Mg, Zn and vitamin E in camel milk might help to increase glutathione production and enzymes production and hence to decrease the oxidative stress in autistic subjects [97].

Opioid peptides are a very critical source of autism, which means that extreme amounts of opioid peptides from milk proteins can be pathophysiology in the autism disease. Some people, there is incomplete metabolization of casein proteins in the intestine; short neuro-active peptides such as β-casomorphins formed, which are derived from casein [6]. Sometimes casein breaks down to β-casomorphin instead of β-CN and β-LG. This β-casomorphins has long been considered as a risk factor for autism behavior. Generally, autism is an autoimmune disorder, which suddenly reaches the intestine, not the brain. The reactions in the intestines begin with diarrhea and influence on appetite [57]. Cow's milk contains both β-CN and β-LA, which produces casein morphine, makes it an important factor for autism patients. Unlike cow milk, camel milk does not contain these proteins, so autism symptoms do not develop [94]. Additionally, camel milk has many antioxidant agents such as vitamins (A, C, and E), minerals (Mg and Zn), and Igs, which necessary for initiating the immune system and nutritional advantages for brain development. These minerals also motivate glutathione manufacturing, which in turn is working to develop autistic behavior. The connection of camel milk and reducing oxidative stress of autistic behavior in children had been assessed. After 15 d of camel milk consumption, the ratios of glutathione, superoxide dismutase, and myeloperoxidase in plasma were significantly raised. Decreasing the oxidative stress over changing the concentration of anti-oxidative enzymes non-enzymatic antioxidants molecules may reduce the marks of children autism [97-98].

5.5. Anti-cancer effect

Camel milk can inhibit the number of cancerous tumors, such as hepatocellular carcinoma, colon carcinoma, human glioma cells, lung cancer cells, breast cancer, and leukemic cells [99]. A formula contained camel milk and camel urine (drinking cure) had been applied to reduce the growth of cancer cells. They tried these doses successfully in mice blood cancer (leukemia) and tried to take place in humans [6]. The high content of Lf, Igs, iron-bound glycoprotein, and lactoperoxidase makes it an effective anti-tumor compounds. Lf, the main iron-bound protein in camel milk, is potent for a 56% reduction of cancer growth. It's influence through increasing the synthesis of RNA and by inhibiting protein kinases and differentiation. Levy et al. [100] stated that camel milk contains highly active antibodies, which make it able to bind and kill cancer cells while maintaining the integrity of healthy cells. It can also generate nitric oxide, which stimulates mucus production, inhibits the adherence of neutrophils to the endothelial cells, and increases the blood flow to the gastric mucous membrane. In addition, camel milk has a thrombolytic activity that inhibits the coagulation and formation of fibrin, which hinders the growth and spread of tumor cells [101].

Kula [94] mentioned that camel milk stimulates apoptosis in HepG2 and MCF7 through apoptotic and oxidative-stress-mediated mechanisms. Also, it has anti-genotoxic and anti-cytotoxic effects through inhibition of MnPCEs and improves the mitotic index of bone marrow cells. Another explanation has been mentioned that the anti-cancer action could be a direct cytotoxic and anti-angiogenic action (cutting off the blood supply to cancer cells) of camel milk Lf. The anti-tumor properties of camel milk are due not only to its potent antimicrobial and antioxidant activities that help in the reduction of liver inflammation but also to its high content of nutrients needed for healthy liver function. Conversely, camel milk appears to have potential thrombolytic action, as it causes inhibition of coagulation and fibrin formation, which in turn hinders the spread and growth of metastatic tumor cells [102].

5.6. Allergy diseases

The absence of allergens in camel milk compared to cow milk is the main reason for making it safe, especially for those suffering from food allergies. Camel milk is an effective alternative for children who suffer from cow's milk allergy, the most famous of which is the compound β-LG, which is absent in camel milk [57]. Beside, camel milk contains β-CN, but its structure is very different from the cow milk protein (it has high β-CN content, 65% vs. 34% in cow). It also includes Igs similar to human milk, which reduces allergic reactions in children, and strengthens their future response to foods. The IgE of children who were allergic to cow milk, only un-reacted with camel milk due to the phylogenetic differences could be responsible for the failed recognition of camel proteins by circulating IgEs and monoclonal antibodies [14, 103].

On the same side, camel milk can be used as an option for the individuals intolerant to lactose of cow milk. It contained low lactose with easily digests as well as metabolized by the human body. Individuals intolerant to lactose are able to accept camel milk without adverse symptoms [95]. Shabo et al. [104] and Ehlayel et al. [105] examined the effect of camel milk on eight children who had severe food allergies. About 24 h after starting the treatment, the children had fewer symptoms, and within four days, all symptoms disappeared. In all cases, the treatment led to a rapid improvement in children's health and subsequently followed by the ability to digest other food. It believed that Igs in camel milk plays a key role in reducing allergic symptoms in children. Another trail was made on 35 food-allergic children (23 males and 12 females), aged 4-126 months. Eighty percent of the treated children have positive results after using camel milk (negative skin-prick test to camel milk). These children with cow's milk allergy could safely take camel milk as an alternative nutrient. The absence of immunological similarity between camel and cow milk proteins can be regarded as important points of nutrition for children allergic to cow milk [103]. Additional scientific research is needed to sufficiently prove the effectiveness of camel milk in treating allergies.

5.7. Gastrointestinal disorders

Camel milk contains a high concentration of anti-inflammatory proteins such as lactoperoxidase, peptidoglycan, Lf and lysozyme which have a positive health effect on the stomach and intestinal disorders. The high proportion of mono and polyunsaturated FA and vitamin-rich composition provide improved carbohydrate metabolism. Moreover, fermented camel milk has angiotensin I-converting enzyme, which facilitates the digestion of the milk proteins. Recent applications have shown the importance of camel milk on the health of the digestive system. It has anti-diarrhea properties for children who suffer from natural stomach contractions and rotavirus contamination of food because camel milk is rich in anti-rotavirus antibodies [6, 106].

5.8. Camel milk and COVID-19

The Coronaviridae has been mentioned that it is the most critical viral family in order to their ability to mutate and reassert [107]. The WHO announced coronavirus disease-2019 (COVID-19), a universal pandemic on 11th March 2020, as its causative virus "severe acute respiratory syndrome coronavirus-2" (SARS-CoV-2) spreads quickly out of control over the world. All efforts must be intensified to control this new epidemic because it has become an enormous pressure on the health sector around the world. We are in a race against time to find a solution and a speedy treatment for this spreading epidemic. Camels can be applied to generate strong immune strains against responses against different strains of the coronaviruses. Camels stock is ready for use around the world and can be used as mobile live factories to synthesise and produce these amazing neutralizing antibodies to treat COVID-19. It strongly recommended that camel milk with camel SARS-CoV-2-antisera can be made safe and would be available and affordable worldwide to all in need [108, 109].

Additionally, camel milk antimicrobial effect is due to its protective proteins and enzymes like Igs, Lf, lysozyme, lactoperoxidase, PGRP, vitamin C and oligosaccharides. Lf has the most anti-microbial and anti-viral action of camel milk as shown in Fig. (1). Camel milk Lf content is higher than cow milk content. It is binding to microbial particles or cell receptors and inhibits the infections. Also, it can bind receptors that SARS-CoV and human coronavirus NL63 use for entry into the host cells. Information on the potential of camel milk Lf against the COVID-19 is rarely reported. Although there are few clinical studies against COVID-19, Lf acts verses viruses such as SARS-CoV. Seventy nine percent of sequences of the SARS-CoV and SARS-CoV-2 and also receptor-binding domain are homologous, therefore, Lf may inhibit SARS-CoV-2 invasion in the same manner to SARS-CoV. The incidence of COVID-19 in infants was mild without ventilation support and lower respiratory tract infections rarely happened. Lf inhibited virus entry via binding to heparan sulfate glycosaminoglycan in the cell surface of human coronaviruses hCOV-NL6310 and pseudo typed SARS-CoVCoV. It also prohibits accumulation of viruses on the cell surface and stops the connection between the viruses and host cells prevent the viral infection that is observed in the SARS-CoV epidemic and may be the same for SARSCoV-2. 50% inhibitory on human coronavirus of pseudo typed SARS-CoV that is most closely related with SARS-CoV-2 which causes COVID-19 was observed as a result of using Lf. It is advised that to take 32 mg Lf /day (liposomal bovine Lf) for 10 days with zinc led to 100 % recovery of 75 SARS-CoV-2 positive patients within 4 – 5 days [110].

5.9. Camel milk for skin beauty

Camel milk is a natural source of α-hydroxyl acids which are known to chubby the skin and smoothies' fine lines. The α-hydroxyl acids have a very small molecular structure which is able to pass through skin and stimulate the production of collagen, leaving your skin smoother, brighter and younger looking [36]. Camel milk contains vital immune properties as well as vitamins, proteins and antioxidants that are ideal for health and beauty. It contains very high concentrations of unique immune proteins that have a high ability to penetrate skin cells and fight off inflammation and disease-causing agents compared to other immune proteins. They penetrate the deep layers of skin to stimulate collagen production to repair and regenerate, protecting the skin from UV damage to produce elastic, strong and firm skin. Vitamin C in camel milk has many functions such as imparts antioxidant skin tissue protective activities, produce collagen protein which helps the growth of cells and blood vessels, consequently, gives strength and firmness to the skin, and protects the skin from free radicals. Furthermore, camel milk protein easily digested and generated bioactive peptides that acts as natural antioxidants and ACE inhibitors [57].

Camel milk soap becoming known for its ability to improve the texture of skin, clear up acne and keep wrinkles away. It is also suitable for all skin types including eczema, psoriasis, dermatitis and acne. The unique milk structure can penetrate lower layers of the skin and provide everything that is needed for healthy, younger, and brighter looking skin. Products from camel milk are already hitting the shelves of shops such as soaps and yogurts [7].

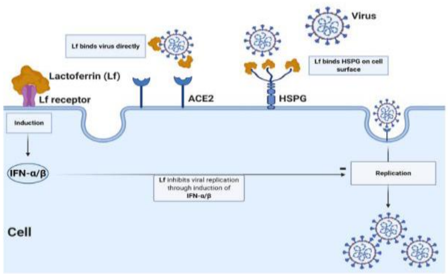

Fig 1. Antiviral mechanisms of lactoferrin Image adapted from Chang et al. [111].

6. Camel milk in dairy industries

6.1. Fermented milk

Fermentation of camel milk is considered a procedure to preserve it for a longer time and extend the shelf life of camel milk in the absence of the cooling facility; their high nutrient contents and potential health benefits [112]. Fermented camel milk has various names in different parts of the world [113] like yoghurt, kefir, matzoon, Dahi, gioddu, lehben, Tarag, Unda, Chal, Susa and Gariss [15, 112, 114, 115]. However, producing fermented products from camel milk is reported to be difficult. Growth of bacterial strains used for cow milk fermentation may be inhibited by the natural antimicrobial activity of camel milk. So that, camel milk has been appeared to be not easily fermentable, the acidification rate in camel milk was lower than in bovine milk [15, 113]. Yoghurt produced from camel milk, with no additives, has some problems such as a thin consistency, flowable and week texture. Dromedary milk coagulum does not have a desirable curd formation and firmness and the curd is instead fragile and heterogeneous and consists of dispersed flakes [43]. Nevertheless, some reports indicated the possibility of yoghurt production from camel milk [116, 117]. Fermentation of camel milk by using exopolysaccharide producing starter cultures could improve the texture of camel milk yoghurt better than additives. Hashim et al. [118] and Muliro et al. [119] confirmed the formation of coagulum from camel milk requires the addition of both gelling, and thickening agents to improve viscosity & the texture, facilitate gel reformation, avoid syneresis, and produced acceptable firmness and body similar to that for yoghurt produced from bovine milk. Also, the weak texture of camel milk yoghurt can be improved by mixing it with other kinds of milks such as bovine milk [10]. Khalifa&Zakaria [120] found that adding buffalo milk to camel milk produces an acceptable classic yogurt to consumers with a long shelf life.

6.2. Cheeses

The processing of camel milk into cheese is technically more difficult than milk from other ruminant dairy animals. There are number of problems associated with the production of cheese such as long coagulation time, poor of coagulation properties. The rennet coagulation time is 2 to 4 times slower than cow milk due to the differences in the size of casein particles that are mainly related to the availability of k-CN [121]. The low amount of k-CN (3.47%), the high ratio of whey protein to casein, and the larger micelle size in camel milk are the main reasons for the difficulty of cheese making; a less firm coagulum and lower yield [27, 122]. Other reasons for weaker curd are the low total solids content of the coagulum, especially casein, the small size of fat globules and the high Na concentration [58, 123]. The coagulum obtained from camel milk by bovine rennet action showed a fragile and heterogeneous structure. Soft white cheese produced from camel milk by traditional processes gives up to a 12% yield, which 50% lower than soft cheese made from cow's milk [123]. The lower yield of 5% was clarified for hard cheese produced from camel milk [124].

However, cheese can be successfully produced from camel milk, but after mixing it with milk of cow, goat, sheep, or buffalo (smaller casein micelles have been improved the gelation properties) and the coagulation time can be reduced by decreasing pH, increasing temperature, and adding calcium [28]. Several studies show that different varieties of cheeses can be produced from camel milk; it includes semi-hard and hard cheeses, Domiati soft cheese, and processed soft unripened cheese [124–125, 126–127]. However, most of those methods demand a longer time for fermentation, coagulation and drainage of the whey. To solve the problem of long-time coagulation, the FAO has developed and confirmed a coagulating agent called "Camifloc" used to coagulate camel milk; it contains calcium phosphate and vegetable rennet. It is sold in small and easy-to-use packets, in Mauritania, Mali, and UAE [58]. Recently, Hansen© (Denmark) delivered recently new coagulant agent named "Chy-Max M" containing transgenic camel chymosin. These technological parameters of camel milk processing into cheese by camel rennet represent informative steps for further trials and could be useful for industrial scale cheese processing of camel milk [128].

6.3. Butter

Producing butter from camel milk by using the traditional churning methods used for cow milk is also difficult. Camel milk shows little tendency to cream up due to fat distribution as small micelle-like globules in the milk, the absence of agglutinin, and the fat is firmly bound to the protein [39]. The high melting point of camel milk fat (41–42°C) also makes it difficult to churn the cream at temperatures used for churning cow's milk, 8–14°C [114]. However, butter can be produced by heating milk at 65°C for 30 min and separating the cream by centrifugation. Camel cream is churned at a high temperature (22–25°C vs. 8–14°C for cow cream) to obtain a sensible butter yield. This difference is attributed to the high melting point of camel milk fat, which is 40–41°C. This appears to shift the ideal ratio of solid to liquid fats at a given temperature toward a point higher than that found in cow milk fat [15].

The average moisture content of camel butter is lower (12.65 %) than that of cow milk butter (15-16%), which may explain the viscous consistency of camel milk butter. Comparing to butter made from cow milk, camel milk butter is prominently white, and the taste and the aroma are neutral [129]. It contains moderate amounts of palmitic acid, and only traces of FA with chains shorter than C12 but rich in polyunsaturated FA, particularly oleic and linoleic acids when compared with butter obtained from the milk of other animals. Camel milk butter may be more sensitive to light oxidation due to the high amount of unsaturated FA. It would be important to study the sensitivity of camel milk fat towards lipolysis and oxidation, bearing in mind that isolation in camel keeping countries is high and the total surface of milk fat is larger since the volume to surface ratio of camel milk fat globules is only 4.40 μm as compared to a value 5.32 μm for cow milk fat globules. Light oxidation of fresh camel milk may be a concern since milk is often stored in transparent containers [15].

Fresh butter obtains from camel milk is used as a base for various medicines instead of eaten alone. It is difficult to preserve as it is not limpid and becomes rancid rapidly. The nomadic tribe of Sahara improves the shelf life by melting down the camel milk butter and transforming it into clarified butter oil called Shmen or Semma. The butter melted at 100–120˚C for 30 min. A clarifying agent added to hot butter, and it is stirred with a wooden spoon [116]. In the area of north-eastern Kenya, they use methods by which only a small amount of camel milk fat is obtained. On a fire, few rocks are heated, and the vessel with raw milk is kept over it. Drops of the fat are formed and appear on the surface. After cooling, milk churned until fat drops turn into butter grains. Whereas in Sahara butter is being produced by leaving camel milk in goatskin at room temperature for 12 h 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 the churning, some cold water is added, which helps in forming butter [114]. Farah et al. [130] attempted to produce butter from camel milk on the industrial scale in the rural part of north-eastern Kenya by heating the milk to 65°C and then centrifuging it. The percentage of fat in cream was standardized to 20–30% and churned at temperatures between 15 and 36°C. After the churning, butter was flushed with water at room temperature of 27°C. The best results were obtained by churning cream with 22.5% fat at 25°C for 11 min [119].

6.4. Ice cream

Ice cream is one of the most popular dairy products throughout the world. Its production and consumption are rapidly increasing, and the substantial part of milk produced in many countries is being utilized for the manufacture of frozen dairy dessert with high calories food value [131, 133]. Ice cream influences the mind, because of its organoleptic characteristics and its importance as thermoregulatory food in the fight against heat [133]. Some researchers confirmed the possibility of converting camel milk into ice cream. Ice cream can be successfully produced from camel milk using a mixture of 12% fat, 11% milk solids not fat (MSNF), and 37% total solids. The overrun of camel milk ice cream significantly depends on the fat and MSNF levels in the mixture [134]. For example, the increase of fat and MSNF content in the mix leads to an increase in the viscosity which decreases the overrun. Ahmed and El Zubeir [135] recommended that gum Arabic and honey could be used as a stabilizing agent and sweetener respectively for making ice cream to strengthen the health benefits of camel milk. Further studies should be carried out on making ice cream from camel milk by adding fruits to enrich nutritionally and the health benefits and provides pleasant flavors to consumers. Camel milk can be also used to produce special ice cream, such as low-fat ice cream. Salem et al. [136] have confirmed the possibility of produce ice cream from camel milk with acceptable quality by using a mixture of cream and camel milk solids not fat at different levels. Ice cream from camel milk combined the benefit of ice cream and the benefits of camel milk to fulfill the requirements of the functional food 135.

7. Conclusion

Camel milk is unique milk which has been a great consideration recently. It is biological value comes as a result of its components. Camel animal became an important issue not only for nomadic but also for researchers and dairy sector producers. It is rich in β-CN, Igs, Lf, lactoperoxidase, lysozyme, α-hydroxyl acids, vitamins (B and C), and minerals (Mg, Fe and Zn). Camel milk is also low in β-LG, αs1-CN, and cholesterol which can cause some health problems for some age groups when present in a high concentration. Thus, the consumption of camel milk is expected to increase in popularity as it is considered more nutritious and helps improve systemic immunity and digestive health, especially those who suffer from lactose intolerance. In addition to the nutritional and therapeutic properties of camel milk, camels can produce milk for a longer period other animal present in the same harsh conditions. The daily yield ranges from 2 to 6 kg under desert conditions while rises to between 12 to 20 kg under the more intensive breeding systems. Camel's milk and its products contain all the essential nutrients and are good nutritional sources for the human diet in many parts of the world and become available in pharmacies throughout the world due to a popular and growing demand. Therefore, camel milk could be the super food of the future by:

- Camels should be incorporated into the dairy sector by establishing specialized farms to produce camel milk.
- Selecting the highest-yielding breeds.
- Use modern technological methods for milking, transporting, and treating camel milk until it reaches the consumer safely.

Finally, when making a comparison between the component ratios and physical properties of camel milk with the milk of other ruminants, similar environmental and feeding conditions, such as the availability of green pastures and water, must be provided to identify the actual differences caused by the type or breed of animal. Further studies must be taken a consideration for knowing the role of camel milk in treating many common diseases, especially the age disease, Corona virus..

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