Chapter 12
Nutritional, Antimicrobial and Bioactive Components of *Gariss*, a Fermented Camel Milk Product

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12.1 Introduction

Milk is generally considered a staple food, and milk and its derivatives can be obtained from many sources, including: cattle, sheep, camels, goats, etc., as may be obtained from other non-animal sources; such as: soy milk, coconut milk, almonds, flax, and rice. Camel milk has been utilized for numerous centuries and it is very similar to mother's milk, as it has a dark color and has a sweet and sharp taste, and it might be salty at times. Moreover, camel milk can be kept for a while, the first without the need to cool it compared to cow's milk, as it acidifies in a longer period of time. Camel's milk production varies according to its breed, the stage of lactation, and the feeding conditions to which it is exposed, but in general, camels produce about 17–26 liters per day (Megan 2017; Wajiha et al. 2015).

Camel milk has usually a desirable taste, is usually sweet in taste, but its sweet taste changes according to the type of herbs that camels eat (Yagil and Etzion 1980). The acidity of fresh camel milk (pH) ranges between 6.5–6.7 and it is slightly lower than that of fresh cow's milk. Its average density is 1.029 g / cm 3 (Farah 1996. Its viscosity at 20 ° C is 1.72 MPa per second, which is less than cow's milk viscosity at the same temperature and is equivalent to 2.04 MPa per second (Kherouatou and Attia 2003). Camel milk's content of lactose and salts controls the sweetness of milk. When the sugar lactose is 5.8%, the milk is sweet and when it drops to 4.2%, it is salty. As for the salt content of camel milk, it really depends on the amount of drinking water that the camel drank and the stage of milk production, and it ranges

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between 0.6–0.8% and may drop to 0.25% in thirsty camels whose milk is salty due to an increase in the concentration of sodium chloride and a decrease in calcium and magnesium phosphate.

Camel milk is associated with many health benefits and it has high nutritive value, hence its products will have a relatively high nutritive value. Investigations have shown that camel milk possess multiple medicinal functions for the human body, including: lowering blood cholesterol, preventing the generation of cancer cells, reducing the incidence of diabetes and preventing high blood pressure, and it is also recommended for children who suffer from allergies to drinking cow's milk and inhibit the enzyme angiotensin activity.

The percentage of water in camel milk decreases, reaching 84% under normal conditions of the availability of drinking water. While the percentage of water increases to reach 91% in the event of water scarcity and lack of availability for camels. This is one of the advantages of camels in their adaptation to the harsh desert conditions and the need to provide food for their babies constantly. The decrease in the solids percentage is due to the lack of fat formation from 2.4% -1.1% in thirsty camel milk. The wisdom of that is that when the Bedouins in the wild are far from water resources, so camel milk becomes light and sufficient for them to drink water. And when it is about water resources, they need food, so God Almighty makes milk as food.

Camel milk is utilized for treatment of various disorders, including dropsy, jaundice, tuberculosis, asthma, and visceral leishmaniasis, or what is called black fever. In addition, camel milk inhibits the growth of pathogenic microorganisms and many groups of bacteria with Gram positive and negative stains as well. In summary, camel milk has many benefits on human health, which makes it a distinctive functional food (Azzeh 2012). It is also effective in the treatment of And chest diseases such as tuberculosis and asthma as well as internal diseases such as stomach, duodenal and colon ulcers, digestive disorders, sugar and pressure reducer, and heart rate regulator, respiratory rates and sunstroke. An Omani study has shown the superiority of camel milk in treating chronic hepatitis compared to using camel milk to treat ascites, jaundice, spleen problems, tuberculosis, asthma, anemia and hemorrhoids, and special clinics have been established in which camel milk is used for such treatments (https://www.alriyadh.com/296947).

Fresh camel milk maintains its quality longer than other types of milk. Camel milk may remain for eight hours until the pH value reaches 5.7 (Lakosa and Shokin, 1964). This is attributed to the presence in camel milk of appreciable amounts of inhibitors for microbial growth such as lysozyme, lactoferrin, and immunoglobulin than in other types of milk such as cow and buffalo milk El-Agamy, 2000; Konuspayeva, et al. 2008b; Shori 2012) (Fig. 12.1).

Fig. 12.1 Sudanese camels from Tambul area

12.2 Benefits of *Garris*

Camel milk is associated with many health benefits, and hence, *Garris t*he fermented camel's milk product, the most important of which are:

1- The possibility of treating liver disease: Hepatitis C is one of the diseases spread all over the world. This disease requires vaccinations to prevent it, and scientific publications show that camel milk cures viral hepatitis B and C, and its fat content has beneficial effects on Chronic liver disease, in addition to that, camel milk might enhance liver function in general. This is because it comprises high concentrations of vitamin C, or ascorbic acid. According to the observed favorable impacts of fermented camel milk on liver enzymes, its utilization might be regarded as a functional food supplement in related circumstances (Falah et al. 2018).
2- The possibility of preventing diabetes: Camel milk contains appreciable quantity of insulin; which helps prevent or even treat type I and type II diabetes. The reason for this protective ability, indicated that one liter of camel milk contains 52 units of insulin; which is equivalent to 60% of the external insulin recommended for patients with type 1 diabetes (Daniel 2014).
3- The possibility of strengthening the immune system: Regular drinking of camel milk is one of the things that may lead to a stronger immune system. This is

because it contains many protective proteins. The most prominent of which is lactoferrin is considered anti-bacterial, anti-inflammatory, and it has anti-disease activity such as HIV and hepatitis. In addition to this milk containing immunoglobulin, which is transmitted from breastfeeding camels to milk, and has many therapeutic functions as well. On the other hand, camel milk does not contain beta-casein protein, and other substances found in cow's milk, which are associated with causing allergic disorders in children (Zafar 2019).

4- The potential for cancer prevention: As it was recently observed that most of the positive effects of camel milk come in particular from its nanoparticles known as exosomes, and in a study conducted to find out the effect of these substances, it was found that the content of camel milk and its derivatives of exosomes showed anti-cancer impacts. This impact might be due to inducing apoptosis, which saves the body from damaged cells, and limits their development into cancer cells, in addition to inhibiting oxidative stress and inflammation (Abdelnaser et al. 1998).
5- Possessing the therapeutic effects of autism spectrum disorder: It is an acute disorder that occurs in neurodevelopment associated with impaired social behavior. In addition, it is associated with a high incidence of autoimmune diseases and gastrointestinal diseases. The studies have shown that oxidative stress plays a significant role in the incidence of many neurological diseases; among them, autism spectrum disorder. Moreover, it was found in a study that camel milk may have the effect of reducing oxidative stress through enzymes and non-enzymatic antioxidant molecules, which leads to improving autism behavior and thus the treatment of autism spectrum disorder (Laila and Nadra 2019).

12.3 Preparation of Garris

Garris is a product made from camel's milk and consumed by pastoralists, and can live on this product for months as the solitary source of nutrition (Sulieman et al. 2007; Dirar 1993). Camel's milk is regularly depicted as not handily fermented and that its butter can not be effectively separated. *Gariss* is processed in large skin bags or *siin*, that contains an enormous amount of a previously soured product. Without starter, especially when utilizing another si'in fermentation is started by adding to the compartment a couple of seeds of black cumin and one onion bulb (Dirar, 1993) (Fig. 12.2).

Garris differs from other sorts of Sudanese fermented milks in that it has significant amounts of ethanol. The product is in this way an individual of the acid alcoholic fermented milks, which include kefir, koumiss and *bukhsa* of central Asia (Kosikowski, 1982). Showed that 10.5% of the nomadic camel herders utilized *Bukhsa* (wooden Gourd) for getting ready *Gariss*, 42.1% utilized plastic compartments, and 42.1% used *Siin* and only 5.3% of the nomadic camel herders utilized stainless steel containers.

Fig. 12.2 Siin (leather bag) image. (Source: https://www.ammonnews.net/image/183617)

12.4 Nutritive Value of Gariss

Camel milk bears an opaque white color and salty taste at times (Abdel Galil et al. 2016) as its taste varies according to the feed type and drinking water avaiabilityfor it, and butter appears when it is shaken a little (Sisay and Awoke 2015). As for the nutritional composition of camel milk, it consists on average of about 3.1% protein, 4.4% lactose sugar, 0.79% minerals, so that it contains about 11.9% as a total of solids, a ratio that is close to the percentage of total solids in breast milk. It is viewed as plentiful in vitamin C and poor in Carotene (Abdel Galil et al. 2016; Sulieman et al. 2004). The water in camel milk ranges between 84–90%, so that the percentage of water in it is higher the less water is available for drinking, in order to ensure that the infant's needs of water are met in cases of dehydration.

Camel milk has a distinctive nutritional composition; this is because it contains less fat, and is often composed of unsaturated fats, omega-3 fatty acid, cholesterol and lactose. And it contains appreciable quantities of minerals and vitamins. As for its protein content; Camel milk contains a number of protective proteins, which contribute in maintenance of the body, in addition to containing antibacterials, antiviruses, and antifungal compounds (Wajiha et al. 2015).

Nutritive value of Gariss is essentially that of fresh camels' milk as changed by fermentation (Sulieman et al. 2006). The average chemical composition of Gariss

ranged between 1.4–1.35% lactose, 2.15–2.9% fat, 3.4–3.85% protein, 0.75–0.8% ash, 91.7–92.65% moisture, 1.3–1.4% ethanol, 0.13–0.2% volatile fatty acids, 1.0–1.8% total acidity (as lactic acid) and the product has a pH value of 3.25–3.4 (Mirghani (1994).

Camel milk is plentiful in vitamin B group, explicitly vitamin B2, it is higher than that found in goat milk, concerning vitamin B1 it is lower and contains vitamin B12 in an amount of 2.3–3.9 micrograms, additionally extremely plentiful in iron, and it contains vitamin A by 0.037–1.264 mg / Ml, it is also rich in vitamin C by 5.03–9.8 mg and three times more than cow's milk.

With regard to salt, it is more than cow's milk, as nomads need to compensate for the lack of salts as a result of travel, as well as less fat than other types of milk, compared positively with human milk, and the total protein in it is similar to cow's milk 2–5.5%, and the taste and quality of the milk is affected by the forage and the nature pasture.

12.4.1 Amino Acid Content of Garris *Protein*

The free amino acids content in camel's milk were as per the following: tyrosine 1.3, aspartic acid 0.7, proline 0.4, alanine 10.8, glutamic acid 13.1, glutamine 3.8, valine 1.6, isoleucine 0.9, leucine 0.5 and arginine 0.7 ug/100 ml (Mehaia and Al-kahal (1992). Glutamic acid was the most plentiful free amino acid in the milk of camel, cow and man. As a rule, of all species studied, human milk had the highest concentration of total free amino acids, while the cow and camel milk has the least concentration.

Garris protein contains appreciable amounts of the essential amino acids (histidine and isoleucine) and the non-essential amino acids (serine, glycine, cystine and aspartic acid) (Sulieman 2001; Alyan et al. 2009). Table (3) show amino acids content of fermented camel milk (Gariss) from Sudan (Table 12.1).

The *Garris* amino acids may have a role in the development of *Gariss* flavour. The capacity to enhance the release of specific free amino acids would encourage analysis of their possible tangible impacts. The increase in free amino acids content in *Gariss* contrasted with those of milk isn't unexpected since numerous investigators announced increments in free amino acids of dairy products as a result of fermentation such as Aim (1982) revealed that, because of bacterial proteolysis during fermentation, yoghurt has higher levels of free amino acids compared to milk.

12.5 Microbiology of *Garris*

It was accounted for that Gariss contained rod-shaped, non-sporing bacterial cells as single cells, pairs or short chains. In less bountiful numbers yet still various are discovered yeasts, mostly of the elongated cell types, in addition to others of oval or

Table 12.1 Amino acids content of fermented camel milk (*Gariss*) from Sudan

Amino acids	Content
Essential amino acids	
Histidine	0.06–0.04
Threonine	0.20–0.07
Valine	0.14–0.09
Methionine	0.09–0.13
Leucine	0.20–0.05
Isoleucine	0.08–0.05
Tyrosine	0.16–0.17
Phenylalanine	0.28–0.17
Lysine	0.10–0.03
Non-essential amino acids	
Arginine	0.16–0.11
Alanine	0.27–0.33
Serine	0.03–0.08
Glycine	0.06–0.09
Praline	0.14–0.15
Cystine	0.06 0.03
Aspartic acid	0.05 0.80
Glutamic acid	0.34 0.24

Source: Alyan et al. 2009

spherical shapes. Three bacterial types are isolated, one of which grows at 45 °C and was tentatively identified as Lactobacillus helveticus. Among the yeast isolates, one belonged to the genus Candida. Lactococci or Streptococci were found in just constrained numbers in Gariss (Mirghani, 1994).

Abdelgadir et al. (1998) made an uncommon note on the presence in Gariss from the Butana (Eastern Sudan) of the regular isolation of yeast and rod-shaped bacteria that were non-fermentative, strictly aerobic, ca.talase-positive and heavy pellicle-forming.

Sulieman et al. (2006) found that LAB dominated the microflora of Garrissamples, and the significant genera were Lactobacillus (74%), trailed by Lactococcus (12%), Enterococcus (10%) and Leuconostocs (4%). The most dominating Lactobacillus species were identified as *Lactobacillus paracasei* ssp. paracasei (64 strains), *L. fermentum* (seven strains) and just three strains as L. plantarum. Most strains produced the enzymes that are relevant to cultured dairy product processing. The Lactococcus species were identified as *Lactococcu slactis.*

In another study, Sulieman et al. (2007) in their study on the microbiology of *Garris* samples, obtained from two production sites in Sudan, they found that Butana *Garris* (BG) contained relatively high numbers of lactobacilli (S.22 ± 0.2S $10g_{10}$cfu mL $^{-1}$), when compared with that found in Kordufa**n** *Garris* (KG) (7.S5 ± 0.45 $10g_{10}$cfu mL $^{-1}$).On the other hand, KG contained relatively higher

Table 12.2 Strains and results of Lactobacillus genus-specific or species-species PCR assays. Identification results based on PCR-based assays

No.	Strain	Source	Genus (ref.1)	Group (ref.2)	Species
1	SL 1–1	KG	±	IV*3	*L. plantarum*
2	SL 1–2	KG	±	III*2	*L. Plantarum*
3	SL 1–3	KG	±	1lI	*L. paracasei*
4	SL 1–4	KG	±	1lI	*L. Paracasei*
5	SL 1–5	KG	±		*L. Paracasei*
6	SL 1–6	KG	±	IV	ND
7	SL 1–7	KG	±	IV	*L. Plantarum*
8	SL 1–8	KG	±	IV	*L. Plantarum*
9	SL 1–9	KG	?	?	ND
10	SL 1–0	KG	±		*L. Plantarum*
11	SL 1–1	BG	±	1lI	ND
12	SL 1–2	BG	±	1lI	ND
13	SL 1–3	BG	±	1lI	*L. Paracasei*
14	SL 1–4	BG	±	IV	*L. Paracasei*
15	SL 1–5	BG	±	1lI	*L. Paracasei*
16	SL 1–6	BG	±	1lI	*L. Paracasei*
17	SL 1–7	BG	±	1lI	*L. Paracasei*
18	SL 1–8	BG	±	1lI	ND
19	SL 1–9	BG	±	IV	*L. Paracasei*
20	SL 1–0	BG	±	–	*L. Plantarum*

KG: Kordofan *Garris*; BG: Botana *Garris.*
ND: not tested, *2 Group III includes *Lactobacillus]XU'acasei* subsp. *p(U″acasei, L. paracasei subsp. casei, L. paracasei* subsp. *tolerans* and *L. rhmnnosus.* *3 Group IV includes *Lactobacillus plantum, L. reuteri, L. salivarius* and *L.fermentum.*

numbers of yeasts (S.42 ± 0.55 $1og_{10}$cfu mL $^{-1}$» when compared with that found in BG (7.65 ± 0.32 $10g_{10}$cfu mL^{-1}) (Table 12.2).

12.6 Antimicrobial Activity of *Garris*

Camel milk contains numerous growth inhibitors of viral, fungal and bacterial microorganisms with Gram positive and negative stain (El-Agamy et al. 2009), and most of these microbes are considered pathogens to humans. Among the most important inhibitors of the growth of microorganisms in camel milk are the following: lactoferrin, lysosome, aminoglobulin, hydrogen peroxide, lactoperoxidase, and peptidoglycan (PGRP) protein (El-Agamy et al. 1992; Konuspayeva et al. 2008a). Among the most important types of microbes that are inhibited by the active substances in camel milk are: E. coli, L. monocytogenes, S. aureus, S. typhimurium and hepatitis C virus (Redwan and Tabll, 2007).

According to Rameh et al. (2019), the bacterial genera Enterococcus, Lactococcus and Pediococcus had been discovered in raw camel milk. From their study, they concluded that antimicrobial activity of LAB became specially due to the manufacturing of 1 or active metabolites during their growth for example, organic acids, hydrogen peroxide and bacteriocins.

Fermented camel milk is having antimicrobial impacts against various microbes. In an investigation, in Iraq, antimicrobial, in Iraq, antimicrobial activity of fermented camel milk was accounted for (Lafta et al. 2014; Rubin 1978; Min-Chei et al. 2001). LAB isolated from Tunisian camel raw milk showed antibacterial activity against *Staphylococcus aureus*, *Listeria monocytogenes* and *Escherichia coli* likewise repressed *Salmonella typhimurium* (Mahmoudi et al. 2016).

In their study, Alyan et al. (2014) found that lactic acid, acetic acid and citric acid inhibited growth of *E. coli* . The found that lactic acid, acetic acid and citric acid were produced as a result of camel milk fermentation into *Garris*. Moreover, the concentration of these organic acids varies among the different samples, while lactic acid was produced in relatively high amounts, acetic acid and citric acid were produced in low amounts.

As fermented camel milk contains different LAB, might create peptides and bacteriocins, which showed inhibitory activity against many pathogenic bacteria including Bacillus, Staphylococcus, Salmonella and Escherichia, reported by various researchers (Rahmeh et al. 2019). The antimicrobial activities of the LAB isolates from fermented camel milk were additionally assessed against a multidrug-resistant Salmonella strain and identified by 16S rRNA gene sequencing as a strain of *Salmonella enterica* subsp. Enterica. This strain exhibited its resistance to various groups of antibiotics whose modes of action involved the inhibition of either cell wall or protein synthesis. Interestingly, most of the tested isolates demonstrated strong antimicrobial activity against this strain (Al-Zenki et al. 2007).

In their previous study, Tagg and McGiven (1971) indicted that LAB strains were tested for their ability to produce bacteriocins against *Listeria monocytogenes* ATCC 7644 by the well-diffusion assay. Among these isolates, CM16 and CM22, which were identified as *Pediococcus pentosaceus* (NCBI accession number MH023512) and *Lactobacillus brevis* (NCBI accession number MH023515), respectively, showed anti-listerial activity estimated at 1600 and 800 AU/mL after neutralization of their cell-free supernatant at pH 6.5.

Mycobacterium tuberculosis was successfully hindered by camel milk (Sharma and Singh 2014). Yateem et al. (2008) gathered raw camel milk (Arabian camel) samples from Kuwait and permitted them for spontaneous fermentation for one week through endogenous bacteria at room temperature. Using 16S rRNA gene sequencing the bacterial species were identified as *Lactococcus lactis*.

12.7 Antioxidant Activity

Camel milk's high antioxidant content can allow it to fight free radicals and protect against oxidative stress, and what's more, it may help reduce cancer symptoms. According to a study published in the Journal of Biomedicine and Biotechnology, researchers found that camel milk can lead to cell death. Carcinogenicity in both HepG2 cells as well as MCF7 cells (Shori and Baba 2014; NRCC 2013–2014; Jrad et al. 2014; Salami et al. 2011; Kansci et al. 2004). An ongoing similar investigation announced that, camel milk fermented with indigenous camel milk probiotic lactic strains (Lb. reuteri-KX881777, Lb. plantarum-KX881772, Lb. plantarum-KX881779) demonstrated greatest antioxidant activity as compared to the bovine milk (Ayyash et al. 2017).

12.8 Hypocholesterolaemic Impact of *Garris*

Camel milk contains a high amount of healthy fatty acids, it helps to reduce the level of bad cholesterol in the body, which reduces the chances of heart attacks, strokes and atherosclerosis, which protects heart health.

Hypocholesterolaemicimpact of *Gariss* containing Bifidobacteriumlactis (BB-12) has been shown to have a hypocholesterolaemic impact through in vivo experiment in rats (Elayan et al. 2008) and in the bringing down of plasma and liver cholesterol levels (Ali et al. 2013; Abdelrahim et al. 2013). However, the hypocholesterolcontrolling system of camel milk is still unclear. Various hypotheses were discussed by researchers (Li and Papadopoulos 1998; Rao et al. 1981; Buonopane et al. 1992).

12.9 Conclusions

Fermented camel milk (*Garris*) is one of the common foods in many areas of camel herders in Sudan, especially residents of Butana and Kordofan regions, and the demand for it increases with time. The components of the bitter camel vary depending on the breed of camels, the type of bush, the amount of water, climate changes and the method of analysis. It is consumed in other areas of Sudan and has many health benefits for humans. *Garris* ferments with strains of lactic acid bacteria and yeasts and has a high nutritional value. It is a functional food that has a role in treating chronic diseases such as treating some types of cancers, jaundice and others.

References

Abdelgadir SW, Ahmed KT, Dirar AH (1998) Review: the traditional fermented Milk products of the Sudan. Int J Food Microbiol 44:1–13

Abdelgadir SW, Nielsen DS, Hamad S, Jakobsen M (2008) A traditional Sudanese fermented camel's milk product, Gariss, as a habitat of Streptococcus infantarius subsp. Infantarius. Int J Food Microbiol 127(3):215–219

Abdel Galil M, Abdel G, Abdulqader A, Alhaider (2016) The unique medicinal properties of camel products: A review of the scientific evidence, review. Journal of Taibah University Medical Sciences 11(2):98–103

Aim L (1982) Effect of fermentation of lactose, glucose and galactose content in milk and suitability of fermented milk products for lactose intolerant individuals. J Dairy Sci 65:346–352

Ali AA, Alyan AA, Bahobail AS (2013) Effect of fermented camel milk and cow milk containing (Bifidobacteria) enriched diet in rats fed on cholesterol level. Agric Sci Res J 3:342–346

Alyan A, Sulieman AE, Elkhalifa AA (2009) The free amino acid composition of the Sudanese fermented Camel's Milk (Garris). Gezira J Eng Appl Sci 4(1):15–24

Alyan A, Sulieman AE, Abdelrahim A, Ali AA, Bahob AS (2014) Determination of inhibitory and flavour compounds in fermented camels Milk (Gariss). Am J Biochem 4(1):1–5. https://doi.org/10.5923/j.ajb.20140401.01

Al-Zenki S, Alnasser A, Al-Safar A, Al-Omirah H, Al-Haddad A, Hendricksen RS et al (2007) Prevalence and antibiotic resistance of salmonella isolated from poultry fam and processing plant environment in the State of Kuwait food borne. Pathog Di 4:367–373

Ayyash M, Al-Nuaimi AK, Al-Mahadin S, Liu SQ (2017) In vitro investigation of anticancer and ACE-inhibiting activity, α-amylase and α-glucosidase inhibition, and antioxidant activity of camel milk fermented with camel milk probiotic: a comparative study with fermented bovine milk. Food Chem. DOI: 10.1016/j

Azzeh FS (2012) Camel Milk as functional food: review paper (in Arabic). Arab J Food Nutr 29:94–111

Badawy A, El-Magd M,AlSadrah S (2018) Therapeutic effect of camel milk and its exosomes on MCF7 cells in vitro and in vivo. www.journals.sagepub.com, ↑ "Apoptosis", www.cancerquest.org

Buonopane GJ, Kilara A, Smith JS, Mc Carthy RD (1992) Effect of skim milk supplementation on blood cholesterol concentration, blood pressure, and triglycerides in a free-living human population. J Am Coll Nutr 11:56–67

Daniel Rasolt (2014) Camel milk helps prevent diabetes www.defeatdiabetes.org, Retrieved 2014, 30-3-2019

Dirar AH (1993) The indigenous fermented foods of the Sudan; a study in African food and nutrition. CAB International, Wallinford, UK

El-Agamy EI (2000) Effect of heat treatment on camel milk proteins with respect to antimicrobial factors: a comparison with cow's and buffalo milk proteins. Food Chem 68:227–232

El-Agamy EI, Ruppanner R, Ismail A, Champagne CP, Assaf R (1992) Antibacterial and antiviral activity of camel milk protective proteins. J Dairy Res 59:169

El-Agamy EI, Nawar M, Shamsia SM, Awad S, Haenlein GFW (2009) Are camel milk proteins convenient to the nutrition of cow milk allergic children? Small Rumin Res 82:1–6

Elayan AA, Sulieman AE, Saleh FA (2008) The hypocholesterolemic effect of Gariss and Gariss containing Bifidobacteria in rats fed on a cholesterol-enriched diet. Asian J Biochem 3:43–47

Fallah Z, Feizi A, Hashemipour M, Kelishadi R (2018) Positive effect of fermented camel Milk on liver enzymes of adolescents with metabolic syndrome: a double blind, randomized. Crossover Trial Mater Sociomed 30(1):20–25. https://doi.org/10.5455/msm.2018.30.20-25

https://www.alriyadh.com/296947

https://www.ammonnews.net/image/183617

Isono Y, Shingu I, Shimizu S (1994) Identification and characteristics of lactic acid bacteria from Masi fermented Milk in northern Tanzania. Biosci Biotechnol Biochem 58:660–664

Warfaa Jibriil (2019). https://commons.wikimedia.org/wiki/File:Somali_camel.jpg
Jiwona C, Millier B (1990) Lactic Flora and Entterococci in cultured Milk (Pindidarn). Manufacture in Adarnaoua, Cameroon. Lait 70:475–486
Jrad Z, El Hatmi H, Adt I, Girardet JM, Kiefer CC, Jardin J, Degraeve P, Khorchani T, Oulahal N (2014) Effect of digestive enzymes on antimicrobial, radical scavenging and angiotensin I-converting enzyme inhibitory activities of camel colostrum and milk proteins. Dairy Sci Technol 94(3):205–224
Kansci G, Genot C, Meynier A, Gaucheron F, Chobert JM (2004) β-Caseinophosphopeptide (f1-25) confers on β-casein tryptic hydrolysate an antioxidant activity during iron/ascorbatein-duced oxidation of liposomes. Lait 84:449–462
Kherouatou N, Attia H (2003) A study of the dromedary milk casein micelle and its changes during acidification. Brazilian J Food Technol 6:237–244
Konuspayeva G, Faye B, Loiseau G (2008a) The composition of camel milk: a meta-analysis of the literature data. J Food Compos Anal 22:95–101
Konuspayeva E, Lemarie B, Faye G, Loiseau D (2008b) Montet Fatty acid and cholesterol composition of camel's (Camelusbactrianus, Camelusdromedarius and hybrids) milk in KazakhstanDairy. Sci Technol 88:327–340
Kosikowski FV (1982) Cheese and fermented milk foods, 3rd edn. Kosikowski, F.V. and Associates, Brooktondale, New York, pp 40–46
Lafta H, Jarallah FM, Darwash A (2014) Antibacterial activity of fermented camel milk using two lactic acid bacteria. J Babylon Univ Pure Appl Sci 22:2377–2382
Laila AL-Ayadhi, Nadra Elamin (2019) Camel Milk as a Potential Therapy as an Antioxidant in Autism Spectrum Disorder (ASD) www.ncbi.nlm.nih.gov, Retrieved 30-3-2019
Lakosa, I.I. and Shokin, A. Milk production. Camel Science Technical Agricultural Publication. Kolov. 113–120, 1964
Li H, Papadopoulos V (1998) Peripheral-type benzodiazepine receptor function in cholesterol transport. Identification of a putative cholesterol recognition/interaction amino acid sequence and consensus pattern. Endocrinology 139:4991–4997
Mahmoudi I, Moussa BO, Khaldi TEM, Kebouchi M, SoligotHognon C, Leroux Y, Hassouna M (2016) Functional in vitro screening of Lactobacillus strains isolated from Tunisian camel raw milk toward their selection as probiotic. Small Rumin Res 137:91–98
Megan Ware (2017) A2 milk: What you need to know. www.medicalnewstoday.com, Retrieved 2017, 30-3-2019
Mehaia MA, Al-Kahal MA (1992) Taurine and other free amino acids in camel, buffalo and ass milk. Milchwissenschaft 45(1):113–115
Min-Chei Wei, Chun-Tan C, Jen-Fan J (2001) Determination of Organic acids in fermentation products of milk with high performance liquid chromatography/on lined-micro dialysis. Chromatographia, 54:601–605
Mirghani AA (1994) Microbiological and Biochemical properties of the Fermented Camel Milk Garris. M.Sc. Thesis, university of Khartoum, Sudan
NRCC (2014) Annual Report. (Published by Director, NRC on Camel, Bikaner, Rajasthan. http://www.nrccamel.res.in 2013; 2014
Rahmeh R, Akbar A, Kishk M, Al-Onaizi T, Al-Azmi A, Al-Shatti A, Shajan A, Al-Mutairi S, Akbar B (2019) Distribution and antimicrobial activity of lactic acid bacteria from raw camel milk. New Microbes and New Infections, Volume 30 Number C, July 2019. . Published by Elsevier Ltd, NMNI, 2019, 30, 100560
Rao DR, Chawan CB, Pulusani SR (1981) Influence of milk and thermophilus milk on plasma cholesterol levels and hepatic cholesterogenesis in rats. J Food Sci 46:1339–1341
Redwan EM, Tabll A (2007) Camel lactoferrin markedly inhibits hepatitis C virus genotype 4 infection of human peripheral blood leukocytes. J Immunoassay Immunochem 28:267–277
Rubin HE (1978) Toxicological model for a two-acid system. Appl Environ Microbial 36:623–624

Salami M, Moosavi-Movahedi AA, Moosavi-Movahedi F, Ehsani MR, Yousefi R, Farhadi M, Niasari-Naslaji A, Saboury AA, Chobert JM, Haertle T (2011) Biological activity of camel milk casein following enzymatic digestion. J Dairy Res 78:471–478

Sharma C, Singh C (2014) Therapeutic value of camel milk–a review. Adv J Pharm Life Res 2:7–13

Shori AB (2012) Comparative study of chemical composition, isolation and identification of micro-flora in traditional fermented camel milk products: Gariss, Suusac, and Shubat. J Saudi Soc Agric Sci 11:79–88

Shori AB, Baba AS (2014) Comparative antioxidant activity, proteolysis and in vitro α- amylase and α-glucosidase inhibition of Allium sativum-yogurts made from cow and camel milk. J Saudi Chem Soc 18(5):456–463

Sisay F, Awoke K (2015) Review on Production, Quality and Use of Camel Milk in Ethiopia. J Fisheries Livest Prod 3:3

Sulieman AE (2001) Chemical, biochemical and microbiological studies on the Sudanese traditionally fermented Milk (Rob) Ph.D. thesis, University of Gezira, Sudan

Sulieman AE, Dirar HA, Hyndriykx M (2004) Isolation and characterization of microorganisms associated with the Sudanese fermented sour milk (robe). Agric Res Corp Jour 2:94–105

Sulieman AE, Ilayan AA, El Faki AA (2006) Chemical and microbiological quality of Garris, Sudanese fermented camel's milk product. Int J Food Sci Technol 41:321–328

Sulieman AE, Osawa R, Tsenkova R (2007) Isolation and identification of lactobacilli from Garris, a Sudanese fermented Camel's Milk product. Res J Microbiol 2(2):125–132. ISSN 1816-4935 © 2007 Academic Journals

Tagg JR, McGiven AR (1971) Assay system for bacteriocins. Appl Microbiol 21:943

Wajiha G, Najaf F, Dania A, et. al (2015) Camel Milk: A Boon to Mankind. www.arcjournals.org, Retrieved, 30-3-2019

Wei M-C, Chang C-T, Jen J-F (2001) Determination of organic acids in fermentation products of milk with high performance liquid chromatography/on lined-micro dialysis. Chromatographia 54:601–605

Yagil R, Etzion Z (1980) Milk yield of camels (*Camelus dromedarius*) in drought areas. Comparative Biochem Physiol Part A: Physiol 67(1):207–209

Yateem A, Balba MT, Al-Surrayai T, Al-Mutairi B, Al-Daher R (2008) Isolation of lactic acid bacteria with probiotic potential from camel milk. Int J Dairy Sci 3:194–199

Zafar R (2019) Medicinal values of bioactive constituents of camel milk: A concise report. www.ncbi.nlm.nih.gov