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Physicochemical and microbiological quality of one humped camel (Camelus dromedarius) milk: A Review

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Abstract
The objective of this paper is to review researches that conducted on physicochemical and microbiological quality of camel milk. Milk is complex biological fluid secreted by mammals for the nourishment and to provide immunological protection for their young. Milk is considered a complete food because it contains proteins, fat, carbohydrates, minerals, vitamins and water. Camel milk is main food especially for those who live in arid zones and also it can be produced in large amount in dry area than other livestock. Even if there are many factors that can affect milk composition including breed variation (within a species, herd to herd), management, feed considerations, seasonal variation, geographic variations and stage of lactation. Camel milk is highly nutritious. The quality of milk can be affected due to physical, chemical and microbiological factors. Camel milk that handled with good hygiene has high antimicrobial effect and its chemical composition is better when compared with other livestock, besides to this in some countries societies use camel milk for therapeutic purpose.
Key words: Camel milk; physicochemical quality; microbiological quality

Introduction

Milk is complex biological fluid secreted by mammals for the nourishment and to provide immunological protection for their young. Milk is considered as a complete food because it contains proteins, fat, carbohydrates, minerals, vitamins and water (Robinson, 1990). One of the camel's major contributions to the socio-economic life of pastoralists is its milk production potential, especially in arid area it is a better provider than cow because the latter is severely affected by the heat, scarcity of water and feed (Sweet, 1965; Park and Haenlein, 2006; Breulmann *et al*., 2007). The milk yields of different breeds of camels vary in different parts of the world. In northern Kenya, Hjort (1993) estimated that one camel can produce 5-10 times the volume of milk of one local cow. The highest yields are probably achieved only at the cost of very high quality and expensive feed (Wilson, 1984). The duration of the lactation period is estimated to vary from 9 to 18 months, the average being around 14 months (Hjort, 1993). Its consistency of production is essential for the existence of the local population since it provides food throughout dry seasons, when milk production from other livestock species is little if any at all. The quality of milk involves many different aspects. The main influences on the quality of raw milk are: physical, chemical and microbiological hygiene (FAO, 2003). So, this paper has tried to review the physicochemical and microbiological quality of *Camelus dromedarius* milk.

Physical properties

Camels' milk is generally opaque white (Yagil and Etzion, 1980a). Types of fodder and the fluctuation in lactose, fat, mineral and protein content of the milk would account for the milk at times tasting bitter while at other times sweet (Yagil, 1985). Normally it has a sweet and sharp taste and can sometimes be salty (Rao *et al.*, 1970). The taste is affected by nutritional and environmental factors (Yagil, 1985). While slightly saltier than cow's milk, camel milk is highly nutritious. At times the milk tastes watery. In certain countries there are prejudices among the urban population concerning camel milk. It is considered as having an unpleasant taste (Yasin and Wahid, 1957). It is frothy when shaken slightly (Shalash, 1979). The pH of camel milk ranges from 6.5 to 6.7 with an average pH around 6.6. It can increase up to 7.2 in case of clinical mastitis (Tuteja *et al.*, 2003) and according to Adugna *et al.* (2013), the acidity and pH of camel milk was 0.156 ± 0.038 and 6.70 ± 0.135, respectively.
When camel milk is left to stand, the acidity rapidly increases (Adugna *et al.*, 2013). In terms of lactic acid content varied between 0.12 to 0.2g per 100g, after standing 3 hours to 6 hours. The density varies from 1.025 to 1.032 with an average of 1.029 (Adugna *et al.*, 2013). Both values (pH and density) are lower than those of cow milk. The buffering capacity of camel milk was studied by Al-Saleh and Hammad (1992) the maximum buffering capacity of skim milk was at pH 4.95. Skim cow milk showed higher buffering capacity at pH 5.65. The colostrum of camel milk is vastly different from that of other mammals. It is white and watery instead of thick and cream colored (Rao *et al*., 1970; Yagil and Etzion, 1980a).

Chemical composition

Camel milk is highly nutritious, even if there are many factors that can affect milk composition such as breed variation (within a species, herd to herd) including management and feed considerations, seasonal variation and

geographic variations, stage of lactation and rations may alter the proportion of constituents to some extent (Robinson, 1990; Park and Haenlein, 2006). The milk composition of camel fluctuates due to the water status (Yagil, 1985).The water content in camel milk, is increasing during lactation and with parities (Guliye, 1996; Gaili *et al.*, 2000; El-Hatmi *et al.*, 2004). Moisture content of camel milk (84 - 90.5%) can be compared to that of cow, goat or human milk it was 87.78, 87.3 and 88.66%, respectively (Knoess, 1976; Park and Haenlein, 2006). Compared to cow milk fat, camel milk fat contains less short-chained fatty acids, but the same long-chained fatty acids can also be found (Farah, 1993). But the fat globule are very small (Ohri and Joshi, 1961) and does not form a fat layer as in other milk (Yagil and Etzion, 1980b). Gast *et al*. (1969) cited in Yagil (1985) claim that the value of camel milk is to be found in the high concentrations of volatile fatty acids and, especially, linoleic acid and other polyunsaturated fatty acids, which are essential for human nutrition. Whereas Stahl *et al*. (2006) reported similar fatty acid patterns in camel and cow milk, On the other hand, the fat content of camel milk is within the range of 1.8 – 5.5% (Yasin and Wahid, 1957; Knoess, 1976; Sawaya *et al*., 2006; Khaskheli *et al*., 2005), it decreases with the progress of lactation (Gaili *et al.*, 2000; El-Hatmi *et al*, 2004). Exceptional about the quality of camel milk is the change that occurs in the quality of milk when the camel is severely dehydrated in the middle of the hot summer, whereas the cow or nanny-goat all secrete a concentrated milk when drinking water is scarce (Park and Haenlein, 2006). Camel secretes highly diluted milk with a low fat content (Yagil and Etzion, 1980b; Park and Haenlein, 2006). According to Merin *et al.* (1998) and El-Hatmi *et al.* (2004) the contents of camel milk vary with husbandry conditions: Protein and fat contents decrease under domestic keeping conditions (free access to water, addition of concentrate feed) while ash content increases and water content does not change.

Milk of all four quarters seems to have the same composition. The protein content of camel milk (2.58 - 3.64%) can be compared to goat milk (3.02%). Its contents are similar to human milk except for lactose content, is little less than human milk, lactose content of camel milk is from 3.8 – 5.7%. But its lactose value is less compared to cow milk (4.65%). As a result the milk is considered suitable for infant feeding (Ohri and Joshi, 1961; Knoes, 1976; Field *et al*., 1997; Park and Haenlein, 2006; Sawaya *et al*., 2006). The lactose content of the milk remained unchanged from the first month of lactation to the end of lactation (Sestucheva, 1958). Finally the ash content of camel milk is within the range 0.7 - 1.2%, it can be compared with the ash content in milk of cows, goats and sheep and it was 0.76, 0.74 and 0.94%, respectively (Knoes, 1976; Farah *et al*., 2004; Park and Haenlein, 2006; Sawaya *et al*., 2006; Konuspayeva *et al*., 2010).

According to Sestucheva (1958) the first colostrum obtained 3 hours post partum contained on average 30.4 % total solids, 0.20 % fat, 19.4 % protein, 7.2 % lactose and 3.8 % minerals. During the first two days of lactation, the solids content fell to 18.4 %, mainly due to the decline of total proteins to 3.6 % and of minerals to 0.1 %. The fat content increased to 5.8 % whereas the lactose level was practically unchanged. The composition then remained fairly constant until the 10^{th} day. Although it is widely accepted that colostrum, owing to its high content of immunoglobulins, is vital for the immunization of the newborn calf, in most countries where camels are kept, the colostrum is considered unsuitable for the calf and is milked onto the ground, leaving only a relatively small quantity for suckling of the calf. This is, therefore, why the mortality of new-born camels is in many areas very high (Yagil, 1985).

The nitrogen content of camel milk is 15.6 g/100g milk (Kuchabaev *et al.*, 1972), the amino acid content of milk declines as lactation progresses. The concentration of methionine, valine, phenylalanine, arginine and leucine are greater in camel milk than in bovine milk (Yagil, 1985) and also Sawaya *et al*. (2006) stated that the levels of Na, K, Zn, Fe, Cu, Mn, niacin and vitamin C were higher whereas thiamin, riboflavin, folacin, vitamin B_{12}, pantothenic acid, vitamin A, lysine and tryptophan were relatively lower than those of cow milk.

Camel milk not only contains more nutrients compared to cow milk (Agrawal *et al.*, 2005) but also it has therapeutic and anti microbial agents (El-Agamy *et al.*, 1992; Gnan *et al.*, 1998). In Russia, Kazakhstan and India doctors often prescribe camel milk to convalescing patients. This can be attributed to compounds that are more active in camel milk whey than in casein (Gnan *et al*., 1998). Aside from this, it is three times as rich in Vitamin C as cow's milk (Hjort, 1993, Yagil *et al.*, 1994). It is known to be rich in iron, unsaturated fatty acids and B vitamins (Abdurahman, 1995). According to Knoess (1976) the vitamin B1 and vitamin B2 concentration in camel milk is higher than in the milk of Afar sheep. El-Agamy *et al.* (1992) has also extracted lysozyme, lactoferrin, lactoperoxidase, immunoglobulin G and immunoglobulin A from camel milk.

Microbiological Quality of Camel Milk

Camel milk possesses superior keeping quality to cows' milk due to its high contents of proteins that have inhibitory properties against bacteria (Younan, 2004). This makes raw camel milk a marketable commodity, even under conditions of high temperatures (Younan, 2004).

The general microflora of camel milk

Milk is a good medium for several bacteria to develop (Robinson, 1990). As camel milk is usually consumed in its raw state, the presence of pathogenic bacteria may be of public health importance besides its influence on

animal health (Younan, 2004; Adugna *et al.*, 2013). According to Adugna *et al*., (2013), from a total of 24 camel milk samples obtained from producers, vendors and retailers, were members of the genera Staphylococcus, Streptococcus, Acinetobacter, and Entrobacter and the species *Escherichia coli* and the authors suggested that the risk of contamination of milk with pathogens is attributed to the practice of mixing milk from different sources, poor hygiene and handling practice of camel milk along the chain and absence of cooling facilities. In addition to that to control the risk associated with consumption of raw camel milk, it is important to apply proper hygienic measures, starting from the production farm until the milk reaches final vending sites and the consumers, as well as heat treatment of milk such as pasteurization.

Total bacterial content of camel milk

According to international dairy federation (1974), total bacterial count (TBC) values may range from <1000/ml, where contamination during production is minimal, to >1 x 10^6/ml of milk. The initial TBC values in milk, e.g. >1 x 10^5bacterial cfu/ml, are evidence of serious faults in production hygiene, where as the production of milk having TBC values <20, 000/ml reflects good hygienic practices. The TBC does not indicate the sources of bacterial contamination in milk, or the identity of production faults leading to high counts. The TBC of camel milk was reported with values that vary between 10^2 and 10^8 cfu/ml (Teshager and Bayleyegn, 2001; Younan, 2004). According to Birhanu *et al*. (2007) the majority of specimens from the milking vessels were more contaminated having grade of fair and poor while 94.12 % of the udder samples were having very good grade by using Sherikar *et al.* (2004) standard. According to Omer and Eltinay (2008), the range of total bacterial counts of the camel's raw milk samples collected from individual farms were varied from 5 x 10^2 to 7.4 x10^5 cfu/ml with an average of $1.8\times10^5 \pm 2.3\times10^4$ cfu/ml. Out of 50 samples tested, for the distribution of bacterial counts of camel's raw milk, two samples were <10^4 cfu/ml, 26 samples were between 10^4 and 10^5cfu/ml, 22 samples were between 10^5 and 10^6cfu/ml, Nil samples approached 10^6 cfu/ml. Al-Mohizea (1986) also reported that the total aerobic colony count of camel's milk in Riyadh markets was 2.2 x 10^5 cfu/ml. If the total bacterial count is low, like when it was kept in a clean container and refrigerated raw milk not to turn sour for 4 days (Younan, 2004).

Enterobacteriaceae

There are more than 25 genera belonging to family enterobacteriaceae (Joklik *et al*., 1992). All genera except *Erwinia, Obesumbacterium, Xenorhbdus, Rhanella, Cedecea and tatumella* and possibly *Edwardsiella, Providencia* can be considered to have potential associations with milk (Robinson, 1990). Enterobacteriaceae are gram negative rods with aerobic and facultative anaerobic metabolism that inhabit the intestine of man and other animals sometimes causing disease (Joklik *et al*., 1992). Some can act as opportunistic pathogen. None of the members are particularly heat resistant and thus, all are easily eliminated from milk by pasteurization or other equivalent heat treatments (Robinson, 1990; Joklik *et al*., 1992).

It includes coliform groups (as *E. coli*, *Klebsiella, Enterobacter*, lactose positive biotypes of *Citrobacter, Serratia* and *Hafnia*) a high percentage of biotypes of these species originate from soil or water, some come from faecal contamination (Robinson, 1990). They are indicator organisms, which are closely associated with the presence of pathogens but not necessarily pathogenic themselves. They also can cause rapid spoilage of milk because they are able to ferment lactose with the production of acid and gas and are able to degrade milk proteins. Eberlein (2007) has reported the presence of *Klebsiella pneumoniae* (0.5 - 7.1 % of the camel milk Coliforms) and *Citrobacter freundii* (0.6 - 3.0 %) in camel milk. Omer and Eltinay (2008) has indicated the mean values (6.8 x10^1 ± 6.6x 10^1cfu/ml) and the range (4 cfu/ml to 2.1x 10^2cfu/ml) of total coliform in camel milk and out of 52 milk samples tested for coliform, 10 samples were <10 cfu/ml, 32 samples were between10^1 and 10^2 cfu/ml and 10 samples were >10^2 cfu/m. Al-Mohizea (1986) found the content of coliform in Saudi Arabia camel milk was $5.1x10^5$ cfu/ml. The prevalence of coliforms and *E. coli* in camel milk ranges from 1.0 and 17.3 % in samples taken from healthy camels (AbdelGadir *et al.*, 2005) and 1.4 % to 29.4 % for coliforms in general (Saad and Thabet, 1993).

Fungi in camel milk

Commercial application of fungus in food and chemical industry is going on. However, some fungi are capable of producing extremely toxic components in foods including milk and milk products, which can pose serious problems to the consumer. Generally these are found in soil, barn dust, feeds, manure, and unclean utensils. The yeasts commonly associated with milk and milk products are: *Saccharomyces* species/*Kluyveromyces* species, *Candida* Species, *Torulopsis* Species (Vishweshwar and Krishnaiah, 2005). El-Jakee (1998) found *Candida albicans* in camels with clinical signs of mastitis. According to Vishweshwar and Krishnaiah (2005), the important moulds in dairy industry are: *Penicillium* spp., *Rhizophus* spp., *Aspergillus* spp., *Geotrichum Candidum*, *Alternaria* spp., *Cladosporium* spp. El-Ziney and Al-Turki (2006) reported that yeasts and moulds were detected in 19 samples out of 33 total samples with the mean and maximum values of 1.9 and 5.65 log cfu/ml, respectively.

Pathogens in camel milk

According to Omer and Eltinay (2008), all 68 samples of raw camel milk tested for the occurrence of pathogenic bacteria were negative for *Listeria monocytogens, Salmonella* spp., and Cl*ostridium perfringens*. On the basis of

this result, the authors attempted to explain the negative result as a possible outcome of the activities of protective proteins (Lysozyme, lactoferrin, lactoperoxldase, immunoglobulm G and A) in raw camel milk and El-Agamy *et al.* (1992), was also assayed the activity of protective proteins that extracted from camel milk against *Lactococcus lactis* subsp. *cremoris*, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* typhimurium and rotavirus and lysozyme extracted from camel milk was effective against Salmonella. A similar result was also reported by Barbour *et al.* (1984) on the other hand, contrary to this finding, Matofari *et al*. (2007) reported that from 196 samples tested, 84 were found to contain *Salmonella* spp. It might be due to poor handling practice. The antibacterial activity spectrum of camel milk lysozyme was similar to that of egg white lysozyme but different from bovine milk lysozyme. Bovine and camel milk lactoferrin antibacterial activity spectra were similar. The camel milk lactoperoxidase was bacteriostatic against the Gram-positive species and bactericidal against Gram-negative species. The immunoglobulins had little effect against the bacteria but high titers of antibodies against rotavirus were found in camel milk.

Conclusion

Raw camel milk that produced with good handling practice from production, processing and up to consumption has not only good antimicrobial quality and physicochemical composition but also it serves as good therapeutic agent, especially for those who are in arid zones other livestock's milk production is less or unsatisfactory.

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