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Specific properties of camel milk and milk products

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1 Introduction

Milk is the primary resource of nutrition for newborn and young mammals until they are able to digest other type of food. The mammary gland produces highly nutritious milk that is tailor-made nourishment for the neonatal after parturition. Other mammals, especially humans take advantage of the nutrition available in the milk.

Since 3500-2800 BC milk from different animals like cow, goat, rein deer, horse buffalo, and camel has been a source of nutrition for human in different part of the world. Milk has been a symbol of purity and was often used in religious ceremonies. Healing properties of camel milk were first mentioned in the “Words of The Prophet Mohamed” in the Surah, a section of the Koran (Khan MM., 1974). Today cow milk is mostly utilized as nutrient resource, but in recent years the interest for camel milk has increased.

In a historical view camels have been used as means of payment. In African cultures it's traditional for the groom to pay a "bride price" to the bride's family, usually in livestock. The price may vary from 3-100 camels reflecting the groom’s wealth (Abokor, 1986; Levy, 1997)

The camel belongs to the kingdom Animalia, phylum Chordata, class Mammalia, order Artiodactyla and family Camelidae. The family can be further divided into two subfamilies Camelini and Lamini whereas the camel belongs to the former one of genus Camelus. Three species belong to the camelus genus; Camelus bactrianus (the domestic Bactrian camel), Camelus dromedaries (the dromedary camel), and Camelus ferus (the wild Bactrian camel).

The domestic Bactrian camel is also called the two-humped camel. The name camel meaning “to bear” originate from latin; camelus and has homophonic sound in different languages like, greek; kamelos, Hebrew; gamal, or Arabic; jamala. The origin of the name bactrian is the latin word bactriana corresponding to Persian bakhtar that means “the west”. The dromedary has other common names like dromedary, Arabian camel and one-humped camel. The name Dromedary probably comes from the greek word dromas that means “running” and the wild Bactrian camel reflects the original name ferus meaning wild.

The evolution of the Camilidae family goes back 40-45 million years and it is believed that they originated from the mountains and deserts in North America. The earliest Camelids were about 30 cm tall at shoulders and could be compared to a rabbit-sized animal. 24-36 million years ago

Camelide was one of the most common ungulates in North America. About 3 million years ago the subfamily Camelini migrated to Asia and India. The other subfamily Lamini migrated to mountains of South America and both subfamilies disappeared in North America.

The Bactrian was probably domesticated 4000-6000 years ago in eastern central Asia. They spread to Asia minor around 4000 BC, and further to Middle East 2000 BC and China 400 BC. The dromedaries were domesticated 4000-5000 years ago (Peters et al, 1997). According to Food and Agriculture organization (FAO) there are currently 16 Bactrian camel breeds and 97 dromedary breeds (FAO, 2008). Recent statistics developed by FAO report that the total population of camels is estimated to about 20 million. It is not explained how the wild Bactrian has been able to avoid domestication, although it has been suggested that the isolation in the Gashun Gobi area and Mongolia, or the shyness kept their distance. However hybrids of genus have been produced. A bukht is a Bactrian camel-dromedary hybrid that has developed a single long hump. The first generation is larger and stronger than both parents. Cama is a hybrid between a camel and a llama. The female llama is fertilized with sperm from a camel.

The camels were spread from Asia to Eastern Europe, and some camels migrated to Africa. Later several domestic camel breeds were introduced all over the world in arid regions. The domestic Bactrian camels prefer cold desert regions such as in Iran, Afghanistan, Pakistan, Kazakhstan, Mongolia and China. The dromedary like hot arid deserts as can be found in Africa and in the Middle-East. There is also a large population of dromedary in Australia (Wilson, 1998). Figure 1 shows a map of the distribution of camilids, where they live and where they have been introduced.

Figure 1 - The map show the distribution of the camels worldwide (Wilson, 1998)

The habitats of the wild Bactrian camel are deserted mountains and desert areas such as sand dunes, flat hard and dry ground with sparse vegetation, but also oasis with poplars. The temperature may vary from 60−70 °C in the summer and down to −30 °C in the winter. The wild camel has adapted a unique feature to drink saltwater slush, making it possible for them to survive in habitat that lack fresh water.

Figure 2 - A domesticated Bactrian camel, (Elinor D)

The anatomy is slightly different between the three species belonging to the genus camelus and it is easy to evaluate the species on the basis of visual characteristic.

The domesticated Bactrian camel (Figure 2) has two large irregularly shaped humps. When they become adult the humps may become flaccid and bend to one side. The camel reaches 1.8 meters on shoulder height and weigh between 600-1000 kg. Their legs are relatively short and heavy built, and the feet are broad two toed with a fat cushion underneath. The hair is dark and long.

The dromedary (Figure 3) has one hump, which is more elastic than the Bactrian humps. It shrinks by age and does not flop to the side. The dromedary can become up to 2 metres tall at shoulder level and weigh 400-600 kg. Their legs are longer and more slender compared to the Bactrian and their hair is somewhat shorter and more light-coloured.

Figure 3 - A domesticated dromedary camel, (Agadez)

The wild Bactrian camel (Figure 4) has two humps similar to the domesticated Bactrian camel. The humps are small and pointed. The shoulder height is 1 metre and the weight is about 450 kg. The camel is smaller and more flat on the lateral side compared to the domesticated Bactrian. Legs are slender and feet narrow. The hair on the body is greyish with long and dark brown hair on the upper legs, tail, neck, and on the top of the humps.

Figure 4 - Wild Bactrian camel, (John Hill)

In general the three species have a body length of 3 metres, they have all long curved necks, broad large feet, tufted tails, four teats and shed hair annually.

Figure 5 - Close up picture of the camels head, (tumblr)

The humps are composed of fat and fibrous tissue. The fat acts as a source of energy and is metabolized from the humps to the body. Almost all fat is gathered in the humps and there is minimal fat in other parts of the body. This is a great advantage in warm climate since fat hold on to the heat. Size and shape on the humps are largely determined by the nutrition and during starvation the humps can almost disappear. Figure 5 shows a close up picture of camels head. The nostrils of camels are more advanced compared to other mammals. They are slit-like, which makes them able to close and protect against blowing sand. Their nasal cavity are developed in a way that they can moisture the air that comes in and trap moisture form going out. They have long lashes that protect against sand grains in the wind and the bony arch over the eyes make a shield form the sun. Their ears are small and round and hairs prevent the blowing sand from entering the ears. The upper lips are divided into two halves, both incisors and canine teeth grow continuously.

The camels are adapted to very dry environment. Several features of the camel have an important role in this matter. Normally in mammals the red blood cells are round, in camel they are oval, and this makes them able to flow faster if the camel is in a dehydrated condition. Kidney and intestines are able to retain water and prevent water loss and make the urine more concentrated, and the faeces dry. Normally most animals will die if they have more than 15 % water loss, while a camel can endure up to 30 % (Franklin, 2011). They are also able to tolerate extreme heat although they have fewer sweat glands compared to other animals, like cow. The camels are unique because they do not sweat until the body temperature reach 41- 42 °C, and their long legs increase the distance between the heated ground and their body.

The domestic camels are kept in a semi-wild state. This means that they receive water from humans and are fed on wild vegetation. They graze for 6 to 8 hours and chew cud for another 6-8 hours. Camels show very little aggression and are usually calm animals, however the male may show some violence during breeding season. Dromedaries may spit cud when they are excited, while Bactrian usually do not. The canine teeth are used as a weapon. In case of extreme fights it may end with death for both the involved camels. They communicate with vocalisation, posture and scent marking.

A normal gait for a camel is pace, the foreleg and hindleg on the same side moves together. They can travel 150 km for 15 to 20 hours. Maximum speed is 65 km/h for short distance and 40 km/h for longer distance.

Figure 6 - Camel caravan, (TopDesert)

Camels are used for their meat, milk, hides and wool. Male are mostly used for transport (Figure 6) and riding and they can carry an impressively large weight of 200 kg and pull more than one ton. Due to their convex back they are able to carry considerably more than a horse. Camels have also shown to be beneficial in use for combat as the horse is scared of the camel scent.

Figure 7 - Saxaul plant, (Jay Sharp)

Camel is a ruminant which means that they have four stomachs. They eat green shoots of saxaul (Figure 7), stems and foliage of Salsola, Ephedra and Zygophyllum. When they visit oases they like to eat poplar, willows and reeds but keep away from the poisonous plants. Camels have the advantage that they can eat thorny, sharp plants in contrast to other animals. They are dependent on a huge intake of salt and need as much as eight times more salt than cattle. (Camel fact sheet, 2009)

Camels differ from true ruminants at several points. Anatomically the adult camel have two incisors in the upper jaws, they lack omasum, have no gall bladder and hooves are reduced to claw-like toes, projecting beyond the pads (Cloudley-Thompson, 1969).

The camel is a very unique animal that can walk for 4-5 days without water intake (Wilson, 1998). In case of cold weather and available green feed camel can go for months without drinking. If the climate is warm and dry and the camel has water available it may drink up to 200 litres of water in one day.

The male develops a dulaa which is a sac like extension of the soft palate. It is triggered by testosterone. The dulaa is used to produce a mating call, and look like a red balloon when pushed outside the mouth and with the salvia it makes gurgle sound. The size of the dulaa is a sign of virility. The urine contains pheromones. The male urinate on its tail and swing it over the back attracting the females.

The estrous cycles of female camels in breeding season are 16-22 days long. They are receptive for 3-4 days and non-receptive the following 10 days. When the female is in heat she will urinate often and move tail up and down in quick movements. Camels copulate in sitting position which is unique for camels among the ungulates. There is a minimum of a 2 year interval in reproduction rate. Gestation is about 12-14 months and mostly they give birth in March or April. The calf size is about 35 kg, and is able to stand and walk shortly after birth. The calves are weaned at 1-2 years of age and start grazing when they are 2-3 months old. Camels are considered adult at 3-4 years and 5-6 years, for female and male respectively, and they can become 40-50 years old (Camel fact sheet, 2009).

During the history camel milk has had an important role in preventing malnutrition in poor countries where the camel is one of the few animals that are able to survive. Another benefit is that camel milk contains all the essential nutrients as the bovine milk (El-Agamy et al, 1998; Karue, 1998). In Saudi Arabia camel milk is a popular product consumed both fresh and soured (Abu-Taraboush et al, 1998). In other regions of the world including India, Russia and Sudan both fresh and fermented camel milk has had an important role in treatment of different diseases as dropsy, jaundice, tuberculosis, asthma and leishmaniasis (Abdelgadir et al, 1998; Shalash, 1984). Lately research has also reported that camel milk shows other potential therapeutic features as anti-carcinogenic (Magjeed, 2005), anti-diabetic (Agrawal, et al 2007a), and as anti-hypertensive (Quan et al, 2008). Camel milk has also been recommended as a milk replacement for children that are allergic to bovine milk (El-Agamy, et al. 2009). The urine of camels has been reported to treat diarrhoea (Al-Attas, 2008).

Most research of camel milk is performed on the one-humped dromedary, and milk from this specie will therefore be the main focus in this thesis. Heat treatment of milk is a preservation method that has been used for century. The result after heat treatment differs between camel milk and cow milk. In this thesis I will discuss problems related to this process.

2 Camel milk

2.1 Production

Figure 8 - Newborn suck milk from mother, (Cuneyt Basegmez)

After giving birth a female camel can produce milk for several years (Figure 8). Dromedary can maximum produce 20 litres/day while Bactrian only produces 5 litres/day (Gauthier-Pilters et al, 1981; Tulgat et al, 1992; Bannikov, 1976).

For dromedary camels the amount produced depends largely on breed, stage of lactation, feeding and management system. (cardellino et al, 2004). The data on camel milk production is based on observation at research stations and not on the pastoral area (FAO, 2003). According to FAO both species of camel produce around 5.3 million ton of milk per year. 4 million ton milk is consumed by the calves and the remaining by the humans. The largest production of camel milk takes place in Somalia followed by Saudi Arabia (FAO, 2008).

Figure 9 - Farmer hand milking camel, (ALAMY)

The camels are ideal animals in extreme dry areas where the conditions are harsh as they have the capability to produce more milk than any other species and also for a longer period of time. (Farah et al, 2007). Another great property is that their feed requirement is relatively low compared to the amount of milk produced (Wilson, 1998). About 1000-2000 L of milk is produced by each camel during one lactation period which last for 8-18 months (FAO, 2006). Daily average production is about 3-10 L for a 12-18 months long lactation period. (Farah et al. 2007). Research show that by improving feed, husbandry practice, water availability and veterinary care the milk yield could increase to 20 L per day (FAO, 2006).

Figure 10 - Newly collected camel milk, (Mohammadian)

Camel milk is mostly consumed by the owners and their animals, and because camel herds are located in arid and desert areas the milk is not that common on the commercial markets yet (Figure 9 and 10). There has been some development during the recent years and camel milk dairies have been established at several locations.

2.1.1 Camel dairy farms

One of the largest camel dairy farms is located in Dubai and holds 2200 camels. It is an intensive camel farming with mechanised milking and producing several products. The farm is known as Camelicious of Emirates industry for camel milk and products. The whole process from milking, processing, testing and distribution is performed on the farm. Their aim is to win the battle against the great prevalence of diabetes that has developed in the local community. Even though studies have not yet confirmed the effect of milk used as diabetes treatment there is a traditional knowledge that the milk can be used to treat disease. Earlier the Bedouin lived mostly on camel milk but after the oil discovery in 1960 the lifestyle changed totally within one generation and today 30 % of the local population suffers from diabetes.

Figure 11 - Camelicious dairy farm in Dubai, (Kamran Jebreili/AP)

The ruler of Dubai, Sheikh Mohammed bin Rashid Al Maktoum, owns this project that has become the most modern camel milk dairy in the world. There are 2200 camels and around 600 to 700 are milked twice every day. 150 workers manage the farm on a daily basis (Figure 11). The milking machines are fully automatic and adapted to the teats of every single camel and the production is around 5000 litres per day. They have managed to train the camels to accept the milking parlour and be relaxed, calm and friendly. The camels have also shown to be very intelligent and emotional compared to other animals (Dr Jutka). Traditionally the calf needs to be present to stimulate milk secretion but with specially designed pens the camels can be milked without the calf present. In contrast to cow and goats the camel milk runs down mammary vein to udder when needed. This is another unique survival property that the camel possesses. The camels are fed with alfalfa imported from New Zealand. Calves are kept in pens next to the mother while pregnant camels are kept together in another pen next to the milking camels. The camels need exercise and can get an hour of exercise every day on a four kilometre long walking track or they can choose to roll around in the sand enjoying themselves.

Figure 12 - Cooling tank for temporary storage for camel milk, (Kamran Jebreili/AP)

The pasteurized milk produced on this farm can be kept for 14 days. With all those camels on the farm the laboratories get a unique situation to gain important information concerning camel milk (Figure 12). The taste of the milk after 21 days is the same as the first day (Dr Ulli). In 2011 EU officials made an inspection to make sure the production standard was good for the export markets. The farm manager for Camelicious is a Hungarian, Peter Nagy. He has a veterinary degree from the University of Veterinary Science in Budapest, Hungary. His role in the development in the world's first large-scale camel farm has been highly important (Philippa Young, 2011).

Mastitis is inflammation of the milk canals and udder of milk producing mammals. When the teats get inflamed they get hard, red, swollen and hot to touch, the camel will also show sign of discomfort and pain when touching the teat and may kick excessively. The camel has two or more canals in each teat. If one camel gets spoiled the teat has other canals to produce milk for the calf. Due to this unique property the methods used for mastitis control in cow cannot be used for camel, thus causing some challenge in mastitis control. Camels, goats and cows are all badly affected by mastitis. The main causes of mastitis are poor hygiene and dirt, milkers with unclean hands, dirty beddings, manure on udder, flies and traumatic injury. The milk will gain a tainted taste when the udder is infected. This taste will not disappear, not even after boiling. Also the shelf life is affected by mastitis. The bacteria use the fat for survival and produces toxins that may cause food poisoning, sore throat etc. Several diseases can be spread from camels to human during milking or through the milk. The biggest health risk is transmission of Brucella, but Tuberculosis may also cause some threat. S. aureus can cause mastitis and may give hair loss and rough coat in camel. Camels have much narrower teat canal compared to cattle. This causes problem since most medications are readymade as intramammary injection for cow and will cause a lot of damage if injected into the camel's milk canal. Some places they let the calf suck milk at an early infection state to avoid milking by hands. In case of mastitis great care should be made to prevent mixing the milk and the camels so that as few camels as possible get infected. California mastitis test (CMT), alcohol test and strip cup is used for detection of mastitis (infonet-biovision).

2.2 Properties of camel milk

The colour of camel milk is white and opaque, with a satisfying taste (Dilanyan, 1959; Kheraskov, 1953; Yagil &Etzion, 1980). The flavours of camel milk has been documented to have a sweet and sharp taste, and sometimes with a touch of salt (Rao et al, 1970). This is regulated by the feedstuff consumed by the camel in the desert. (Khaskheli et al, 2005). The variations in taste are mainly affected by type of fodder and the amount of drinking water available (Farah, 1996). Average density is 1,029 g cm^{-3} (Farah, 1996), and the camel milk has shown to be less viscous than bovine milk. (Laleye et al, 2008). The viscosity of camel milk at 20 °C is 1.72 mPa s compared to bovine milk which is 2.04 mPa s (Kherouatou, 2003)

In fresh camel milk the pH ranges from 6.5-6.7. (Khaskheli et al, 2005; Mehaia et al, 1995, Shalash, 1979), but it has also been measured as low as 6.0 (El-Hadi Sulieman et al, 2006). The pH of camel milk resembles sheep milk (yagil et al, 1984) and is slightly lower than cow milk (Sawaya et al, 1984).

Ohri et al. (1961) showed that camel milk being left to stand in room temperature will rapidly increase the acidity. Compared with milk from other animal, camel milk could remain stable for longer period of time at room temperature. In 3 hours bovine milk turned sour (pH 5.7) at 30 ℃ while camel milk used 8 hours to reach pH 5,8 at the same temperature. (Lakosa et al, 1964; Ohri et al, 1961) The difference is probably due to camel milk containing a larger amount of antimicrobial components like lysosome, lactoferrin and immunoglobulin compared to bovine and buffalo milk (Benkerroum, 2008; El-Agamy, 200; Kappelar et al, 1999; Konuspayeva et al, 2007). A study done by Yagil et al in 1984 showed that stored in 30 ℃ bovine milk turned sour and completely coagulated in 48 hours, while camel milk turned sour in 5 days and coagulated in 7 days at 30℃.

2.3 Composition of camel milk

The composition of camel milk is less stable compared to bovine milk. The variations can be due to several factors such as measurement procedure, feeding conditions, breeds, stage of lactation, age, calving number, seasonal variations and geographical locations (Khaskheli et al, 2005). The two latter factors are found to cause most influence on the milk composition. In a study performed by Konuspayeva et al, 2009 it was reported that camels living in east Africa display a higher fat content in the milk than camels in other parts of Africa and western Asia. There were also distinct variations in camel milk composition from same species but domesticated in different part of the world (Mehaia et al, 1995). The variations in seasons play an important role for the milk content. (Bakheit et al, 2008; Haddadin et al, 2008; Shuiep et al, 2008). During mid-winter all the components reach their maximum levels except from lactose, while the levels are at the lowest in the summer. This is the result of an inverse relationship between total solids in the milk and the water intake of the camels. Measurements has shown that total solid in august was at 10,2 % while in the winter-time (December and January) at 13,9% (Haddadin et al, 2008). The fat content decreased from 4.3 % to 1.1 % as the water intake increased (Yagil et al, 1980).

2.3.1 Proteins in camel milk

The total protein content in camel milk is estimated to 2.15 – 4.90 % (Konuspayeva et al, 2009), where the average is 3.1+/- 0.5 %. Breeds and seasonal conditions play a role for the protein content. The protein in camel milk consists of casein and whey proteins. Milk from the Majaheim breed demonstrates a higher protein content than other dromedary breeds, (Mehaia et al, 1995). According to Elamin et al. (1992) and Sawaya et al. (1984) the camels from the same breed have very similar protein content, but there are huge differences between the breeds. It has also been reported that season has large impact on the protein content within the same breed. The protein content was highest in December/January with 2.9% and lowest in August with 2.48 % (Haddadin et al, 2008).

Caseins

In camel milk the major part of the protein is casein. It constitutes about 52-87% of the total proteins. About 1.63-2.76% casein is found in dromedary camel milk (Farag et al, 1992). Camel milk contains high percentage of beta-casein and this can be the reason for the higher digestibility rate and lower allergy incidence in the guts in children. Beta-casein has shown to be more sensitive to peptic hydrolysis than the alpha s casein. The high percentage of beta-casein in camel milk is similar to the human milk (Abou-Soliman, 2005; El-Agamy et al, 2009). In a study of amino acid composition of dromedary milk it was reported that camel milk is similar to bovine milk except from glycine and cysteine. These two amino acids were significantly lower in dromedary milk casein (Farah et al, 1989). Camel milk has shown to have a lower degree of hydrolysis after reaction with pancreatic enzyme compared to bovine milk (Salami et al, 2008).

Whey proteins

Whey protein represents 20 – 25% of the total protein in camel milk. It is the second largest component of camel milk protein and it ranges from 0.63 – 0.80 % of the milk (Farag et al, 1992; Khaskheli et al, 2005; Mhaia et al, 1995). Beta-lactoglobulin is deficient in the whey protein (El-Agamy, 2000; Farah, 1986; Farah et al, 1992; Kappeler et al, 2003; Laleye et al, 2008; Merin et al, 2001) while alpha-lactalbumin is the main component. The camel whey has a white colour after coagulation (El-Zubeir et al, 2008) while bovine whey has a green colour. Several studies have tried to explain this colour difference. In one study it was reported that the white colour come from the light scattered from the increased concentration of small particles of caseins and fat globules in the whey of camel milk (Mohamed et al, 1990) while another study claimed that it was due to the low concentration of riboflavin (Farah, 1993; Webb et al, 1974). Whey proteins have also been reported to affect the heat stability of camel milk. Heating up to 140 ℃ has shown to cause very poor stability in camel milk compared to bovine milk. This is due to the deficient beta-lactoglobulin and k-casein in camel milk (Al-Saleh, 1996; Farah et al, 1992). Studies have demonstrated that whey from camel milk is more heat stable than bovine and buffalo whey (Al-Saleh, 1996; El-Agamy, 2000; Wernery, 2006). A study comparing antioxidant activity of alpha-lactalbumin between camel and bovine milk showed that camel milk had a greater antioxidant activity because it contains a higher amount of antioxidant amino acid residues (Salami et al, 2009).

2.3.2 Fats in camel milk

In dromedary camel milk, the fat content is about 1.2-6.4 % (Konuspayeva et al, 2009). The average fat content is around 3.5 +/- 1.0 %. There is a strong correlation between fat and protein (Haddadin et al. 2008). A study done by Yagil et al. (1980) reported that in milk from thirsty camels, the fat content decreased from 4.3 to 1.1 %. Camel milk contains a smaller amount of short chain fatty acid and lower content of carotene compared to bovine milk that makes it whiter in colour (Abu-Lehia, 1989; Stahl et al, 2006). Dromedary camel milk has higher unsaturated fatty acid values compared to bovine milk but lower compared to human milk (Abu-Lehia, 1989; Haddadin et al, 2008; Sawaya et al, 1984; Bracco et al, 1971). Compared to bovine milk fat the cholesterol is also higher in camel milk fat.

2.3.3 Lactose content

In camel milk the lactose content is about 2.40-5.80 %, with an average of 4.4+/- 0.7 % (Konuspayeva et al, 2009). The camel consumes plants that contain different amounts of lactose, causing the wide variations in the milk (Khaskheli et al, 2005). To reach their physiological requirements of salts the camels eat mostly Atriplex, Salosa and Acacia which are halophilic plants (Yagil, 1982). Lactose seems to be the only component in the milk composition that stays stable during the season (Haddadin et al, 2008), also during hydrated and dehydrated times (Yagil et al, 1980).

2.3.4 Mineral content

The minerals expressed in total ash are between 0.6-0.9 % with an average of 0.79 +/- 0.07 in Dromedary camel milk (Konuspayeva et al, 2009). The variations are found to be due to breed types, feeding systems (Mehaia et al, 1995) and water intake (Haddadin et al, 2008). Chloride is found in rich amount in camel milk (Khaskheli et al, 2005) due to the feedstuff (Yagil, 1982). During dehydration there is a loss of milk components and increase amount of chloride may contribute to the salty taste of the camel milk (Yagil et al, 1980). Compared to bovine milk the levels of sodium, potassium, iron, cupper and manganese have been found to be significantly higher in camel milk. (Mehaia et al, 1995; Sawaya et al, 1984). Iron is important in several biological systems like oxygen transport and storage, and DNA synthesis (Al-Attas, 2008; Miller, 1996) while manganese has an essential role in cellular metabolism for the function of several enzymes (Al-Attas, 2008). Mn also plays a role in the function of enzymes protecting the cell from damage caused by free radicals (Combs et al, 1997).

2.3.5 Vitamins in camel milk

Camel milk contains vitamin A, B group, C, D, and E (Farah et al, 1992; Haddadin et al, 2008; Sawaya et al, 1984; Stahl et al, 2006). Especially vitamin C has been measured in high amounts, and compared to bovine milk the vitamin was found three times (Farah et al, 1992) and five times (Stahl et al, 2006) higher in camel milk. Ascorbic acid intake through camel milk, both fresh and fermented, is an important vitamin supplement in desert areas where the availability for vegetable and fruits is limited (Sawaya et al, 1984).

2.4 Products

Camel milk can be used in several forms and many products are based on camel milk ie. soft cheese (El-Zubeir et al, 2008; Inayat et al, 2003; Mehaia, 1993, 2006), fermented milk (Elayan et al, 2008; Farah et al, 1990), youghurt (Hashim et al, 2008), ice cream (Abu-Lehia et al, 1989), butter (Farah et al, 1989; Ruegg et al, 1991) and chocolate (Figure 13). By mixing 12% fat, 11% Milk Solids not Fat (MSNF) and 37% total solids, ice cream can be made. Levels of the fat and MSNF is the determining factors for a successful ice cream (Abu-Lehia et al, 1989). Cheese from camel milk is more difficult to produce. The main causing factors are long coagulation time, weak curd, rennet action and cheese yield. A new product called Camelicious has been introduced in the United Arab Emirate market (AME Info, 2006). Today there are several dairy products like cheese, ice cream and chocolate produced from camel milk available in markets of gulf countries due to increasing demands.

Figure 13 - Camel milk products; different types of milk, butter, different type of cheese, ice cream and chocolate

2.5 The functionality of milk

Camel milk was in the beginning used as a nutritional source containing essential amino acids for humans (Hambræus. 1992). Newer research has demonstrated other benefits both in the fresh and fermented form. Bioactive substance are naturally occurring components in the camel milk (Agrawal et al, 2007; El-Agamy et al, 1992) and is assumed to be a potential medication against dropsy, jaundice, tuberculosis, asthma and leishmaniasis (Abdelgadir et al, 1998, Shalash, 1984).

2.5.1 Angiotensin 1-converting enzyme (ACE) inhibitory activity

ACE is an important component in the circulatory system as a regulator of blood pressure. “ACE is an exopeptidase that cleaves dipeptides from the c-terminal end of various peptide substrate and regulate the activity of several endogenous bioactive peptides” according to Pan, Luo and Tsnokura (2005). Milk protein must be hydrolysed by proteolytic enzyme to produce these bioactive peptides (Alhaj et al, 2007). To release the ACE inhibitory peptide from camel milk proteins Lactobacillus helveticus is used (Quan et al, 2008)

2.5.2 Hypocholesterolaemic effect

Elevated levels of blood and dietary cholesterol increase the risk for coronary heart diseases (Reddy et al, 1977). Experiment, in vivo, reported that fermented camel milk with or without containing bifidobacterium lactis (BB-12) caused a hypocholesterolaemic effect when given to rats (Elayan et al, 2008). The overall mechanism of hypocholesterolaemic effect still needs more research. Several hypothesis have been suggested ie. the interaction between the cholesterol and the bioactive peptides hydrolized from camel milk proteins reduces the cholesterol level in blood (Li et al, 1998; Seelig et al, 1996). Orotic acid is found in camel milk and is thought to decrease cholesterol level in humans (Buonopane et al, 1992) and in rats (Rao et al, 1981

2.5.3 Hypoglycaemic effect

Studies have demonstrated that frequency of diabetes is much lower in Raica in India compared to other places. This is probably caused by the consumption of camel milk (Agrawal et al. 2007; Singh et al, 2008). The milk is also effective for people suffering from diabetes type 1 (Agrawal et al, 2003) due to concentration of insulin or insulin like substance like half- cystine (Agrawal et al, 2003; Beg et al, 1986). Small immunoglobulins of camel milk has an effect on the Beta-cells (Agrawal et al, 2007a, 2007b) and together with the non-coagulation of camel milk in the stomach of humans, they will contribute to the hypoglycaemic effect. (Agrawal et al, 2003)

2.5.4 Antimicrobial effect

The antimicrobial effect in the camel milk has been demonstrated to work against gram positive and negative bacteria including E.coli, L. monocytogenes, S. aureus, S.typhimurium (Benkerroum et al, 2004; El-Agamy et al, 1992). The antimicrobial substance contains among others immunoglobulins, lactoperoxidase (LP), lactoferrin, hydrogen peroxide and lysozyme (El-Agamy et al, 1992). Especially the presence of lactoperoxidase, hydrogenperoxide and lysozyme seems to have an inhibitory effect against L. monocytogense, S. aurus and E.coli (Benkerroum et al 2004). Studies on S. thyphimurium and camel milk demonstrated that the lactoferrin found in camel milk attaches to the iron and prevent the S. typhimurium to grow (El-Agamy et al, 1992; Ochoa et al, 2009). The immunoglobulin, lactoferrin and lysozyme are found in greater amounts in camel milk compared to bovine milk (Benkerroum, 2008; El-Agamy, 2000; Kappeler et al, 1999; Konuspayeva et al, 2007). Due to the large amount of lysozyme in camel milk that prolongs the gelantin process, yoghurt production has been problematic (Abu-Taraboush, 1996; Jumah et al, 2001). An important study demonstrated that during heat treatment at 100℃ for 30 min these antimicrobial agents lost their activity in camel milk (El-Agamy, 2000).

2.5.5 Hypoallergenicity effect

Studies have reported that children suffering from bovine milk allergy may use camel milk as an alternative. The human milk contains a high percentage of beta-casein and a low percentage of alpha-casein and in addition there is a deficiency of beta-lactoglobulin. This may be the reason for the hypoallergenicity (El-Agamy et al, 2009; Kappeler et al, 1998). Bovine milk contains a large amount of alphas-casein (Taylor, 1986) and beta-lactoglobulin and this is may be the cause of the allergenicity among infants (El-Agamy, 2007).

3 Preservation

Milk is sterile when it is secreted inside the udder but becomes contaminated by pathogens as it leaves the teats. The milk can be infected by microorganism during milking, handling, storage and other preprocessing procedures. Untreated milk that is consumed may cause diseases including diarrhoea (caused by *E. coli*), food poisoning (caused by Staphylococcal enterotoxins), diptheria, typhoid fever and tuberculosis (*M. bovis*). The US Centers for Disease Control (CDC) has reported that improperly handled raw milk can be responsible for nearly three times more hospital visits than any other food-borne disease outbreak, making it one of the world's most dangerous food products (Centers for Disease Control and Prevention). Milk is an excellent medium for microbial growth, and when stored at ambient temperature bacteria and other pathogens will proliferate.

At the beginning of 20th century the society became more industrialized causing an increase of milk production and distribution. Untreated milk was the reason for several outbreaks of various diseases. During that time it was common to have milk-born disease as typhoid fever, scarlet fever, septic sore throat, diphtheria and diarrhea. Due to pasteurization and improved management practice at farms these diseases are almost eliminated. Earlier 25% of all food and waterborne disease came from milk products, while less than 1% of diseases are due to milk products.

3.1 Non-heating types of preservation

3.1.1 Short-term preservation

Short preservation means that the method used for the preservation keeps the milk at an accepted level of quality for a short period of time. There are two types of short term preservation; cooling and the use of the natural lactoperoxidase (LP) system.

Cooling

The cooling method is simple. The milk is immediately cooled to 4℃. This will slow down the enzyme activity and the growth of bacteria. The shelf life for cooled raw camel milk is up to 7 days, which is substantially longer compared to cooled raw cow milk (24 to 48 hours) (Yagil, 1984).

LP system

LP is a naturally occurring glycoprotein in colostrum, milk and other secretions of animals and human (Kussendrager et al, 2000). The glycoprotein take part in the non-immune host defence system and has a bacteriostatic and bactericidal activity on gram negative bacteria (Touch et al, 2004). Hydrogen peroxide and thiocynate have to be present for LP to work as an antimicrobial. Due to the antimicrobial effect LP has been considered as an alternative way for preservation of raw milk (Haddadin et al, 1996). The LP system will maintain an acceptable milk quality for 8 hours in room temperature while cow milk will become sour after 3 hours (Ohri et al, 1961; Lakosa et al, 1964). The activity of LP can also be used as a good indicator for accurate pasteurization process (procedure/method/practise). A total loss of LP will indicate an acceptable pasteurization. LP can also be activated after heating giving the milk a longer shelf life in places with unsatisfying cooling (Barrett et al, 1999; Fox et al, 2006).

3.1.2 Long-term preservation

Long preservation of milk imply that the milk will go through a treatment that maintain the quality of the milk and at the same time increases the shelf life considerably. More nutrients are lost with these methods but the milk can be used up to several months after treatment if handled correctly.

Freezing

Freezing is an easy preservation method. Milk can be frozen at – 20 °C for up to 6 months. Today both untreated and heat treated milk can be frozen before shipment to the consumers. Freezing is an expensive preservation method that is reliable on stable energy supply (desertfarms, 2014).

Dehydration

Dehydration of milk is an expensive preparation method. Normal milk contains 87% of water making it liquid. During dehydrating there is almost a complete removal of water from milk (milkfacts.info). Microorganisms are unable to reproduce at such low water content, and this will increase shelf life immensely. Weight and volume of the milk will be reduced. Skim milk powder has a maximum shelf life of about three years while whole milk powder has a maximum shelf life of six months. The fat in the powder oxidize during storage, with consequent of decline in flavour (Paul, 2010).

Cold methods are freezing out water and centrifuging, freezing milk and sublimation. From these methods it produces very high quality powder. The product is deep-frozen and the water frozen in product is sublimated under vacuum. No protein denaturation takes place compared to drying milk at higher temperature where proteins are denaturised to a greater extent. The hot method like film roller or drum drying is less common used (Paul, 2010).

3.2 Heat treatment

Heat treatment of camel milk includes the methods of fermentation, pasteurisation, and sterilization.

3.2.1 Fermentation

Fermentation is a metabolic process of converting carbohydrates into acid or alcohol by using bacteria naturally found in milk or added to the milk. Lactic acid fermentation process is very important in milk preservation. It has low cost and display highly organoleptic properties. There are three major preparation methods; gariss, suusac and shubat, all of them semi-continous (Shori, 2012). The methods are presented in Figure 14.

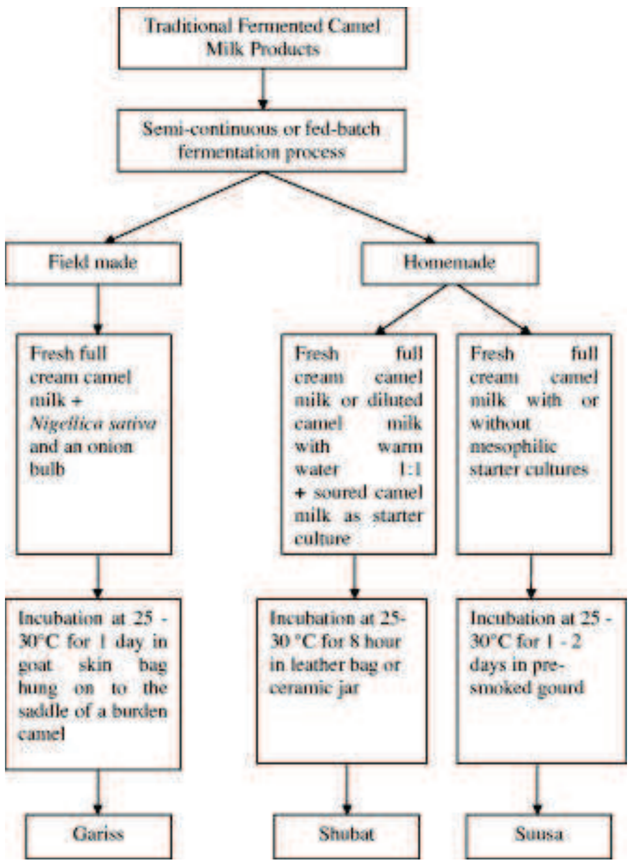

Figure 14 - Different fermentation methods, (Shori, 2012)

Gariss is a fermentation method that makes full cream sour milk. The process is an outside or field preparation method. Spontaneous fermentation is initiated by adding Black cumin seeds and onion bulb to the milk. The milk is shaken well to give it a thorough mixing. Two bags of milk are often placed on each side of the camel and when walking, there will be an optimal shaking of the milk. This milk is called gariss and when some of the milk is consumed the same amount of fresh camel milk is replaced. This process can go on for months (Abdelgadir et al, 1998; Dirar, 1993,; Mirghani, 1994)

Suusac can be prepared by two methods. Traditionally fresh camel milk become fermented in pre-smoked gourd and incubated at 25-30 ˚C for some days (Lore et al, 2005). The other method use mesophilic starter culture. The milk is heated to 85 ˚C for min 30 min, than cooled to room temperature. Further it is inoculated with 2-3 % starter culture at 27-30 ˚C for 24 hour (Farah et al, 1990).

The Shubat is traditionally prepared by using raw milk or camel milk diluted with warm water. It is inoculated with 1/3 to 1/5 of previously soured milk and incubated at 25-30˚C. After 3-4 hours the milk will coagulate. It will stay for another 8 hours to gain the typical taste (Marynenko et al, 1997). By adding lactobacillus casei, streptococcus thermophiles and lactose-fermenting yeast cultures to the milk and inoculate for 8 hours at 25 ˚C followed by 16 hours at 20 ˚C shubat will be produced (Kuliev, 1959)

3.2.2 Pasteurization

The method of pasteurization was developed by Louis Pasteur and named after him. The first test with heat treatment of milk was performed in 1862. The purpose of pasteurization is to increase safety, quality and shelf life of the milk.

The process of pasteurization slows bacterial growth and therefore preserves the milk for long-term use. Unlike sterilization, pasteurization is not intended to kill all micro-organisms in the food. Instead, it aims to reduce the number of viable pathogens so they are unlikely to cause disease (assuming the pasteurized product is stored as indicated and is consumed before its expiration date). Commercial-scale sterilization of food is not common because it adversely affects the taste and quality of the product. Certain foods, such as dairy products, may be superheated to ensure that pathogenic microbes are destroyed.

Pasteurization can be performed in two ways either as a batch or as continuous process, the latter being most used. Vat pasteurizer is a closed vat with temperature control. Milk is pumped in to the vat, and heated to the correct temperature for a fixed time, followed by cooling. The cooled milk is pumped out of the vat and continues onto the processing line. In the continuous pasteurization system the milk is pumped into a holding tank that let the milk continuously flow over thin plates that heat the milk up to an appropriate temperature for a fixed time. Then the milk flow further to a cooling station and continue on the processing line like bottling station.

Table 1 – Pasteurization methods, based on Tabel shown in milkfacts.info

Pasteurization type	Storage	Temp ˚C	Duration
Batch, vat	Refrigerated	62.8	30 min
Continous, high temperature short time		71.7	15 sec
Continous, higher heat shorter time		88.3	1 sec
		90	0.5 sec
		93.8	0.1 sec
		96.2	0.05 sec
		100	0.01 sec
Continous, Ultrapasteurization	Refrigerated, extended storage	137.8	2 sec
Aseptic, ultra high temperature	Room temperature	135-150	4-15 sec
Steralization (Canned products)		115.6	20 min

Pasteurization is the process where a liquid is heated to below boiling point. The requirement for pasteurization has been changed several times during the years. It was first set to 61.7 °C for 30 minutes or 71.1 °C for 15 seconds to inactivate *Mycobacterium bovis* (causing tuberculosis). These temperatures were too low to inactivate *Coxiella burnetti* which causes q-fever in humans (Enright et al, 1957). The new demands, which are still used today, require the milk to be heated to 71.7 °C for 15 seconds for a continuous process. Table 1 demonstrates different pasteurization temperatures and durations (milkfacts.info)

High-temperature, short-time (HTST) pasteurized milk, typically has a refrigerated shelf life of two to three weeks, whereas ultra-pasteurized milk can last for two to three months. When ultra-heat treatment (UHT) is combined with sterile handling and container technology (such as aseptic packaging), it can even be stored unrefrigerated for up to 9 months. The shelf life for pasteurized camel milk (74 °C/15 sec) is 15 days at 4 °C (Wernery, 2007).

3.2.3 Sterilization

The definition of sterilized milk is that the milk contains neither bacteria nor bacterial spores. There are different methods of sterilization. In the complete in-bottled system the milk is bottled and heated for some time at 100 °C to 120 °C. In the UHTST or VHTST (ultra- or very-high-temperature-short-time system) the milk is sterilized in a continuous-flow sterilizer at very high temperature (130 – 150 °C) for very short times (1- 20 seconds), and then aseptically packed in containers. The last method, the two-stage process, the milk is sterilized according to the UHTST process, then it is bottled, and finally submitted to further heat treatment to destroy any spores which may have entered it during bottling.

Consume of sterilized milk has become somewhat popular. The almost unlimited expiration date, make the milk very valuable for the buyer. Although sterilized milk has an impaired flavour and high cost many consumers prefer it (Galesloot, Th. E, 1962).

3.2.4 Thermal effect on milk component

Camel milk whey proteins are more heat stable than whey protein from caw and buffalo (Elagamy, 2000). According to a study performed by Hattem et al (2011) the protein content was negligible increased when heated. Raw milk was measured to 3.1 %, and when heated to 90 °C/30 min the protein content was increased to 3.4%.

Whey protein of camel milk contains high level of serum albumin (SA), alpha-lactalbumin (alpha-la) while beta-lactoglobulin (beta-lg) is found in minor amount. Heat treatment at 65 °C has not displayed significant changes (Elagamy, 2000; Farah, 1986).

Figure 15 demonstrate that the solubility of protein is dependent of both temperature and pH. At pH 5 the solubility is around 100% at 60 ˚C and at 100˚C the solubility about 55%.

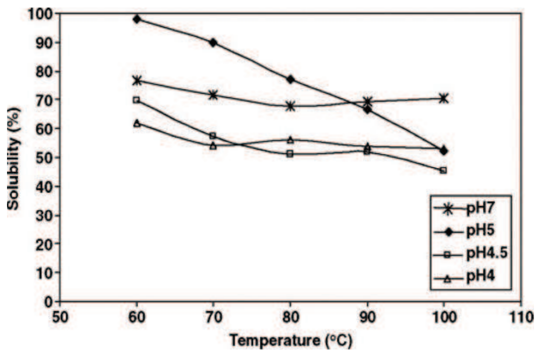

Figure 15 –Effect of temperature on camel whey protein solubility. (Laleye, 2008)

Table 2 – Heat stability of cow and camel milk, based on Tabel from Farah, 1986

	Camel mg/100g	Cow mg/100g	Camel % of WPN	Cow % of WPN
Raw milk	77-100	88-97	0	0
63˚C/30 min	65-85	81-90	13-16	7
80˚C/30 min	50-67	22-26	32-35	70-75
90˚C/30 min	41-49	17-23	47-53	74-81

A study by Farah (1986) investigated the heat stability of cow and camel milk. The result displayed in Table 2 show that camel milk whey proteins generally has a higher heat stability compared to cow milk (Farah, 1986). The denaturation of both camel and cow milk decreased with increasing temperature. At lower temperature, the cow milk was more stable but when reaching 80 °C the cow milk had a profuse loss compared to camel milk demonstrating the good heat stability of camel milk.

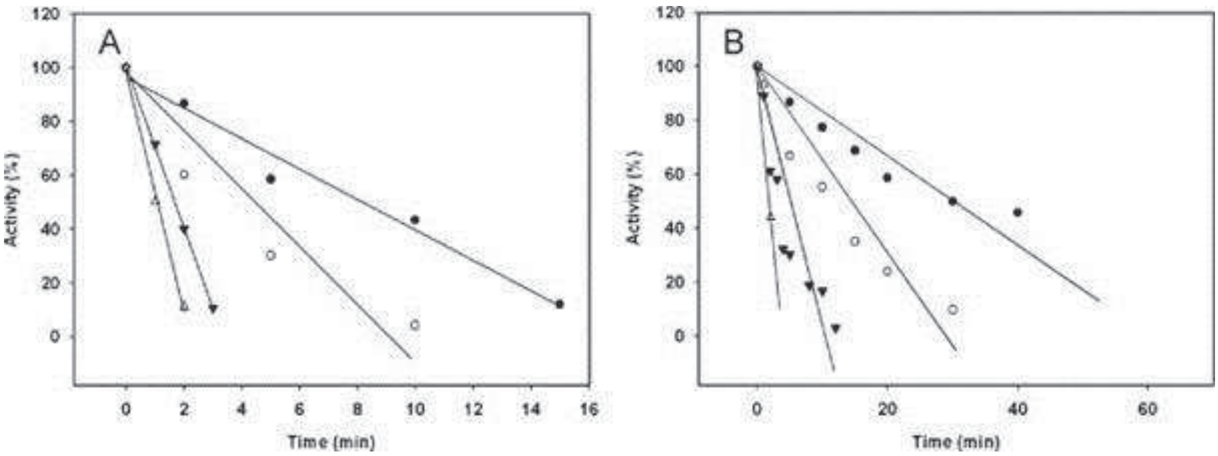

Figure 16 – Effect of heat treatment on camel (A) and bovine (B) milk lactoperoxidase activity as a function of treatment time at different temperature: 67˚C (black dot), 69 ˚C (white dot), 71 ˚C (black arrow), 73 ˚C (white arrow). (Tayefi-Nasrabadi, 2011)

Protective proteins

The lactoperoxidase activity is greatly affected by heating. Figure 16 demonstrate the different temperature with the percent activity and the time. At 67 ˚C there is a slow reduction in activity compared to the other temperatures, and after 15 minutes the loss is 80 %. At 69 ˚C after 10 minutes the loss was almost 100%. At 71 ˚C and 73 ˚C the loss was greater after a shorter period of time. Increasing temperature at a shorter period of time induced a greater loss of activity (Hossein Tayefi-Nasrabadi, 2011). A study of Elagamy, (2000) has investigated the impact of heating on antimicrobials in camel milk. Figure 17 show the percent activity of lysozyme, immunoglobulin G and lactoferrin in milk from camel, cow and buffalo by different temperature and time. The level of lysozyme in raw camel milk was considerable higher compared to cow and buffalo milk. By increasing temperature the lysozyme activity was reduced for all, however by 100 ˚C there was still some measurable amount of lysozyme left in the camel milk while in cow and buffalo there was a total loss. The immunoglobulin G concentration in raw camel milk was a significantly higher than the corresponding values of

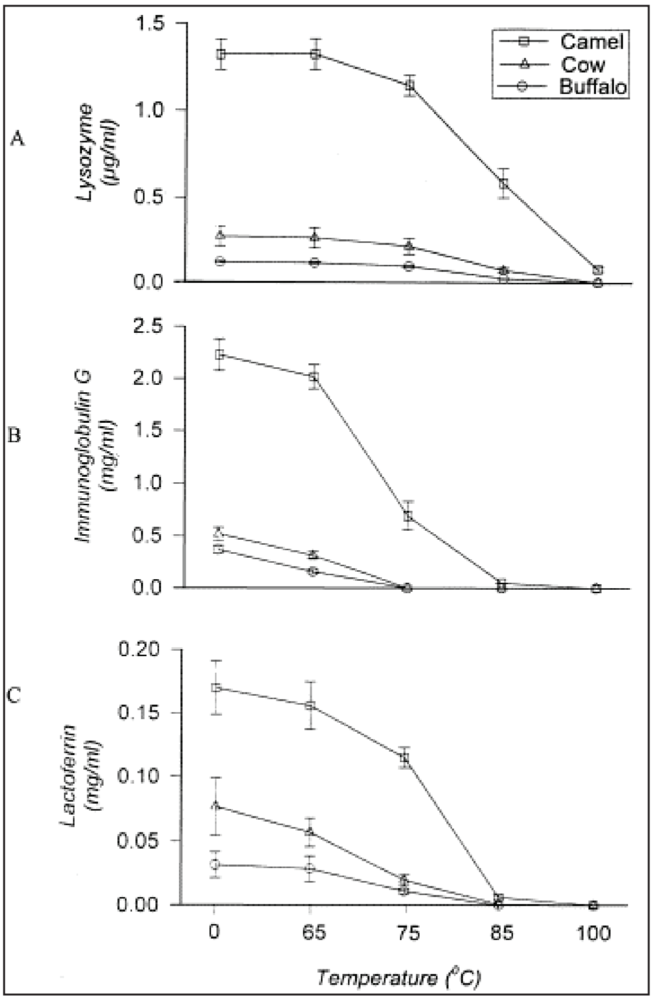

Figure 17 - Percent activity of lysozyme, IgG and lactoferrin by different temperature in camel, cow and buffalo milk, (Elagamy, 2000)

cow and buffalo. The camel milk showed a substantial loss of 69% at 75 ˚C and a total loss at 100 ˚C. In comparison the cow and buffalo had a complete loss at 75 ˚C. Lactoferrin content in raw milk had a more or less constant decrease by increased temperature and a total loss at 100 ˚C (Elagamy, 2000).

Fat

A study has estimated the fat content in raw camel milk to 3.2%. By heating the milk to 63 ˚C/30 min, 72 ˚C/15 sec, 80 ˚C/30 min and 90 ˚C/30 min, no changes were registered in the fat content (Hattem et al, 2011). In 2013 Desouky et al (2013) came to the same result and concluded that fat in camel milk is very heat stable.

Rennet clotting time

Coagulation of milk is important for different camel milk products, ie. cheese and yoghurt. Experiment with thermally treated milk at 63, 80 and 90 ˚C for 30 min compared to HTST process demonstrated an increasing rennet time in presence of $CaCl_2$ by increasing temperature (Hattem et al, 2011).

Minerals

A study performed by Suliman et al (2013) investigated the impact of heat treatment on mineral constituents of camel milk. Samples of raw (n=30) and heat treated (n=30) milk was compared. The milk was heated to 60, 80 and 100 ˚C and the milk was tested for calcium (Ca), cupper (Cu), phosphor (P), sodium (Na), potassium (K), zink (Zn) and ferrous (Fe). The P, K and Ca did not display any change at 80 ˚C while Cu and Z was significantly increased by 100 ˚C. The concentration of Na decreased slightly, while Ca, P and Fe had negligible change by increased heat treatment.

Vitamins

A study investigating vitamin C in raw camel milk reported an average level of 24.9 mg/kg. The measurement was used as base line. When milk was heated with low temperature for long time (LTLT) at 63 ˚C for 30 minutes the vitamin C content was reduced to 18.2 mg/kg, a loss of 27 %. A new sample was heated with high-temperature short time (HTST) method at 73˚C for 15 seconds; the loss of vitamin C content was reduced to 21.2 mg/kg a loss of 15 %. Heat treatment at 80 ˚C/30 min, 90 ˚C/10 min, 90 ˚C/30 min and 100 ˚C/30 min caused a loss of vitamin C of 41% (14.6 mg/kg), 45% (13.8 mg/kg), 53 % (11.7 mg/kg), and 67% (8.3 mg/kg) respectively (Mehaia, 1993). Mehaia performed heat treatment for testing of riboflavin (vitamin B2) loss. Compared to raw milk the loss was relatively small and the highest loss was 7 % seen at the highest temperatures. Vitamin A, D, E and B-complex are relatively insensitive to heat treatment. Usually no losses are seen at temperatures below 100 ˚C, but when sterilized some reduction in vitamin A, E and B2 may occur (Renner, 1983).

Insulin

Wernery et al (2006) performed a study investigating insulin content comparing raw to pasteurized camel milk 72 ˚C/5 min and boiled at 98 ˚C/5 min. In raw camel milk the insulin concentration was measured to be 41.9 μU/ml. The insulin contents decrease by increasing temperature. After pasteurization there was a minor loss of 7 % while after boiling there was a loss of 26 %.

4 Discussion

Camel milk has been consumed by humans for more than 5000 years and has always played an important nutritional role. Traditionally the camel milk has been consumed freshly and any treatment has not been necessary due to the short distance between the camel and the user, however, fresh camel milk will be useless in short time if not consumed. During century fermentation has been the most common way of long-term preservation of the milk. Heating or cooling the milk was first applied by the end of 19^{th} century when the pasteurization was discovered and the refrigerator was invented. Both storage methods had an immense impact on milk quality and shelf life. Earlier disease and death was often the outcome for human when consuming untreated milk.

Milk is an excellent media for bacterial growth and the main spoilage of milk is caused by infecting microbes. Studies have reported that these milk spoiling microbes are killed by heating at 65 ˚C for 15 minutes, while pathogens in general are killed by using LTLT or HTST methods. Milk sterilized at 130-140 ˚C for 3-5 seconds makes the milk free from microorganism. Sterilization is an expensive method that gives the milk an extremely long shelf life. The method results in a loss of several components like vitamin C, immunoglobulins and insulin. Although the method also reduce the organoleptic properties like flavour many consumers prefers sterilized camel milk.

The heat treatment of camel milk is an easy, safe and stable method of preservation and is the most common used method in camel dairies today. Heat treatment increases the shelf life profusely compared to fresh milk. The camel milk exhibits more heat stability compared to the cow and buffalo however the camel milk does show some losses when heated. Augustin (Augustin, 2000) defined heat stability as the ability of milk or concentrates to resist severe heat treatments without thickening, galantine or coagulation.

Making cheese from camel milk has been a technical difficult process compared to milk from other domestic animals. A few fresh cheeses have traditionally been made in herding communities by fermentation method, heating and adding pepsin (Yagil 1982). Milk coagulation is an important part of the cheese making process. Due to relatively high heat stability at pasteurization temperature it is difficult to coagulate the camel milk proteins. At sterilization temperature the camel milk proteins become unstable and precipitate irreversible making the milk useless for cheese production. Camel milk produced in the hot season (shortage of food and water supply) has poor cheese-making capability and should not be further heated. Today cheese of camel milk is fabricated by using vegetable rennet and camel rennet after pasteurization (Ramet, J. P, 2011; FAO).

The content of vitamin C is 4-6 times higher in camel milk compared to cow milk and is an important vitamin supplement in desert areas where the availability for vegetable and fruits is limited. After heat treatment using the LTLT method the amount of vitamin C is decreased considerably. Using HTST the loss has been reported significantly lower though still considerable large.

Studies focusing on the antimicrobial effect show that lysozyme, immunoglobulin G and lactoferrin display a constant decrease by increasing temperature. The loss of the natural antimicrobial effect during heating is however compensated by the reduction of microbes and will therefore not have large effect on the microbial situation.

In recent years there has been an increased global interest in the health benefits of the camel milk. The therapeutic effects from drinking camel milk have been known since ancient time (Khan 1974). Assumed healing properties include general well-being, anti-aging effect and syndromes like autism, Chron's disease, liver disease, tuberculosis, allergy, cancer and diabetes. Most of the alleged healing effects have not been scientifically recognised however there is some documentation with respect to diabetes, immunological benefits, allergy and cancer.

The concentration of insulin is relatively high in raw milk, especially in colostrum, and according to reports it is used for treatment of diabetes mellitus type 1 (Agrawal et al, 2011). Insulin is sensitive to heat treatment and will be somewhat reduced by increasing temperature but it still has a considerable level after heat treatment at 98 °C.

The camel immune system is significantly stronger than in human. Immunoglobulins can be passed from camel milk to human blood and may therefore strengthen the immune system. The content of IgG in camel milk is largely influenced of heat treatment (Elagamy, 2000) reducing the concentration by increasing pasteurization temperature. The immunological quality is optimal in fresh camel milk and will be ruined by heat treatment.

Children having lactose intolerance cannot drink cow milk. As the camel milk has very low content of lactose it is an excellent substitute for children with cow milk allergy. Small children and even newborn, that depends on milk as the main source of nutrition, may extensively benefit from the pasteurized camel milk. The high beta-casein content in camel milk makes it highly more digestible than cow milk and is an excellent alternative for allergic children.

Some studies have demonstrated anti-tumor properties in camel milk. Hesham et al. (2012) showed that camel milk can induce aptoptosis in Human Hepatoma HepG2 and breast cancer MCF7 cell lines. Lactoferrin being the main iron-binding protein of milk has the potential to inhibit the proliferartion of the colon cancer cell line (Habib et al, 2013). Lactoferrin is relatively heat stable at 65℃ but denaturates at normal pasteurization temperature (75℃)

Raw milk is probably the best alternative when it comes to the health advantage. The balance between the required pasteurization of camel milk and the many health beneficial properties is a challenge. Today raw frozen camel milk can be purchased however only especially clean dairies can deliver such milk.

Raw camel milk has a skimmed consistency and is described as sweet, delicious smooth, refreshing and fulfilling. Some describe the milk as slightly salty or having a sharp after taste. The taste may differ from farmer to farmer depending on the local diet. Although pasteurization does not seem to have large impact on taste or consistence, sterilization will impair the taste and change the consistency greatly as the milk proteins will precipitate. Fermented camel milk has a sour taste and a high density giving the milk a higher consistency, firmness and viscosity compared to raw milk. During storage these properties will decrease.

Currently camel milk can be found in supermarkets in the UAE (United Arab Emirates), Somalia, Saudi Arabia, Mauritania, and the United States. Both frozen raw milk and heat treated milk is available for consumers. Keeping milk or milk products frozen add extra costs and make purchase expensive for the consumers. If the camel milk should be distributed worldwide, heat treatment of the milk will be essential to achieve commercial sustainability.

What do we gain and what do we lose during heat treatment of camel milk?

The major gain is the elimination of bacterial growth that provides a highly safe product that can be used world-wide containing most of the nutritional components. The pasteurized milk can be safely given to children suffering from cow milk allergy. Also diabetes patient can utilize the pasteurized milk as the insulin will maintain an acceptable level. The pasteurization will preserve the taste and consistence of the milk while sterilization will ruin it.

During heat treatment we will lose several healing properties. Raw camel milk contains a large amount of vitamin C (important vitamin C supplement), IgG (strengthen the immune system) and lactoferrin (effect against cancer) all of them having special qualities. These components are heat labile and will therefore be spoiled by heat treatment.

Camel milk is more heat stable than cow milk and is in that respect a better alternative than cow milk, but the worldwide production of camel milk is substantial lower compared with cow milk. It will also be a trade-off to decide what temperature to use to achieve the optimal result for the different end products.

5 Conclusion

The future for camel milk is very promising. It has a wide field of applications and the results from studies make way for worldwide distribution and consummation in the future. The camel milk seems to have several health benefits, however more research is needed. Heat treatment causes some difficulties for production of certain camel milk products such as cheese. It also causes some losses of milk components like vitamin C and antimicrobials. The gain from heating the milk is larger than the losses when consumed for nutritional use. If the milk is prepared for specific health benefits a different preservation method may be necessary for keeping certain components that is lost by heat treatment.

Figure 18 – Camel milk, The worlds next super food, (Paul Caridad)

6 Summary

Since 3500-2800 BC milk from different animals like cow, goat, rein deer, horse buffalo, and camel has been a source of nutrition for men in different part of the world. Three camel spesies belong to the camelus genus; Camelus bactrianus (the domestic Bactrian camel), Camelus dromedaries (the dromedary camel), and Camelus ferus (the wild Bactrian camel). During the history camel milk has had an important role in preventing malnutrition in poor countries where the camel is one of the few animals that are able to survive. Untreated milk that is consumed may cause diseases including diarrhea, food poisoning, diptheria, typhoid fever and tuberculosis. The purpose of pasteurization is to increase safety, quality and shelf life of the milk. Whey proteins are more heat stable in camel milk compared to cow and buffalo. The content of vitamin C is 4-6 times higher in camel milk compared to cow milk and is an important vitamin supplement in desert areas. Research has reported that heat treatment cause loss vitamin C, IgG, lactoferrin and lactoperoxidase. Bioactive substances are naturally occurring components in the camel milk and are assumed to have health benefits. The balance between the required pasteurization of camel milk and the many health favourable properties is a challenge. Today one of the largest camel dairy farms is located in Dubai and holds 2200 camels and camel milk can be purchased in gulf countries, America and some African countries.

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9 Appendix

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