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CAMEL MILK, THE WHITE GOLD OF THE DESERT

Ulrich Wernery
Central Veterinary Research Laboratory, P.O. Box 597, Dubai, UAE

ABSTRACT

New World Camelids are not milked, but the milk of Old World Camelids is being used for many centuries. The two-humped camel lives in cold climate, hence their milk fat can reach levels of 8% which serves as an energy source for the newborn. The one-humped camel lives in hot climate zones, hence the fat content is low, but the water content is high. The camel udder possesses 4 quarters, one teat per quarter and 2 teat canals per teat, sometimes even 3. One of the most remarkable features of dehydrated camels is the ability to continue lactation, and to secrete milk that is highly diluted with over 90 % water content. A temperamental camel cow which does not like or know its milker, will simply cease production, but a contented camel, on the other hand, can produce milk for a very long period. Globally, the milk productivity of camels is more than five times lower than milk productivity of cattle. The camel's mammary gland possesses at least 8 (4 x 2) independent milk units. The camels are milked by hand. A pilot camel milking project using bucket milking machines began at CVRL in 2001. A modern camel dairy farm with the intention of milking several hundred dromedaries will be opened in autumn 2006 in Dubai under the name "Dubai Camel Dairy Farm" (DCDF). Mastitis in camels is rare. Treatment of camel mastitis is carried out parenteral due to the narrow teat canals. No bacteriological standards exist for raw and pasteurised camel milk. Transformation from *colostrum* to normal milk is reached after 7 to 10 days. The *colostrum* of camels is white like normal milk. Duration of milk let-down is very short: about 1 to 2 mins, therefore milking from both sides is essential. Camels should be milked several times a day. Good milkers can produce 20 to 30 litres daily. Camel milk is a rich source of proteins with potential anti-microbial and protective activity. Components of camel milk differ considerably of those from ruminants and have strong similarities to those of human milk. Camel fat contains much higher concentration of long-chained fatty acids (C 14 – C 18) than short-chained fatty acids, and is therefore healthier. Camel milk contains less vitamin A, B_2 folic acid and panthothenic acid than cow milk. On the contrary the content of niacin and vitamin C is remarkably higher than in cow milk. The high concentration of vitamin C and the high water content are the most eminent factors of camel milk. Whey proteins in camel milk were more heat resistant than those of cow milk. The degree of denaturation varied in camel milk from 32 % to 35 % at 80°C. In cow milk, 70 to 75 % of whey proteins were denaturated at this temperature. Pasteurisation at 72° C for 5 min revealed only 5-8% losses of camel milk compositions investigated.). Lactation periods of up to 24 months are known to occur in dromedaries. Camel milk proteins are different to cow milk, this may be the reason why no allergies to camel milk proteins are known. Camel milk does not coagulate easily. It passes the acid stomach undisturbed, and reaches the intestines for absorption. Camel milk contains five times more vitamin C compared to cow milk. Camel milk contains insulin and is therefore used to treat *Diabetes mellitus* camel milk contains medicinal properties to treat different ailments such as-autoimmune diseases, allergies,asthma, rash, diabetes, infectious diseases like tuberculosis, stress, peptic ulcers and cancer. It is a booster of the immune system. Camel milk products are consumed commercially as fresh raw or pasteurised camel milk, cheese, especially soft cheese in West Africa, e.g. "Caravane" made in Mauritania, ice creams with different flavours and milk shakes, puddings, such as crème brulée, panna cotta and the Arabian dish "Mohabila" and "Susa" (North-Eastern Africa) or "Shubat" (Kazakhstan) as sour milks.

Key words: Camel, constituents, milk, physiology, products

Physiology of the milking camel

New World Camelids are not milked, but the milk of Old World Camelids is being used for many centuries. The milk of bactrians possesses a higher amount of milk compositions than the milk of dromedaries which is more diluted. Nature follows logical rules. The two-humped camel lives in cold climate, hence their milk fat can reach levels of 8 % which serves as an energy source for the newborn. The one-humped camel lives in hot climate zones, hence the fat content is low, but the water content is high.

In drought-stricken areas of the world where continuous severe drought decimates cattle, sheep and goat populations, only the camel survives and continues to produce milk. One of the most remarkable features of dehydrated camels is the ability to continue lactation, and to secrete milk that is highly diluted with over 90 % water content. In true

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ruminants the reservoir for milk-water is lost for cooling and via faecal and urinary excretion. In cattle, sheep and goats, the lack of water leads to cessation of lactation or to a very concentrated high fat and low water content in the milk. A 600 kg camel has about 200 litres of fluid in the alimentary tract, which is available for milk production, giving 20 litres per day for 10 days. Lactating camels, therefore, will guarantee ample food with the desired content for their offspring and humans alike (Yagil, 2000).

Camels are far better suited than goats and sheep for animal husbandry in desert areas. Unlike sheep and, especially goats, which chew every piece of vegetation to the roots and denude areas around oases, camels take only a few bites from a shrub and a bush and then move on. They are true browsers, thus not destroying their habitat. A camel can go for many days without drinking, whereas sheep and goat must be watered every day. A camel can, therefore, graze over an area fifty times larger than that of a goat before returning to drink (Wernery and Wernery, 2002).

It has been shown that camels can be managed in closed farms where they produce a high quality food product: the milk. Unfortunately, very few countries produce camel milk commercially, but it is hoped that this magnificent mammal will be used to fight malnutrition in parts of the world in the near future.

Camels do not "store" their milk in the udder like bovines. The camel is able to produce or cut-off its milk supply at will. A temperamental camel cow which does not like or know its milker, will simply cease production, but a contented camel, on the other hand, can produce milk for a very long period.

The factors effecting milk yield are those common to all dairy animals: genetic potential, health care and nutrition.

Improving the genetic potential is one of the priorities, which will culminate in a milk camel with a uniform mammary gland producing 30 to 40 litres of milk daily. With artificial insemination and embryo transfer which has gained a major momentum in camel racing, this should be possible in the very near future. The possibility of cross-breading between Bactrians and dromedaries should also be carefully considered.

Globally, the milk productivity of camels is more than five times lower than of cattle. However, in arid zones where camels are reared, the milk yield is higher in camels than in cattle. The dromedary has the best chance to survive a prolonged drought period and helps camel keeping societies alive.

Camel research is scarce. An average of only 210 publications are annually dedicated to camel research with an average of merely 24 papers focussed on camel milk. Given the impact this animal species has on the social and economical situation in arid countries, there is no doubt, that a serious step up in camel milk research should be encouraged (Kappeler, 1998).

Mammary gland

The camel udder possesses 4 quarters, one teat per quarter and 2 teat canals per teat, sometimes even 3.

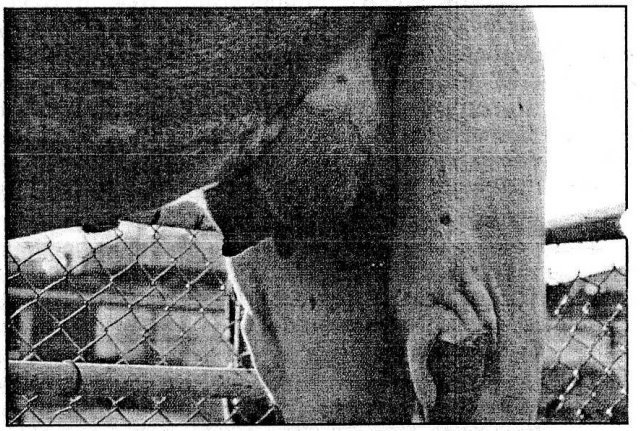


Fig 1. A good milking camel with a prominent milk vein

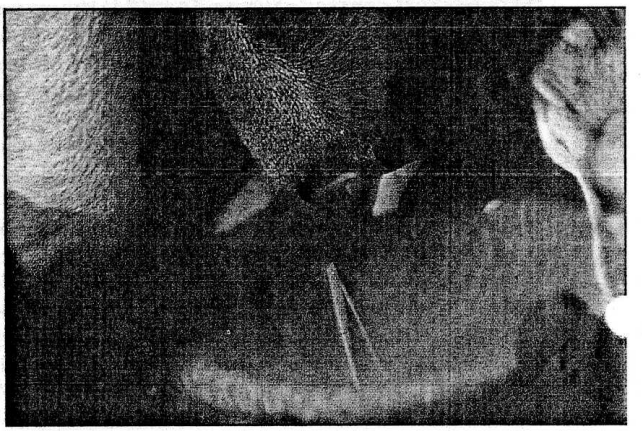
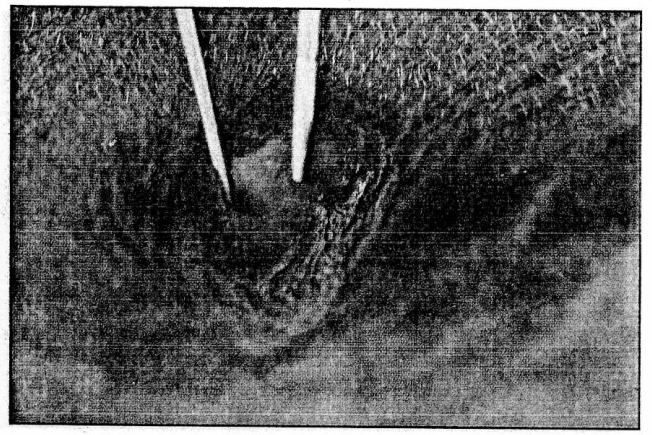


Fig 2. Hand milking of a dromedary showing a double flow of milk caused by 2 streak canals

Each teat canal leads to a separate milk cistern. This means that the camel's mammary gland possesses at least 8 (4 x 2) independent milk units. One unit consists of the alveoles, the milk ducts, the gland cisterns, the teat systems and the teat canals. The milk which is produced in the alveoles reaches the teat canals via the milk cisterns. To produce 1 litre of milk, 500 litres of blood is pumped through the udder. Milk production and release is hormonally regulated. Through suckling or massage an impulse is created which releases the hormone oxytocin into the blood. Oxytocin is transported to the muscle cells



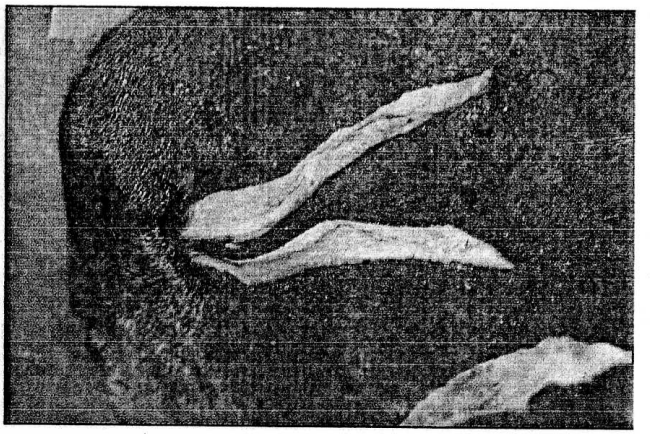


Fig 3 a+b. a) Two teat canals are **b)** opened leading to 2 separate cisterns on the right of the picture

surrounding the alveoles resulting in contraction. This procedure presses the milk into the cisterns. The teat canals are very narrow. For the treatment of mastitis, these anatomical particulars are important to know.

Only in a few camel rearing countries, camels are bred for commercial milk production. The camels are milked by hand. Therefore, it is difficult to imagine using a milking machine for camels, due to a great variability in shape of udder and teats.If in future camel milk is produced commercially, camels with a uniform udder must be bred. If milking machines are introduced, this will give a tremendous impetus to the camel herders to breed camels with standard sized udders and teats. Moreover, milking machines will not only guarantee higher milk production and better milk hygiene, but would also improve the social status of camel farmers. A pilot camel milking project using bucket milking machines began at CVRL in 2001 (Albrecht, 2003; Wernery *et al*, 2006b) the outcome of which was very encouraging. Camels are intelligent animals and easily accepted fish herring parlors and the automatic milking process. This led to the construction of a modern camel dairy farm with the intention of milking several hundred dromedaries. It will be opened in autumn 2006 in Dubai under the name "Dubai Camel Dairy Farm" (DCDF).

Mastitis

Mastitis is the inflammation of the mammary gland. Two forms are differentiated: the clinical and the subclinical mastitis. In clinical mastitis, the milk is alterated, not so in subclinical mastitis.

Somatic Cells	Pathogenic micro organisms	
	-	+
< 100.000/ml	Normal secretion	Subclinical mastitis
> 100.000/ml	Unspecific mastitis	Clinical mastitis

This definition refers to the examination of quarter milk samples.

Mastitis in camels is rare (Wernery and Kaaden, 2002). This has several reasons:

- camels are generally not milked with a milking machine and therefore stress and mechanical damage can be exclude

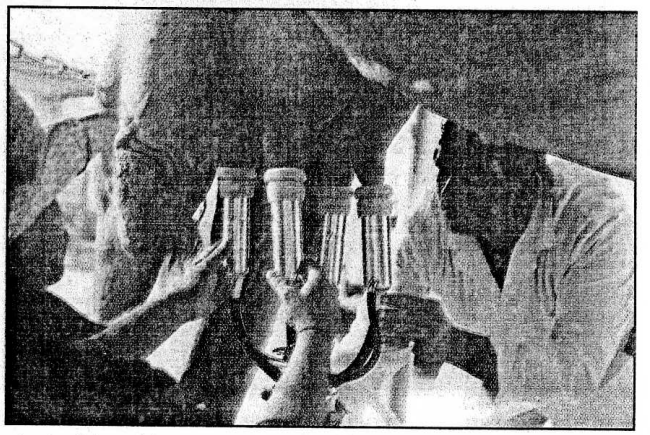


Fig 4 a+b. a) A dromedary udder with very large teats, **b)** making automatic milking difficult

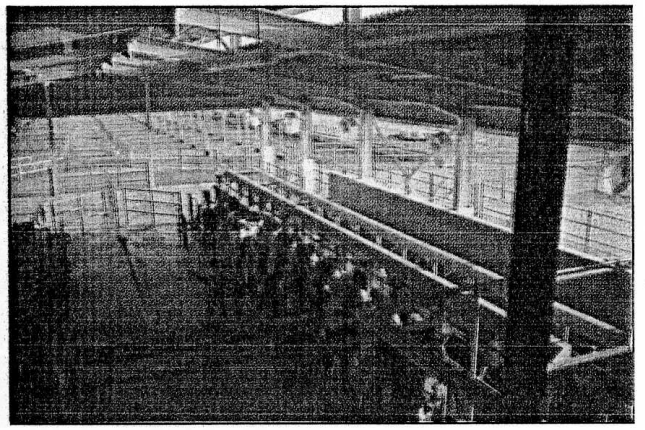


Fig 5. "Dubai Camel Dairy Farm". Dromedaries are milked in fish herring parlors

- camel milk boosts several anti-bacterial and anti-viral components (see under milk particulars)
- the teat canals are very narrow and may not allow dirt and /or bacteria to enter
- camels do not soil their legs, tails or udders because they release very hard and dry faecal droppings

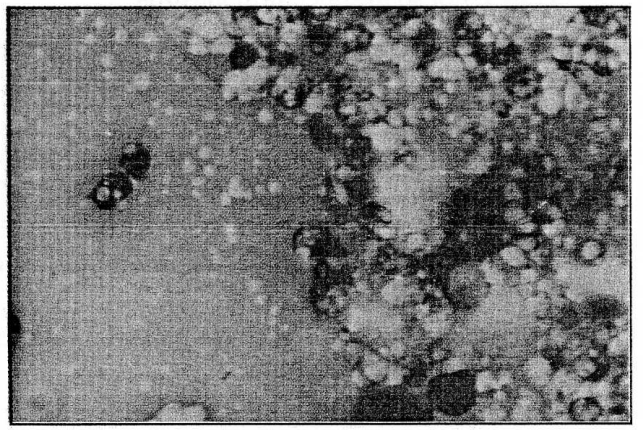


Fig 7. Inflammatory cells with coccal bacteria chains in a stained milk sample indicating mastitis

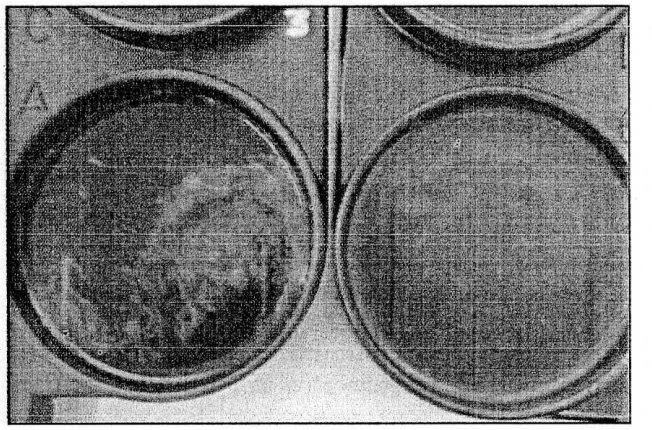


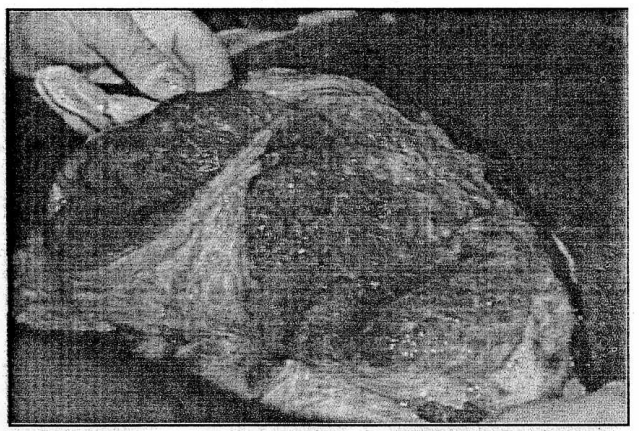
Fig 6. CMT positive indicating mastitis (left), no mastitis on the right

- camel calves go in general with their dams for nearly a year, suckling frequently so that there is no accumulation of a great amount of milk in the cisterns, avoiding bacterial growth; camels do not "store" milk

Peracute, acute and chronic mastitis have been described (Kinne and Wernery, 2002). The most prevalent bacteria isolated from these cases are:

- *Pasteurella multocida*
- *Staphylococcus aureus*
- *Corynebacterium pyogenes*
- *Escherichia coli*
- *Streptococcus agalactiae*

In mastitis, the California Mastitis Test (CMT) is always positive and inflammatory cells and pathogenic bacteria are observed in the milk. The udder or affected quarters are painful, hard and swollen. The milk sample may contain blood, flakes and has changed colour from white to yellow or red. The CMT can only be used for quarter milk samples and not for bulk or tank milk samples.



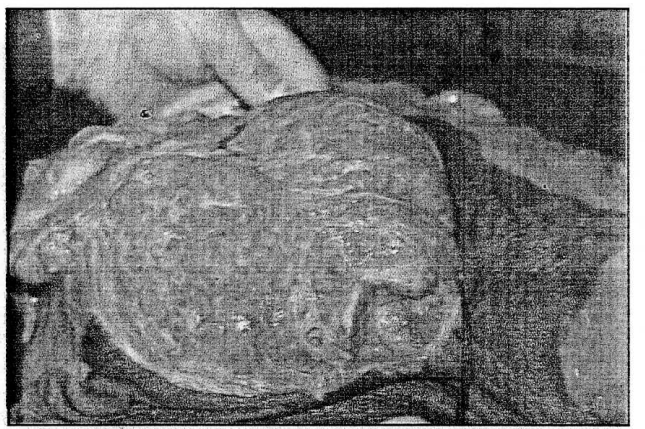


Fig 8 a+b. Acute haemorrhagic mastitis caused by *Pasteurella haemolytica* (a) indicated by red udder tissue and anormal lactating udder (b)

Very few publications have been written about the application of the CMT in camel milk (Younan et al., 2001). So far no somatic cell counts (SCC) have been carried out and therefore no reference values of SCC in camel milk exist. It is yet unknown if the reference values meant for cows of Table 1 can also be applied to camels. However, the globally acknowledged definition for the diagnosis of mastitis is based on the somatic cells in the milk. For the diagnosis of mastitis a sterile milk sample must be withdrawn from the quarter and send to the laboratory for testing.

In general, treatment of camel mastitis is carried out parenteral due to the narrow teat canals. However, local application is also possible. The camel has to be restrained to avoid any damage to the teat canals. If one quarter is effected the medicine has to be applied into both or all three teat canals. So far no special applicators have been designed to treat mastitis in camels.

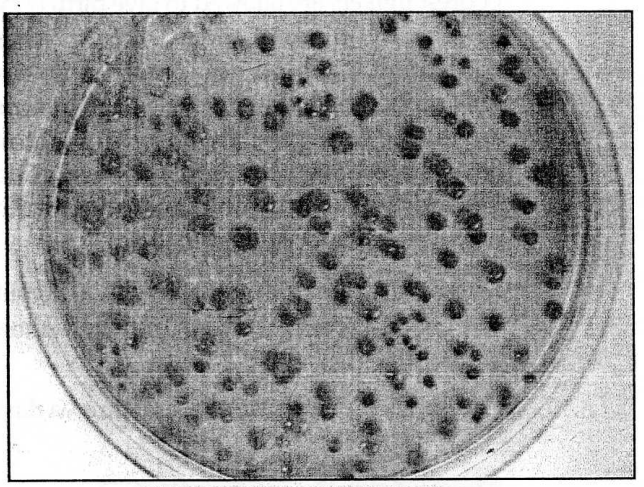


Fig 9. Coliforms from a mastitis milk sample

Currently, trials are conducted at DCDF to evaluate the effect of machine milking with different liners onto the udder and especially onto the teats. The outcome of these experiments will be published in the near future.

No bacteriological standards exist for raw and pasteurised camel milk.

Very few reports deal with the microbiological status of raw camel milk and there is virtually no report on the microflora of pasteurised camel milk. These investigations show that raw camel milk is highly contaminated when camels are milked under nomadic conditions lacking proper hygiene. However, when dromedaries were hand-milked under circumstances where precautions were taken to avoid any contamination, only a small amount of milk samples (5 %) did not meet bacteriological milk parameters laid down in milk hygiene regulations of the EU for cows. According to EU milk hygiene legislations, microbiological standards for other milk producing animal species like buffaloes, sheep and goats are more modest, and therefore all samples tested by CVRL researchers would have passed these standards (Wernery *et al*, 2002b). There is no doubt that microbiological parameters of camel milk can meet international standards when proper hygienic conditions are implemented and followed.

At CVRL, work is currently conducted on bacterial parameters of pasteurised and raw camel milk under machine milked conditions. Additionally, research work is currently carried out on the detection of antimicrobial residues in camel milk (Strasser *et al*, 2006). It was found that the commercially available test kits can also be used to diagnose residues in camel milk.

Colostrum

A healthy camel calf stands up 4 to 6 hours after parturition, and starts suckling the first milk (*colostrum*), which is essential for surviving. This milk contains the vital ingredients (maternal antibodies) for the protection against infectious diseases to which a newborn is exposed during the first weeks of its life. Peak IgG levels must be reached 24 hours after parturition and failure of Passive Transfer (FPT) is likely to have occurred if levels are less than (Wernery, 2001) :

- 50g/l for TP
- 8-10g/l for IgG
- 20g/l for Globulin
- 45 U/l for GGT

Transformation from *colostrum* to normal milk is reached after 7 to 10 days. The *colostrum* of camels is white like normal milk, not yellow like *bovine colostrum*, and is not consumed by humans. Advisably, camels should immediately be milked after parturition to gain a high yield.

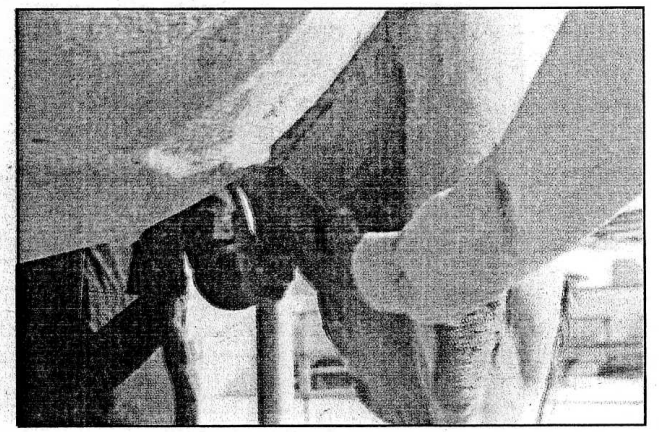


Fig 10. Before milking, the udder must be stimulated by hand

Milk let-down

The let-down of milk in camels is of special importance. The udder can be stimulated by hand massage or by suckling of the calf.

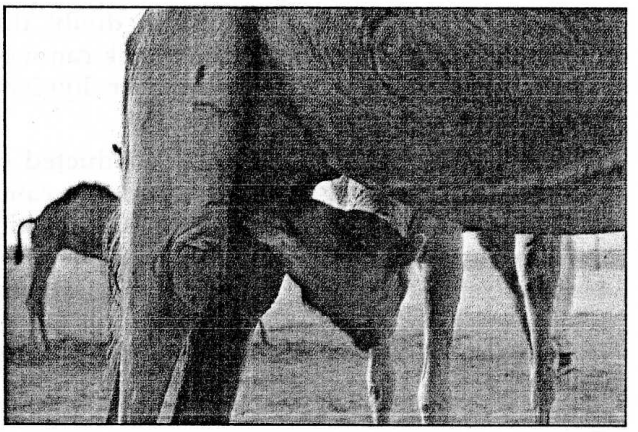


Fig 11. by calf suckling

The let-down is of short duration and milking must therefore be conducted as quickly as possible. The nomads in Africa and the Middle East are aware of this fact and the hand milking is carried out on both sides simultaneously by two milkers (Yagil, 2000).

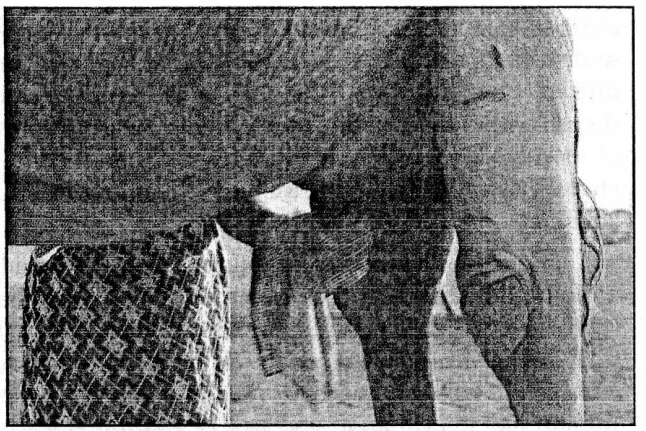
The future will show if this "disadvantage" can be overcome by automatic milking.

Milk quantity

This is the most controversial subject when it comes to camel milking. In the literature the daily milk yield has been reported to be between 3 to 40 litres (Yagil, 2000; Bekele *et al*, 2002; Wernery *et al*, 2004). This vast discrepancy is due to many misunderstandings and misconceptions. The facts are:

- Camel milk has been used for many centuries, but camels have never been systematically selected for milking quality and there are no large scale dairy enterprises
- It is often not considered that calves which are grazing with their dams for more than a year, will drink several litres per day even when the calves start to graze.
- The dams are not regularly hand-milked, because the herders' family does not require large amounts of milk, and there is hardly any market to sell the surplus milk. Even if milking is done every day, it is always incomplete, because only the amount consumed is milked. These practices of not emptying the udder will immediately reduce the milk production due to hormonal influence.
- Negative selection of milk camels. The poorest milkers are allowed to give birth once a year by mating them shortly after parturition. They do not contribute to the milk support of the family while good milkers are milked for more than one year without being mated. They give birth once every 2 to 3 years. This practice favours calves with negative genes for high milk yield.
- Duration of milk let-down is very short: about 1 to 2 mins, therefore milking from both sides is essential.
- Camels should be milked several times a day.

Fig 12 a+b. Milking a camel from both sides in Kazakhstan and UAE



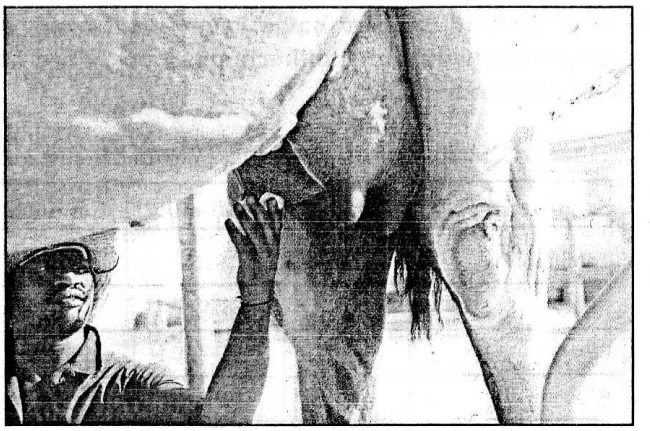


Fig 13 a+b. Before milking and after stimulation the teats are thoroughly cleaned by a sterile towel or tissue containing a disinfectant

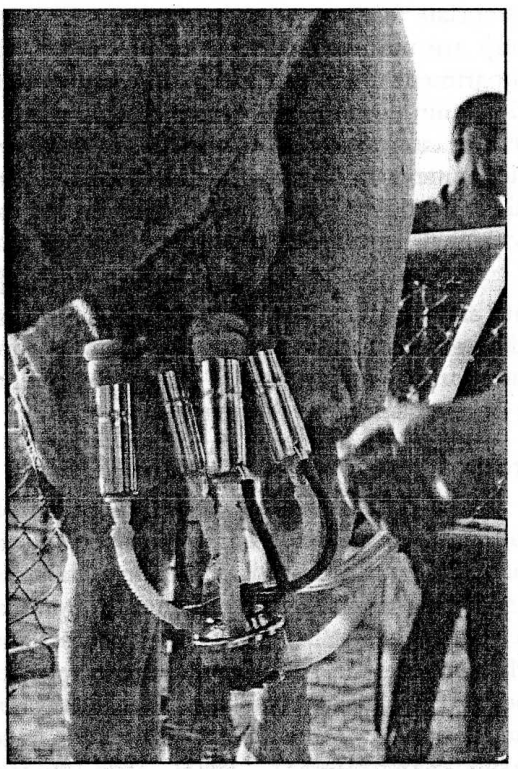


Fig 14. A camel is milked with an automatic milking machine

Camels can become high milk producers if their full potential is realised. Good milkers can produce 20 to 30 litres daily. If in the future camel milk is produced commercially, the following recommendations should be considered:

- Breed a milk camel with high milk yield and a uniform mammary gland and teats.
- Milk with an automatic milking machine 2 to 3 times a day.
- Remove the calf after parturition. This is very controversial, but should be achieved after several generations of selective breeding. The current practice favours the separation of the calf from the dam several hours prior to milking.
- Few camel owners believe that camels have a significantly lower daily total milk yield after having lost their calves in comparison to those who's calves stayed alive. However, in future the objective should be to remove the calf entirely.

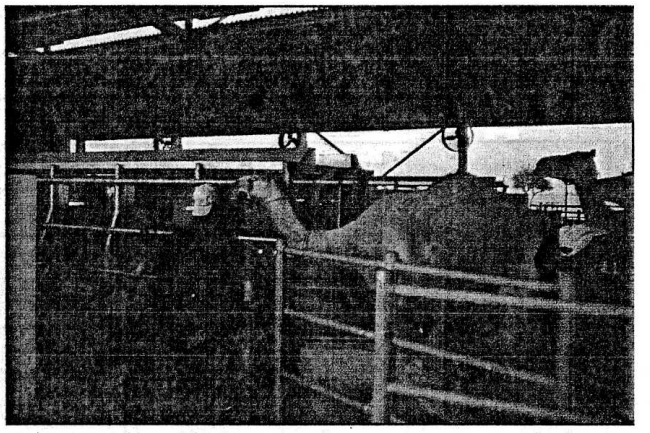


Fig 15. Camels are led into a proper milk stand

Milk quality

Camel milk is a rich source of proteins with potential anti-microbial and protective activity. Some proteins are not found in cow milk, or only in minor concentrations, such as the novel peptidoglycan recognition protein and the whey acidic protein.

The special properties of camel milk have been published by several researchers. Components of camel milk differ considerably of those from ruminants (cow, sheep, goat), and have strong similarities to those of human milk. These special properties and the abundant availability of camel milk guarantees a survival under harsh conditions of the desert.

Several studies have been conducted in connection with camel milk compositions. They are summarised in Table 1.

Table 1. Compositions of camel milk compared to cow milk

Parameters	Units	Camel milk**	Cow milk
Total solids	%	9-13	13
Water	%	87-91	87
Protein	%	2.7-4.0	2.7-4.7
Fat	%	1.8-3.8	3.8
Lactose	%	3-5	3.7
Calcium	mg/100 ml	100-160	100-140
Copper	mg/l	**1.3-1.8***	0.1-0.2
Phosphate	mg/l	580-1.040	650-1.100
Iron	mg/l	**1.3-2.5***	0.3-0.8
Potassium	mg/l	600-2.100	1.350-1.550
Magnesium	mg/l	75-160	100-150
Manganese	mg/l	0.08-0.2	0.04-0.2
Sodium	mg/l	360-620	350-600
Zinc	mg/l	4.0-5.0	3.5-5.5
Vit C	mg/l	24-36*	3-23
Vit B 12	mg/l	0.002	**0.002-0.007***
Folic Acid	mg/l	0.004	**0.01-0.10***
Niacin	mg/l	**4.6***	0.5-0.8
Panthothenic Acid	mg/l	0.88	**2.6-4.9***
Vit B 6	mg/l	0.52	0.40-0.63
Vit A	mg/l	0.10-0.15	**0.17-0.38***
Vit B 2	mg/l	0.42-0.80	**1.2-2.0***
Vit B 1	mg/l	0.33-0.60	0.28-0.90
Vit. E	mg/l	0.53	0.2-1.0

* elevated values are highlighted
** Farah (1996) and Kappeler (1998)

Interpretation of the compositional values of camel milk should be done with care. Some values may vary due to differences in feeding and husbandry, and there are no data on different breeds. In general, there is a need for a more systematic approach for the determination of compositional values.

However, these are the facts: The relative amount of the main components of camel milk protein, fat and lactose are similar to cow milk. The percentage of fat changes according to the water content. We found that it is low in summer with less than 2 %. Furthermore, the fat does not form a layer when kept undisturbed, and is evenly distributed throughout the milk in small micelles. This makes the fat easier to digest. Camel fat contains much higher concentration of long-chained fatty acids (C 14 – C 18) than short-chained fatty acids, and is therefore healthier (Stahl, 2005).

Camel milk contains less vitamin A, B_2, folic acid and panthothenic acid than cow milk which could be considered a disadvantage in the composition of camel milk. Especially the low level of vitamin A is a problem, since green vegetables are not readily available in the human diet in arid areas and lack of vitamin A leads to higher child mortality rate and blindness. However, a higher level of vitamin A could be achieved by appropriate feeding, whereas the vitamins of the B-group are mainly provided by the microflora of compartment 1. On the contrary the content of niacin and vitamin C is remarkably higher than in cow milk. The high concentration of vitamin C and the high water content are the most eminent factors of camel milk. In the desert, camel milk is often the only source of vitamin C since fruits and vegetables are scarce.

The amount of the main minerals are similar in camel and cow milk. Nevertheless, variations exist due to different feeding practices and breeds. We found low concentrations of copper and iron in dromedaries of the Arabian Peninsula (Wernery *et al*, 2002a).

Effect of heat treatment of camel milk

Very little is known about the effect of heat treatment on camel milk compositions. The purpose of heat treatment of milk is the protection of the consumer from pathogenic microorganisms. In general, the internationally applied milk heating process destroys pathogenic bacteria. Few scientific papers reported that whey proteins in camel milk were more heat resistant than those of cow milk (Farah, 1986; Mohamed and Larsson-Raznikiowicz, 1991). The degree of denaturation varied in camel milk from 32 % to 35 % at 80° C. In cow milk, 70 % to 75 % of whey proteins were denaturated at this temperature. A similar effect has been observed by CVRL scientists in a preliminary investigation. Pasteurisation at 72° C for 5 min revealed only 5-8% losses of camel milk compositions investigated. This is a tremendous advantage when it comes to the commercial production of camel milk (Wernery *et al*, 2003). So far very little is known of the effect of higher temperature on camel milk. Ultra heat treated (UHT) camel milk does not yet please the taste of the consumer.

Length of lactation

Camels have the ability to maintain lactation for

much longer periods than cattle (Yagil, 2000). Lactation periods of up to 24 months are known to occur in dromedaries. Because of the long lactation period, it is common practice to mate the female once every 2 years which has a negative effect on the selection. It has to be stressed again that bad milking practices not only effect the overall milk yield, but also reduces the length of lactation. Therefore, it is extremely important keeping the camel at its maximal milking capacity. The practice of "strengthening the calf" by not milking its mother during the first days after parturition, will certainly depress milk production per day and per lactation period.

Lactation tends to end 2 to 3 months after the camel cow has successfully mated. With a gestation period of 13 months, this means that a pregnant camel is dry for 10 months.

Camel milk particulars

Camel milk has the ability to inhibit the growth of micro organisms because it contains enzymes with anti-bacterial and anti-viral properties (El-Agamy *et al*, 1992). They are :

- Lactoferrin : prevents microbial growth in the gut, the amount is higher in camel milk than in cow milk.
- Lactoperoxidase : contributes to the non-immune host defence system, suppresses Gram-negative bacteria, is most effective in raw milk during the first 4 days.
- Peptidoglycan recognition protein (PGRP) : broad anti-microbial activity, stimulates the immune system, possible effect on breast cancer, is higher in camel milk than in cow milk.
- N-acetyl-glucosaminidase (NAGase) : anti-bacterial activity and antiviral activity.
- Lysozyme : inhibits the growth of bacteria, and has a positive influence on the storage of camel milk, but several authors have not detected it in camel milk.
- Immunoglobulins : IgGs are very different to other mammals, they possess several particulars giving them tremendous advantage over conventional antibodies (Hamers-Casterman *et al*, 1993).

Camel milk proteins are different to cow milk, this may be the reason why no allergies to camel milk proteins are known. Camel milk could be an interesting alternative for infant milk products. The absence of β-lactoglobulin, which may result in infant allergy towards cow milk, the low amount of lactoperoxidase, the high amount of α-lactalbumin, which has a high nutritional value, the high amount of lactoferrin (like in human milk), and the absence of non-protein nitrogen could be of advantage for infants and people with allergies.

Table 2. Water, fat, protein and lactose content (%) in milk of different animal species and man

Origin	Water	Fat	Protein	Lactose
Human	88	3.8	1.0	7.0
Cow	87	4.5	3.4	4.8
Buffalo	83	7.4	3.8	4.8
Sheep	82	7.1	5.8	4.6
Goat	87	4.1	3.4	4.6
Reindeer	67	18	11	1.5
Dromedary	87-91	2.0	3.0	4.0

Nothing is known about the chemistry and properties of lactose in camel milk. The amount of lactose concentration would account for the milk being described as sometimes sweet and other times salty. The amount of lactose varies according to the lactation stage of the camel. Lactose intolerance occurs in people above 5 years as a result of the decrease or absence of an enzyme called lactase in the gastrointestinal tract. Lactase metabolises the milk sugar lactose. The production of lactose is genetically programmed. Approximately 90-95% of black individuals and only 20-25% of white individuals throughout the world have partial or complete lactose intolerance associated with nausea, vomiting, abdominal distention, cramps and diarrhoea. Lactase deficiency is a classic example of a genetic trait that has been influenced by cultural factors. Low levels of lactase deficiency are found in European populations with a long history of dairy farming. To our current knowledge, camel milk lactose intolerance most probably does not occur.

Milk allergy is a completely different entity and occurs in very young children (Stear *et al*, 2005). It is directed against milk proteins of both the casein and whey proteins. It is an autoimmune disease, which occurs globally in 1 to 7% of all infants. The symptoms are similar to lactose intolerance plus involvement of the skin: urticaria (hives) and eczema.

Camel milk does not coagulate easily. It passes the acid stomach undisturbed, and reaches the intestines for absorption. Because the milk does not coagulate neither with acid nor with rennet, especially hard cheese is difficult to produce. The reason for this is poorly understood, but the following may be contributory factors could be low amount of total solids, casein with bigger casein micelles (double the size of casein micelles in cow milk) and fat and smaller

fat globules and high amount of whey proteinsand sodium concentration

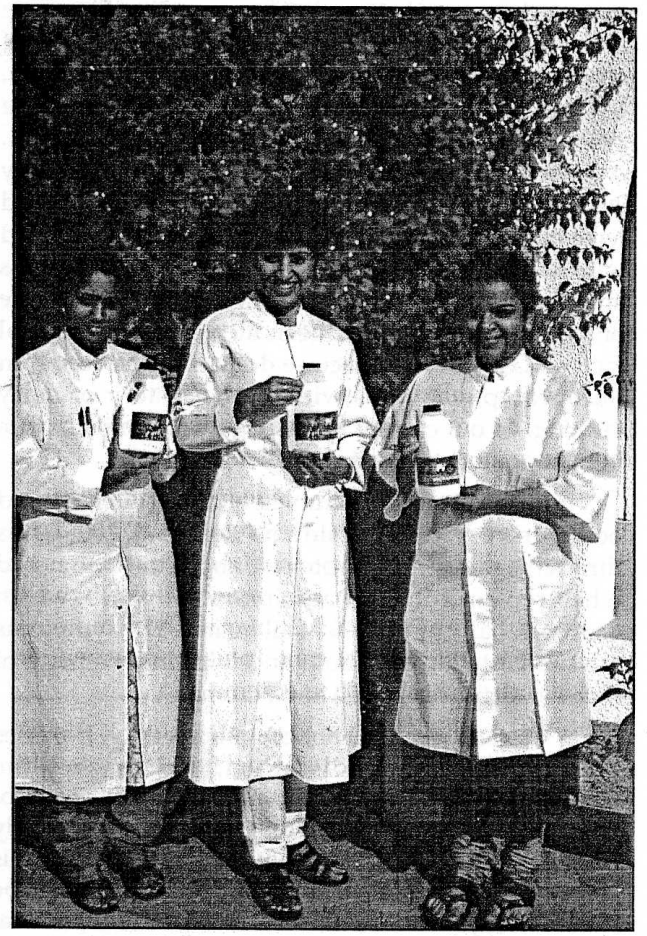
Camel milk contains five times more vitamin C compared to cow milk. Vitamin C is a strong anti-oxidant, is essential for brain function and growth, and protects against respiratory ailments.

Camel milk contains insulin and is therefore used to treat *Diabetes mellitus* (Agrawal *et al*, 2005). The insulin content is not much higher with 42 µU/ml than in cow milk (Wernery *et al*, 2006a), but trials in rabbits and rats showed that the insulin is not destroyed in the stomach. It passes into the intestines causing a reduction in blood sugar.

There are many stories about the medicinal properties of camel milk, many of them are not substantiated by proper scientific investigations. Several of these reports are from countries of the former members of the Soviet Union and it is extremely difficult to retrieve them. Fortunately, data recently have emerged which suggest that camel milk contains medicinal properties to treat different ailments i.e., autoimmune diseases such as multiple sclerosis, Crohn's disease, psoriasis, lupus, pemphigus; allergies -asthma, rash; diabetes; stress induced peptic ulcers, infectious diseases like tuberculosis (patients which were given standard therapy along with raw camel milk of 1 litre per day as supplement, gained body weight due to increased appetite. Radiological improvement in terms of lung expansion with no pus formation was also observed). It serves as a booster of the immune system. Lotions and creams with camel fat (cosmetics, pharmaceuticals) may protect against skin cancer.

Milk products

The far greatest amount of camel milk is consumed fresh or as a naturally fermented product. Only very few countries sell pasteurised camel milk. Since camel milk does not cream up, butter can only be produced by centrifugation. The camel milk products being consumed are fresh raw or pasteurised camel milk, "Susa" (North-Eastern Africa) or "Shubat" (Kazakhstan) (these are sour milks), ice creams with different flavours and milk shakes and puddings, such as crème brulée, panna cotta and the Arabian dish "Mohabila."



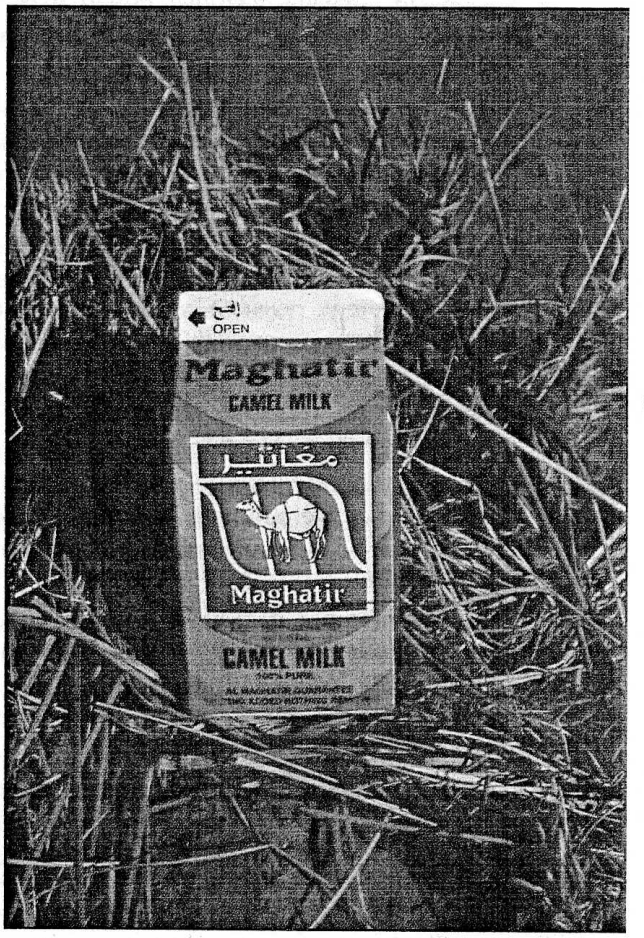


Fig 16 a+b. a) Fresh raw and pasteurised camel milk being produced at CVRL and **b)** pasteurised milk in a 500 ml tetra pack from Saudi Arabia

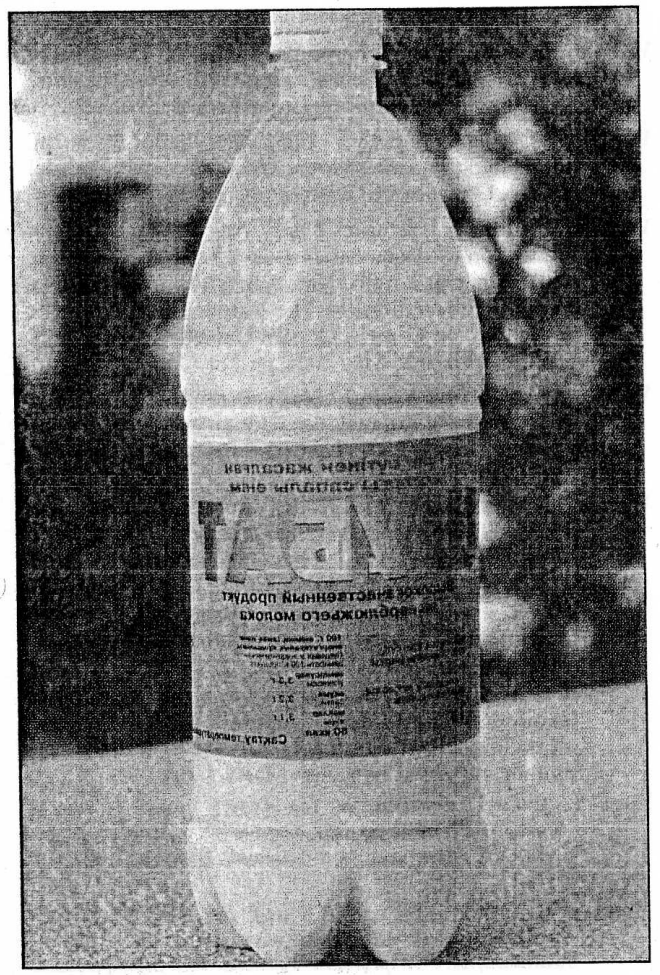


Fig 17. "Shubat", a camel sour milk from Kazakhstan

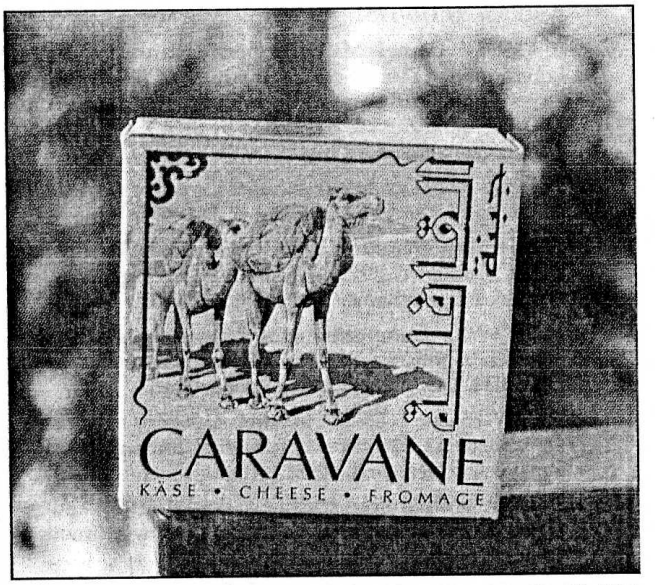


Fig 18. Soft French-type cheese made from camel milk (250 g, 25 % fat)

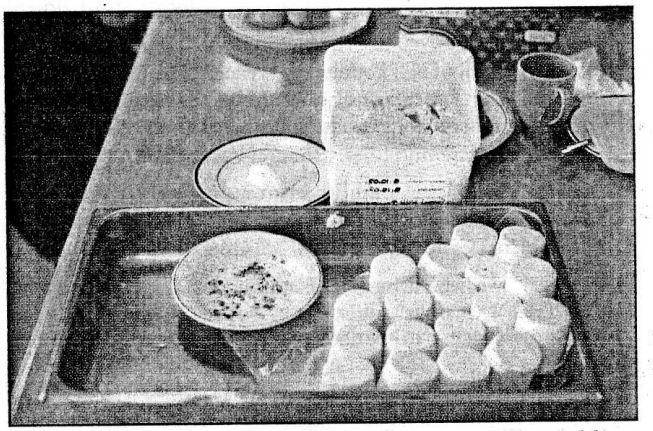


Fig 19. Ice cream with different flavour, milk pudding (creme brulee, panna cotta) and Mohabila (milk soup) made in Dubai, UAE

Further research

Future research should concentrate on the following:

1. Why are camel milk proteins more resistant to heat treatment than cow milk proteins?
2. Why does camel milk not coagulate?
3. Production of cheese, yoghurt and other milk products
4. Microbiological status of raw and pasteurised camel milk, evaluation of microbiological standards
5. Evaluation of tests in connection with mastitis e.g. California Mastitis test (CMT), phosphatase, lactoperoxidase, somatic cell count (SCC)
6. Heat treatment of camel milk and evaluation of losses of some camel milk components
7. Evaluation of "sub-clinical mastitis"
8. Evaluation of the medicinal properties of camel milk

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