



Milk Hygiene and Udder Health

4.1 Milk Hygiene

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Introduction

The unhygienic handling practices in traditional camel milk production and in the informal camel milk trade represent serious obstacles for the introduction of modern dairy processing and marketing. The successful adaptation of pastoral subsistence production to the needs of an improved camel milk production and marketing system will depend, to a large extent, on safeguarding the milk quality at production, during transport, processing and marketing.

The present status

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

In Somalia and Kenya, camel milk production areas are often located far from markets. Distances to provincial markets range from 20 to 90 km and may be up to 400 km for distant urban markets. During periods of milk surplus (rainy season) transport on dirt roads is unreliable resulting in breakdowns and delays in milk delivery. Storage in unhygienic containers, mixing of evening and morning milk, pooling of milk from different suppliers, prolonged transport times, high environmental temperatures and road-side selling out of open containers all increase contamination and spoilage of milk. Spoilage does not always equal wastage. Sour camel milk is part of the traditional diet (Somali "Susa", Arabic "Al-Garss") and sour milk of acceptable quality is sold and consumed. But growth of contaminants in raw camel milk poses a threat to consumer health when milk of poor hygienic quality is sold. Spoilage reduces

the market value of the milk causing income losses to producers and vendors. Souring or sour camel milk is also unsuitable for heat treatment in dairy plants. The common practice of smoking traditional milk containers and milking buckets (made from gourds, natural fibres) achieves high temperatures and appears to have a beneficial effect on the keeping quality of milk, although this has not been studied in detail. However, the obvious advantages of plastic containers (cheap, light weight, durable, large volume per container, better suited for transport in vehicles) coupled with the limited availability, high costs and small volumes of traditional containers leads to the increasing use of these containers in the camel milk trade. In Kenya and Somalia, smoking of plastic containers is standard practice to keep the traditional flavour of the milk in accordance with customer preference. Such "cold smoking" of plastic containers is unlikely to have a sanitising effect. Plastic jerry-cans of cheap quality (e.g. recycled cooking oil containers) have a fast corroding surface and are very difficult to clean in pastoral areas because of the lack of clean water. The non-availability of safe clean water also implies that the introduction of common hygiene recommendations will be difficult and adapting hygiene practices and guidelines to the pastoral situation remains a challenge.

The hygienic quality of camel milk

The monitoring of hygienic quality of camel milk from pastoral production areas by performing Total Bacteria Counts (TBCs) has serious logistical problems because of the distances to the laboratory. Hence bacterial counts in milk from pastoral regions must be interpreted with caution. The figures presented here almost certainly reflect higher TBCs than originally present in the samples. Spoiled camel milk has been found to have TBCs of 10^7 cfu/ml to 10^8 cfu/ml, although milk with lower TBCs is occasionally perceived as spoiled by organoleptic testing. The results of Coliform Counts (CC) are even more affected by the delays before laboratory testing, CC's of less than 10^2 cfu/ml have been found in milk samples from traditional milking buckets. The following is a compilation of examples from camel milk analysis.

Total bacteria counts (TBC) in camel milk in Kenya

Milk sample	TBC* (cfu/ml)
From udders milked directly into clean container	10^2 - 10^4
From traditional milking bucket	10^3 - 10^4
From transport container immediately after end of milking	10^3 - 10^5
From bulk milk stored 24h without cooling	10^5 - 10^8
From milk purchased	
– in the production area (less than 24h old milk)	10^6 - 10^7
– in Nairobi (24h to 36h old milk)	10^6 - 10^8

* For comparison: EU-standard for raw cow milk TBC < 10^5 cfu/ml

These results show that good quality raw camel milk is produced but it deteriorates rapidly as it enters the informal marketing chain. Pooling of different raw milk batches and unhygienic plastic containers accelerate spoilage with non-refrigerated bulk milk reaching a TBC of 10^8 cfu/ml and turning sour in less than 24 hours at 25°C or in less than 12 hours under hot conditions (35°C). However, provision of clean containers and chilling of raw milk taken from milking buckets after normal (traditional) milking, resulted in TBCs remaining within acceptable limits ($\leq 10^5$ cfu/ml) for four days. This milk also tasted fresh for up to four days.

The influence of pooling of different camel milk batches along the collection and marketing chain is illustrated by the increase in prevalence of *Streptococcus agalactiae*, a mastitis pathogen that originates from the udder. This pathogen was found in 50% of transport containers coming from producing herds, in 62% of milk containers sampled at primary collection sites and in 70% of milk containers sampled from an urban market of the same region.

Aseptically sampled milk from non-infected bovine udders contains 10^2 to 10^3 cfu/ml. The TBCs increase to 10^5 cfu/ml from cattle with subclinical mastitis. In comparison, mastitic camel milk seems to have a lower pre-secretional bacterial load. Milk from four subclinically infected camel udders (with bacteriologically confirmed *Streptococcus agalactiae* infections) ranged in TBC from 1.0 to 6.5×10^3 cfu/ml. Under pastoral production conditions, environmental contamination is likely to play a bigger role in the hygiene of raw camel milk than mastitis bacteria.

Adulteration of marketed camel milk occurs. Addition of up to 15% water to marketed camel milk has been reported from South Somalia. The quality of the water added to the milk represents an additional hygiene risk. – The specific gravity of camel milk tested in three large commercial herds in Kenya over a two months period varied between 1.026 and 1.029 indicating a difference to the specific gravity of cows milk.

The following list of milk hygiene risk factors is based on the current practices of Somali milk producers/traders:

Camel milk production and marketing chain	Milk hygiene risk factors
lactating camel	unclean udder, subclinical mastitis, zoonotic infections with lactogen transmission
↓	
milker (male)	unclean hands, personal hygiene and health status, unclean (plastic) milking bucket, unclean milking site
↓	
milk handler (male/female)	no/unclean filtration, unclean storage container (plastic), pooling of fresh and old milk
↓	

primary milk collector (mostly female)	no/unclean filtration, unclean (plastic) transport container, pooling of milk from different producers, high environmental temperatures during intermediate storage, adding unclean water
↓	
transporter (male)	delayed transport, prolonged exposure to high environmental temperatures
↓	
secondary milk collector (mostly female)	additional pooling, exposure to high environmental temperatures, adding unclean water
↓	
milk vendor (female)	selling from open containers in unclean environment, further exposure to high environmental temperatures, adding unclean water
↓	
consumer	traditional preference for consumption of raw milk

How to improve camel milk hygiene

Machine milking and hygienic milk production from camels, in line with both EU and German raw milk standards, have been achieved in a modern commercial intensive stationary camel dairy farm in Dubai. However, this must be regarded as exceptional given the production conditions and economic constraints that normally apply in pastoral camel herds.

Optimising milk hygiene under pastoral conditions requires the availability of safe clean water, an unrealistic expectation in most situations. However, the introduction of clean metal containers to producing herds has a measurably positive effect on raw milk quality. Camel milk transported from four producing herds to a local market in metal containers had TBCs between 0.7×10^7 cfu/ml and 7.1×10^7 cfu/ml while the TBCs from duplicates of the same milk transported in plastic containers ranged from 2.7×10^7 cfu/ml to 60×10^7 cfu/ml. The milk was sampled on arrival at the market and the average transport time between herd and market was $6 \text{ h} \pm 40 \text{ min}$.

Another simple approach to improving camel milk hygiene is the provision of clean gauze for filtration. Pooled camel milk sampled at a primary collection point immediately after it had been filtered through old reused gauze into the transport container ranged in TBC from 10^7 cfu/ml to 10^8 cfu/ml. The TBC was reduced to 10^6 cfu/ml when the same milk was filtered through fresh gauze. Receiving milk directly from producers without pooling of different batches coupled with shorter transport distances may offer hygiene advantages. However, such a system can cover only a very limited milk-production area and is unlikely to provide sufficient quantities of milk for commercially viable processing and marketing.

Potentials and *constraints* for improving camel milk hygiene in pastoral production systems

- replacement of cheap plastic with quality steel containers for storage and transport
⇒ *problem of increased weight/transport costs;*
 - filtration of milk with disposable clean gauze/paperfilters
⇒ *problem of availability, old filters are often reused;*
 - rotation of sealed sanitised containers between production areas and dairy processors
⇒ *used successfully by some traders who receive milk directly from large herds without any intermediate collection/pooling, difficult to implement in the widespread complex collection and trade chain with repeated pooling and transfer of milk (inconsistent milk containers);*
 - short heating/flash boiling of raw milk at primary collection sites
⇒ *used increasingly by long-distance milk traders, potentially negative effect on valuable milk components (e.g. vitamin C) and on the taste;*
 - reducing milk temperature at primary/secondary collection sites using solar or gas-powered refrigerators, evaporative cooling from charcoal-walled cooling chambers or simply by wrapping milk containers in a moist cloth, provision of shade/cooling box during vehicle transport;
 - encouraging the use of quality steel buckets or traditional "smokable" milking buckets rather than plastic milking buckets in the producing herds, using only boiled water as hot as possible for final cleaning of storage-containers in milk producing herds,
⇒ *costs/availability of heating/firewood;*
 - training and extension to raise awareness among producers on clean milking and handling practice;
 - accelerated transport from production to market
⇒ *economic constraints to setting up an independent milk transport system.*
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The introduction of the lactoperoxydase system (LPS) to the camel milk trade may prolong the keeping quality of camel milk. Currently there is no information on whether any significant extra keeping time is gained by the use of LPS in raw camel milk.

Consumer Health

Milk contaminants, including faecal organisms, pose an important threat to consumers of marketed camel milk. Zoonotic risks from camel milk must be considered in view of the traditional preference for raw milk for consumption. Brucellosis prevalence in camels varies widely ranging from 1% to 30% positive reactors in the Rose Bengal Plate Test according to the literature. Brucellosis prevalence seems to be higher in regions where camels are kept under more stationary conditions and close together with other livestock. Many pastoralists rank raw camel milk as safe while raw goats milk is regarded as potentially harmful. This empirical experience could be related to both lower lactogen *Brucella* excretion rates in camels and a higher *Brucella melitensis* prevalence in goats.

The two most common mastitis pathogens in camels, *Streptococcus agalactiae* and *Staphylococcus aureus* (see chapter on mastitis), are both potential human pathogens. While toxin producing *Staphylococcus aureus* may cause food poisoning, *Streptococcus agalactiae* is a known cause of human infections, particularly in newborn children. *Streptococcus agalactiae* isolates from camels seem to be more closely related to the human than to the bovine biotype and may survive for up to 7 days in souring camel milk, showing no significant decline in viable numbers down to a pH of 4.5.

Raw camel milk may occasionally play a role in transmission of tuberculosis to humans. Tuberculosis is rare among camels under nomadic conditions, with almost all reports on tuberculosis in camels originating from non-pastoral situations where camels are kept in confinement and/or in close contact with other livestock. Salmonella infections are common in camels, but human *Salmonella* infections originating from raw camel milk have not been documented. Numerous other zoonotic diseases, including Plague and Rift Valley Fever, have been recorded from camels, but the literature provides no detailed information on lactogen transmission.

The Future

Consumer consciousness about the hygienic quality of camel milk has yet to be developed. Although higher prices for fresh camel milk as compared to souring camel milk is an indication that urban consumers are prepared to pay more for better hygienic quality. In most countries, food safety regulations do not include camel milk but such regulations are necessary and may be enforced in the near future.

For modern processing, the heat stability of camel milk proteins and other camel milk constituents are clearly an advantage. Selling heat-treated packed camel milk could provide the solution to hygiene woes and, at the same time, eliminate zoonotic risks for camel milk consumers. The problem faced by any fixed milk processing plant is to ensure an adequate and regular supply of raw milk with acceptable quality from mobile lactating camel herds. The presence of centralised modern milk processing plants may lead to over-concentration of lactating camel herds in a limited grazing area with severe negative impact on the very fragile environment and increased disease prevalence in lactating animals. Decentralised and possibly mobile processing systems relying on simple adapted technology might be more sustainable and should be tested. Another possible solution could be cooling or flash-boiling of camel milk in the production area, coupled with an improved hygiene-conscious collection and transport system. Extension, training and regular monitoring will be important elements in any attempts to improve the hygiene of marketed camel milk.

4.2 Udder Health

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Introduction

Camels are kept for cultural and food security reasons in large areas of the horn of Africa. They make an important contribution to human survival and utilization of these dry and arid lands. The horn of Africa region has and is undergoing major changes that require new production strategies. These changes mainly limited the free movement of camel herds and affect their husbandry system. They include:

- Increasing human population growth,
- Frequent drought due to climate change,
- Competition for resources,
- Insecurity,
- Settlement and expanding rural cultivation and increasing sedentarisation of pastoralists to obtain schooling for children and healthcare.

The development of camel dairying and the commercialization of milk are elements of the new production system that will have important implications for the future management and husbandry of camels. The commercialization of camel milk is on the increase and milk is now taken regularly to urban centers for sale. Small commercial dairy farms and processing plants are planned in an attempt to supply fresh pasteurized milk to urban consumers. The introduction of modern dairy processing means that mastitis and other production related problems would play a bigger role than in traditional subsistence husbandry systems. There is likely to be an increasing demand for clean milk from consumers and by regulatory agencies (food safety authorities) in the near future. This chapter highlights the main udder infections of camels and describes simple methods for mastitis diagnosis and ways to improve udder health.

Mastitis

Mastitis is defined as inflammation of the mammary gland. It is associated with chemical, physical and most commonly bacteriological changes in the milk, and pathological changes in the mammary tissue. Reports of mastitis in the camel have increased tremendously during the past decade. However, much of the reports are not planned studies, but single or compiled case reports and surveys.

Mastitis causes suffering for the animal, reduces milk production and poses public health risk. Mastitis also influences the technological properties of milk.

In bovine mastitis the changes related to inflammation of the mammary gland include an increase in the concentration of chloride and sodium, an increase in the pH, a decrease in the dry matter content as well as a decrease in casein concentration and a negative effect on the coagulation of milk casein (delayed rennet coagulation). These changes have deleterious effects on the processing of milk. Mastitis is considered to be a multifactorial disease, closely related to the production system and environment that the animals are kept in. Mastitis risk factors or disease determinants can be classified into three groups: host, pathogen and environmental determinants (including management).

Bacteria, which can cause mastitis, are present in air, water and other surfaces in the environment including human and animal skin. *Streptococcus agalactiae*, other *Streptococcus* spp., *Staphylococcus aureus*, coagulase-negative staphylococci, and *Escherichia coli* are incriminated as the major bacterial causes of mastitis in the camel. There is evidence that *Streptococcus agalactiae* and *Staphylococcus aureus* are the two most important mastitis pathogens in camels (Table 4.1).

Table 4.1: Prevalence of *Streptococcus agalactiae* and *Staphylococcus aureus* mastitis in different camel populations, n=number of milk samples.

Country	Mastitis pathogen	
	<i>Streptococcus agalactiae</i>	<i>Staphylococcus aureus</i>
KENYA* (n=1305)	12.1% Individual herd prevalence 250%	10.6% Individual herd prevalence 9–13%
SUDAN** (n=757)	26.7%	17.0%
SUDAN*** (n=391)	17.6%	5.4%

* Younan et al. (2001), ** Obied et al. (1996), *** Abdurahman et al. (1995)

In Somalia, the prevalence of *Streptococcus agalactiae* in raw camel milk sampled from producers (n=10), primary collectors (n=37), milk vendors (n=23) and from raw milk batches received at a dairy plant for processing (n=18) was 50%, 62%, 70% and 89%, respectively. These findings indicate a very widespread occurrence of the pathogens in milk-producing camel herds and in the milk collection and distribution systems.

Streptococcus agalactiae is the single most important organism affecting the overall productivity of dairy cows. This pathogen causes a 30% decrease in milk yield on an individual animal basis and a 15% decrease on a herd basis. In Sudan and in Kenya subclinical *Streptococcus agalactiae* infections were found to be the most common intramammary infections in camels. – *Staphylococcus aureus* has been ranked as the most frequent or second most frequent microorganism isolated from udder infections in camels.

Mastitis occurs in clinical or subclinical forms. Clinical mastitis is self-evident and can be detected without special tests. There are changes in the secreted milk (color, consistency, floccules etc.) and/or the udder (red, swollen) and other generalized signs exhibited by the animal (fever, anorexia, deteriorating body condition). Subclinical mastitis, on the other hand, is difficult to diagnose. A camel with subclinical mastitis produces less milk, but does not have a swollen udder or abnormal milk. Infection is present but can only be detected with the help of indirect methods. These include the California Mastitis Test (CMT see section 3.2.9), a simple and rapid test that can be applied in the field. The CMT is particularly useful for subclinical udder infections caused by either one of the two major mastitis pathogens, *Streptococcus agalactiae* and *Staphylococcus aureus*. A second method is the direct microscopic somatic cell count (DMSCC) that requires only simple laboratory equipment and produces results on the same day.

Subclinical mastitis causes an increase in the total bacterial count in milk. It is a major factor in depressing milk yield and has a much greater impact on the productivity of lactating animals than the sporadic clinical forms of the disease. In a longitudinal study of 207 lactating camels, only 3.4% were affected by clinical mastitis while 21.3% were affected by subclinical mastitis. – Chronic intramammary infection ultimately leads to loss of intact quarters by destruction of the gland tissue. Loss of teats is reported from one third of Gabra and Somali camels in northern Kenya, in a smaller sample in the same area, between 10% and 50% of female camels had less than four intact quarters. Early culling of female camels due to chronic mastitis is reported from Iraq. Control of mastitis has been estimated to result in a 9% increase in milk yield from Somali camels in Kenya. Bacterial mastitis pathogens also represent a potential threat to humans if the milk is consumed raw, a common practice in most camel keeping communities.

Mastitis can be prevented or reduced by improving animal health and udder hygiene. Currently there is almost a complete absence of modern mastitis control measures practised by camel keepers. And there is little evidence of effective ethno-veterinary interventions in treating and curing mastitis. Good quality dairy products can only be obtained from healthy camels. Attention must be paid to udder health and hygiene, not only during lactation, but continuously, even when the animal is dry. Animals suffering from any contagious disease, including mastitis should be separated from the healthy animals and milk from diseased camels should be kept separate and disposed of safely.

Management

Management practices prevalent in traditional husbandry systems include tying the teats with soft bark to prevent the calf from suckling and cauterization

of the udder skin, that aggravates the existing lesion and leaves behind scar tissue, blind teats and permanent loss of milk production. The traditional practice of tying teats may contribute to the development of mastitis in camels. The effect of the unrestricted (ad lib) suckling of calves when small and the simultaneous and frequent milking (up to six times a day) and their relationship with mastitis is not known. The build up of the keratin barrier inside the teat in-between milking may be weakened. Further studies are needed to examine this relationship.

The udder is a predilection site for tick infestation. It is a good practice to remove ticks even when the animal is not lactating. Tick infestation causes skin lesions, facilitates bacterial entry and leaves behind permanent tissue damage. In a limited study in Kenya, 22% of tick bite lesions were shown to harbour *Streptococcus agalactiae*. Teat canal blockage with dilatation of the gland is a commonly observed problem in dromedaries. The cause of this blockage is not known and needs further investigation.

It is cheaper and easier to prevent mastitis by improving hygienic measures and culling chronically infected camels to eliminate important pathogen reservoirs, than to treat by medication. The cost of treatment includes veterinary fees, medicines, and risk of quackery and loss of milk production. Treatment also contributes to the build up of antibiotic resistance.

The teat of the camel udder contains two, sometimes three, separate teat canals, that open independently into the teat sphincter. The separate canals drain separate gland complexes. This implies that for intramammary treatment of mastitis not only must each quarter but also each gland complex be treated separately, that is, one intramammary tube per gland complex. Great caution is necessary when applying intramammary treatment to camels. The teat canal openings are smaller than those of the cow and thus require smaller cannula. Unhygienic and traumatic application of intramammary treatment is very likely to do more harm than good.

Future Research Work

There is limited information or knowledge regarding effective camel mastitis management. Organized problem oriented research is needed to monitor udder health and milk quality of camels. Camel herds should be carefully monitored for a range of quality and disease parameters throughout lactation to establish baseline values and infection information. Both formal and informal methods should be employed to strengthen the understanding and reliability of data collected and to achieve analytical quality. This kind of research must fulfill the needs of the camel owners and the consumers. The cost benefit relationship of mastitis control measures in camels needs to be examined in detail before making treatment recommendations.