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Full Length Research Paper

Analysis of microbial quality and safety of camel (*Camelus dromedarius*) milk chain and implications in Kenya

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The camel milk chain was investigated for microbial quality and safety and its implications to public health. At production, 66% of the samples had microbial load less than 10^5 cfu/ml compared to 54% at bulking and marketing where the microbial load was over 10^6 colony forming units (cfu)/ml. Gram-positive cocci (42%) were the majority at production. Gram-negative rods formed the majority (54%) at bulking and marketing. Salmonella spp. were detected at production and bulking levels. There was slow rate in acid development in camel milk decreasing total viable count at market level by 29% in 5 h.

Key words: Camel milk chain, microbial quality, safety, acid development.

INTRODUCTION

Camel milk is traditionally consumed raw by the pastoralists in Kenya. However, due to urbanization, population increase, search for alternative income sources, and insecurity in the low lands where camels are concentrated, the demand for camel milk has increased. About 12% of the national milk in Kenya is camel milk. The bulk of it is sold raw in urban markets by informal milk traders (Field, 2001). Milk is an excellent culture medium for the growth of microorganisms. The rate of multiplication of microbes depends mainly on storage temperature and time, level of nutrients and handling conditions. The external sources of microbes include the equipment, the personnel and water. The ability of microorganisms to cause spoilage and disease depends upon the type present, the initial load of contamination of the milk, handling conditions and the time lapse from production before consumption (Bachmann, 1992).

Common means of transporting camel milk in pastoral areas from production, about 10 to 20 Km away to bulking or market centres are bicycles, donkeys and occasionally vehicles. The ambient temperature in the production environment is about 39ºC. The milk reaches the nearest bulking centres in 2 to 3 h and to major markets in cities in 6 to 8 h. The growth of contaminating microorganisms in raw milk therefore poses a threat to consumer health. The camel milk being marketed is of unknown microbial quality and safety to the public. This study investigated the microbial quality and safety and effect of developed acidity on microbial load along the chain of camel milk supply from production to the market.

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MATERIALS AND METHODS

Sampling

Composite samples of 10ml of milk were taken from the camel udder at production in the morning and evening at normal milking time. The samples were kept in a cool box maintained at 8-10ºC using iced accumulators. A total of 107 samples were collected at production. At bulking centres, 52 bulk milk samples were taken after pooling milk for storage or distribution to consumers or transportation to distant markets. Fifty nine (59) milk samples were collected from the city market and other sales outlets. All samples were transported to the laboratory within six hours.

Examination of samples for microbial load

Standard methods (ISO 4833:2003 method) for enumeration of total

Table 1. Initial microbial load along the chain of production.

Farm					Bulking				Market			
Range	≤ 30	≤ 10^5	> 10^6	N	≤ 30	≤10^5	> 10^6	N	≤30	≤10^5	> 10^6	n
TVC (cfuml)	18	71(66%)	18	107	0	2	50(96%)	52	0	1	54(92%)	55
CC (cfu/ml)	2	38(73%)	12	52	0	2	19(90%)	21	0	0	50(100%)	50
Spores (cfu/ml)	25	7	0	32	0	14	2	16	0	1	0	6
Total		191				80				111		

viable counts (TVC), coliform counts (CC), yeast and mould count and aerobic spore counts were used. Analysis for *Salmonella* spp from milk samples and the production environment represented by soil, water and faeces was done according to ISO 6785:2001 methods. This procedure results in the detection of Salmonella spp.

Acid development

Developed acidity was monitored as milk was handled at production and market levels using standard procedure as described by International Dairy Federation (IDF) (1990) to determine its effect on microbial load and type in raw camel milk. Acid development was measured in percent lactic acid (% LA) against time of incubation in spontaneous fermentation of raw camel milk. 9 ml of the milk sample was pipetted into a conical flask. 1 ml of 0.5% alcoholic phenolphthalein indicator was added and then titrated against 0.1 N sodium hydroxide (NaOH) until a faint pink colour appeared. The number of ml of sodium hydroxide solution or titre was divided by ten and expressed as percent lactic acid.

Statistical evaluation

The data on microbial counts was expressed in percentages to compare the occurrences of groups of microorganisms at different levels of milk handling along the chain. Least significance deviation was used to compare means of total counts of different types of microorganisms at different levels of milk handling. Different locations of milk chain were compared for Salmonella incidences. Regression analysis was used to predict the rate of TVC reduction against acid development in camel milk along the chain.

RESULTS AND DISCUSSION

The results presented in Table 1 shows microbial load at different levels of the camel milk chain. 66% of raw milk samples from farm environment had microbial load of less than 10^5cfu/ml. The results suggest that at the farm, the camel milk is less contaminated as compared to recommended standards for milk acceptance for processing. For example, Kenya bureau of standards recommends a maximum of 10^6cfu/ml for raw milk acceptance for processing (KEBS, 1976). The pastoralists prefer consuming camel milk in raw form. At this microbial load, they may argue that it is safe. However, at this microbial load, it is advisable to use preservation methods like pasteurization or cooling at farm environment to enable transportation to distant market outlets. Facilities for these methods are hardly available in pastoral environment where camel milk is produced. Camel milk is also less contaminated at farm because it has not undergone many handlers. The only contamination at this stage may come from the infected udder mostly caused by the cocci group. Table 2 indicates an incidence of 42% of the cocci at farm. The cocci are mostly associated with camel mastitis involving organisms (Younan , 2001; Guliye et al., 2002).

At bulking and market centres, microbial contamination increased to almost 100% cfu/ml as shown by TVC and CC in Table 1. This is associated with post harvest handling of the milk. However, this percentage was reached after 12 to 48 h of camel milk being stored at environmental temperatures at production or on transit to other distant markets from farm environment. In marginal areas, food production, processing and marketing is highly fragmented and dependents on small producers and their indigenous knowledge. Most of the food goes through many handlers and middlemen and women. This increases the risk of exposing the food to unhygienic environments, contamination and adulteration (Bachmann, 1992).

The coliforms and spore counts increased from farm to market level (Table 2). The coliforms formed the majority of the TVC. This is in agreement with Abee et al. (1995). Coliforms are known to dominate over other organisms in milk with time. They can adapt to several survival strategies in any food material. These survival strategies range from temperature evasions, acid tolerances and production of probiotics like colicins to forming complex patterns or cooperative organizations of colonies against adverse conditions in their environment especially acid environments. This is shown in Figure 2 where the acid increase had slow effect on microbial load reduction.

The Gram-negative rods (GNR) dominated the farm environment with an incidence of 55% along the chain (Table 2) and the main isolates included Pseudomonas and *Flavobacterium spp* (Table 3). These can be found on humans and animals, in soil, on plants and in water. According to Christina and Bromley (1983) and Wolfgang and Gunter (1988) they are described as environmental microorganisms. The faecal coliforms (*Escherichia coli* and *Enterobacter aerogenes*) (Table 4) had an incidence of 47% at bulking and market level along the chain. These originate from the colon of humans and animals and are indicators of hygiene. The implication here is that camel milk handling at bulking and market level is not hygienic, hence contamination by faecal material from

Table 2. Incidence of main groups of microorganisms detected in raw camel milk.

Parameter	N	G+vecocci	G-ve rods	G+ve rods	Spores	Y and M
Farm	107	45(42%)	58(54%)	2	1	1
Bulking	52	12(23%)	28 (54%)	7	3	2
Market	59	10	32 (54%)	7	6	4
Total	218	67	118	16	10	7
Incidence (%)		31	55	8	5	3

G+ve, Gram-positive; G-ve, Gram-negative; Y and M, yeast and moulds.

Table 3. Microbial spp isolated in chain of camel milk (N=218).

Parameter	Number	*Escherichia coli*	*Enterobacter aerogenes*	*Micrococci*	*Pseudomonas*	*Flavobacterium*	Yeast/mould
Farm	107	0	0	15	4	4	4
Bulking	52	31	29	0	1	0	0
Market	59	26	16	0	0	0	0
Incidence (%)		26	21	7	2	2	5

Table 4. Salmonella detection along the camel milk chain.

Chain level	n	+ve
Environment (soil, water, faeces)	31	6
Farm (udder)	120	15
Processing	19	5
Marketing	26	0
Total	196	26 (13%) incidence

animals and humans.

Salmonella enterica occurrence along the camel milk chain had an incidence of 13% with the highest being at the farm environment (Table 4). The sources of this pathogen may constitute the risk factors that are associated with the prevalence in the environment. Camels, soil and water and pastoralists themselves are possible sources of contamination. The pastoralists and the camels may be healthy carriers, and they may persistently shed the pathogen in the environment. The pathogen finds its way into other transmissible avenues like water, soil, milk and equipment.

The acid effect on microbial load in camel milk chain is shown in Figure 1. The acid increased from an initial value of 0.17 to 0.24% L.A in 5 h when there was a noticeable coagulation while there was a steady decrease in TVC by 2 log cycles from a high value of 6.5 - 4 log10 cfu/ml. FAO (1982) reported that lactic acid content of camel milk increased from 0.03 to 0.14% after 6 h of fermentation while in Pakistan; a noticeable increase was detected after 8 to 10 h (Khaskheli et al., 2005). The slow acid development in camel milk during spontaneous fermentation despite the high microbial contamination may be associated with the chemistry and antimicrobial components of the camel milk. Antibacterial protective milk proteins, especially lysozyme, lactoferin and lactoperoxodase are high in camel milk. These proteins are bacteriostatic and sometimes bactericidal to the Gram-positive and Gram-negative species of bacteria (Barbour et al., 1984; Farah, 1996). The preservation of raw camel milk may possibly be due to these proteins that naturally occur in camel milk in large amounts. Chemically, camel milk has non-compactcasein micelle hence very low κ-casein as compared to cow milk as substrate for enzymes to coagulate the milk proteins. The availability of κ-casein decreases with increasing micelle size. Its low content in camel milk may also be the cause of slow coagulation of camel milk as observed by Eksterend et al. (1980) and Walstra and Jenness (1984).

As compared with cow milk which coagulates in less than 2 h under the same conditions, camel milk inhibits acid development. This could be due to weak organic acids as a result of slow fermentation of camel milk becoming potent inhibitors of microbial metabolism. The

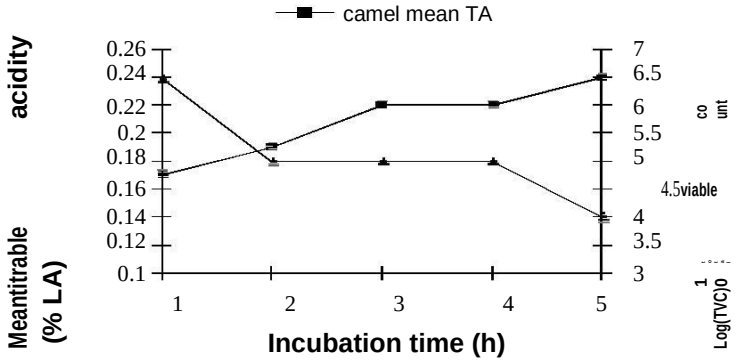

Figure 1. Acid development in relation to total viable counts (TVC) in raw camel milk during spontaneous fermentation at production environment. Mean titrable acidity (TA) *is expressed as* percentage lactic acid (%LA).

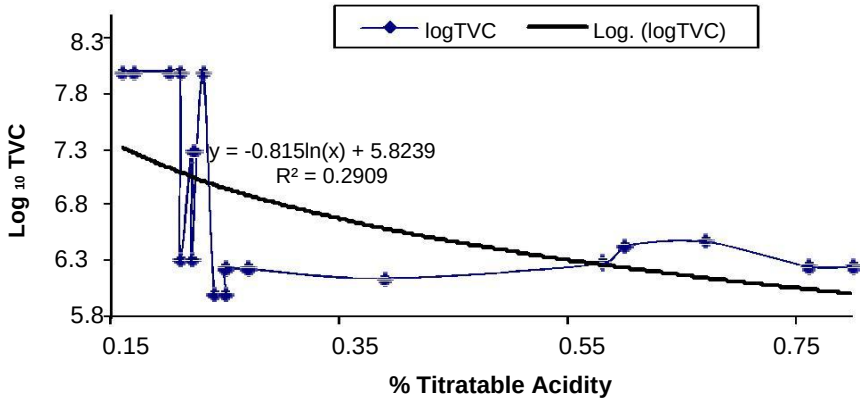

Figure 2. The relationship between $\log_{10}$ total viable counts (TVC) and titratable acidity for market camel milk samples.

weak organic acids like lactic acid, acetic acid and propionic acid resulting from the fermentation of lactose in camel milk are known to be potent to microorganisms (Adams and Moss, 1997).This may explain why the acid increased slowly in camel milk on transit to market and at the market level while TVC reduced at 29% rate (Figure 2).

Conclusion

In view of the observed results of the analysis of microbial quality and safety of camel milk, it could be concluded that camel milk at farm has less microbial contamination. However, with commercialization, there is need to address handling procedures along the chain to reduce further contamination and possibility of occurrence of pathogens. This could contribute to food security and nutrition of the consumers. The result on acid development depicts the physico-chemical properties of camel milk which imply that the milk can be self preserving. However, product development as value addition on camel milk will be dependent on this property. Much still needs to be learned on this property.

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