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Subclinical mastitis affecting hygienic quality of marketed camel milk from North-Eastern Province, Kenya

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ABSTRACT

In North-Eastern Province, camel is the dominant livestock; it provides subsistence to many people especially during the frequent droughts when other animals either die or are unthrifty. This is because camel is highly suited for hot environments. In this region, camels number approximately 3 million and are the main producers of milk for the residents, who are mainly of Somali origin, and are pastoralists. Currently, the milk is also sold in Nairobi and other far places; and there is a fast-growing demand for it. This has necessitated examination of the milk quality, in response to food-safety awareness, especially noting that some of the bacteria causing subclinical mastitis can cause disease in humans. This study was carried out to establish the hygienic quality of camel milk from this area, zeroing down to 2 districts, Garissa and Wajir. Three hundred and eighty four bulk camel milk samples were collected in volumes of 200 to 300 ml. They were transported to the laboratory in cold/ice boxes and bacterial isolation and characterization done not later than 24 h after arrival at the laboratory. Before culturing, the milk samples were screened using California Mastitis Test (CMT); samples testing positive (an indication of subclinical mastitis) were then subjected to bacteriological investigation, using standard methods. Results of this study have shown that subclinical mastitis is prevalent in dromedary camels of Garissa and Wajir districts of North-Eastern province of Kenya, and that Gram-positive cocci (*Staphylococcus* and *Streptococcus)* are the dominant mastitis pathogens isolated. Other isolated bacteria included Klebsiella/Enterobacter, *Escherichia coli* and *Bacillus.* The positive correlation of CMT with the presence of mastitis pathogens in camel milk showed that CMT is a useful screening test in the detection of subclinical mastitis in camels; it is thus a useful tool for farmers, aiding them in picking the affected animals, segregating and treating them. The results also contribute towards coming up with respective control measures so as to keep camel milk fresh for longer periods and also make it safe for human consumption.

Keywords: Subclinical mastitis, camel milk, North Eastern Kenya.

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INTRODUCTION

The camel population in Kenya is approximately 3 million of which more than half are reared in North Eastern Province (National census, 2009). The camels are reared together with sheep, goats and cattle but the camels are the key milk providers especially during the dry seasons when other animals die or are unthrifty (Guliye, 2006). The milk is used by pastoralists to provide high quality nutrition especially to children as well as serving as a source of income for many livelihoods. Milk is a good medium for several bacteria to thrive in. The growth of bacteria in milk depends mainly on temperature and presence of other bacteria (Heeschen, 1994). As camel milk is usually consumed in its raw state, either fresh or in varying degrees of sourness by the pastoralists, the presence of pathogenic bacteria may be of public health importance besides its influence on animal health as reported by Saad and Thabet (1993) as well as Younan (2004). Generally, bacteria in milk can occur through

colonisation of the teat canal or an infected udder (clinical or subclinical mastitis), or as contaminants (Younan, 2004).

Milk can get contaminated at different points; first during milking (the source being udder infection, milking equipment, or milking person); others are: during transportation and/or storage of the milk. The main reasons for spoilage of milk are bacteria; most of which are saprophytic, but some are pathogenic and zoonotic (Heeschen, 1994; Semereab and Molla, 2001).

A high percentage of subclinical mastitis in camels is reported by several authors (Barbour et al., 1985; Abdurahman et al., 1995; Obeid et al., 1996; Almaw and Molla, 2000). The pathogenic bacteria reported by different scientific groups are similar to bacteria reported in mastitis of cows or other animals kept in traditional nomadic environment or camel farms (Barbour et al., 1985; Almaw and Molla, 2000). The total bacterial count (TBC) of camel milk is reported with values that vary between 10^2 and 10^8 cfu/ml by Semereab and Molla, 2001; Wernery et al., 2002; Younan, 2004. These differences underline the fact that TBC depends on several parameters: bacteria originally present in the camel milk, contamination of the camel udder, contamination of the person doing the milking, contaminated containers etc. The relation of the different sources of contamination varies according to the keeping and milking conditions of the camels. Under pastoral production conditions, environmental contamination is likely to play a major role in the hygiene of raw camel milk than initial bacterial contamination of the camel milk (Younan, 2004). If the TBC is low, raw milk was observed not to turn sour for 4 days, when it was kept in a clean container and refrigerated (Younan, 2004).

Poor management and unhygienic milking practices prevalent in the traditional husbandry systems, which include tying of the teats with soft barks to prevent the calf from suckling, tick infestations and cauterization of the udder and skin, are few of the factors responsible for contamination of milk (Abdurahman, 1995; Almaw and Molla, 2000; Obeid et al., 1996; Woubit et al., 2001). This study was therefore aimed at determining the bacteriological quality of raw camel milk.

MATERIALS AND METHODS

Study area

The study was carried out in Garissa and Wajir districts of North-Eastern province from January 2008 to December 2008. These are two of the four districts making up the expansive North Eastern province of Kenya. They lie in the Arid and Semi-Arid Lands (ASAL) of the country. The rainfall pattern is erratic and unreliable. It is always less than 600 mm annually. Temperature ranges between 22 and 42°C. The districts are flat, covered by trees and shrubs with grass undergrowth. Water sources are rivers (permanent and seasonal), pans, boreholes, dams and shallow wells. The mainstream activity of the two districts is livestock keeping. The livestock are kept under pastoralist system. They include cattle, sheep, goats, camels, donkeys and poultry. Nomadic pastoralist communities living in ASAL regions largely depend on milk produced by camels which contribute 80% of the household needs (Schwartz and Dioli, 1992; Guliye, 2006). Surface water is a serious problem in this area. Animal husbandry is characterized by extensive pastoral production system and seasonal mobility. Camel and cattle herd splitting into mobile "*forra*" and home-based "*herd*" is practiced as strategy to mitigate forage and water shortage. Camel herd movement may be moving the whole herd to water point and to relatively high altitude where green forage is available.

Study design

The study was cross-sectional. Marketed milk was used and subclinical mastitis was detected using California mastitis testing and isolation and characterization of bacteria. CMT was done first, samples testing positive were then subjected to bacteriological study (Gram staining, culture and identification).

Sample collection

Samples of raw milk, produced by locally-kept camels, were collected from various market points in the two districts. Volumes of 200 to 300 ml of bulk camel milk (from producers or hawkers) were collected into labeled sterile bottles and kept in an ice box. They were then transported to laboratory for bacteriological isolation and identification; this was done either immediately or after keeping them for not more than 24 h in a refrigerator. The number of samples processed was 384 (230 km from Garissa and 154 km from Wajir).

Sample size determination for the milk samples

The sample size (n) was determined by estimation of the proportion as anticipated prevalence of mastitis in camels. The prevalence of mastitis in camels in Kenya is estimated at 25% as reported by Younan et al. (2001).

Sample size (n) = $Z\alpha^2 pq/L^2 = 1.96^2 \times 0.25 \times 0.75/0.05^2 = 300$ (camel milk samples)

Where;
n = the required sample size
$Z\alpha = 1.96$ = the normal deviate at 5% level of significance
p = the estimated prevalence (in percentage)
q = 1 – p

California mastitis test (CMT)

California mastitis test was done using a modification of the procedure described by Schalm et al. (1971). A CMT kit, carried out following standard methods (Quinn et al., 1994; Schalm et al., 1971), was used to screen the 384 milk samples for subclinical mastitis. Interpretation of the test was based on the amount of gel formation in the sample (Table 1).

Demonstration of bacterial presence in the milk samples

This was done through direct observation (Gram staining) and later through culture and characterization.

Gram stain procedure was performed according to the method described by Forbes et al. (2002) and Bebora (2007), while bacterial culture and characterization were carried out following

Table 1. CMT reaction and equivalent milk somatic cell counts (SCC) in cattle applied to camel milk.

Test results	Reaction observed	Equivalent milk SCC (cells/ml)
Negative	No gel formation	0 – 200,000
Trace	A slight slime formation	150,000 - 500,000
1+	Distinct slime formation immediately	400,000 - 1,500,000
2+	Formed slime settles at the bottom and side	800,000 - 5,000,000
3+	Formed slime is convex and domed up	>5,000,000

Source: Radostits et al. (2005)

Table 2. Frequency distribution for California Mastitis Test for Garissa and Wajir milk samples, separately and collectively.

Parameter	Garissa n = 230		Wajir n = 154		Garissa and Wajir combined n = 384	
	No. positive	% positive	No. positive	% positive	No. positive	% positive
Overall positive	139	60	96		235	61.2
2+	4	3	10	6	14	3.7
1+	58	25	40	26	98	25.5
Trace score	77	33	46	30	123	32.0

standard methods as described by Quinn et al. (1994) and Sears et al. (1993). Culture was done on 7% sheep Blood Agar and MacConkey agar plates, incubated aerobically at 37°C for 24 to 48 h. Presumptive identification of bacterial isolates on primary culture were made based on colony morphology and hemolytic characteristics on blood agar. These were then subcultured to produce respective pure cultures, which were Gram stained. Further characterization of members of the family Enterobacteriaceae comprised carrying out of several tests, including: Indole test, methyl-red test, Voges Proskauer test, citrate utilization test, urease test, catalase test, oxidase test, reaction on triple sugar iron agar and on sulphur indole motility medium (Quinn et al., 1994; Sears et al., 1993; Forbes et al., 2002). *Staphylococcus* and *Micrococcus* species were identified based on their growth characteristics on mannitol salt agar (MSA), coagulase production, catalase, and oxidase tests. *Streptococcus* species were evaluated according to CAMP reaction, growth characteristics on 7% sheep blood agar, catalase production and sugar fermentation tests (Quinn et al., 1994; Sears et al., 1993; Forbes et al., 2002).

Primary bacterial isolation was done in the field laboratory (Garrissa District Veterinary Investigation Laboratory (VIL). Bacterial colonies from the two primary isolations (7% sheep blood agar and MacConkey agar) were inoculated into nutrient agar slants (transport media), incubated at 37°C for 12 h, and then stored at 4°C in Garissa VIL. These colonies were later transported in a cool box to the University of Nairobi, bacteriology laboratory for secondary bacterial culture and further biochemical testing/characterization, using the same type of media.

Data analysis

Data collected was entered into Ms-Excel as data package for processing and was analyzed with Instat for windows to obtain frequency distribution for California Mastitis Test (CMT) and isolation of various bacterial microorganisms including *Staphylococcus* species, *Micrococcus* species, *Streptococcus* species, *Bacillus* species, *Escherichia coli, Klebsiella* species and *Enterobacter* species.

Figure 1. Wajir and Garissa Districts.

RESULTS

Results of California mastitis test (CMT)

Frequency distributions for CMT positive reactions for Garissa and Wajir districts, separately and collectively, are given in Table 2, while Figure 1 gives comparison of frequencies, in percentage, of CMT for the 2 areas, separately and collectively.

Table 3. Bacteria isolated from camel milk samples from Garissa and Wajir districts.

Bacteria		Garissa n = 230		Wajir n = 154		Garissa and Wajir combined n = 384	
		No.	%	No.	%	No.	%
Staphylococcus species	Total isolated	202	87.8	144	93.5	346	90.1
	Coagulase positive	69	30.0	22	14.3	91	23.7
	Coagulase negative	133	57.6	122	79.2	255	66.4
Streptococcus species	Total isolated	195	84.8	131	85.1	326	84.9
	CAMP positive	72	31.3	30	19.5	102	26.5
	CAMP negative	123	53.5	101	65.6	224	58.3
Bacillus species		116	50.4	60	39.0	176	45.8
E. coli		168	73.0	62	40.3	230	59.9
Klebsiella/Enterobacter		221	96.1	148	96.1	368	95.8

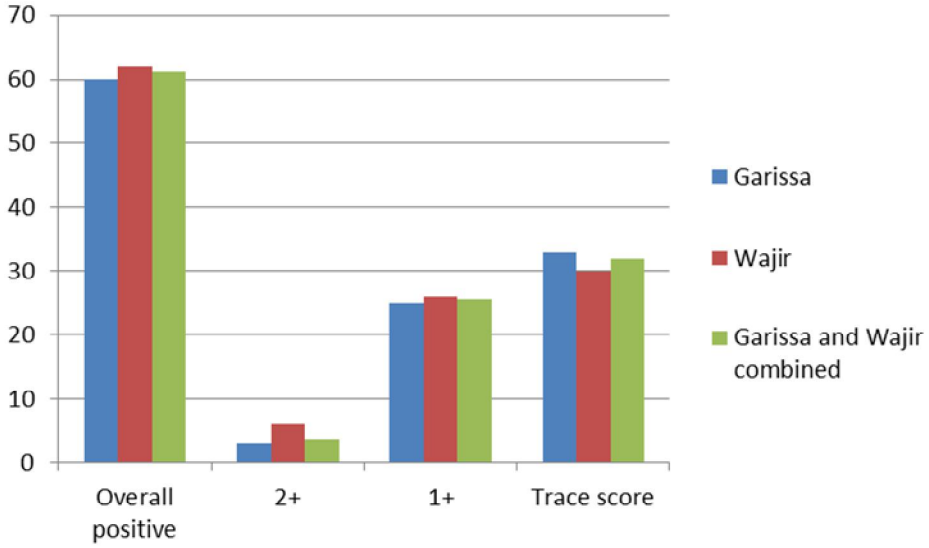

Figure 2. Percentage comparison of CMT score.

Of the 384 camel samples (230 from Garissa and 154 from Wajir) investigated for subclinical mastitis, 235 (61.2%) gave positive reactions. The equivalent somatic cell counts (SCC/ml) of the positive samples (as extrapolated from CMT observations) ranged from 1.5 × 10^5 to 5 × 10^6 leucocytes per milliliter of milk. Majority of the CMT reactions were traces (representing cell counts of between 800,000 and 5,000,000 cells/ml), followed by 1+ (representing cell counts of 150,000 to 500,000 cells/ml); few gave reactions of 2+ (representing cell counts of 400,000 to 1,500,000 cells/ml). For Garissa and Wajir, separately, 139/230 and 96/154 gave positive reactions, respectively. For both, the majority of the reactions were traces, followed by 1+ scores. Those with 2+ scores were fewer. It was noted, however, that Wajir samples gave a higher percentage of 2+ scores and lower percentage of trace scores than Garissa.

Bacteriological results

Gram staining revealed the presence of both Gram positive and Gram negative bacterial cells in the milk samples tested. This result was used as an indicator for the primary isolation of the bacteria in media. The various bacteria (and their respective prevalences) isolated from the camel milk samples from Garissa and Wajir, respectively, and as combined data, are given in Table 3, while respective percentages are given in Figure 2. Breakdowns of isolated *Staphylococcus* and *Streptococcus*, with respect to coagulase production and CAMP reaction, respectively, are given in Figures 3 and 4.

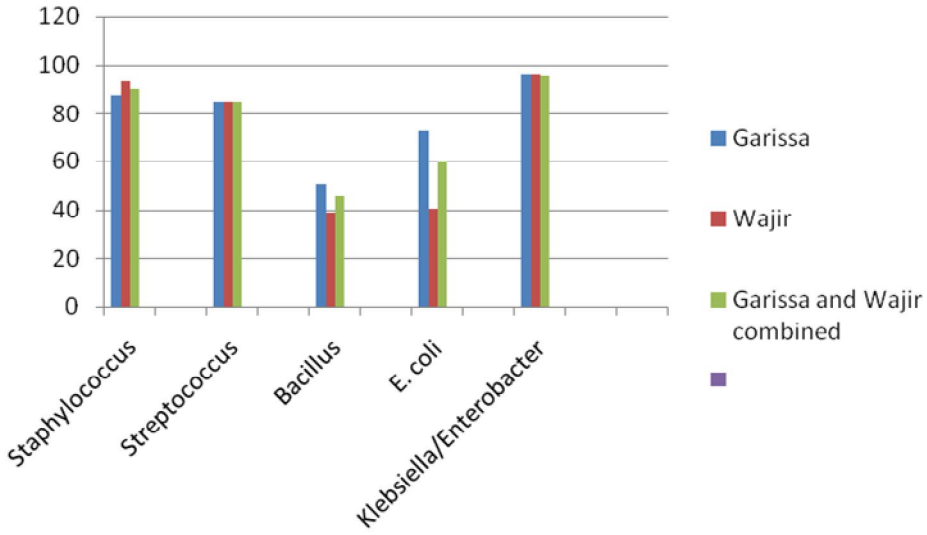

Figure 3. Comparison of percentage occurrences per bacterial organism.

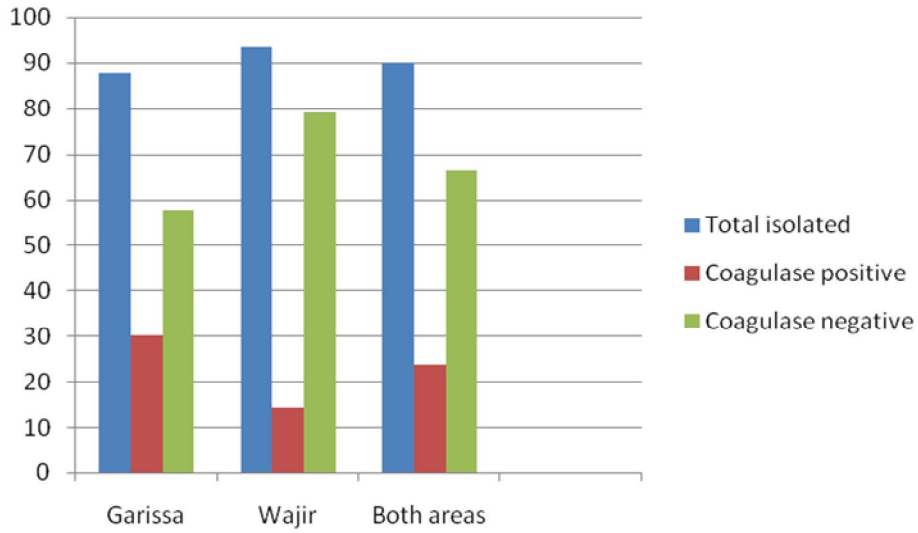

Figure 4. Comparison of staphylococcus prevalences (coagulase positive and negative).

Overall all the milk samples yielded mixed types of bacteria on culture. The most isolated bacterium was *Klebsiella/Enterobacter* (at 96%), followed closely by *Staphylococcus* (90%) *and Streptococcus* (85%). The others were *E. coli* (60%), and *Bacillus* (46%). Coagulase-positive *Staphylococcus* was isolated at 24% and CAMP-positive *Streptococcus at* 27%. When considered separately, Garissa yielded more of *Bacillus* (Garissa 50% and Wajir 39%) and *E. coli* organisms (Garissa 73% and Wajir 40%) than Wajir, while Wajir yielded more *Staphylococcus* than Garissa (94% in Wajir and 88% in Garissa); *Streptococcus* (85%) and *Klebsiella/Enterobacter* (96%) were isolated at more-or-less the same rate in both areas. Garissa yielded more (30%) coagulase positive *Staphylococcus* than Wajir (14.3%), despite more *Staphylococcus* having been isolated from Wajir (93.5%) as compared to Garissa (87.8%). Garissa also yielded more (31.3%) CAMP positive *Streptococcus* than Wajir (19.5%); *Streptococcus* was isolated at same prevalence (85%) for the two areas (Figure 5). This high bacterial carriage indicated presence of subclinical mastitis, leading to sale of poor-quality milk, the source of contamination being both inherent and environmental. If not processed properly, the milk could be a source of disease in humans.

Discussion

The prevalence of sub-clinical mastitis in the two districts

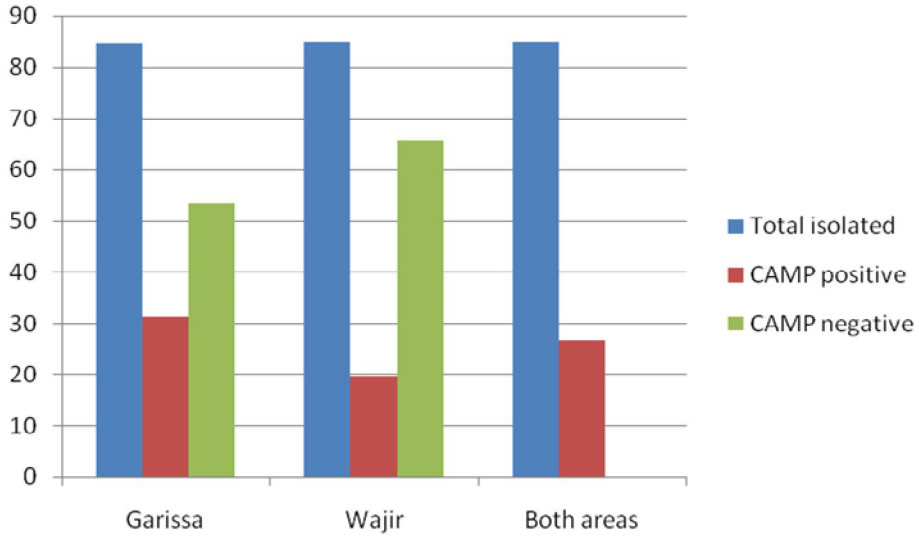

Figure 5. *Streptococcus* prevalences (%): Total, CAMP positive, CAMP negative.

according to CMT results was 61.2%, with a CMT trace score accounting for 32.0%, 1^+ score accounting for 25.5% and 2^+ score accounting for 3.7%. These findings are in accordance with earlier published report from dromedary she-camels in Jordan (Hawari and Hassawi, 2008), with the most predominant bacterial isolates being Gram-positive cocci of genera: *Staphylococcus, Streptococcus* and *Micrococcus*. Since the milk samples in this study were collected from bulked/pooled milk from different camels and producers, this was taken as an explanation for the recorded high prevalence of these two major mastitis-causing pathogens, which normally originate from the udder. The prevalences were higher than those recorded by other researchers (Abdurahman et al., 1995; Al-ani and Al-Shareefi, 1997; Barbour et al., 1985; Obied et al., 1996; Quadil and Quadar, 1984) who based their figures on quarter-milk samples. However the high prevalence of coliforms (*Escherichia, Klebsiella/Enterobacter*) and *Bacillus* was attributed to contamination of milk containers from the environment due to the poor hygiene in handling milk along the collection and marketing chain, including the various containers used. The influence of pooling of different camel milk batches along the collection and marketing chain was illustrated by the increase in prevalence of *Streptococcus agalactiae* (26.56%), an observation supported by Younan et al. (2002). The positive correlation of CMT with the bacteriological findings indicated that camel milk, like that of cows (Schalm et al., 1971), goats and sheep (Coetzer et al., 1994), has phagocytic cells which normally constitute one of the essential defenses against microbial infections. It also indicated that these phagocytic cells constitute one of the essential defenses against microbial infection of the mammary glands. An increase in the number of somatic cells, particularly granulocytes (as extrapolated through CMT), in camel milk is a good indication of inflammation. As in the cow, the intensity of the cellular reaction correlates with the degree of irritation of the mammary gland. This confirms that CMT can be used as a screening test to detect subclinical mastitis in camels; an observation that was also made by other researchers (Barbour et al., 1985; Saleh and Fave, 2011). The estimates of the somatic cell counts of the milk samples, as extrapolated through CMT, (of between 1.5×10^5 and 5×10^6 leukocytes/ml of milk), found in this study, are in agreement with those of Kospakove (1976), cited by Abdurahman et al. (1995), who reported a mean score of 1.3×10^6 leukocytes/ml from milk samples in Bactrian camels.

The relative number of the various pathogens isolated in this study, especially that of *Staphylococcus aureus* and *Streptococcus species*, is very similar to that reported by Woubit et al. (2001) and Abdurahman (2006). This study has thus confirmed what other researchers (Barbour et al., 1985; Woubit et al., 2001) have found that *S. aureus* and *Streptococcus* spp. are major causative agents of mastitis in camels. However, camels have not been the subject of experimental mastitis studies and the epidemiology and pathogenicity of mastitis-causing organisms remain unclear. Camels affected by mastitis are reported to have considerably shorter lactation periods (Barbour et al., 1985). The disease is not usually treated in traditionally managed camels and will often take a natural course to chronicity resulting in permanent loss of milk production (Abdurahman et al, 1991; Obeid et al., 1996). The isolation of *Streptococcus agalactiae* and other major mastitis pathogens could thus be attributed to the lack of supply and infrequent use of antimicrobials, and inaccessibility of veterinary services for the camel owners, as compared to the dairy cow owners, in urban and peri-urban areas (Woubit et al., 2001).

Considering the isolated environmental coliforms, *Klebsiella/Enterobacter* species were isolated at a much higher rate (96%) than *E. coli* (60%).

It was demonstrated through another study that the traditional husbandry systems carried out by these people included poor managemental and unhygienic milking practices like dry milking and tying of the teats with soft barks to prevent the calf from suckling, and cauterization of the udder skin. The animals were also infested by ticks on the udders. These predispose the udders to bacterial infections, which may persist as chronic infections. These factors have also been documented by other workers (Abdurahman et al., 1995; Obeid et al., 1996; Almaw and Molla, 2000; Woubit et al., 2001). The chronic infections could result in induration and atrophy of injured quarters and loss of milk production (Obeid et al., 1996; Abdurahman et al., 1991).

Conclusions

Results of this study have shown that subclinical mastitis is prevalent in dromedary camels of Garissa and Wajir districts of Northeastern province of Kenya, and that Gram-positive cocci are the dominant mastitis pathogens isolated. The positive correlation of CMT with the presence of mastitis pathogens in camel milk showed that CMT is a useful screening test in the detection of subclinical mastitis in camels; it is thus a useful tool for farmers, aiding them in picking the affected animals, segregating and treating them. The results are significant as they contribute towards coming up with respective control measures so as to keep camel milk fresh for longer periods and also to make it safe for human consumption. Increased awareness on hygienic milking practices and use of simple tests like CMT as well as use of aluminum cans (which are easy to clean) can greatly contribute to improved quality of milk for sale and consumption. The use of these technologies and their impact on milk hygiene need to be evaluated in the future.

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REFERENCES

Abdurahman OA, 2006. Udder health and milk quality among camels in the Errer valley of eastern Ethiopia. Livest Res Rural Dev, 18:8.

Abdurahman OA, Agab H, Abbas B, Astrom G, 1995. Relations between udder infection and somatic cells in camel (*Camelus dromedarius*) milk, Acta Veterinaria Scand, 36(4):423-432.

Abdurahman OA, 1995. Milk N-acetyl-B-D-glucosaminidase and serum albumin as indicators of subclinical mastitis in the camel. J Vet Med A, 42:643-647.

Abdurahman OAS, Borstein S, Osman KS, Abdi AM, Zakrisson G, 1991. Prevalence of mastitis among camels under two different milking management systems. Doctorate thesis, Veterinary Faculty, Ludwig-maxmillians- Universitat Munchen, pp 120.

Al-Ani FK, Al-Shareefi MR, 1997. Studies on mastitis in lactating one humped camels (*Camelus dromedarius*) in Iraq. J Camel Pract Res, 4:47-49.

Almaw G, Molla B, 2000. Prevalence and etiology of mastitis in camels (*Camelus dromedaries*) in Eastern Ethiopia. J Camel Pract Res, 7: 97–100.

Barbour EK, Nabbut NH, AL-Mukayel AA, 1985. Mastitis in *Camelus dromedarius* in Saudi Arabia. Trop Anim Health Prod, 17:173–179.

Bebora LC, 2007. Immunology Practical Manual for Master of Science (MSc) Students, University of Nairobi, College of Agriculture and Veterinary Services, Faculty of Veterinary Medicine, Department of Pathology, Microbiology and Parasitology: Exercise 5: pp 7 – 8.

Coetzer JAW, Thomson GR, Tustin RC, 1994. Infectious disease of livestock with pecial reference to Southern Africa, Vol. II. Cape Town, South Africa, Oxford University Press.

Forbes BA, Sahm DF, Weissfield AS, 2002. Bailey and Scotts Diagnostic Microbiology. 11th Edition. Mosby Inc., 11830 Westline industrial Drive, St. Louis, Missouri 63146. pp 119–132, 148 – 168.

Guliye AJ, 2006. Camel adaptations to ASALS in Kenya. Camel association proceedings in Turkana Kenya.

Hawari AD, Hassawi DS, 2008. Mastitis in one humped she-camels (*Camelus dromedarius*) in Jordan. J Biol Sci, 8:958-961.

Heeschen W, 1994. Milk as food. In: KH Wendt Bostedt HM and HW Mielke fox (eds): Diseases udder and Gesäuge. Gustav Fischer Verlag, Stuttgart, Jena, Germany, pp: 138-180, cited in Eberlein 2007.

Kospakove ZK, 1976. Cell content in the milk of Bactrian camels depending on stage of lactation and condition of the udder problemy veterinarnoi Sanitari, 55: 21-25 (in Russian). Vet. Bull. 1978, 48(11) No 1566.

Obeid AI, Bagadi HO, Muctar MM, 1996. Mastitis in *Camelus dromedaries* and somatic cell content of camel milk. Res Vet Sci, 61:55–58.

Quadil SS, Qudar J, 1984. Bacteriological study of a few mammitis cases on she-camel (*Camelus dromedarius*) in United Arab Emirates (preliminary note). Rev Med Vet, 135:705–707.

Quinn PJ, Carter ME, Markey B, Carter GR, 1994. Clinical veterinary microbiology, London wolfe publishing: pp: 21, 118.

Radostits OM, Mayhew IGJ, Houston DM, 2005. Veterinary clinical examination and diagnosis: WB. Saunders (eds). Page: 122 – 123, 727 – 731.

Saad NM, Thabet AER, 1993. Bacteriological quality of camel’s milk with special reference to mastitis. Assiut Vet Med J, 28:194-199.

Saleh SK, Fave B, 2011. Detection of subclinical mastitis in dromedary camels (*Camelus dromedarius*) using somatic cell counts, California mastitis test and udder pathogen. Emir J Food Agric, 23(1):43-53.

Schalm OW, Carall EJ, Jain NC, 1971. Bovine Mastitis. Philadelphia PA, USA, Lea and Fahiger: 24: 128.

Schwartz H, Dioli M, 1992. The one humped camel in eastern Africa. A pictorial guide to diseases, health care and management. Berlin VJ Margraf, p. 263.

Sears PM, Gonzalez RN, Wilson DJ, Han HR, 1993. Procedures for mastitis diagnosis and control. Vet Clin N Am Food Anim Pract, 9:445-467.

Semereab T, Molla B, 2001 Bacteriological quality of raw camel (*Camelus dromedaries*) in Afar region (Ethiopia). J Camel Res Pract, 8:51-54.

Wernery U, Becker H, Meertlbauer E 2002. Microbiological status of raw dromedary milk. J Camel Pract Res, 9 (1):1-4.

Woubit S, Bayleyegn M, Bonnet P, Jean–Baptiste S, 2001. Camel (*Camelus dromedarius*) mastitis in Borena lowlands pastoral area, Southwestern Ethiopia. Elev Med Vet Pays Trop, 54 (3–4):207–212.

Younan M, 2004. Milk hygiene and udder health. In. Milk and meat from the camel: Handbook in products and processing. Zurich. Eds Farah and Fischer, 232:67-76.

Younan M, Bornsteins A, Muller W, 2001. Application of the California

mastitis test in intrammary *Streptococcus agalactiae* and *Staphylococcus aureus* infection of camels (*Camelus dromedarius*) in Kenya. Prev Vet Med, 51:307–316.

Younan M, Fink K Laemmler C Kenyanjui M, 2002. *Streptococcus agalactiae* in marketed camel milk. In: Livestock Community and Environment. Proc. 10th Int. conf. Association of Institutions of Tropical Veterinary Medicine, Copenhagen, Denmark. Royal Veterinary and Agricultural University. pp: 555.

APPENDIX

Questionnaire format for camel milk producers (pastoralists and farmers) in Garissa and Wajir Districts

Camel milk chain enhancement in Garrissa and Wajir District questionnaire for camel milk producers (farmers and pastoralist) - 2008/2009

[I]: Introduction

Good morning/afternoon/evening. My name is DR. WANJOHI. I am an interviewer from the University of Nairobi which is a teaching and a research institution. Today, we are conducting a study to identify the constraints in the camel milk chain with a view to designing appropriate solutions and we would be very grateful to get your input. We uphold the secrecy and confidentiality of any information provided. I wish to state that any information provided will be used for the purpose of the study only.

[II]: General

Date: Day / Month / Year. _____ / _____ / _____

1. Name of the respondent._____
2. District._____ Division._____ Location_____
   Sub-location_____ Village_____
3. Name of the group _____. Membership _____
4. GIS (Geographical Information System) location._____
5. Number of people in the household._____

[III]: Livestock keeping

1. What livestock do you keep and how many of each? (i) Cattle_____ (ii) Camels_____
(iii) Sheep_____ (iv) Goats_____ (v) Others (Specify) _____
2. Why do you keep Camels? (i) Consumption_____ (ii) For sale_____ (iii) For traditional ceremonies_____ (iv) For milk production_____ Others (specify)_____
3. Where do you graze and water your Camels? (i) Graze_____ (ii) Water_____
4. How often do you water your camels? (i) Daily_____ (ii) Every 3 to 5 days_____
(iii) Once a week_____ (iv) Monthly_____ (v) Others (specify) _____
5. Do you give extra feed to your camels apart from grazing? _____
6. If yes why do you give these extra additives? _____. Where do you obtain them from? _____
7. What are the age groups of the camels that you have and what are the numbers? (i) Adult-females ____ (ii) Adult-males _____ (iii) Wearners and Growers _____ (iv) Calves _____
8. How many adult females are milking? _____
9. How many times do you milk your camels in a day and how much milk is produced per milking? _____ (i) Morning_____ (ii) Evening_____
10. What is the average amount of milk produced by the camel per day? (i) During dry season_____
(ii) Wet season_____
11. Who does the milking? _____
12. What milking procedure do you use? _____
13. What problems are encountered during milking? (i) Swollen painful udder and teats _____ (ii) Milk discoloration (bloody /reddish) _____ (iii) Change in milk consistency (watery, clotted, creamy) _____ (iv) Traumatic lesions on the udder and teats _____
14. For how long do you milk your camels before they deliver again? _____
15. What containers do you use for milking, preserving and transportation of the camel milk and what are their costs?

	Milking	Transportation	Preservation	Cost per container
(i) Plastic containers	_____	_____	_____	_____

(ii) Gourds/Traditional _____ _____ _____ _____
(iii) Aluminium/steel _____ _____ _____ _____
(iv) Others (specify) _____ _____ _____ _____
16. Do any of the above containers belong to any group? _____. If yes what is the name of the group? _____
17. How often do you wash / clean your milk containers? (i) Immediately after milking _____ (ii) Just before the next milking _____ (iii) Others (specify) _____
18. How do you wash your milk containers? (i) Use of detergent _____ and its name _____ (ii) Use of cold, warm or hot water _____ (iii) Use of disinfectant and its name _____
19. What is the purpose of the milk produced by the camels? (i) Sale _____ (ii) Domestic consumption_____ (iii) Feeding calves_____ (iv) Others (specify) _____
20. What quantity of camel milk is sold? (i) Fresh _____ (ii) Sour _____
21. Who takes care of the camels by grazing and watering them? _____ and who makes management decisions? _____
22. What diseases have you noticed in your herds of camels (i) Mastitis _____ (ii) Trypanosomiasis _____ (iii) Brucellosis/ Abortion _____ (iv) Diarrhoea _____ (v) Udder injury (physical) _____ (vi) Others (specify) _____
23. How do you have your animals treated when they are sick? (i) Gok Veterinarian_____ (ii) Private veterinarian _____ (iii) Traditionally using herbs_____ (iv) Owner treatment using conventional medicine _____ (v) Others (specify) _____
24. What happens to milk from a mastitic camel? (i) Sold _____ (ii) Pour it _____
(iii) Given to calves _____ (iv) Domestic consumption _____
25. What do you do with milk produced from treated camels? (i) Sold _____ (ii) pour it _____ (iii) Given to calves _____ (iv) Domestic consumption _____
26. How is the camel milk meant for home use consumed? (i) Consumed raw _____ (ii) Boiled before consumption _____ and for how long boiling _____
27. Why is camel milk consumed raw without pasteurizing first? _____
28. Do you add any additives to camel milk after milking? _____. What are the reasons? _____
29. How do you store your camel milk after milking before disposing? _____
30. How long does it take to dispose of camel milk for sale after milking? _____
31. Who are your customers for the camel milk? (i) Neighbours _____ (ii) Hawkers _____ (iii) Bulkers /Retailers _____ (iv) Co-operatives/Processors _____
32. How much do you sell a litre of camel milk? ,(i) During wet season _____ , (ii) During dry season _____. Are you comfortable with these prices? _____
33. How strong is the demand for camel milk during wet and dry seasons? (i) Wet season _____ (ii) Dry season _____
34. Do you have any intention of coming together and form a camel-milk marketing society? __
35. What else do you think will help you fetch more money from your camel milk? (i) Process own milk _____ (ii) Improve on milk hygiene _____ (iii) Others (specify) _____
36. Would you or any member of your family / group like to be trained in camel-milk and udder hygiene? _____. For how long would you like to be trained? (i) Three days _____ (ii) Four days _____ (iii) Five days _____ (iv) One week _____
37. Do you have any credit access to improve on your camel rearing / keeping activities? _____.If no would you be interested in some? _____. What would you do with such a credit? _____
38. What do you do to preserve your camel milk for longer periods of time? (i) Boiling _____ (ii) Cooling _____ (iii) Adding Antimicrobials _____ (iv) Adding Hydrogen peroxide _____ (v) Others (specify) _____
39. How would you suggest camel milk be cooled? _____. Would you be willing to pay for cooling services? _____