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Full Length Article

Associations between milking practices, somatic cell counts and milk postharvest losses in smallholder dairy and pastoral camel herds in Kenya

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Abstract This study investigated the relationship between milking practices, mastitis as well as milk somatic cell counts (SCC) and the effects of high SCC on milk production and post-harvest losses (PHL) in smallholder dairy (n = 64) and pastoral camel (n = 15) herds in Kenya. The collected data included milking practices, mastitis test on udder quarters (n = 1236) and collection of milk samples for laboratory analyses: SCC, detection of *Staphylococcus aureus* and *Streptococcus species*. Production losses were computed as a proportion of cows and herds with SCC (>200,000 cells/ml) and PHL as quantity of milk exceeding 4×10^5 cells/ml. Practices associated with production herds included hands, udder washing and drying, and milk let down stimulation with calves suckling or manually ($p < 0.001$). Udder drying was only applied in peri-urban herds (100%). Herd level prevalence of mastitis was lower in smallholder than in pastoral herds (60.7% vs 93.3%). Mastitis positive samples had higher prevalence of *S.aureus* than of *Streptococcus species* in both smallholder (57.9% vs 23.7%) and pastoral (41.6% vs 36.5%) herds. SCC was significantly affected by presence of mastitis and *S.aureus* ($p < 0.001$). Milk PHL from high SCC was higher in smallholder rural herds (27%) compared to peri-urban (7%) and in pastoral peri-urban (81%) compared to rangelands (76%). Milking practices may have contributed to maintain mastitis pathogens in herds. This has led to substantial pre and postharvest milk losses in smallholder and pastoral herds. Therefore teat dipping, dry cow period and herd level mastitis treatment may complement current practices for lower SCC and milk PHL.

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1. Introduction

Milk consumed in Kenya is from cattle, camels and goats reared in smallholder or pastoral herds [1,2]. On-farm hygienic practices are important in assuring quality and safety of milk for consumers and for reducing losses at production and at post-harvest. Hygiene practices of importance include cleanliness of animals (udder), milking environment, milking person and milk harvesting and storage containers [3].

Mastitis is a complex disease characterized by inflammation of the mammary glands with heavy economic losses related to medication and veterinary services, microbiological diagnostic and additional management inputs, culling and replacement of the infected animals [4]. Significant reduction in milk yield has been associated with intra-mammary infection [5,4]. The inflammation severity depends on the causative agent and the host response whose somatic cells play an essential role in immediate defense against local infection [6]. Somatic cells are cells of the immune system and are part of the natural defense mechanisms, including lymphocytes, macrophages, polymorphonuclear and some epithelial cells [7]. Somatic cell count (SCC) provides good indications of infected and uninfected quarters, the former identified by increased SCC as a result of the inflammatory response to the infection [6,7]. The assessment of udder inflammation has therefore been based on detection of elevation of SCC either in individual quarter milk or in bulk milk from farms [8,9].

The most common mastitic pathogens identified in cow and camel milk and presenting high risk of pathogenicity to humans are *Streptococcus agalactiae* and *Staphylococcus aureus* [3,10]. *S. aureus* has toxin producing activity which may cause intoxication while *S. agalactiae* may cause human infections, particularly in newborn children. *S. agalactiae* isolates from camels seem more closely related to the human than to the bovine biotype and can survive for up to 7 days in souring camel milk and at pH of 4.5 [3].

This study determined the: relationship between milking practices, intra mammary infections and milk somatic cell counts (SCC) as well as effects of high SCC on milk production and post-harvest losses in a sample of smallholder dairy and pastoral camel herds.

2. Materials and methods

2.1. Sampling procedure

Milk sampleswere obtained from lactating cows and camels in smallholder dairy and pastoral herds respectively in Nakuru and Isiolo Counties in Kenya. Smallholder dairy herds were categorized into two groups: rural and peri-urban herds. Farmers in Olenguruone Division in the highlands of Nakuru County represented rural herds because of high concentration of dairy farmers practicing free grazing system, long distance (80 km) to Nakuru town center and limited access to diversified market outlets.Peri-urban dairy farmers were sampled in Bahati and Dundori Divisions within the vicinity of Nakuru town center (Fig. 1). This was because of low concentration of dairy farmers, milk production in intensified systems (semi-zero and zero grazing systems), short distance to town center and access to diversified market outlets in Nakuru town. In these two production herds, sampling was done randomly. Pastoral camel herds, however, could only be sampled from those willing to participate in the study and ease of accessing grazing fields where the herds had been moved to. Local Country livestock and veterinary offices aided identification and access to the herds.

2.2. Data collection

Milk samples were collected from 32 smallholder rural and peri-urban herds each, and 15 pastoral camel herds. In the pastoral system, two distinct categories of herds were observed: rangeland browsing herds (n = 11 herds) and peri-urban herds feeding on *Euphorbia tirucalli* (n = 4 herds). Udder quarters (n = 1236) of all milking animals (n = 94 and 222 in smallholder and pastoral herds respectively) were tested for mastitis using California Mastitis Test (CMT) (KENOTEST, Belgium). Individual quarter milk samples were collected when found positive for mastitis; otherwise a composite milk sample of the four quarters was collected in a sterile sampling bottle for further analysis. Milk yield per animal was weighed and information on animals' characteristics was recorded for each sample herd.

All collected milk samples taken to the laboratory were subjected to direct microscopic somatic cell count in accordance with Sarikaya, [11].

Milk samples were further subjected to microbiological identification of *S. aureus* and *Streptococcus*, being the major contagious pathogenic mastitis causing organisms. Milk was diluted in peptone water to 10^{-1} then streaked using an inoculating loop on Baird Parker agar and KF streptococcal agar (HIMEDIA).

Production (pre-harvest) losses in smallholder herds were estimated as a proportion (percentage) of sample herds with high somatic cell count in milk based on the procedure of Tyler et al. [4] to quantify milk yield losses (Table 1). Milk post-harvest losses (PHL) were estimated as quantity of milk exceeding 4×10^5 cells/ml corresponding to the level of clinical mastitis. However, most of the milk with high SCC reached the market since both milks failing and passing the tests were pooled, collected by transporters and delivered to the targeted market outlet (collection centers or informal outlets). In pastoral camel herds an assumption was made that all milk positive for mastitis was a postharvest loss because of the insufficient good postharvest handling practices to making '*suusa*' (traditionally fermented camel milk) on the basis of observations of Mwangi [12]. Therefore, the proportion of milk from camels positive for mastitis was used to estimate the PHL.

2.3. Statistical analysis

Chi-square test of dependence was used to determine association of milking routine and handling practices with the herds. Logistic regression (PROC LOGISTIC) was used to determine the relative risk of mastitis presence over total cases at quarter, cow/camel and herds type (smallholder vs pastoral camel) level [13]. Herd type was treated as factor with smallholder (peri-urban vs rural) and pastoral camel (rangelands vsperi-urban).

Regression models were run using GENMOD procedure of SAS [14] to assess relationship between practices and log transformed SCC. From this analysis, regression models with

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