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Raw milk hygiene at farms, processing units and local markets in Burkina Faso

V. Millogo [a], K. Svennersten Sjaunja [a], G.A. Ouédraogo [b], S. Agenäs [a,*]

[a] Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, P.O. Box 7024, SE-750 07 Uppsala, Sweden
[b] Département d'élevage, Institut du Développement Rural, Université Polytechnique de Bobo-Dioulasso, BP 1091, Bobo-Dioulasso, Burkina Faso

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ABSTRACT

The aim of this study was to investigate raw milk hygiene and composition along the dairy chain in Burkina Faso. Milk samples were taken during the rainy and dry seasons from individual cows, farm tanks, milk collectors' churns, dairy processing unit tanks and at local markets. The results showed lower total bacteria count (10–10^4 cfu/ml) in individual cow milk than later in the dairy chain. The total bacteria count in farm tank milk was 10^6 cfu/ml and 10^7 cfu/ml in tank milk at dairy processing units, in milk collectors' churns and in market buckets. Somatic cell count (100,000–150,000 cells/ml) did not show significant variation between individual cow milk and in the rest of the chain. Higher pH and lower milk fat and lactose contents were found in market bucket milk than in farm and processing unit tank milks.

It was concluded that milk from the cow is of good hygienic quality, but milk is often contaminated after milking, and the hygienic quality is very low when it reaches the consumers. Also, milk sold at local markets had low fat and lactose contents and high pH during the rainy season, indicating that the milk may have been diluted, which may further increase the hazards for human health.

1. Introduction

In most developing countries, numerous dairy programmes have been implemented to increase milk production (Bonfoh et al., 2006; Gran, Mutukumira, Wetlesen, & Narvhus, 2002; Rhone, Koonawootrittriron, & Elzo, 2007; Sraïri, Moudnib, Rahho, & Hamama, 2006) but have not always included milk hygiene. Instead, the objective of most of the dairy development programmes have been to increase milk yield for human consumption for the growing population (Delgado, Rosegrant, Steinfeld, Ehui, & Courbois, 1999). However, control of bacteria content in raw milk is very important for public health (Barbano, Ma, & Santos, 2006; Brovko, Froundjian, Babunonova, & Ugarova, 1999; Elmagli, Ibtisam, & El, 2006) and a high bacteria count in raw milk decreases the shelf-life of liquid milk and other dairy products. Therefore, raw milk hygiene also affects dairy economy.

In Burkina Faso, raw milk hygiene in the dairy chain is uncontrolled and pasteurisation is not commonly used as a quality management method (Millogo, Ouédraogo, Agenäs, & Svennersten-Sjaunja, 2008; Savadogo et al., 2004). People consume raw milk and local raw milk sellers have an important part of the market. The situation is similar in Mali, Zimbabwe, Sudan and Morocco (Bonfoh et al., 2006; Elmagli et al., 2006; Gran et al., 2002; Sraïri et al., 2006). Burkina Faso today has a similar dairy production system as Mali, Sudan and Morocco. People in these countries have centuries old traditions in animal production but the environmental temperatures are high and milk is sold at the road-side, out of open containers which increases contamination and spoilage. Most consumers in Burkina Faso are not aware of the risks associated with poor milk hygiene and do not know how much they risk their health by consuming such milk.

It has been demonstrated that milk must be cooled below +4 °C, processed and well conserved immediately after milking or processing (Harding, 1999; International Dairy Federation, 1990). However, there is no equipment available at farm level and during transport for cooling milk in Burkina Faso.

Very little work has been done on milk hygiene in Burkina Faso, since resources like laboratory equipment are scarce. However, in a previous study several species of bacteria were isolated from traditional fermented milk sold in Burkina Faso (Savadogo et al., 2004). The predominant microbial flora were *Lactobacillus* (30%), *Leuconostoc* (30%), *Leuconostoc/Beta-bacterium* (10%), *Streptococcus* (6%), *Enterococcus* (2%), yeast, moulds and *Enterobacteria,* not distinguishing between pathogenic and positive fermentation bacteria. In addition small numbers of the pathogens *Salmonella* and *Shigella* were detected. It was concluded that milk was contaminated both before and after fermentation, indicating insufficient routines regarding milk hygiene in Burkina Faso.

Milk is an excellent medium for bacteria growth and the population can double every half hour at +25 °C when pH is in the range of 6.0–6.5 (International Dairy Federation, 1990; Marandi, Brasca, Alfieri, Lodi, & Tamburini, 2005). There are immunoactive substances in milk, for example lysozyme, lactoperoxidase, lactoferrins and immunoglobulins, and these have anti-microbial flora

* Corresponding author. Tel.: +46 706973231.
E-mail address: Sigrid.Agenas@huv.slu.se (S. Agenäs).

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properties (Harding, 1999). In healthy cows, milk is sterile inside the mammary gland and bacteria contamination starts at milking. Other critical points where contamination may occur are storage on farm, during transport and at dairy industry level (Bonfoh et al., 2003; Gran et al., 2002; Sraïri, Benhouda, Kuper, & Le Gal, 2009).

The aim of the present study was to investigate raw milk hygiene along the chain from dairy cows to consumers, and on what future dairy programmes should focus to improve milk hygiene. The hypotheses were that contamination of milk occurs at several points along the dairy chain and that contamination on farm is higher in the rainy season than in the dry season.

2. Materials and methods

The experiment was conducted both during the rainy and dry seasons at five stages where raw milk is handled in Burkina Faso: individual cow milk, farm tank, collectors churn milk, local market milk and dairy processing unit tank milk. In Burkina Faso, the three main chains for milk to get from the cow to the consumer are: (i) dairy cow – dairy farm – milk collector – local market, (ii) dairy cow – dairy farm – milk collector – dairy processing unit and the shorter (iii) dairy cow – dairy farm – dairy processing unit. However, milk can also be sold by farmers at local markets, without the milk collector step. The study was carried out from July to August 2008 during the rainy season and from January to February 2009 during the dry season around and in the city of Bobo-Dioulasso in the West of Burkina Faso. The main inclusion criteria were that dairy processing units, milk collectors and farms were linked to each other in the dairy chain. In the rainy season the study included 14 dairy cows, nine farms, nine milk collectors, six local milk sellers and three dairy processing units In the dry season fewer cows and farms were producing milk, therefore less cows, farms and milk collectors could be included in this part of the study. Six dairy cows, six farms, six milk collectors, six local milk sellers and three dairy processing units were sampled in the dry season part of the study. Although the dairy processing units, milk collectors and farms were linked to each other, it was not possible to control that milk from collectors, local markets and processing units was exclusively dairy cattle milk, it may have been mixed with milk from small ruminants. Routines for cleaning the teats before milking, and cleaning the equipment, as well as milk transport time were previously described by Millogo et al. (2008). Milk was transported either by the farmer himself or picked up by a milk collector. Transport time depended on the distance from farm to the dairy processing units and also on the kind of transport the farmer or collectors used. The mean transport time was reported to be around 1 h by motorcycle and 2 h by bicycle (Millogo et al., 2008).

2.1. Collection and analyses of milk samples

Milk samples were collected twice at each site with a 1 month interval between sampling days. Milk samples were taken from individual cows, farm tanks, collector churns, processing unit tanks and local sellers' buckets, and were divided into two aliquots and put in 30 ml sterile tubes immediately after sampling. One aliquot was used for determination of pH, temperature, milk somatic cell count (SCC), milk fat content, milk protein and lactose contents, and the other for determination of total bacteria count. Temperature and pH were determined directly after sampling using a pH-meter (Jenway 370 pH-meter, European Union). SCC was also determined directly after sampling, by a fluorescence method (DeLaval Cell Counter, DeLaval, Tumba, Sweden). Samples were then transported to the laboratory in a cool box at +10–12 °C, and all samples reached the laboratory within 1 h. Total bacteria count was determined by a petrifilm method (Aerobic Count Plates, 3 M Petrifilms GmbH Hammfeldamm, Deutschland) and contents of fat, protein and lactose were determined by mid-infra-red spectroscopy (FMA 2001, Miris AB, Uppsala, Sweden).

2.2. Statistical analyses

Normal distribution of data was tested according to Anderson–Darling's test and all included variables were found normally distributed. The general linear model was used for analysis of variance (Minitab version 15) and Tukey's test was used for pairwise comparisons of least square means for the different levels of handling the milk. Log_{10}SCC values were used in the data analyses for SCC. Differences were considered significant at $P < 0.05$. The results are presented as least square mean (LSMean) ± standard error of mean (SEM).

3. Results

Three different levels of total bacteria count were found in the rainy season material ($P < 0.05$) (Table 1). The microbiological quality was highest in individual cow milk, followed by farm tank milk, with 10^4 cfu/ml and 10^6 cfu/ml, respectively. Total bacteria count did not differ between dairy processing unit tank milk, collector churn milk and local market milk (10^7 cfu/ml).

In the dry season, two levels of total bacteria count were distinguished (Table 1). The total bacteria count found in individual cow milk (10^5 cfu/ml) was lower ($P < 0.05$) compared to the other stages of handling raw milk (10^7 cfu/ml). The overall bacteria count was 10^6 cfu/ml and did not differ among the stages of handling raw milk included in the study, both in the rainy and dry seasons. The average SCC was $\log_{10} = 5–5.54$ (between 100,000 and 150,000 cells/ml milk). SCC did not show any difference between the different stages of handling raw milk. However, some samples had a high SCC, but there was no significant variation between rainy and dry seasons (Table 1).

In the rainy season the pH in market bucket milk (6.98 ± 0.06) was higher than in individual cow milk, farm tank milk, dairy processing unit tank milk and collector churn milk (Table 2). Milk temperature was significantly lower in market bucket milk (+26.6 ± 0.9 °C) and dairy processing unit tank milk (+25.2 ± 1.3 °C) than the temperatures measured in individual cow milk samples, farm tank milk and collector churn milk. Milk temperature did not differ between market bucket milk and dairy unit tank milk and it did not differ between the rainy and the dry season.

Table 1
Somatic cells count and total bacteria count in raw milk at different stages in the dairy chain.

Seasons	Variables	Cows	Farms	Dairy Units	Collector	Local market
Rainy season ($N = 41$)	Log_{10} SCC (cells/ml)	5.16 ± 0.07[a]	5.18 ± 0.09[a]	5.54 ± 0.15[a]	5.25 ± 0.09[a]	5.02 ± 0.11[a]
	Log_{10} TBC (cfu/ml)	3.65 ± 0.26[b]	6.64 ± 0.33[c]	7.11 ± 0.57[a]	8.21 ± 0.33[a]	7.30 ± 0.40[a]
Dry season ($N = 27$)	Log_{10} SCC (cells/ml)	5.13 ± 0.11[a]	5.22 ± 0.11[a]	5.34 ± 0.15[a]	5.62 ± 0.11[a]	5.18 ± 0.09[a]
	Log_{10} TBC (cfu/ml)	4.52 ± 0.40[a]	7.00 ± 0.40[b]	7.09 ± 0.57[b]	7.68 ± 0.40[b]	7.89 ± 0.40[b]

LSMeans in the same row with different superscripts [a, b and c] are statistically significant different at $P < 0.05$.