Food Control 21 (2010) 1070–1074

Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

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

ARTICLE INFO

Article history:
Received 20 August 2009
Received in revised form 21 December 2009
Accepted 31 December 2009

Keywords:
Milk
Raw
Hygiene
Dairy

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).

0956-7135/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodcont.2009.12.029

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 $P < 0.05$.

Table 2
Raw milk temperature and pH from cows to the points of sale.

Seasons	Variables	Cows	Farms	Dairy units	Collector	Local market
Rainy season ($N = 41$)	T °C	30.2 ± 0.6^{a}	27.8 ± 0.7^{a}	25.2 ± 1.3^{b}	29.8 ± 0.7^{a}	26.6 ± 0.9^{b}
	pH	6.51 ± 0.04^{a}	6.60 ± 0.05^{a}	6.64 ± 0.09^{a}	6.60 ± 0.05^{a}	6.98 ± 0.06^{b}
Dry season ($N = 27$)	T °C	29.6 ± 0.9^{a}	30.3 ± 0.9^{a}	25.5 ± 1.3^{b}	29.1 ± 0.9^{a}	29.3 ± 0.9^{a}
	pH	6.69 ± 0.06^{a}	6.58 ± 0.06^{a}	6.71 ± 0.09^{a}	6.52 ± 0.06^{a}	6.97 ± 0.06^{b}

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

Table 3
Raw milk fat, lactose and protein contents at different stages of handling of raw milk.

Seasons	Variables (%)	Cows	Farms	Dairy units	Collector	Local market
Rainy season ($N = 41$)	Fat	4.36 ± 0.09^{a}	4.50 ± 0.12^{a}	4.74 ± 0.20^{a}	3.98 ± 0.12^{a}	3.48 ± 0.14^{b}
	Protein	3.50 ± 0.08^{a}	3.94 ± 0.11^{a}	3.76 ± 0.19^{a}	3.42 ± 0.11^{a}	3.54 ± 0.13^{a}
	Lactose	4.92 ± 0.06^{a}	4.73 ± 0.08^{a}	4.71 ± 0.14^{a}	4.30 ± 0.08^{b}	4.35 ± 0.10^{b}
Dry season ($N = 27$)	Fat	3.92 ± 0.14^{a}	4.23 ± 0.14^{a}	4.20 ± 0.20^{a}	3.83 ± 0.14^{a}	3.87 ± 0.14^{a}
	Protein	3.33 ± 0.13^{a}	3.53 ± 0.13^{a}	3.48 ± 0.19^{a}	3.61 ± 0.13^{a}	3.44 ± 0.13^{a}
	Lactose	4.69 ± 0.10^{a}	4.77 ± 0.10^{a}	4.52 ± 0.14^{a}	4.54 ± 0.10^{a}	4.40 ± 0.10^{a}

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

In the rainy season there was no difference ($P < 0.05$) in milk fat, milk protein or lactose between individual cow milk, farm tank milk, dairy processing unit tank milk and collector churn milk. However, fat and lactose contents were lower in market bucket milk (Table 3). Lactose content was also lower in collector churn milk. In the dry season there were no differences in milk fat, protein and lactose among the different stages of handling raw milk. There was no effect of season on milk fat and milk protein content, while lactose content was lower ($P < 0.05$) in collector churn milk in the rainy season and in market bucket milk both in rainy and dry seasons. The SCC, total bacteria count and milk fat content was numerically slightly higher in the rainy season than in the dry season but the difference was not significant.

4. Discussion

4.1. Contamination of raw milk

The total bacteria count was low in individual cow milk, on average 10^4 cfu/ml ($P < 0.05$) and was 100-fold higher in farm tank milk and 1000-fold higher when it reached the local markets and dairy processing units. Moreover, there were samples from individual cows with less than 10 cfu/ml, which suggest very good milk quality at cow level. It is known that high total bacteria count (10^8 cfu/ml) is linked to several pathogenic micro-organisms (*Staphylococcus aureus*, *Escherichia Coli*, *Coliforms*) and the consumption of fermented, pasteurised or boiled milk processed from milk with high bacteria counts implies a considerable health hazard for consumers, including the risk of ingestion of toxins that make the milk unsuitable for human consumption (Harding, 1999; Hetzel et al., 2004). The current study shows that the lack of milk hygiene in the handling chain between cow and consumer in Burkina Faso subjects the consumers to a high risk of milk borne disease.

The main finding in the current study was that the hygienic quality of the milk, shown as total bacteria count, became so much worse during storage already at the farm and continued to decrease a further along the dairy chain. The large increase in total bacteria count from individual cow milk to farm tank milk can be explained by contamination by manure or dust and established bacteria in the storage containers, which can double in number at optimal pH and when the temperature is above 25 °C (Harding, 1999). Also, it might be possible that storage conditions allowed bacterial growth in the milk. However, the anti-microbial activity of raw milk usually inhibits bacteria growth for the first hours after milking (Fonteh, Grandison, & Lewis, 2002; Zhang, Zhao, Jiang, Dong, & Ren, 2008). Initial bacteria count, temperature and time of conservation are the main factors that determine bacteria growth. Lysozyme is an enzyme which can stop the division of gram-positive bacteria (Fonteh et al., 2002; for review see Benkerroum, 2008), but lactic acid bacteria (LAB) growth does not seem to be affected by the anti-microbial enzymes present in milk (Zhang et al., 2008). Intense reproduction of other bacteria than LAB in fresh milk is only seen if the initial bacteria count is very high (Felice, Madrid, Olivera, Rotger, & Valentinuzzi, 1999). High initial bacteria counts in combination with an optimum temperature (+15–30 °C) for mesophilic and psychotropic bacteria, results in bacteria generation time of 20 min (Felice et al., 1999; International Dairy Federation, 1990). However, in the current study, the total bacteria counts in samples taken during milking were relatively low, only 10^4 cfu/ml. It is therefore most likely that the increase in bacteria count from milking to farm tank level and further along the dairy chain was caused by contamination rather than bacterial growth. It is known that precipitates of machine milking equipment that is cleaned according to the manufacturers' instructions have bacteria contents ranging from 10^3 to 10^{11} cfu/ml (Sandholm, Honkanen-Buzalski, Kaartinen, & Pyörälä, 1995). It is reasonable to assume that precipitates of hand cleaned milking equipment and milk storage containers contain even more bacteria. The increase in bacteria count on farms, from cow to farm tank, was most likely caused by contamination either by the milker, hands of milker, the environment at the milking location on the farms or dirty storage vessels with established bacteria colonies. The total bacteria count in individual cow milk was 10^2 cfu/ml in Mali (Bonfoh et al., 2003), which is in line with the current results. In addition, total bacteria count in individual cow milk was also lower compared to that reported by Sraïri et al. (2009), but was similar in the rest of dairy chain. Sraïri et al. (2009) also reported, in agreement with other authors, a high total bacteria count at the point of sale up to 10^9 cfu/ml (Bonfoh et al., 2003; Sraïri et al., 2006).

The poor hygienic quality of milk started in the farm tank which influenced the rest of the dairy chain. The results are in agreement with several previous studies along the dairy chain in Zimbabwe (Gran et al., 2002), in Mali (Bonfoh et al., 2003), in Ghana (Donkor, Aning, & Quaye, 2007), in Uganda (Grimaud, Sserunjogi, & Grillet, 2007) and in Morocco (Sraïri et al., 2006). In conclusion, the cleaning procedure during milking, cleaning of milking and milk storage equipment and hygiene in the handling of milk after milking

requires attention to avoid contamination of milk and poor hygiene of milk sold at local markets and processed at the dairy processing units.

4.2. Somatic cells in milk, milk temperature, pH and conservation of milk

SCC in milk samples obtained during milking was lower in this study than values reported in a similar production system by Bonfoh et al. (2005). Low SCC was also found in two previous studies performed in Burkina Faso (Millogo, Ouédraogo, Agenäs, & Svennersten-Sjaunja, 2009; Millogo et al., 2008). The low average SCC suggests that udder health is good in Burkina Faso, but higher SCC levels have also been recorded, indicating cases of mastitis.

Milk temperature was high and favourable for bacterial growth both at farm, dairy processing unit and local market levels. The lack of facilities such as electricity and cooling systems is the main reason for this, as shown by Bonfoh et al. (2003) and Millogo et al. (2008). When milk has just been collected from the cow udder, milk temperature can reach 37–38 °C and offers a good medium for the growth of mesophilic micro-organisms, because milk is stored at their optimum growing temperature.

The study showed no difference ($P > 0.05$) between the temperature in individual cow milk, farm tank milk and collector churn milk (Table 1), which means that no cooling was done to decrease milk temperature at the farm and during the transport. All pH values recorded in this study were within the biological variation described by Walstra, Wouters, and Geurts (2006). The higher pH value (6.98) of milk at local markets could be explained by several factors such as feeding and stage of lactation but could also be an indicator of manually added water. Several previous authors (Gran et al., 2002; Sraïri et al., 2006) found similar pH, but addition of water does not necessarily increase milk pH. The freezing point is the best tool to measure added water (Harding, 1999; International Dairy Federation, 1990), but freezing point was not measured in the current study. It is possible that an increase in pH caused by addition of water was masked by the high temperature and the ongoing bacterial growth, which lowers pH. It is known that milk pH is affected by milk temperature; when milk temperature increases, milk pH decreases (International Dairy Federation, 1990; Walstra & Jenness, 1984). The same authors reported that high and rising temperature in raw milk in tropical conditions activates mesophilic bacterial growth. Therefore, addition of water of poor hygienic quality to the milk involves a severe risk for human health.

Milk composition was similar to what has been observed previously in individual cow milk and in composite milk samples in Burkina Faso (Millogo et al., 2008, 2009; Sidibé-Anago, Ouédraogo, & Ledin, 2006). However, milk fat and lactose content was unexpectedly low and milk pH relatively high in milk at local markets. Low lactose levels are often seen in milk when SCC is elevated (Berglund, Pettersson, Östensson, & Svennersten-Sjaunja, 2007; Linzell & Peaker, 1972) but since SCC was generally low in this study, including local market milk, SCC did not explain the low lactose content in milk at local markets. Lactose decreases when fermentation starts but if this was the case pH would also be low in the local market milk, which it was not. Therefore, the low fat and lactose contents together with the high pH in local market milk indicates that the milk was most likely diluted with water, probably to increase the milk volume during the rainy season (Table 3).

5. Conclusions

The deterioration in milk hygiene quality between cow and farm tank level was probably due to contaminated milking vessels and tank milk containers. The data presented here and in previous studies in Burkina Faso suggests that udder health is probably good in Burkina Faso. However, milk is often contaminated after milking, and the hygienic quality is very low when the milk reaches the consumers. Also, milk sold at local markets had low fat and lactose contents and high pH during the rainy season, which indicates that milk have been diluted with water.

It is important to train farmers, milk sellers and collectors in milk hygiene and the physical aspects of raw milk. Routines for minimizing contamination of milk need to be put in place. The cows' teats and the milkers' hands should be washed carefully before milking starts and all containers used for storing and transporting milk should be cleaned each time milk has been emptied, before used again. In order to manage milk container cleanliness, the plastic bottles used today should be replaced with milk containers with a large opening and an inside which is easy to clean. One possibility for achieving this would be that the dairies provide milk containers for the milk collectors and farmers and that the equipment is cleaned at the dairy, when milk is delivered. Furthermore, milk should be pasteurised before reaching the consumer. Milk hygiene after pasteurisation could be maintained either by cooling the milk or by fermenting the milk and selling only fermented products. Even if milk is fermented, temperature should be kept as low as possible to avoid deteriorated hygiene. Furthermore, analyses for monitoring milk quality are essential in order to monitor milk production and marketing. It is concluded that it is a major public health concern to intensify milk hygiene quality control by regular milk sampling, visits to farms, milk collectors and dairy processing units. Future studies on milk hygiene in Burkina Faso should aim at improving the routines for handling raw milk.

Acknowledgments

The authors would like to acknowledge the Swedish International Development Authority (SIDA), Department for Research Cooperation (SAREC), for financial support of this research. We are grateful to the DTA laboratory in Bobo-Dioulasso for the determination of total bacteria count.

References

Barbano, D. M., Ma, Y., & Santos, M. V. (2006). Influence of raw milk quality on fluid milk shelf life. *Journal of Dairy Science, 89*(E. Suppl.), E15–E19.

Benkerroum, N. (2008). Antimicrobial activity of lysozyme with special relevance to milk. *African Journal of Biotechnology, 7*(25), 4856–4867 (A review).

Berglund, I., Pettersson, G., Östensson, K., & Svennersten-Sjaunja, K. (2007). Quarter milking for improved detection of increased SCC. *Reproduction in Domestic Animals, 42*(4), 427–432.

Bonfoh, B., Roth, C., Traoré, A. N., Fané, A., Simbé, C. F., Alfaroukh, I. O., et al. (2006). Effect of washing and disinfecting containers on the microbiological quality of fresh milk sold in Bamako (Mali). *Food Control, 17*(2), 153–161.

Bonfoh, B., Wasem, A., Traoré, A. N., Fané, A., Spillmann, H., Simbé, C. F., et al. (2003). Microbiological quality of cows's milk taken at different intervals from the udder to the selling point in Bamako (Mali). *Food Control, 14*, 495–500.

Bonfoh, B., Zinsstag, J., Farah, Z., Simbé, C. F., Alfaroukh, I. O., Aebi, R., et al. (2005). Raw milk composition of Malian Zebu cows (*Bos indicus*) raised under traditional system. *Journal Food Composition Analysis, 18*, 29–38.

Brovko, L. By. Y., Froundjian, V. G., Babunonova, V. S., & Ugarova, N. N. (1999). Quantitative assessment of bacterial contamination of raw milk using bioluminescence. *Journal of Dairy Research, 66*, 627–631.

Delgado, C. L., Rosegrant, M. W., Steinfeld, H., Ehui, S., & Courbois, C. (1999). The Coming Livestock Revolution. *FAO/Department of Economic and Social affairs*. 11 p.

Donkor, E. S., Aning, K. G., & Quaye, J. (2007). Bacterial contaminations of informally marketed raw milk in Ghana. *Ghana Medical Journal, 41*(2), 58–61.

Elmagli, A. A. O., Ibtisam, E. M., & El, Z. (2006). Study on the hygienic quality of pasteurized milk in Khartoun State (Sudan). *Research Journal of Animal and Veterinary Sciences, 1*(1), 12–17.

Felice, C. J., Madrid, R. E., Olivera, J. M., Rotger, V. I., & Valentinuzzi, M. E. (1999). Impedance microbiology: Quantification of bacterial content in milk by means of capacitance growth curves. *Journal Microbiological Methods, 35*, 37–42.

Fonteh, By. F., Grandison, A., & Lewis, M. J. (2002). Variation of lactoperoxidase activity and thiocyanate content in cows's and goats' milk throughout lactation. *Journal of Dairy Research, 69*, 401–409.

Gran, H. M., Mutukumira, A. N., Wetlesen, A., & Narvhus, J. A. (2002). Smallholder dairy processing in Zimbabwe: Hygienic practices during milking and the microbiological quality of the milk at the farm and on delivery. *Food Control, 13*, 41–47.

Grimaud, P., Sserunjogi, M. L., & Grillet, N. (2007). An evaluation of milk quality in Uganda: Value chain assessment and recommendations. *African Journal of Food, Agriculture, Nutrition and Development, 7*(5), 16.

Harding, F. (1999). Milk quality. Editorial Service: Ruth Bloom, Library of Congress Catalog Card Number: 95-76793, ISBN: 0-8342-1345-1. 166 p.

Hetzel, M., Bonfoh, B., Farah, Z., Traoré, M., Simbé, C. F., Alfaroukh, I. O., et al. (2004). Diarrhoea, vomiting and the role of milk consumption: Perceived and identified risk in Bamako (Mali). *Tropical Medicine and International Health, 9*(10), 1132–1138.

International Dairy Federation (1990). Milk collection in warm developing countries. Handbook, special issue No. 9002, ISBN 92 9098 0040, 148 p.

Linzell, J. L., & Peaker, M. (1972). Day-to-day variations in milk composition in the goat and cow as a guide to the detection of subclinical mastitis. *British Veterinary Journal, 128*, 284–295.

Marandi, S., Brasca, M., Alfieri, P., Lodi, R., & Tamburini, A. (2005). Influence of pH and temperature on the growth of Enterococcus faecium and Enterococcus faecalis. *Lait, 85*, 181–192.

Millogo, V., Ouédraogo, G. A., Agenäs, S., & Svennersten-Sjaunja, K. (2008). Survey on dairy cattle milk production and milk quality problems in peri-urban areas in Burkina Faso. *African Journal of Agricultural Research, 3*(3), 215–224.

Millogo, V., Ouédraogo, G. A., Agenäs, S., & Svennersten-Sjaunja, K. (2009). Day-to-day variation in yield, composition and SCC of saleable milk in hand-milked zebu dairy cattle. *African Journal of Agriculture Research, 4*(3), 151–155.

Rhone, J. A., Koonawootrittriron, S., & Elzo, M. A. (2007). Factors affecting milk yield, milk fat, bacterial score, and bulk tank SCC of dairy farms in the central region of Thailand. *Tropical Animal Health and Production*. doi:10.1007/s11250-007-9074-5.

Sandholm, M., Honkanen-Buzalski, T., Kaartinen, L., & Pyörälä, S. (1995). The bovine under mastitis. University of Helsinki, Faculty of Veterinary Medicine, Helsinki ISBN: 951-834-047-1. Printing in Finland by Gummerus Kirjapaino Oy, Jyväskylä. pp. 282.

Savadogo, A., Ouattara, C. A. T., Savadogo, P. W., Ouattara, A. S., Barro, N., & Traoré, A. S. (2004). Microorganisms involved in fulani traditional fermented milk in Burkina Faso. *Pakistan Journal of Nutrition, 3*(2), 134–139.

Sidibé-Anago, A. G., Ouédraogo, G. A., & Ledin, I. (2006). Effect of partly replacing cottonseed cake with Mucuna spp. (Var Ghana) hay on feed intake and digestibility, milk yield and milk composition of zebu cows. *Tropical Animal Health and Production, 38*, 563–570.

Sraïri, M. T., Benhouda, H., Kuper, M., & Le Gal, P. Y. (2009). Effect of cattle management practices on raw milk quality on farms operating in two-stage dairy chain. *Tropical Animal Health and Production, 41*, 259–272.

Sraïri, M. T., Moudnib, J., Rahho, L., & Hamama, A. (2006). How do milking conditions affect the hygienic quality of raw milk? Case study from Morocco dairy farms. *Livestock Research for Rural Development, 18*(17), 9.

Walstra, P., & Jenness, R. (1984). *Dairy chemistry and physics*. New York: John Wiley & Sons [467 p].

Walstra, P., Wouters, J. T. M., & Geurts, T. J. (2006). *Dairy science and technology*. New York: Taylor & Francis.

Zhang, X.-Y., Zhao, L., Jiang, L., Dong, M.-L., & Ren, F.-Z. (2008). The antimicrobial activity of donkey milk and its microflora changes during storage. *Food Control, 19*, 1191–1195.