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Microbiological Quality of Goat Milk in Degahbur District of Jarar Zone, Somali Regional State, Ethiopia

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Abstract

A cross-sectional study was carried out to evaluate microbiological quality of raw goat milk in Degahbur district of Jarar zone, Somali Regional State, Ethiopia. A total of 40 pooled raw goat milk samples (each with a volume of 450 mL) were collected from the udders and milk handling equipment of targeted goat milk producers in the study area. The milk samples were subjected to laboratory analysis to evaluate total bacterial count (TBC) and total coliform count (TCC) in order to determine the microbiological quality of the raw goat milk in the study area. The study showed that the mean total bacterial count (TBC) and total coliform count (TCC) for raw milk samples collected from the udder were 4.92 ± 0.23 and 2.68 ± 0.36 $\log_{10}$ cfu·mL^{-1}, respectively. The mean counts for samples collected from milk equipment were 5.61 ± 0.32 and 3.93 ± 0.21 $\log_{10}$ cfu·mL^{-1} for TBC and TCC, respectively. The values for the samples collected from pastoral production system were 5.63 ± 0.13 and 4.02 ± 0.20 $\log_{10}$ cfu·mL^{-1} for TBC and TCC, respectively. The average means of TBC and TCC for samples collected from the agro-pastoral production system were 4.9 ± 0.41 and 2.59 ± 0.37 $\log_{10}$ cfu·mL^{-1}, respectively. Significant difference ($P < 0.05$) in mean TBC and TCC was observed between milk samples collected from pastoral and agro-pastoral production systems as well as milk samples collected from udders and milk handling equipment of the producers. It could be concluded that both TBC & TCC of goat milk samples collected from the udder as well as from the milk handling equipment of producers exceeded the acceptable limits. This indicated that production practices performed during milk production and postharvest handling in the study area were unhygienic. Therefore, hygienic and proper milk production procedures should be followed to improve the quality of goat milk for its intended use in the study area.

Keywords

Goat Milk, Microbiological Quality, Hygienic, Production System

1. Introduction

Milk is the lacteal secretion of the mammary glands of a mammal and plays an important role in human nutrition throughout the world where it promotes growth and maintenance of body tissues [1]. It is the most complete food product of animal origin providing more essential nutrients (protein, energy, vitamins and minerals) in significant amounts than any other single food [2].

Milk from good hygienic production practices and the udder of a healthy dairy animal contains very few bacteria. But poor hygiene introduces additional bacteria that cause the milk to spoil very quickly. To ensure that raw milk remains fresh for a longer time, good hygiene practices are required during milking and when handling the milk afterwards [3]. Production of quality milk is a complicated process [2]. Milk is a complex biological fluid and by its nature, a good growth medium for many microorganisms, because of its high water content, nearly neutral pH, and variety of available essential nutrients [4]. Therefore, the microbial content of milk is a major feature in determining its quality [5].

In addition, poor hygiene, practiced by handlers of milk and milk products, may lead to the introduction of pathogenic micro-organisms into the products [6]. Hygienic practices are the major factors to produce safe and quality products for consumption with minimum microbial contamination, and thereby reducing loss of products and improving the position of smallholder milk producers in marketing of quality milk and milk products [7] [8].

Moreover, unhygienic practices performed during production and postharvest handling expose goat milk contamination with harmful microorganisms, and cause spoilage of milk before it reaches its final destination points as well as pose public health risk to consumers [9]. The risk of milk including goat milk contamination with harmful microorganisms is high for milk produced in developing countries like Ethiopia as their milk production practices are a traditional type which lacks appropriate hygienic measures [10]. The risk is high in lowland regions especially in pastoral and agro-pastoral areas of tropical regions. This is mainly due to high ambient temperatures prevalent in the area combined with lack of cooling facilities, scattered distribution of producers, long distance to markets and lack of transportation [11] [12].

Therefore, detail investigation of sanitary condition and microbial quality is very important to identify existing hygiene related problems in order to reduce the risk of public health as well as to improve the livelihood of smallholder farmers by engaging them in quality milk production and handling of dairy products in the district. However, there is a limited study undertaken so far to assess

the hygienic milk production and the microbial quality of goat milk in Degahbur district of Jarar Zone. Therefore, this study was designed to assess hygienic milk production practices and identify the microbial quality of goat milk in Degahbur district of Jarar Zone, Eastern Ethiopia.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted from January to August 2020 in Degahbur district of Jarar Zone, Somali Regional State, Ethiopia (Figure 1). It is located at 8˚13' North of longitude and 43˚34' East latitude at the distance of about 160 km south of Jigjiga town. The altitude of the district is 1044 meters above sea level. It has a mean annual minimum and maximum temperatures of 11˚C and 33˚C, respectively. The mean annual rainfall and humidity of the area range from 300 to 400 mm and 31% to 36%, respectively. The rainfall pattern is erratic and has uneven distribution. The farming system in the area is primarily pastoralists, who mainly keep livestock, particularly goat, camel, cattle, and sheep; and to some extent crop (like sorghum and maize) production is also practiced in the district. According to Central Statistical Agency [13], the total human population of the district is estimated at 150,000 of whom 85,000 are men and 65,000 are women.

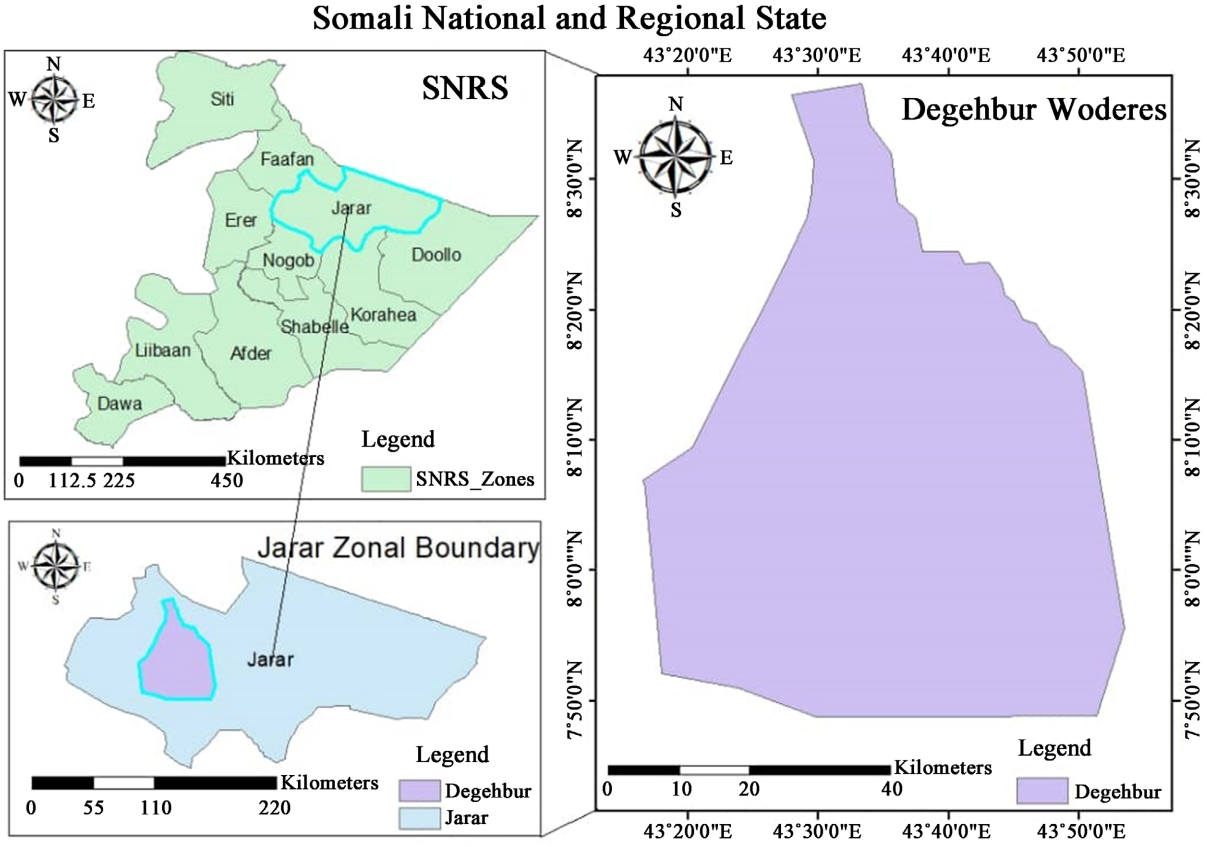

Figure 1. Map of the study area.

2.2. Study Design

A cross-sectional study was carried to determine the microbiological quality of raw goat milk in Degahbur district. Pooled raw goat milk samples were taken repeatedly from udders of lactating goats as well as from milk handling equipment of producers, and subjected to laboratory analysis. The laboratory analysis was done in Jigjiga University Veterinary Microbiology Laboratory, Ethiopia.

2.3. Sampling Targets

Degahbur district was selected for this study due to its potential of goat milk production. The district was stratified into two production systems namely pastoral and agro-pastoral. Each production system was further stratified into *kebeles* (*kebele* = smallest administrative unit in Ethiopia). Thus, a total of four *kebeles* (2 from pastoral and 2 from agro-pastoral production systems) with high goat milk production potential were purposively selected for this study. Finally, thirty goat milk producer households were selected randomly from each rural *kebele* (RK), and were considered for sampling of raw goat milk.

2.4. Milk Sample Collection

For the evaluation of microbiological quality of raw goat milk, a total of 40 pooled raw goat milk samples (each with a volume of 450 mL) were collected from the udder (n = 20; 5 from each *kebele*) and milk handling equipment of targeted producers (n = 20; 5 from each *kebele*) following the sampling stratification described above (under Section 2.3). The samples were placed in an ice-box (≤4˚C) to restrict microbial multiplication and transported to Jigjiga University Veterinary Microbiology Laboratory. Upon arrival at the laboratory, the samples were kept in a refrigerator (having temperature between 0˚C - 4˚C) until the time of analysis. The analysis was carried out within a period of 24 hours after collection.

2.5. Microbiological Analysis

2.5.1. Standard Plate Count

The total bacterial count (TBC) was determined using standard plate count agar. One mL of raw milk sample was added into a sterile test tube containing 9 mL of sterile peptone water. After thoroughly mixing, the suspension was serially diluted up to 10^{-11} and duplicated samples from the appropriate dilution (1 mL) was pour plated using a 15 - 20 mL of cooled but still molten standard plate count agar solution and mixed thoroughly. The resulting plates were allowed to solidify and then incubated at 32˚C for 48 hours [14]. The plates with colonies ranging from 30 to 300 colony forming units (cfu)·mL^{-1} were selected for determination of standard plate count [14]. Standard plate count was determined as the total number of cfu per milliliter of milk sample was calculated using the formula provided by FDA [15].

$$N = \left(\sum c\right) \Big/ \left(\left[\left(1 \times n_1\right) + \left(0.1 \times n_2\right)\right] d\right)$$

where, N = number of colonies per ml of milk sample;

$\sum C$ = sum of all colonies on plates counted;

n_1 = number of plates used in lowest dilution counted;

n_2 = number of plates used in highest dilution counted;

d = the dilution from which the first counts were obtained.

2.5.2. Total Coliform Count

The total coliform count (TCC) was determined using sterile violet red bile agar (VRBA). One ml of raw milk sample was added into a sterile test tube containing 9 mL of sterile peptone water. After thoroughly mixing, the suspension was serially diluted up to 10^{-9} and duplicate samples (1 mL) were pour-plated using a sterile 15 - 20 mL VRBA. After thoroughly mixing, the resulting plates were allowed to solidify and then incubated at 32˚C for 24 hours [16]. After incubation, typical dark red or purplish-red colonies appearing on the plates were counted as coliforms. For confirmatory test, five to ten typical colonies from each plate will be transferred into tubes containing 2% Brilliant Green Lactose Bile Broth and incubated at 37˚C for 48 hours [14]. Growth and gas production within incubation period was considered as sufficient evidence for the presence of coliforms [14]. Plates with 15 to 150 cfu·mL^{-1} were used [15] for determining total coliform counts using the formula provided by IDF [17].

2.6. Data Analysis

The General Linear Model (GLM) procedure of SAS (2008) was used to analyze microbiological quality of raw goat milk. The TBC and TCC expressed in colony forming units per milliliter (cfu·mL^{-1}) data were transformed to $\log_{10}$ values before subjected to statistical analysis. Mean comparison was carried out using the Least Significant Difference (LSD) technique when analysis of variance shows significant differences between means and differences were considered statistically significant at $P < 0.05$ level of significance.

$$Y_{ijk} = \mu + \alpha_i + \beta_j + e_{jk}$$

where, Y_{ijk} = total bacterial count & total coliform count;

μ = overall mean;

α_i = effect of i^{th} production system (i = 1, 2; pastoral & agro-pastoral);

β_j = effect of j^{th} milk sources (j = 1, 2; udder & equipment);

e_{ijk} = error.

3. Results and Discussion

3.1. Microbiological Quality of Goat Milk

3.1.1. Total Bacterial Count

The mean total bacterial count (TBC) for raw goat milk samples collected from the milk handling equipment of producers (5.61 ± 0.32 $\log_{10}$ cfu·mL^{-1}) was significantly higher ($P < 0.05$) than the mean TBC for samples collected from the udder (4.92 ± 0.23 $\log_{10}$ cfu·mL^{-1}) (**Table 1**). This might be due to the use of un-

clean and poor milking equipment. Mean TBC for raw goat milk samples collected from pastoral production system (5.63 ± 0.13 $\log_{10}$ cfu·mL^{-1}) was also higher ($P < 0.05$) than that of samples collected from agro-pastoral production system (4.9 ± 0.41 $\log_{10}$ cfu·mL^{-1}). This might be also due to the improper and unhygienic practices during milking, health and hygiene of goats and cleaning of milk equipment.

The overall average TBC of the current study was 5.26 $\log_{10}$ cfu·mL^{-1} (**Table 1**) which is higher than the value (4.5 $\log_{10}$ cfu·mL^{-1}) for raw goat milk in Penang Island of Malaysia reported by Suguna *et al.* [18]. The higher bacterial load might associate to poor and improper hygienic practices during milking and inadequate cleaning of milk equipment.

According to O'Connor [19], the acceptable limit of TBC for raw milk is 5 $\log_{10}$ cfu·mL^{-1}, which is lower than that the value of the present finding (5.26 $\log_{10}$ cfu·mL^{-1}). This might be due to poor farm/herd hygiene and health care management practices performed by smallholder milk producers. Moreover, failure to use cooling facilities during milk storage and transport, long storage period after milking could be the main reasons for the exceeding of TBC than the upper acceptable limit.

The higher TBC was due to low hygienic and sanitation practices, such as no cleaning of the udder and teats before milking and improper hygienic practices trigger microbial contamination during milking. Mohammadi *et al. [20]* reported that milk quality is determined by its composition and hygienic practices that are applied during milking processes, such as cleanliness of milking equipment, conditions of storage and transportation, and cleanliness of the udder of the individual animal. Suranindyah *et al. [21]* also reported that improving environmental sanitation during milking and dipping of teats can reduce total microbes in raw milk.

3.1.2. Total Coliform Count

The mean total coliform count (TCC) for raw goat milk samples collected from the udders was 2.68 ± 0.36 $\log_{10}$ cfu/mL which is lower ($P < 0.05$) than the mean count of 3.93 ± 0.21 $\log_{10}$ cfu/mL for samples collected from the milk handling equipment (**Table 2**). This might be due to the use of unclean and poor milking equipment.

Moreover, the mean TCC for raw goat milk samples collected from pastoral production system (4.02 ± 0.20 $\log_{10}$ cfu/mL) was higher ($P < 0.05$) than that of

Table 1. Least square mean (±SE) TBC ($\log_{10}$cfu·mL^{-1}) of goat milk samples.

Milk source	N	Pastoral	Agro-pastoral	Overall	*P-value*
Udder	20	5.24 ± 0.08^{a}	4.60 ± 0.38^{b}	4.92 ± 0.23	
Equipment	20	6.03 ± 0.18^{a}	5.20 ± 0.45^{b}	5.61 ± 0.32	<0.0001
Overall	40	5.63 ± 0.13	4.9 ± 0.41	5.26 ± 0.27	

Means followed by different superscript letters within a row are significantly different at $P < 0.05$, n = number of samples, SE = standard error, TBC = total bacterial count.

Table 2. Least square mean (± SE) TCC (log_{10} cfu·mL^{-1}) of goat milk samples in the study area.

Milk source	N	Pastoral	Agro-pastoral	Overall	*P-value*
Udder	20	3.35 ± 0.15^{a}	2.01 ± 0.57^{b}	2.68 ± 0.36	
Equipment	20	4.68 ± 0.25^{a}	3.18 ± 0.17^{b}	3.93 ± 0.21	0.004
Overall	40	4.02 ± 0.20	2.59 ± 0.37	3.30 ± 0.27	

Means followed by different superscript letters within a column are significantly different at $P < 0.05$, n = number of samples, SE = standard error, TCC = total coliform count.

collected from agro-pastoral production system (2.59 ± 0.37 log_{10} cfu/mL) (Table 2). This might be attributed to unhygienic conditions such as dirty equipment, contact with manure of the goats during milking and personal hygiene of the milking persons.

The overall mean TCC for raw goat milk samples in the study area was 3.30 ± 0.27 log_{10} cfu/mL (Table 2), which is relatively higher than the value (2.2 log_{10} cfu/mL) reported by Suguna *et al.* [18] for goat milk samples in Penang Island, Malaysia. However, it is lower than 3.61 log_{10} cfu/mL reported by Abo El-Makarem [22] in Egypt. Moreover, it is lower than the value (5.52 log_{10} cfu/mL) reported by Merlin *et al.* [23] in Brazil.

According to Fernandes [24], the acceptable limit of TCC for raw milk should be less than 2 log_{10} cfu/mL, which was lower than the present finding (3.30 ± 0.27 log_{10} cfu/mL). This might be due to poor farm hygiene, use of unclean equipment, improper milking procedures, poor awareness of milk producers, poor herd hygiene, use of contaminated water for hygienic practices, lack of cooling facilities during milk storage etc. Abo El-Makarem [22] and CDFA [25] provided similar suggestions.

4. Conclusion and Recommendations

In general, it could be concluded that the milk production practices performed in the study area were unhygienic which could be mainly due to a lack of proper hygienic milk production measures. Thus, the microbial load of raw milk samples collected from the udders as well as from the equipment of producers in the study area exceeded the upper acceptable international limits. This shows that raw goat milk samples collected from different sources in the current study were substandard in their microbiological quality, and are unsafe for their intended uses. Therefore, the concerned governmental and non-governmental organizations should pay great attention to the improvement of hygienic practices through undertaking different relevant development interventions like awareness creation and capacity development of milk producers on hygienic milk production practices, improving the health condition of milking animals. In addition, further investigations with a wider area coverage are needed to identify the different species of microorganisms that might cause public health hazards.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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