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Bacteriological Quality of Fresh Cow Milk from Dairy Farms

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Abstract

Background: Milk is an important source of high-quality protein, fat, carbohydrates, vitamins and minerals and is widely consumed as part of the human diet. However, its high nutritional value and water content also make milk an excellent medium for the growth of microorganisms. Freshly obtained cow milk may become contaminated during milking, collection, transportation, storage and handling. The bacteriological quality of raw milk is therefore an important indicator of hygienic conditions at the dairy farm and has direct implications for consumer safety.

Objective: The present study was designed to assess the bacteriological quality of fresh cow milk collected from selected dairy farms and to determine the levels of total aerobic bacterial count, total coliforms, *Escherichia coli* and *Staphylococcus aureus*.

Materials and Methods: A cross-sectional laboratory-based study was designed to evaluate fresh cow milk obtained from selected dairy farms. A total of milk samples were collected aseptically in sterile containers and transported to the laboratory under refrigerated conditions. Samples were examined for total aerobic bacterial count, total coliform count, presumptive *E. coli*, and *S. aureus* using standard microbiological procedures. Bacterial counts were expressed as colony-forming units per millilitre (CFU/ml). Descriptive statistics were used to summarize the microbiological results, while associations between hygienic practices and bacteriological quality were assessed using appropriate statistical tests.

Results: Among the samples examined, the mean total aerobic bacterial count was ^[value] log₁₀ CFU/ml, while the mean total coliform count was log₁₀ CFU/ml. *E. coli* was detected in ^[7/%] of the samples, whereas presumptive *S. aureus* was detected in ^[8/%]. Samples obtained from farms with inadequate udder cleaning, unclean milking utensils, poor hand hygiene and inadequate cooling generally demonstrated higher bacterial counts than samples obtained from farms following better hygienic practices.

Conclusion: The study indicates that the bacteriological quality of fresh cow milk is closely associated with hygienic practices during milking and subsequent handling. Regular microbiological monitoring, improved udder and equipment hygiene, proper hand washing, rapid cooling and appropriate storage are recommended to improve the safety and quality of fresh cow milk.

Keyword: Cow Milk, Raw Milk, Bacteriological Quality, Total Bacterial Count, Coliforms, *Escherichia coli*, *Staphylococcus aureus*, Dairy Hygiene, Food Safety

Introduction

Milk is one of the most nutritionally important foods consumed by humans. It contains proteins, lipids, lactose, minerals and vitamins and is used directly as a beverage as well as in the manufacture of numerous dairy products. Because of its nutrient-rich composition, milk can also support the survival and multiplication of a wide range of microorganisms when adequate hygienic and temperature-control measures are not maintained.

Fresh milk leaving a healthy udder may contain relatively low numbers of microorganisms; however, contamination can occur from the cow's skin, udder, feces, environment,

water, handlers, milking equipment, storage containers and transportation system. The microbiological composition of raw milk therefore reflects both animal-related factors and the hygienic conditions under which milk is produced and handled ^[1,2].

The microbial population of raw milk is diverse. Some microorganisms contribute to dairy fermentation, while others cause spoilage or may be associated with foodborne disease. Important bacterial groups reported in raw milk include *Pseudomonas*, Enterobacteriaceae, *Bacillus*, *Staphylococcus*, *Listeria*, *Salmonella*, *Escherichia coli* and *Campylobacter* ^[1,3].

Total bacterial count is commonly used as an indicator of the general microbiological quality of raw milk. High bacterial counts may indicate inadequate hygiene during milking, contaminated equipment, prolonged storage or inadequate temperature control. Modern approaches to raw-milk quality assessment also emphasize the importance of understanding the sources and types of bacteria present throughout the dairy production chain ^[1].

Coliform bacteria are commonly used as indicators of hygienic conditions. Their presence at elevated levels may indicate contamination from the environment, fecal material, water or poorly cleaned equipment. *E. coli* is particularly important because its presence can indicate fecal contamination and may, in some circumstances, signal the potential presence of enteric pathogens.

Staphylococcus aureus is another important microorganism associated with dairy production. It may originate from infected udders, particularly cases of bovine mastitis, as well as from handlers and contaminated equipment. Some strains of *S. aureus* are capable of producing enterotoxins associated with food poisoning ^[3, 4].

Raw milk may also carry bacterial pathogens capable of causing human illness. A systematic review of raw milk studies identified *Listeria monocytogenes*, *Salmonella* spp., Shiga toxin-producing *E. coli* and *Campylobacter* spp. among important bacterial hazards associated with raw milk ^[5].

The Food and Agriculture Organization emphasizes that good-quality raw milk should have a low bacterial count and should be produced and handled under appropriate hygienic conditions. It also recommends milk testing and quality control throughout the dairy chain ^[6].

Several studies have demonstrated that bacterial contamination can increase between the farm and milk collection points. Earlier work on raw cow milk showed that total bacterial and coliform counts were higher at milk collection centers than at farms, highlighting the importance of handling and transportation after milking ^[7].

Therefore, assessment of the bacteriological quality of fresh cow milk is important for evaluating farm-level hygiene, identifying potential contamination sources and protecting public health.

Aim

The aim of this study was to assess the bacteriological quality of fresh cow milk collected from selected dairy farms.

Specific Objectives

The specific objectives were:

1. To determine the total aerobic bacterial count of fresh cow milk.
2. To determine the total coliform count of fresh cow milk.
3. To detect and estimate the occurrence of presumptive *E. coli*.
4. To determine the occurrence of presumptive *Staphylococcus aureus*.
5. To assess selected hygienic practices associated with milk production and handling.
6. To examine the relationship between farm hygiene practices and bacteriological quality of milk.

Materials and Methods

Study Design

A cross-sectional laboratory-based study was conducted to evaluate the bacteriological quality of fresh cow milk collected from selected dairy farms.

Study Area

The study was conducted in [name of district/city/state/country] during [month and year]. The study area contains several dairy farms producing fresh cow milk for household consumption, local markets and/or dairy collection centers.

Study Population

The study population consisted of fresh cow milk produced at selected dairy farms within the study area.

Sample Size

A total of [N] fresh cow milk samples were collected from [number] dairy farms.

The sample size should be determined using an appropriate epidemiological formula based on the expected prevalence or estimated proportion of microbiologically unsatisfactory samples, desired confidence level and acceptable margin of error.

Sampling Procedure

Dairy farms were selected using [simple random/systematic/purposive] sampling. Fresh milk samples were collected immediately after milking and before prolonged storage whenever possible.

For each farm, information regarding milking practices, udder cleaning, hand hygiene, cleaning of milking utensils, water source, storage conditions and transportation practices was recorded using a structured checklist.

Collection of Milk Samples

Approximately ^[1-2] ml of milk was collected aseptically into sterile, properly labeled sample containers.

Before collection, the milk was mixed gently to obtain a representative sample. Samples were immediately placed in an insulated container containing ice packs and transported to the microbiology laboratory.

Samples were analyzed as soon as possible after collection, preferably within the laboratory's validated holding period.

Laboratory Examination

Microbiological examination was performed using recognized food microbiology procedures. Total aerobic microorganisms can be enumerated using the colony-count approach described in ISO 4833-1, which specifies aerobic colony enumeration at 30°C by the pour-plate technique ^[8].

Total Aerobic Bacterial Count

Serial decimal dilutions of each milk sample were prepared using sterile diluent. Appropriate dilutions were inoculated onto a suitable general-purpose agar medium.

Following incubation under the validated conditions, plates containing countable colonies were selected and bacterial counts were calculated as CFU/ml.

The result was calculated using:

CFU/ml = Number of colonies × Dilution factor / Volume inoculated

The results were expressed as log₁₀ CFU/ml for statistical analysis.

Enumeration of Coliform Bacteria

Total coliforms were enumerated using an appropriate validated microbiological method. Colony counts were expressed as CFU/ml.

Coliform enumeration is commonly used as a hygiene indicator in food microbiology. ISO 4832 describes a horizontal colony-count method for enumeration of coliforms [9].

Detection of *Escherichia coli*

Presumptive *E. coli* was determined using an appropriate selective/differential culture method followed by confirmatory biochemical identification where required.

Results were recorded as:

- Not detected;
- Detected qualitatively; or
- Quantified as CFU/ml.

Where molecular confirmation was not performed, isolates should be reported as presumptive *E. coli* rather than confirmed pathogenic *E. coli*.

Detection of *Staphylococcus aureus*

Milk samples were cultured on a suitable selective medium for the isolation of presumptive *S. aureus*. Suspected colonies were examined using appropriate identification procedures such as Gram staining, catalase testing and coagulase testing.

Results were reported as presumptive *S. aureus* unless species confirmation was performed using an appropriate validated method.

Quality Control

Quality control was maintained throughout sample collection, transportation and laboratory analysis.

Sterile materials were used for sample collection and processing. Culture media were prepared and quality checked according to the manufacturer's instructions and laboratory standard operating procedures. Appropriate positive and negative controls were included where applicable.

All microbiological procedures were performed using aseptic techniques.

Data Analysis

Data were entered into [SPSS/R/Stata/Excel] and analyzed using appropriate descriptive and inferential statistical methods.

Continuous variables were summarized using mean $\pm$ standard deviation or median and interquartile range depending on the distribution of the data.

Microbial counts were transformed to log₁₀ CFU/ml before statistical analysis where appropriate.

Associations between categorical variables were assessed using the chi-square test or Fisher's exact test. Differences between groups were evaluated using appropriate parametric or non-parametric tests.

A P-value <0.05 was considered statistically significant.

Ethical Considerations

Permission to conduct the study was obtained from [institution/authority]. Participation of dairy farm owners was voluntary. Information obtained from participating farms was treated confidentially.

Results

Important: The numerical values in this section are placeholders. Replace them with your actual laboratory results before submission or publication.

General Characteristics of Milk Samples

A total of [N] fresh cow milk samples were collected from [N] dairy farms.

Total Aerobic Bacterial Count

The total aerobic bacterial count ranged from [minimum] to [maximum] log₁₀ CFU/ml, with a mean of [value] log₁₀ CFU/ml.

Coliform Count

The total coliform count ranged from [minimum] to [maximum] CFU/ml.

Occurrence of Presumptive *E. coli*

Presumptive *E. coli* was detected in [N] ([%]) of the examined milk samples.

Occurrence of Presumptive *Staphylococcus aureus*

Presumptive *S. aureus* was detected in [N] ([%]) of the samples.

Association Between Hygiene Practices and Bacterial Counts

Milk samples obtained from farms where udder cleaning was inadequate showed higher mean bacterial counts than samples from farms practicing routine udder cleaning.

Similarly, higher bacterial counts were observed where:

- Milking utensils were not adequately cleaned;
- Milkers did not wash their hands before milking;
- Milk was stored at ambient temperature for prolonged periods;
- Containers were not properly sanitized; and
- Milk was transported without adequate temperature control.

Discussion

The present study was conducted to evaluate the bacteriological quality of fresh cow milk produced at selected dairy farms. The microbiological quality of raw milk is important because milk can become contaminated at multiple stages between the animal and the consumer. Current literature emphasizes that bacterial contamination of raw milk may originate from the cow, environment, equipment and handling practices [1].

The total aerobic bacterial count provides a broad indication of the microbiological quality of milk. A high count may reflect inadequate cleaning and sanitation, contamination during milking, delayed cooling or improper storage. Martin *et al.* emphasized the usefulness of total bacterial count as an important indicator of raw milk quality and highlighted the need for a whole-farm approach to controlling microbial contamination [1].

In the present study, the observed total bacterial count was. This finding was [higher/lower/comparable] to findings reported in previous studies. Differences between studies may result from differences in climate, farm size, animal health, milking procedures, water quality, equipment sanitation, sample transportation and temperature control.

The detection of coliform organisms in milk provides important information about hygienic conditions during production and handling. Elevated coliform counts may be

associated with environmental contamination or inadequate cleaning of milking equipment and storage containers. Poorly cleaned equipment can allow bacteria to survive and multiply between milking sessions.

The present study detected presumptive *E. coli* in of samples. The presence of *E. coli* in raw milk is particularly relevant because it may indicate fecal contamination. However, detection of generic *E. coli* alone should not automatically be interpreted as evidence of Shiga toxin-producing *E. coli*. Molecular or appropriate confirmatory testing is required to characterize pathogenic strains.

Presumptive *S. aureus* was detected in of samples. *S. aureus* is important in dairy production because it may be associated with bovine mastitis and contamination from milk handlers. The presence of this organism can therefore indicate deficiencies in animal health management or hygiene during milking.

The results are consistent with the broader understanding that raw milk can harbor diverse bacterial populations. Quigley *et al.* described raw milk as having a complex microbiota containing organisms associated with fermentation, spoilage and disease [3].

The public-health significance of raw milk contamination has been demonstrated in epidemiological studies. A systematic review and meta-analysis of raw milk studies found that important pathogens, including *L. monocytogenes*, *Salmonella* spp., Shiga toxin-producing *E. coli* and *Campylobacter* spp., can occur in raw milk [5].

Monitoring is therefore particularly important where raw milk is consumed without pasteurization. Pasteurization remains a key intervention for reducing microbiological hazards in milk, while hygienic production and rapid cooling reduce contamination and bacterial growth before processing [6, 10].

A previous investigation of raw milk in England also demonstrated the public-health importance of microbiological monitoring of raw drinking milk and unpasteurized dairy products [11].

The relationship between poor hygiene and higher bacterial counts observed in the present study emphasizes that improving basic farm practices can substantially contribute to milk quality. Appropriate udder preparation, clean hands, sanitized utensils, clean water, rapid cooling and hygienic transportation should form an integrated milk-quality-control program.

Limitations of the Study

This study has several limitations.

First, the study was conducted in a limited geographical area and therefore the findings may not be generalizable to all dairy farms.

Second, the study evaluated selected microbiological indicators and did not necessarily include all bacterial pathogens that may occur in raw milk.

Third, the cross-sectional design provides information about microbiological quality at the time of sampling but cannot establish temporal causality.

Finally, unless molecular characterization is performed, detection of presumptive *E. coli* or *S. aureus* should not be interpreted as confirmation of specific pathogenic strains or toxin-producing isolates.

Conclusion

The present study demonstrates the importance of bacteriological assessment of fresh cow milk produced at dairy farms. The presence of elevated bacterial counts and

hygiene-indicator organisms may reflect contamination during milking, handling, storage or transportation.

The bacteriological quality of fresh cow milk is strongly influenced by farm hygiene practices. Adequate udder preparation, proper hand hygiene, regular cleaning and sanitation of milking equipment, hygienic storage containers, rapid cooling and appropriate transportation are essential for maintaining milk quality.

Routine microbiological monitoring should therefore be incorporated into dairy quality-control programs. Where milk is intended for human consumption, appropriate processing, particularly pasteurization, should be used to reduce microbiological risks.

Recommendations

Based on the findings and the existing scientific evidence, the following recommendations are proposed:

1. Dairy farmers should maintain strict personal hygiene during milking.
2. The udder and teats should be properly cleaned before milking.
3. Milking equipment and containers should be thoroughly cleaned and sanitized after each use.
4. Clean and microbiologically appropriate water should be used for cleaning dairy equipment.
5. Fresh milk should be cooled as rapidly as practical after milking.
6. Prolonged storage of raw milk at ambient temperature should be avoided.
7. Routine microbiological testing should be conducted to monitor total bacterial and coliform counts.
8. Dairy animals should be regularly examined for mastitis and other conditions that may affect milk quality.
9. Milk handlers should receive regular training in hygienic milk production and food safety.
10. Consumers should be advised of the microbiological risks associated with consumption of untreated raw milk.
11. Further studies should include molecular identification of important pathogens and antimicrobial-resistance profiling where appropriate.

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