A comparison of selected air quality criteria in raw milk

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Abstract

The study was conducted to assess the impact of the changes in the milk collection two systems – small farms – the “semi-modern production system” and family farms or domestic farms – the “traditional production system” in the Cluj region (from twice daily collection to once, introduction of chilling facilities to the collection and transportation of milk to the processing plant in insulated truck instead of in metal churns at ambient temperature) on the microbial load and antimicrobial residue quality of the milk as well as the temperature and pH of milk, using standard methods. Milk quality is a broad concept that generally encompasses composition, hygiene and the addition of chemical substances or water. The demands on quality can vary, and depend on the end use of the milk. Hygienic quality is naturally of great importance, since bacterial growth in milk during storage can be a health hazard for the consumer and can cause changes in milk composition through enzymatic activity.

Keywords: milk “traditional production” system, milk production “semi-modern system”, public health criteria, milk quality

1. Introduction

Cow’s milk has long been considered a highly nutritious and valuable human foodstuff as a main food on the diet, and is consumed by millions daily in a variety of different products. Its nutrient composition makes it an ideal medium for bacterial growth, and therefore it can be considered one of the most perishable agricultural products because it can so very easily be contaminated [2-4]. Many containing organisms only spoil the product, thereby reducing its shelf-life. Some, such as lactic acid bacteria, are useful in milk processing, causing milk to sour naturally. Other bacteria are pathogenic to humans and can transmit disease if the milk is consumed untreated [4,5]. Unlike meat and meat products, milk is less likely to be subjected to any subsequent heating by the consumer before consumption and contaminated milk is therefore potentially more dangerous [6]. The high fat content of milk protects pathogens against gastric acid, while its fluid nature ensures a fairly short retention time in the stomach [6,7].

Raw milk as good hygienic quality is necessary to produce milk products of good quality and adequate shelf-life and to provide a safe, sound and wholesome food for the consumer. Since milk is a liquid, it is in contact with some type of equipment or surface from the time it is removed from the cow until it is consumed.

Milk freshly drawn from a disease-free udder contains small numbers of bacteria (500 to 1 000 bacteria per ml) which derive from organisms colonizing the teat canal [3]. Milk quality starts to deteriorate immediately after milking due to bacteria entering the milk from a wide variety of sources.

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These bacteria may originate from soil, water and faeces that collect on the skin of the cow and unavoidably end up in the milk. Once microorganisms get into the milk they multiply rapidly.

The speed at which quality declines depends on the hygiene of the milker, milking equipment and bulk tank, as well as the temperature and length of time that milk is stored before sale to the consumer or treatment at a factory. Microbial growth can be controlled by cooling the milk, as most-organisms reproduce more slowly in colder environments.

Pathogenic bacteria may also be present in raw milk as a direct consequence of clinical or subclinical mastitis. Mastitis affects a variety of compositional parameters of milk which in turn may affect the dairy technological usefulness, the nutritional and hygienic characteristics of milk. Among the organisms commonly producing mastitis, *Streptococcus agalactiae*, *Staphylococcus aureus* (*S. aureus*) and *Escherichia coli* (*E. coli*) are pathogenic for man [3].

Production of quality milk on dairy farms depends on minimizing bacteria and excluding chemical contaminants. Premilking udder hygiene is a vital component of a total quality milk program and should be evaluated by effects on the quality of milk and on incidence of mastitis.

Microbial contamination of raw milk may occur from three main sources: from within the udder (mastitis-associated organisms), from environmental organism transfer via dirty udder and teat surfaces, and from improperly cleaned and sanitized milking equipment.

Additionally, improper cooling and prolonged storage of milk can also influence bacterial count by increasing the rate of bacterial growth during storage of milk.

Environmental sources of bacteria are numerous. High bacteria counts in milk are commonly associated with improper sanitation of milking equipment or poor cooling. Dirty teats and udders are another environmental source of bacteria in milk [8]. Contamination of teats and udders can be minimized by proper management of cows between milkings in clean, dry areas. In 1946, Bryan et ai. [1,2,9] wrote: "Proper stall hygiene is a prerequisite to udder hygiene".

A 24-h hygiene program is still mandated to maximize production of quality milk and mastitis control. Milk quality is also reduced by bacteria that cause mastitis.

Total bacteria count can be significantly increased by some mastitis pathogens, particularly *Streptococcus agalactiae* [10]. Milk composition is altered by mastitis pathogens. Fat, lactose, and casein contents are usually decreased, and cheese yields are reduced [11]. Proteolytic activity is significantly higher in milk from quarters infected with *Strep. agalactiae*. This activity persists and continues to reduce milk quality after elimination of the causal organism [11].

The third source of bacteria in milk is the normal udder flora, species of bacteria that commonly live on teat and udder skin. *Staphylococcus species*, other than *Staphylococcus aureus, are the primary group* [12]. Improper udder preparation prior to milking can increase the numbers of these bacteria in milk [13-15].

Chemical residues in milk are another aspect of a quality milk program and can be caused by feed, therapy for systemic or local infection, or direct contact of milk with chemicals in milking systems or on teat skin. Only chemical contamination related to udder preparation will be addressed in this paper. A number of premilking udder hygiene procedures are used by dairy farmers.

The purpose of this paper is to assess the impact of the changes in the milk collection two systems – small farms – the “modern production system” and family farms or domestic farms – the “traditional production system” in the Cluj region (from twice daily collection to once, introduction of chilling facilities to the collection and transportation of milk to the processing plant in insulated truck instead of in metal churns at ambient temperature) on the microbial load and quality of the milk as well as the housing environment (atmosphere microbiological load), milker hygiene, milking equipment and bulk tank hygiene. In this study, three (3) bacterial quality parameters were used: total aerobic count (TAC), coliform count (CC), and staphylococcus count (SC). The TAC is an alternative to the standard plate count (SPC). It estimates the total number of aerobic bacteria in raw milk samples and is an important parameter in regulatory and quality incentive programs in many parts of the world.

The TAC indicates the general hygienic conditions during milk production; therefore, it may be of less importance in identifying specific sources of contamination [17].
Romanian’s regulation set up for TAC the Acceptable Limit at 250,000/m³ [16]. The CC enumerates coliform bacteria. Coliforms inhabit the intestinal tract of cows and are commonly found in manure, bedding material, soil, and contaminated water. Coliforms contaminate raw milk through the exterior of udder and teats and contaminated milking equipment.

2. Materials and Method

**Farm Selection and Data Collection.** A case-control study was conducted to identify specific on-farm risk factors that influence bacteriological quality of bulk tank milk in two the milk collection systems – small farms (coded as F₁, F₂, F₃, and F₄) – the “semi-modern production system” and family farms or domestic farms (coded as A, B and C) – the “traditional production system” in the Cluj region (from twice daily collection to once, introduction of chilling facilities to the collection and transportation of milk to the processing plant in insulated truck instead of in metal churns at ambient temperature) dairy herds.

The study was conducted during two years 2004 to 2006 with a seasonal variation during winter (January), spring (April), summer (July), autumn (October) of milk collection and analysis. The raw milk samples were collected from the small farms as well as from family farms.

Microbiological count data (TAC – total aerobic count, CC – coliform counts, SC – staphylococcus count) from individual bulk milk loads were assessed from each sample in triplicates collected from family farms as well as from small farms before and after hygienic procedures.

**Study Design.** Bulk tank raw milk was collected from all dairy herds (n =7) every other week by licensed milk haulers over a 2-yr period (January 2004 to March 2006). For each sample, TAC, CC, and SC counts were conducted using Koch sedimentation method according to Standard Methods for Examination of atmospheric microorganisms [18,19].

The determinations were done in various stages of stall/housing preparation: at 25-30 minutes after faeces evacuation and ventilation (A); during dietary fibre feed providing and nutrition (B); during administration and nutrition with concentrated feed (C); during milking (D).

The determinations were done twice on a day in the morning and in the evening. Samples were collecting on the selective microbiological culture medium: TAC on nutritive gel, Stphylococcus bacteria on Baird-Parker culture medium, and coliforms were cultured on Istrati-Meitert specific isolation culture medium. Petri dishes were incubated for 24–48 hours at 37°C (to determine the total number of bacteria).
Results were shown by colony forming units in 1 m$^3$ of air (cfu/m$^3$). Bacteria were identified by macroscopic estimation (description of colony).

Statistical analysis of the data was performed with Two-way ANOVA and Correlation, using GraphPad Prism version 3.00 for Windows, GraphPad Software, (San Diego California, USA, www.graphpad.com).

3. Results and Discussion

Variation of microorganism concentrations in the air of stall – farms in four case-study. The average level of microbiological air contamination inside investigated stall farms is shown in Table 1.

Microorganism concentrations in the air varies not only in the course of a season but also throughout the day (morning higher values than evening data).

Results presented in Table 1 shown that during morning hygiene procedures (GMP and SOP) the values are higher than evening hygiene procedure and microbiological air parameters, in all the four case-study (Figure 1).

TAC load of the air stall/housing of the four case-study during administration of dietary fiber feed is the higher value recorded over the study, and the lower value is recorded at 25-30 minutes after faeces drain-off and stall ventilation.

| Table 1. Microbiological air contamination inside the stall/housing farms (family farms) |
|-----------------------------------------------|---------------|---------------|---------------|---------------|
| month            | After 25-30 min. faeces evacuation and ventilation (A) | During dietary fibre feed administration (B) | During administration of concentrated feed (C) | During milking (D) |
| month            | Mean | evening | Diminecta Seara | Mean | Diminecta Seara | Mean | Diminecta Seara | Mean | Diminecta Seara |
| January          | 320781 | 301127 | 910250 | 874138 | 766237 | 594261 | 750320 | 412863 |
| April            | 307261 | 295846 | 16900279 | 920647 | 894781 | 721509 | 523160 | 470781 |
| July             | 251048 | 218704 | 683714 | 548012 | 602142 | 519278 | 397874 | 351186 |
| October          | 260730 | 178039 | 844371 | 602614 | 634080 | 590605 | 430109 | 394529 |
| Mean             | 284955 | 248429 | 859653.5 | 736352.7 | 724310 | 606413.2 | 450365.7 | 407339.7 |

Figure 1. Mean values of TAC in the morning and evening count during the four case-study. A: after 25-30 min. faeces evacuation and ventilation; B: During dietary fibre feed administration; C: During administration of concentrated feed; D: During milking.

Figure 2. Staphylococcus count during the four case-study; A: after 25-30 min evacuation and ventilation; B: During dietary fibre feed administration; C: During administration of concentrated feed; D: During milking.
SC of the stall air microbiota during fiber dietary feed administration shown the higher values, and the lower SC values is recorded at 25-30 minutes after faeces drain-off and ventilation (fig. 2).

CC of the stall air microbiota have the higher values during dietary fiber feed administration and in the evening cleaning procedures, and the lower value is shown at 25-30 minutes after faeces drain-off and ventilation (fig. 3).

We compare the data of microbiological quality criteria during each case-study evaluated (fig. 4, fig. 5 and fig 6).

4. Conclusion

Premilking udder hygiene is an essential part of a quality milk program. Sanitation of teats before milking reduces bacterial contamination of milk, enhances milk quality, and aids in the control of mastitis. The major objective of premilking udder preparation is to milk clean and dry teats. Prevention of chemical residues in milk is equally important. The procedure of manually washing and drying teats minimizes sanitizer contamination and maximizes mastitis control.

Stall air microbial load significant influence the microbial load of the equipments and suppliers used in milking process, the TCA maximum acceptable limit is overlap in all the four case-study evaluated.

The family farms, domestic farms - „traditionally production system” where is using manual milking are the main effect by the microbial load (TAC, CC and SC) due to the direct germs sedimentation on the milking tank.

Microbial load (TAC, CC and SC) is higher in the morning than evening in all the four case-study assessed due to the fact that overnight most of the ventilations are blocked.

The case-study A shown the lower stall microbial load for all the hygiene quality criteria evaluated.

References


