JAP&T
TPA-Timişoara

Available online at http://journal-of-agroalimentary.ro

Journal of Agroalimentary Processes and Technologies 2010, *16*(3), 367-372

Journal of Agroalimentary Processes and Technologies

A comparison of selected air quality criteria in raw milk

Angela Carmen Bocşa-Oarga, A. Cristina Semeniuc*, Ancuța M. Rotar, Camelia Guş, Ramona Suharoschi, Cornel Laslo

[1] *Agricultural University and Veterinary Medicine Cluj-Napoca, Address – 400372 –Cluj-Napoca, Mănăştur Street, number3-5, Români*

Received: 07 July 2010; Accepted: 05 September 2010

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.

Corresponding author: *e-mail:* cristinasemeniuc@yahoo.com

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 micro-organisms 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].

Producfion 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 (mastitisassociated 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 productjon 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 signiflcantly higher in milk from quarters infected with *Strep. agalactiae.* This activity persists and continues to reduce milk quality after eliminanon 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 preparåtion 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 fanners.

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 reglementation set-up for TAC the Acceptable Limit at 250.000/m^3 [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 F_1, F_2, F_3, and F_4) – 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 (Janury 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].

Microbiological quality of indoor air was investigated in select study-groups specified in Table 1 and data were stored in Excel spreadsheets (Microsoft, Seattle, WA) before transfer into statistical analysis software.

Total number of mesophilic aerobic bacteria, coliforms and staphylococcus bacteria in the air of selected farms was determined using Koch sedimentation method according to Romanian Standard for farms stall [16]. Air microorganisms were settled gravitationally directly on the Petri plates filled with nutrient media and exposed in sampling points for a period of time. The number of microorganisms expressed as CFU/m^3 was estimated according to the equation [16]:

$$CFU/m^3 = a\ 10000/p\ t\ 0.2$$

where:
a – the number of colonies on the Petri plate
p – the surface of the Petri plate
t – the time of Petri plate exposure

Results obtained by Koch sedimentation method are less accurate then those from impaction methods with the use of an air sampler. However, the sedimentation method is still quite popular in Romania and some other countries [20, 21, 23-25]. The method does not require expensive instrumentation, it is cheap and simple and it is recommended by Polish Standards. Sedimentation method does not permit exact quantitative determination, some earlier observations reported that results of sedimentation method are usually higher than numbers obtained with the use of air samplers[22,25]. However, data collected by sedimentation method allow the drawing of correct conclusions on types of microorganisms present in the air and can give a rough approximation of bacterial concentration. For the determination of microorganisms in the air of investigated rooms Petri dishes were exposed for 1 minute.

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 37^0C (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 (Figure1).

TAC load of the air stall/housing of the four case-study during administration of dietary fiber fee dis 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)	
	morning	evening	Dimineata	Seara	Dimineata	Seara	Dimineata	Seara
	Mean		Mean		Mean		Mean	
January	320781	301127	910250	874138	766237	594261	750320	412863
	310954		892194		680249		431591.5	
April	307261	295846	1000279	920647	894781	721509	523160	470781
	301553.5		960463		808145		496970.5	
July	251048	218704	683714	548012	602142	519278	397874	351186
	234876		615863		560710		374530	
October	260730	178039	844371	602614	634080	590605	430109	394529
	219384.5		723492.5		612342.5		412319	
Mean	284955	248429	859653.5	736352.7	724310	606413.2	450365.7	407339.7
	266692		798003.12		665361.6		428852.75	

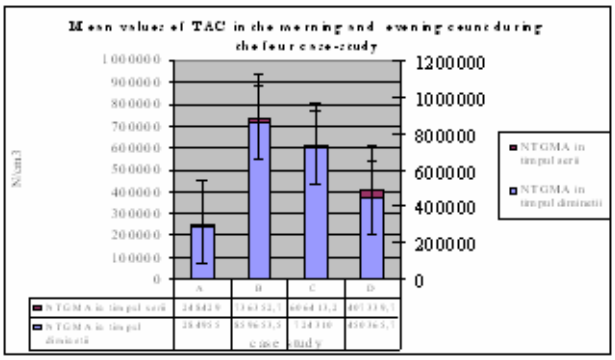

Figure 1. Mean values of TAC in the morning and evening count during the four case-study. A:after 25-30 min. faeces evacuation and ventilation; B: During dietary fibre feed administration; C: During administration of concentrated feed: D: During milking

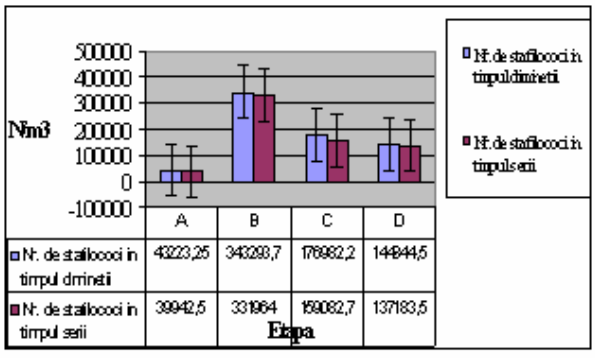

Figure 2. Staphylococcus count during the four case-study; A:after 25-30 min evacuation and ventilation; B: During dietary fibre feed administration; C: During administration of concentrated; feed: D:During milking

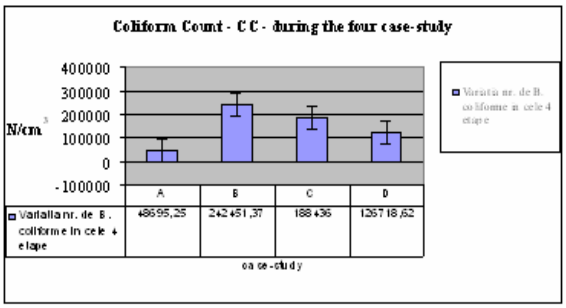

Figure 3. Coliform Count (CC) during the four case-study

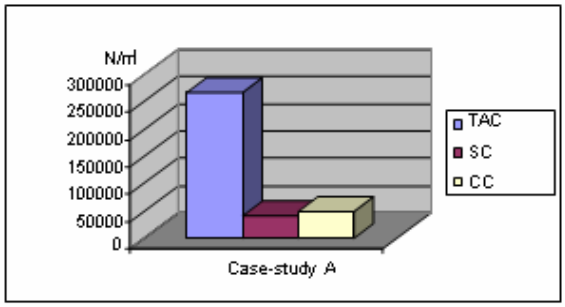

Figure 4. Variation of TAC, SC and CC values during A case-study CC values

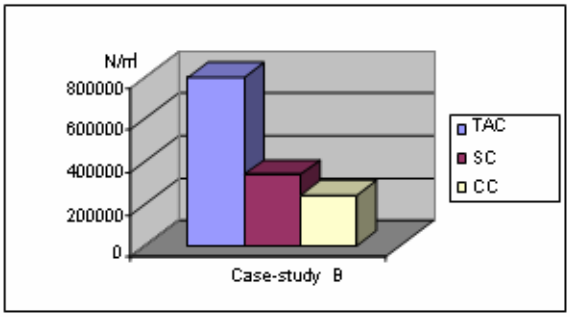

Figure 5. Variation of TAC, SC and during B case-study

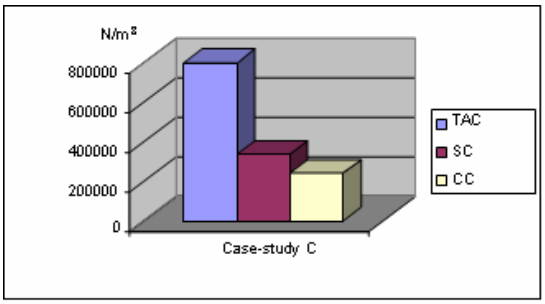

Figure 6. Variation of TAC, SC and CC values during C case-study

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 masatis. 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 duet o 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

1. Ranieri, M. L., Huck, J.R, Sonnen, M, Barbano, D. M., Boor, K. J., High temperature, short time pasteurization temperatures inversely affect bacterial numbers during refrigerated storage of pasteurized fluid milk, *Journal of Dairy Science,* **2009**, *92*(10), 4823–4832
2. Bryan F.L., Epidemiology of milk-borne diseases. *Journal of Food Protection,* **1983**, *46*(7), 637-649

3. Bramley A.J., McKinnon C.H., *The microbiology of raw milk.* In: Robinson RK (ed) Dairy Microbiology vol 1. Elsevier Applied Science, London, **1990**, 163-208.
4. Heeschen W.H., *Introduction. In: Monograph of the significance of pathogenic microorganisms in raw milk*, International Dairy Federation, Brussels, **1994**, 8-11
5. Sharp J.C.M., Paterson G.M., Barrett N.J., Pasteurisation and the control of milkborne infection in Britain, *British Medical Journal*, **1985**, *291*(6493), 463-464, doi: 10.1136/bmj.291.6493.463
6. Steele M.L., McNab W.B., Poppe C., Griffiths M.W., Chen S., Degrandins S.A., Fruhner L.C., Larkin C.A., Lynch J.A., Odumern J.A., Survey of Ontario bulk tank raw milk for food-borne pathogens, *Journal of Food Protection*, **1997**, *60*(11), 1341-1346
7. Potter M.E., Kaufmann A.F., Blake P.A., Feldman R.A., Unpasteurized milk-the hazards of a health fetish, *JAMA*, **1984**, *252*(15), 2048-2052
8. Galton, D. M., Adkinson R.W., Thomas C.V., Smith T.W., Effects of premilking udder preparation on environmental bacterial contamination of milk, *J. Dairy Sci*., **1982**, *65*(8), 1540-1543, doi:10.3168/jds.S0022-0302(82)82379-5
9. Bryan, C. S., Schalm O.W., Plastridge W.N., *Stable hygiene in the control of mastitis for production of clean milk.* Page 457 *in* Bovine mastitis - A symposium. R. B. Little and W. N. Plastridge, ed. McGraw-Hill Book. Co., Inc., New York, NY., 1946
10. Hogan, J.S., Pankey J.W., Murdough P.A. Howard D. B., Survey of bulk tank milk using blood-esculin agar counts, *J. Food Prot.*, **1986**, *49*(12), 990-993
11. Saeman, A.I., Verdi R.J., Galton D.M., Barbano D.M., Effect of mastitis on proteolytic activity in bovine milk, *J. Dairy Sci.*, **1988**, *71*(2), 505-512, doi:10.3168/jds.S0022-0302(88)79581-8
12. Hogan J.S., White D.G., Pankey J.W., Effects of teat dipping on intramammary infections by *Staphylococci* other than *Staphylococcus aureus*. *J. Dairy Sci*., **1987**, *70*(4), 873-879, doi:10.3168/jds.S0022-0302(87)80086-3
13. Galton D. M., Adkinson R. W., Thomas C. V., Smith T.W., Effects of premilking udder preparation on environmental bacterial contamination of milk, *J. Dairy Sci.*, **1982**, *65*(8), 1540-1543, doi:10.3168/jds.S0022-0302(82)82379-5
14. Galton D.M., Merrill W.G., *Effectiveness of premilking udder preparation practices on milk quality and udder health*, Proc. Milking Systems and Milking Management Symp., Harrisburg, PA.,1988
15. Galton D.M., Petersson L.G., Mcrrill W.G., Bundler D.K., Shuster D.E., Effects of premilking udder preparation on bacterial populauon, sedimem, and iodine residue in milk, *J. Dairy Sci.*, **1984**, *67*(11), 2580-2589, doi:10.3168/jds.S0022-0302(84)81616-1
16. Decun, M., *Igienă veterinară şi protecţia mediului*, Ed. Helicon, Timişoara, 1997
17. Chambers, J. V., *The microbiology of raw milk*. Pages 39–90 in Dairy Microbiology Handbook. 3rd ed. R. K. Robinson, ed. John Wiley & Sons Inc., New York, NY., 2002
18. Richardson G.H., *Standard Methods for the Examination of Dairy Products*., 15th ed. Am. Public Health Assoc., Washington, DC., 1985
19. H. M., Wehr, J. F. Frank, *Standard Methods for the Examination of Dairy Products*, 17th ed. Am. Publ. Health Assoc., Washington, DC., 2004
20. Sarica S., Asan A., Otku N M.T., Ture M., Monitoring Indoor Airborne Fungi and Bacteria in the Different Areas of Trakya University Hospital, Edirne, Turkey, *Indoor and Built Environ.*, **2002**, *11*(5), 285-292, doi:10.1159/000066523
21. Daisey J.M., Angell W.J., Apte M.G., Indoor air quality, ventilation and health symptoms in schools: an analysis of existing information, *Indoor Air*, **2003**, *13*(1), 53-64, doi: 10.1034/j.1600-0668.2003.00153.x
22. Filipiak M., Piotrasze Wska-Pajak A., Stryjako Wska-Sekul Ska M., Stach A., Silny W., Outdoor and indoor air microflora of academic buildings in Poznań, *Progress in Dermatology and Allergology*, **2004**, *21*(3), 121-127
23. Fle Ische R M., Bober-Gheek B., Bortkiewicz O., Rusiecka-Ziolko Wska J., Microbiological control of airborne contamination in hospitals, I*ndoor and Built Environment*, **2006**, *15*(1), 53-56, doi: 10.1177/1420326X06062230
24. Ruczalak K., Anczuk O.L., Ney Man K. Microorganisms In the Air Over Wastewater Treatment Plants, *Polish Journal of Environmental Studies*, **2004**, *13*(5), 537-542
25. Simsekli I Y., Gücin F., Asan A. Isolation and identification of indoor airborne fungal contaminants of food production facilities and warehouses in Bursa, Turkey, *Aerobiologia*, **1999**, *15*(3), 225-231, doi: 10.1023/A:1007623831010