Review Article

Impact of Raw Milk Quality on Dairy Products & Payment Systems

Abstract

The microbiological quality of raw cow milk was assessed inadequate, suggesting that hygienic standards must be improved.~~the~~ The trend of microbial quality of a greater number of milk samples were shifting towards fair, poor and very poor from February, March, April, May and June due to seasonal variation in raw milk quality as affected by variations in milk production practices and ambient temperature with the season.A payment system, which includes testing for selected parameters, with subsequent rejection and/or penalties or bonuses, is considered functional to improving raw milk quality. In addition to the minimal legal requirements, milk may be graded (and paid) according to its "quality," usually measured according to composition (fat, protein, lactose, other solids, free fatty acids), hygienic quality.Psychrotrophic microbes, particularly *Pseudomonas* spp., are found in the microbiota of chilled milk because they can grow at temperatures below their optimal growth temperature. Psychrotrophic counts ranging from 105 to 108 CFU/ml in refrigerated raw milk affect cheese quality, since the synthesized thermoresistant enzymes affect the nutritional value, sensory properties and texture. Therefore, stringent measures must be implemented throughout the dairy supply chain to ensure the microbial quality of raw milk is maintained at safe levels, thus safeguarding the integrity and safety of dairy products for consumers.

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Keywords: milk quality, payment system, hygienic quality, Psychrotrophic microbes

Introduction

In India, millions of small farmers and dairy farms produce raw milk. Despite the fact that many dairy farms have adopted clean milk production procedures, the quality of raw milk produced on the farm does not match that of raw milk produced in developed countries (Murphy and Boor, 2000). Sameera *et al*. (2020) evaluated quality of raw and pasteurized milk from two different locations in Hyderabad region, Telangana state, India for a period of six months from January to June. The bacterial count (TPC and TCC collectively) ranged from 1.5×10^8 to 1.25×10^7 CFU/ml. The study concluded that the microbiological quality of most of the milk samples collected from different areas of Hyderabad city were not up to the standards, as evidenced by their high number of microorganisms and also the presence of coliform bacteria. Further, the trend of microbial quality of a greater number of milk samples were shifting towards fair, poor and very poor from February, March, April, May and June due to seasonal variation in raw milk quality as affected by variations in milk production practices and ambient temperature with the season.

Comment [Dr1]: Provide a list of abbreviations throughout used in this article, before References.

Kakati *et al*. (2021) assessed the quality of raw milk sold in and around Guwahati city based on the microbial load. All of the raw milk samples had a significantly higher standard plate count and coliform count than the permissible standard. It was concluded that raw milk sold in most parts of Guwahati city do not confer to the legal microbiological standard and may pose a high risk of milk-borne illness among consumers of the city. While Dinki and Balcha (2013) evaluated raw milk samples of cattle collected from six different consumers collection centres of Guwahati city, India. It was reported that 23.3 per cent of samples were having antibiotic residues with 23.3 per cent detection rate. The mean standard plate count and the mean coliform count of raw milk were 6.38±0.02 and 2.85±0.03 log10 CFU/ml, respectively. The study indicated that the milk produced and distributed in the study area can be considered as of fair quality. In Madurai, India, researchers assessed the microbiological quality and safety of raw cow milk gathered from 60 dairy farms in four regions: northern, eastern, western, and southern (Lingathurai and Vellathurai, 2010). TPC, psychrotrophs, and thermophiles had mean numbers per ml of 12.5×10^6, 5×10^3, and 6.85×10^3, respectively. *E. coli* had a range of 10^3 to 10^4CFU/ml. Minj and Behera (2012) analysed and compared the microbial quality of raw cow milk samples procured from rural and urban farms of Sambalpur City, Odisha, India. In relation to total viable count, the bacterial load of both rural and urban milk samples was found to be much greater than the permitted limits. The preliminary incubation count was significantly higher in urban samples indicating unhygienic milk production/handling practices. The laboratory pasteurisation count of rural milk samples was higher than that of urban milk samples. The enteric microorganisms isolated from both rural and urban milk samples indicated that the urban samples were highly contaminated in comparison to that of the rural ones. Whereas Chatterjee *et al*. (2006) assessed the milk quality in Tarakeswar, India. Six out of ten raw milk samples had significant microbial colony level, whereas the remaining four samples had low colony content, according to the SPC method. The methylene blue test on raw milk samples revealed that five samples were poor, two samples were acceptable, two samples were good, and only one sample was exceptional out of 10 samples. In another study, Srujana *et al*. (2011) evaluated microbial quality of raw milk samples collected from different places of Warangal District, Andhra Pradesh, India for a period of six months for microbial quality. Among the raw milk samples, only 19.1 per cent of samples were of good quality and 28.3 per cent were of very poor quality. *Lactobacilli, Staphylococcus aureus, Escheritia coli, Bacillus subtilis, Salmonella typhi*, and feacal coliforms were among the bacteria isolated from milk samples. Mubarack*et al*. (2010) evaluated microbial quality of raw milk samples collected from different villages of Coimbatore District, Tamilnadu, South India. Among the 80 raw milk samples evaluated, bacteriological identification revealed a definite dominance of *Lactobacillus sp*. Besides it, the other genera *Staphylococcus, Escherichia, Bacillus, Salmonella* and *Pseudomonas* were isolated on selective agar and broth.

Jadhav and Rajaram (2016) analysed the milk samples for assessing its microbial quality and physico-chemicals parameters, along with sensory attributes of Dapoli and villages around Dapoli, Maharashtra, India in three distinct seasons' viz. summer from April to June, Monsoon from July to August and winter from November to December. It was observed that in winter season, per cent fat and per cent total solid was higher while in rainy season, per cent acidity, per cent ash and *E. coli* count was higher. The summer season showed highest Direct Microscopic Count (DMC) and SPC count. Kavitha (2017) evaluated the microbial quality of raw milk of cows collected from Upparapalayam and Aarikkamedu villages of Thiruvallur District, Tamil Nadu. Methylene blue reduction test (MBRT) and microbiological quality of each sample was analysed using standard procedures. The MBRT values, Standard plate count, and total coliforms were all considerably higher above the standard levels. It was inferred that poor milk handling practices during milking, poor animal health services, and use of poor potable water may have resulted into poor quality of raw milk. The microbiological and chemical composition of cow milk from different places in Madurai, Tamil Nadu, was compared by Lingathurai*et al*. (2009). The average levels of major chemical components were found for fat (6.14 per cent), crude protein (3.77 per cent), lactose (4.25 per cent), total solids (18.10 per cent) and ash (0.80 per cent). Total mesophilic aerobic bacteria, 5.84 log CFU/ml; bacterial endospores, 2.37 log CFU/ml; lactic acid bacteria, 4.46 log CFU/ml; coliforms, 2.76 log CFU/ml; *Escherichia coli*, 1.63 log CFU/ml; coliforms, 2.76 log CFU/ml; *Escherichia coli*. In all of the samples, *Listeria* spp. were below the detection level. The microbiological quality of raw cow milk was assessed inadequate, suggesting that hygienic standards must be improved.

Evaluation of Raw Milk Quality

Raw milk quality can be evaluated either through microbiological tests (total aerobic plate count for mesophilic aerobes, total counting of psychotropic aerobes) or physicochemical tests (pH value, titratable acidity, clot-on boiling test, etc.) (Tetrapak, 2014; Alimentarius, 2004). Total bacterial count/standard plate count/total viable count: The quality of milk is measured by the standard plate count. The lower the SPC, the better the quality of the raw milk. In this test, general purpose growth media are used to quantify total bacteria load. The total bacterial count (TBC), which quantifies aerobic mesophilic bacteria in milk, is the most common test performed by milk processors to determine milk microbiological quality.

Counts were slightly higher in milk collected during the summer months while cows were grazing outside (Kable *et al*. 2019; Priyashantha*et al*. 2021). Psychotropic bacteria grow and multiply under improper refrigeration conditions. Many psychrotrophic bacteria are capable of producing heat stable enzymes like proteases and lipases and cause degradation and reduction in the shelf-life of pasteurized milk and milk products (Fusco *et al*., 2020; Hayes and Boor, 2001). These organisms can also create undesirable odors and off-~~flavors~~flavours. The number of thermoduric bacteria that survive a laboratory-scale batch pasteurisation process is measured by the thermoduric count. Pasteurized milk degradation has been associated with thermoduric bacteria. Thermoduric organisms are mostly found on the surfaces of farm equipment that hasn't been properly cleaned.The Somatic cell count (SCC) has been widely used to indicate the prevalence of mastitis in dairy herds. Bulk tank milk with high SCC has a higher level of proteolytic and lipolytic enzymes, which affect the ~~flavor~~flavour and shelf life of dairy products (Barbano *et al*., 1991).

The pH of milk should be between 6.65 and 6.8 to ensure trouble-free processing and high quality of the final product. A lower pH will risk product stability and cause fouling. A higher pH increases chances of mastitis-infected milk. As a result, milk that does not fulfil these requirements is not appropriate for UHT processing **(**Tetrapak, 2014). The natural acidity of milk is due to casein, mineral substances, and phosphates. The developed acidity is due to the lactic acid produced by lactose degradation because of microorganisms. The titratable acidity test is used to determine whether milk has a high acidity level that affects its keeping quality and heat stability. The acidity of milk is not a true measure of lactic acid present but in practice, gives a good indication of the quality of milk.

Quality Based Milk Payment System (QBMPS)

A payment system, which includes testing for selected parameters, with subsequent rejection and/or penalties or bonuses, is considered functional to improving raw milk quality. In addition to the minimal legal requirements, milk may be graded (and paid) according to its "quality," usually measured according to composition (fat, protein, lactose, other solids, free fatty acids), hygienic quality (total microbial count, thermoduric count, spore count, mycotoxins, drugs, and residues), physical properties (renneting ability, density, freezing point, temperature at reception, etc.) and animal health (somatic cell count). QBMPS are important in the dairy sector as they enable farmers to improve profitability of dairy farm based on milk quality. Furthermore, in order to be properly assessed, milk quality evaluation should take into account its desired use, as it is clear that the criteria for manufacturing fluid milk, yoghurt, cheese, and other milk products differ significantly. As a result, QBMPS tries to deliver premium grade milk to all players (Ndambi *et al*., 2018). Multiple criteria are often used in milk quality payment incentive programmes, such as no detectable antibiotics and added water, total bacteria count of 25,000 CFU/ml, laboratory pasteurised count of 500 CFU/ml, low sediment test, and low SCC of 300,000 cells/ml.

Entrepreneurs in India are now attempting to reach out directly to their customers using farm fresh milk. The consumer has begun to recognise the importance of fresh, pure milk, and this niche of high-paying customers is likely to rapidly grow to smaller communities (Sharma, 2015). Therefore, an Indian dairy farm and industry have to pay increasing attention to quality and innovation as its products have to compete not only globally but with imported products in the domestic market as well. Busanello*et al*. (2020) evaluated data for QBMPS from a dairy farm referring to a four-year period. It was observed that protein and fat positively and SCC and TBC negatively affected QBMPS value. Summer and winter months have an inverse relationship, as per principal component analysis. In summer months, the QBMPS was affected by the increase of TBC and SCC and decrease protein, whereas in winter months, protein increase and TBC and SCC decrease were relevant. There was seasonal effect on QBMPS, with QBMPS being higher in winter months and lower in summer months. It was recommended that seasonal variation in milk composition and payment should be considered by farmers to reach higher values of bonuses, and by the dairy sector to receive adequate payment throughout the year. Four factors are important in the pursuit of a better microbiological quality of the raw milk throughout the dairy chain: (1) the number of bacteria that are initially present in the raw milk, since a high initial contamination results in a rapid outgrowth of psychrotrophic bacteria in raw milk; (2) the type of bacteria; (3) storage temperature; and (4) storage time (Heyndrickx*et al*., 2010). In order to avoid the repercussions of poor raw milk quality on finished dairy products, several remedies like proper cooling, clean milk production, hygienic farm management, efficient cleaning of equipment, maintaining cold chain etc can be practised at farm, dairy plant and distribution channels.

Effect of Raw Milk Quality on Dairy Products

Raw milk quality can clearly affect dairy product production, yield, quality and safety through a variety of different mechanisms. Raw milk with low bacterial counts is likely to be favourable for production of high-quality finished products. Although pasteurization can significantly reduce the initial bacterial counts in raw milk, some thermoduric bacteria and bacterial spores can survive pasteurization, with later multiplication and degradation of dairy products. Additionally, pasteurization process does not affect lipolytic and proteolytic enzymes produced by certain bacteria. Therefore, there are continuing demands upon producers to improve their raw milk bacterial numbers (Elmoslemany*et al*., 2016). The impact of raw milk quality on various dairy products is described below.

Pasteurized fluid milks (e.g., 72°C for 15 seconds or 63°C for 30 minutes) are the most exposed to microbiological or taste defects due to poor quality of raw milk. Acid, malty, bitter, coagulated, rancid, filthy, fruity, and fermented are common microbiological defects in pasteurised fluid milk (Alvarez, 2008). Fluid nature of milk, with its high-water content, a pH close to neutral render milk as an ideal medium for the growth and multiplication of diverse microorganisms resulting in its early deterioration (Barros *et al*., 2011). Pasteurized milk has a shelf life of only three days in undeveloped countries as compared to seven to ten days in developed countries. Ribeiro *et al*. (2018) observed that spore-forming bacteria in refrigerated raw milk can degrade the product. The spore count, lipolytic, and proteolytic counts of the milk samples all were assessed. It was concluded that preventive measures must be adopted to reduce contamination with spores to extend the shelf life of pasteurized milk as one-third of these microorganisms exhibited proteolytic and/or lipolytic activity

Psychrotrophic microbes, particularly *Pseudomonas* spp., are found in the microbiota of chilled milk because they can grow at temperatures below their optimal growth temperature. Psychrotrophic counts ranging from 10^5 to 10^8 CFU/ml in refrigerated raw milk affect cheese quality, since the synthesized thermoresistant enzymes affect the nutritional value, sensory properties and texture. In addition to significantly affecting cheese yields, the enzymes produced by psychrotrophic microbes cause taste alterations, unfavourable clotting times, increased concentrations of free fatty acids and free amino acids, and a shorter shelf-life. Surprisingly, psychrotrophic bacterial growth may represent a serious defect both for fresh or ripened cheeses (Caputo *et al*., 2015). Use of raw milk with somatic cell counts >100,000 cells/ml has been shown to reduce cheese yields, and at higher levels, generally >400,000 cells/ml, have been associated with textural and ~~flavor~~flavour defects in cheese and other products (Murphy *et al*., 2016).

Mesophilic and thermophilic spore-formers that originate from the raw milk as well as from the processing environment are primary concern in milk powders (Watterson *et al*., 2014). These thermophilic spore-formers, as well as others often found in milk powders, have been demonstrated to create heat-stable proteolytic and lipolytic enzymes, which could lead to quality issues in milk powders and even their end-use applications (Chen *et al*., 2004). The UHT process produces a commercially sterile product. However, some proteases produced by bacteria in raw milk survive UHT treatment, lowering UHT milk's shelf life. Proteolysis of milk casein by enzymes derived from psychrotrophic bacteria is thought to be one of the key causes of poor UHT milk quality (Mateos *et al*., 2015). Cow's milk with less than 100,000 CFU/ml and a pH of 6.7 to 6.9 is considered as high-quality. When the bacterial level approaches 1 million CFU/ml, problems in manufacturing UHT milk with a long shelf life begin. Even if the pH is in the normal range, if the milk has more than 5 million CFU/ml, there is a considerable possibility that the milk includes too many bacteria that have generated heat-resistant enzymes, leaving the milk unsuitable for UHT production due to the risk of short shelf life. Poor milk quality can cause fat separation, Sedimentation, Gelation, off-flavours and off smell in UHT products. By controlling these spoilage enzymes and their activities, raw milk can be directed towards an extended shelf-life product (Glantz *et al*., 2020).

Conclusion

The microbial quality of raw milk plays a pivotal role in determining the safety and quality of dairy products. Raw milk can ~~harbor~~harbour various bacteria, including pathogens such as Salmonella, Escherichia coli, and Listeria monocytogenes, as well as spoilage microorganisms like Pseudomonas and psychrotrophic bacteria. The presence of these microbes can lead to rapid spoilage of dairy products and pose serious health risks to consumers if not properly controlled. Additionally, certain bacteria present in raw milk can adversely affect the fermentation processes used in dairy production, leading to off-~~flavors~~flavours, decreased product shelf life, and compromised texture. Therefore, stringent measures must be implemented throughout the dairy supply chain to ensure the microbial quality of raw milk is maintained at safe levels, thus safeguarding the integrity and safety of dairy products for consumers.

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