REVIEW

Risk and benefits of consuming raw (unpackaged) and pasteurized (packaged) milk

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ABSTRACT

The aim of this review is to overview important literature data on milk and its composition, methodology of quality assurance throughout its processing and preservation, and to compare risks and benefits of consuming raw (unpackaged) and pasteurized (packaged) milk. Milk contamination risks are of various types, including physical contamination (foreign components, such as manure, feed, dust, pieces of broken glass, strands of hair, wood, plastic, or metal chips), chemical impurities (antibiotics, hormones, pesticides, detergents, or heavy metal residues), and microbiological agents (germs and somatic cells). Our study addresses the quality and safety of raw and pasteurized milk consumed by humans. If one considers risks and benefits simultaneously, there are many pros and cons of consuming raw and pasteurized milk. One can conclude that pasteurized milk is more appropriate for consumption as compared to the lower quality raw milk. For manufacturing high quality pasteurized milk, one should implement good hygienic practices, proper pasteurization process, as well as pre and post pasteurization preservation.

Keywords: raw milk, unpackaged milk, pasteurized milk, packaged milk

1. Introduction

We are always on the fence about whether we should take the leap toward drinking raw milk or continue to drink pasteurized milk. As suggested by the Food and Drug Administration (FDA), consumers should only drink pasteurized milk, since the milk undergoes a process that kills harmful bacteria, also called the pasteurization of milk. Unfortunately, this process also kills many nutrients contained in raw milk. Studies reveal that raw unpasteurized milk provides greater health benefits than pasteurized milk. In a study with regular consumption of raw milk by immune depressed adults a strong improvement was observed in health, immunity, bowel problems and mood of individuals and women showed strong improvement than men (Baars *et al*., 2019). There are many pros and cons between raw and pasteurized milk, which create conflict to choose one from them (O'Callaghan *et al*., 2019).

Raw milk consumption is gaining popularity as consumers learn more about healthy microorganisms and

other nutrients present in milk, which are destroyed by pasteurization. From 1998 to 2011, the Centers for Disease Control and Prevention received reports on 2,384 infection cases originating Pre raw milk dairy products. These incidents resulted in 284 hospitalizations and two death cases. Regrettably, even milk produced in facilities, which test for bacteria and follow high cleanliness standards can become contaminated and create health risks (Robinson *et al*., 2019).

Raw milk benefits include vitamins, enzymes, and healthy microorganisms, which reduce the incidence of respiratory infections and fever in infants and provide protection against asthma and allergies. In the meanwhile, it also poses risks for contamination from a variety of sources, such as cow feces, microbial infections, and diseases (Baars, 2013).

Pasteurized milk is the most common form of milk sold in grocery stores and other retail stores. The pasteurizing process of milk involves exposing it to high temperatures for a short time period, to destroy all harmful bacteria that might be lurking in the milk. The most common type of pasteurization in the United States is High Temperature Short Time pasteurization, which heats the milk to at least 161 F degrees, for 15 s or more. Ultra-pasteurization is the most intense technology used, which heats the milk to 280 F, for 2 s, yielding milk with shelf life (before opened) of 30-90 days. Hence, benefits of pasteurized milk include killing most harmful bacteria, but at the same time the heat of pasteurization kills valuable nutrients, enzymes, and microorganisms present in milk. Pasteurized milk is typically homogenized, which is a process that breaks down fat in milk, so that it incorporates them over the entire mass of milk, rather than separating at the top. Homogenized milk is high in xanthine oxidase, which can contribute to many chronic illnesses, such as atherosclerosis, diabetes, and other chronic disorders (Deeth, 1983).

These said, there is tremendous dilemma to users in choosing the type of milk they consume. Therefore, our review has been focused on analyzing pros and cons of consuming raw or pasteurized milk.

2. Milk as food

Milk, considered a whole food, is a highly nutritious and energetic food to mammals. It provides 18 out of 22 essential nutrients, including calcium, folate, magnesium, phosphorus, potassium, vitamin A, vitamin B-12, proteins (casein and whey), iron, selenium, vitamin B-6, vitamin E, vitamin K, niacin, thiamin, and riboflavin (Deeth, 1983; Pehrsson *et al*., 2000). Therefore, milk is commonly included in healthy and balanced diets, being required for proper growth and development of children, and the formation of bone mass. Nevertheless, there are various controversies on the consumption of milk and dairy products by humans, given that they are obtained from other species. Milk prevents humans from various chronic diseases, like diabetes, cardiovascular diseases (CVDs), obesity, and some forms of cancer, but at the same time it also has negative effects on humans, such as lactose mal-absorption symptoms and cow's milk protein allergy. Importance of milk consumption, its nutritional value and composition for good health and prevention of disease have been studied extensively (Pereira, 2014).

Though there is controversy on consuming cow's milk in the pediatric community, the medical community has suggested that iron deficiency caused by cow's milk consumption is seen in children up to 9 to 12 months. Nevertheless, this can be balanced with daily intake of maximum 500 mL cow's milk and iron-enriched food afterwards. A quantity of 250 mL of cow's milk can be ingested by lactose intolerance patients, without any negative effects. Allergy associated with cow's milk is not permanent, and atopic children may get poor diet, prescribed for allergy toward cow's milk. There is no relation established between the effects of cow's milk and autistic spectrum disease or type 1 diabetes mellitus or chronic degenerative, noncommunicable diseases. It has been also suggested that after 24 to 36 months, upon need, fat-reduced milk should be given. Cow's milk is considered a nutrient rich, proteinaceous, healthy diet for children, guaranteeing proper growth and appropriate formation of bones. Regular milk consumption has positive effects on children, rather than negative ones (Agostoni and Turck, 2011).

3. Milk adulteration

Milk and dairy products represent a nutritious and healthy diet to human, being consumed worldwide. Because of high demand on food market, adulteration of milk is done by many unscrupulous people for illegal profit, which depleting milk quality. There are various reports on milk adulteration, stating that hazardous substances, such as extraneous water, foreign proteins, whey proteins, melamine and urea, vegetable or animal fats, plus many minor constituents of milk fat are being added milk and milk products. Different methods developed and employed over the past 25 years to detect adulterants in milk include DSC, RP-HPLC, LC-GC, HPTLC, immunoassays: CE, ELISA, FAMPST, FTIR, NIR spectroscopy, PAGE, IEF, DNA-based methods, and MALDI-MS techniques. A powerful tool for quality and authenticity in analysis of milk is the combination of advanced IR spectroscopy and chemometrics. For detecting caprine milk adulterations with bovine milk, a straightforward and cost-effective tool is used, known as electronic tongue. For the detection of urea in milk, biosensors have been developed that possess the ability

to furnish real-time signals. Many of these methods offer high degree of repeatability (Poonia *et al.*, 2017).

Milk and fruit juices are of great importance in human diet; they can be economically adulterated, which is, unfortunately, encouraged by the increasing demand in the processing and supply chain. Adulteration of milk constitutes an emerging social problem, because adulterants are difficult to detect by consumers. So rapid, accurate and sensitive detection methods are required.

In this review, potential adulterants in milk and fruit juices are analyzed and their limits set by different regulatory bodies are briefly described. Various techniques such as physicochemical methods, chromatography, immunoassays, molecular and electrical techniques, spectroscopy with chemometrics, electronic nose, and biosensors have been described for easy detection of adulterants. For rapid, precise, and sensitive detection of adulterants in liquid foods, spectroscopy in combination with chemometrics shows very good potential (Jha *et al*., 2016).

Adulteration of milk is an illegal practice done by some fraudulent people to benefit economically; the process masks the quality parameters (e.g., protein and fat content) and increases the product shelf life unnaturally. Various milk adulteration practices include addition of toxic substances, like formaldehyde, hydrogen peroxide, hypochlorite, dichromate, salicylic acid, melamine, and urea. For securing food safety and avoiding health risks to consumers, detection of these adulterants should be done in every step of diary chain. Detection methods include sample pretreatment, improved detection and data processing, including chemometric tools. A critical evaluation of analytical approaches for the assay of milk adulteration, was needed, with emphasis on applications published after year 2010. Highlighted were alternatives for fast, environmentally friendly, in-situ detection of milk adulterants (Nascimento *et al*., 2017).

4. Raw milk contamination

Organo-halogenated pollutants (OHPs), such as organochlorine pesticides, polybrominated diphenyl ethers, and polychlorinated biphenyls are introduced illegally and intentionally in raw cow milk samples in the Konya District of Turkey. These contaminants have also been detected in Ultra high temperature (UHT) cow milk of 15 different brands sold at supermarkets in Turkey. Estimated daily intake (EDI) values obtained for both adults and children, who consumed raw and UHT milk, exceeded the maximum residue limits (MRLs) set for the OHPs, which involves high risk to consumers (Aydin *et al*., 2019).

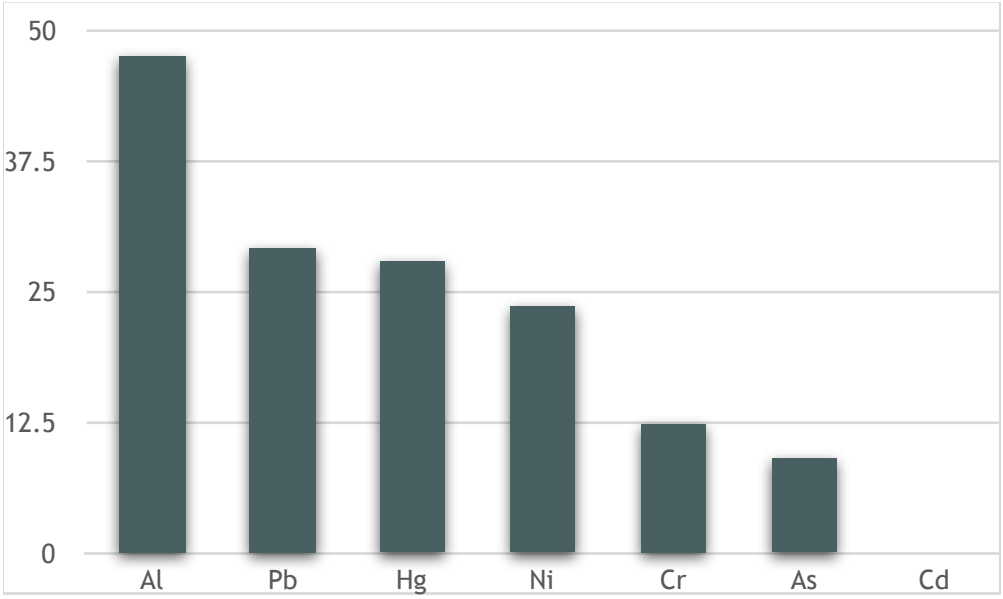

Figure 1. Concentration levels toxic elements in raw bovine milk samples

Concentration levels of seven toxic elements, namely arsenic (As), lead (Pb), cadmium (Cd), chromium (Cr), mercury (Hg), aluminum (Al), and nickel (Ni) residues were evidenced in 178 raw bovine milk samples from eight main milk producing provinces and from three types of milk stations in China, by means of inductively coupled plasma-mass spectrometry (ICP-MS), the analyzed milk samples were contaminated with toxic elements (Figure 1). Nevertheless, Cd was not detected in any milk sample. It was documented that milk samples collected from industrial areas contain high levels of toxic elements. Also, samples from processing plants comprise lower levels of toxic elements, as compared to large scale farms and small farm cooperatives. Margin of exposure (MOE) values suggest that Pb levels are riskier than other toxic elements, particularly to infants and children in an early stage of development (Qu, *et al*., 2018).

Milk sold on markets in the coastal area of Sindh province of Pakistan was screened for various adulterants in year 2014. A total of 100 milk samples were collected in the vicinity of Badin, and were analyzed at the Department of Animal Products Technology, Faculty of Animal Husbandry and Veterinary Sciences of Sindh Agriculture University in the town Tando Jam. From each source twenty milk samples (n= 20) were gathered, including milk producers, milk collectors, middlemen, processors, and dairy shops. In the majority of analyzed milk samples water (76%) was the common adulterant, followed by detergents (25%), rice flour (22%), caustic soda (18%), salt (17%), and cane sugar (14%). The extent of extraneous water was significantly higher ($P < 0.05$) in milk samples collected from dairy shops, middlemen, and milk collectors as compared to samples harvested from milk processors and milk producers. For the latter the proportion of adulteration at all the milk intermediaries had an insignificant value ($P > 0.05$). Except for samples collected from dairy shops and middlemen, the pH values of milk samples from different marketing chains were significantly different from each other ($P < 0.05$). Also, in marketing channels, milk had significantly different freezing point ($P < 0.05$). Likewise, significant differences ($P < 0.05$) in specific gravity of milk sold in marketing channels were found (Barham *et al*., 2015).

Intentional food adulteration for obtaining financial advantage is known as economically motivated adulteration (EMA) of food and constitutes food fraud. A common form of EMA is the undeclared substitution of natural milk components with alternative ingredients; this usually poses health concerns, as allergen labeling requirements are bypassed. EMA may also trigger serious public health problems, as demonstrated by the nearly 300,000 illnesses in China, caused by melamine adulteration of infant milk formula. Furthermore, gaps in testing methodologies used for quality assurance are revealed by EMA incidents and could be exploited for intentional harm. EMA incidents present a challenge to food industry and regulators, as they are not easily detected. Everstine *et al*. (2013) reviewed the comprehensive food protection, as outlined by the Food Safety Modernization Act for detecting EMA and for targeting crucial resources toward the riskiest food products.

Brindha *et al.* (2017) revisited the composition of milk to establish, whether it is truly necessary as a complete food for humans. Authors reassured that while milk is required for proper growth and maintenance of good health, it also acts as a carrier of chemicals and other impurities. Next, the study focused on various adulterants of milk, used to increase its marketability. Revealed is the hygienic status and content in adulterants of packaged milk samples collected from cooperative societies, local vendors, and private sector in and around the Thuraiyur District of Tamil Nadu, India. 30 samples were analyzed for quality by using standard adulterant kits, purchased from a private dealer in Thuraiyur, Tamil Nadu, India. Milk samples from cooperative societies contained 13% neutralizer, 16% sodium chloride, 23% acidity and heat stabilizers, and 20% mastitis. On their turn, milk samples originating from local vendors comprised 10% neutralizer, 13% sodium chloride, 40% acidity and heat stabilizers, and 23% mastitis. By contrast, packaged milk samples gathered from the private sector had only 3% of sodium chloride. Percent values document the presence of adulterants in all analyzed milk samples. It was also determined that most branded milk companies follow standards for producing hygienic, good quality milk, as imposed by Food Safety and Standards Authority of India (FSSAI) regulations, of severe concern is that the majority of milk samples were adulterated with commonly used adulterants and preservatives, which result in both economic and public health problems. Therefore, one should create urgently awareness among consumers, local milk vendors, and cooperative societies on unethical practices frequent in milk supplying chains and try to stop adulteration of milk and milk products.

5. Microbial pathogens in milk

The microorganisms present in milk have an implication in deteriorating the quality and influencing the safety of milk consumption, in this event there is involvement of environmental parameters that enhance the growth of pathogenic organism in milk, unhygienic practices during procurement and processing of milk, which effects the quality and safety of milk (Singhal *et al*., 2020). Food Standards Australia New Zealand (FSANZ) 2009 for dairy processing provided risk assessment toward consumption of raw or unpackaged cow milk, and evaluated microbiological pathogens associated with raw milk, including Campylobacter spp., entero-hemorrhagic Escherichia coli, Salmonella spp., Listeria monocytogenes, and others (Assessment, R., 2009). This assessment did not specifically examine risks to public health and safety, associated with consuming raw cow milk; however, it did confirm that internationally, unpasteurized dairy products are the most common cause of dairy-associated food borne illness. Based on available scientific data the study revealed risks of consuming raw cow milk, caused by unhygienic milk production systems, prevalence and levels of pathogens in raw cow milk and in cattle, consumption data, and epidemiological data. Risk of triggering illness persists upon consuming raw cow milk, although its pathogen level may be very low. Detection of pathogens in raw milk depends on the accuracy of testing, skill of

personnel, and the limit of detection (LOD) for specific testing methodologies and targeted pathogens. Reducing microbial load in raw milk is important for controlling animal health, adherence to good milking practices, and monitoring milking parlors hygiene.

Microbiological hazards posed by raw milk from animal species other than cows have been scrutinized by Verraes *et al*. (2014). Their experiment assessed the quality of the milk collected from other animal species, warning on the occurrence frequency of several human pathogenic microorganisms. Reviewed are human cases of illness and outbreaks produced by raw milk from non-bovine species; only raw milk from goats and camels were associated with outbreaks. Raw milk from horse and donkey may have higher microbiological quality as compared to other animal species, although human pathogenic strains of Streptococcus are found in them, which create microbiological hazard. Main microbiological hazards are likely to be, however, human pathogenic Escherichia coli, Campylobacter spp., tick-borne encephalitis virus, and Brucella spp. for raw milk from other animal species.

Safety and high quality of raw milk are crucial, whether produced on small farms (less than 75 cows) or on mega-farms (several thousand cows). Animals must be kept healthy and be fed high-quality feed. Milking should be done in clean and well-ventilated parlors by milking machines, and the bulk tanks must be properly cleaned and sanitized. Throughout the dairy chain, milk must be stored at low temperatures (less than 4.5 ^{o}C) and handled under good manufacturing practices. Before the acceptance of raw milk by the processing plant, it must be critically tested. These techniques and hygienic practices secure safe, high-quality milk, beneficial to consumers. Raw milk must be free of inhibitory substances, should be microbiologically acceptable, and must exhibit desirable sensory properties. It is important to remember that raw milk with high microbiological numbers or poor sensory properties fail to meet established shelf-life standards for finished products. Consumer acceptance of raw milk is based on high-quality, preservation at low temperatures, as well as processing and packaging under safe sanitary conditions (White, 2011).

Various pathogens like Listeria monocytogenes, Campylobacter jejuni, Salmonella species, Brucella species, and Escherichia coli O157 may be present in raw milk obtained from different species, such as cows, goats, sheep etc. They can infect both healthy and immunodeficient individuals, elderly people, adults, infants, children, pregnant women and their unborn fetuses. Sometimes severe infections and fetal miscarriages occur. In at least 30 states of the United States, it is still legal to sell raw or unpasteurized milk and milk products (Committee on Infectious Diseases, 2014). Some proponents raise their voice for health benefits of consuming raw milk and milk products. They argue that raw milk contains some natural ingredients, which offer more health benefit than pasteurized milk, but they cannot document clearly the benefits of these natural substances. Nevertheless, evidence is provided against the consumption of unpasteurized milk and milk products, which is very risky to pregnant women, infants, and children. Authors conclude that there are equal health benefits of pasteurized milk as compared to raw milk, without the risk of bacterial infections or diseases (Committee on Infectious Diseases, 2014).

Aflatoxin M1 (AFM1) is prevalently found in raw milk as a bio assimilatory product from fodders, the legal permissible limit of AFM1.

6. Consumption of raw milk

Although cow's milk is important part of human diet, there are some individuals having or developing allergy to this food source. Consumption of raw milk is strongly discouraged by medical professionals, given the presence of pathogenic bacteria and the health risk associated with them. There is epidemiological evidence showing that consumption of unprocessed cow's milk does not increase, but rather decreases the risk of asthma, hay fever, and atopic sensitization. Based on epidemiological literature, Braun-Fahrlander and von Mutius evaluated the components of unprocessed milk, potentially providing health protection. They explained the role of bacteria in raw milk, the fatty acid profile, whey proteins, and the role played by allergens in milk. Although a protective role of unprocessed cow milk against development of asthma, hay fever and atopic sensitization was evidenced, the mechanisms behind this protection are not yet understood. Therefore, consumption of raw milk cannot be considered as a preventive measure against allergy (Braun-Fahrlander and von Mutius, 2012).

Intake of raw milk is advocated by many people based on its high nutritional value and health benefits, but there is no specific scientific data to support these claims. People consume, however, raw milk, which can be contaminated with human pathogens. According a survey by Oliver *et al*. (2009), from 2000 to 2008 several people suffered from infectious diseases, associated with milk borne pathogens, and got hospitalized, while a few passed away. Even some milk-borne diseases were associated with pasteurized milk consumption. Introduction of rules and regulations is suggested, to control the microbial standards for raw milk, specifically, and for pasteurized milk, as well. Proper sanitation before and after milking can reduce the action of pathogens and the overall contamination of milk. Otherwise, people should stay away from

consuming raw milk and dairy products obtained from raw milk.

Raw milk consumption is preferred by people because of its health benefits as a natural product, which is "destroyed" by boiling as widely believed. There are, however, many foodborne pathogens found in raw milk, such as Campylobacter, Salmonella spp., and human pathogenic verocytotoxin-producing Escherichia coli. 2-6% of the bacterial foodborne diseases occur in industrialized countries, as a result of pathogens found in raw milk. Claeys and co-workers in 2013 reviewed the risk and benefits of raw milk consumption relative to heated cow milk. Nutrional or health aspects, including nutritional value, immunity, allergies, lactose intolerance, diabetes, milk digestibility etc. and the microbiological aspects, such as milk borne pathogens, inhibition of pathogen growth by antimicrobial systems and by lactic acid producing bacteria, probiotic bacteria etc. are considered in the study. It demonstrated the health threat caused by the human pathogens associated with raw milk consumption. Authors concluded that milk should be heated prior to consumption, which this will not change the nutritional value and other benefits of raw milk.

Currier and Widness reviewed infant mortality from 1875 to 1925, considering the impact of milk hygiene. Consumption of cow milk by infants should be pasteurized for safety of milk nutrients and to decrease infant mortality caused by milk pathogens, such as human and bovine tuberculosis, brucellosis, salmonellosis, streptococcal infections, diphtheria, and summer diarrhea (Currier and Widness, 2018). In European and American societies of the early and mid-19th century infant mortality rates were 30 to 60 times greater than present mortality rates of five or six deaths per 1000 live births per annum. With the development of pasteurization technique by Louis Pasteur in 1864, infant mortality decreased to half by the early 20th century. So, emphasis should be given to milk hygiene practices in every step and implementation of pasteurization of raw milk for the safety of infants.

7. Consumption of pasteurized milk

Pasteurization or heating of milk up to a specific temperature, provides safety to milk for human consumption via reducing the number of viable pathogenic bacteria. Although the benefits of pasteurization for health are well established, some organizations advocated the promotion of raw milk as "nature's perfect food." They claim that pasteurization destroys important vitamins, but raw milk consumption can prevent and treat allergies, cancer, and lactose intolerance. Effects of pasteurization on vitamin levels have been assessed in forty studies; it was found that qualitatively, vitamin A increased but vitamins B12 and E decreased as a result of pasteurization. There is no significant effect of pasteurization on vitamin B6 concentration (standardized mean difference [SMD], -2.66; 95% confidence interval [CI], -5.40, 0.8; $P = 0.06$), but there was a decrease in concentrations of vitamins B1 (SMD, -1.77; 95% CI, -2.57, -0.96; $P < 0.001$), B2 (SMD, -0.41; 95% CI, -0.81, -0.01; $P < 0.05$), C (SMD, -2.13; 95% CI, -3.52, -0.74; $P < 0.01$), and folate (SMD, -11.99; 95% CI, -20.95, -3.03; $P < 0.01$) (Macdonald *et al*., 2011). As many of these vitamins are naturally found at relatively low levels, the effect of pasteurization on milk's nutritive value was minimal. However, the impact of heat treatment on vitamin B2 in milk should be further considered as milk is an important dietary source of vitamin B2. Six studies reveal that raw milk consumption may have a protective association with allergy development. Two studies state that raw milk consumption is not associated with cancer, while one study evidences that raw milk is not associated with lactose intolerance. Overall, these findings depend on the methodology. Many of these studies are cited in this review.

In African population, there is a growing demand for milk. Reported was the microbiological status of milk and milk products in Rwanda, analyzed via the milk and dairy chain (Kamana *et al*., 2014). The total mesophilic count, coliforms, and detection of Staphylococcus aureus, Salmonella and Listeria monocytogenes were obtained. It was found that 5.2% of milk contained Salmonella, but the quality of raw milk was found satisfactory in most samples. The total mesophilic count and coliform numbers indicated contamination due to ineffective heat treatment over the pasteurization process or post pasteurization preservation. Insufficient temperature control during storage increased bacterial contamination throughout the retail chain. Pasteurized milk sold in supermarkets was safer in comparison with the milk and dairy products sold in milk shops, which are of variable microbiological quality.

In diary industry, raw milk refrigeration or refrigerated storage is a prerequisite for keeping milk safe from pathogens. When temperature is not maintained properly in farming and processing units, the microbiological quality of raw milk can be significantly affected. Vithanage and colleagues in 2017 investigated the effect on microbiological quality of raw milk in different refrigeration conditions, at 2, 4, 6, 8, 10, and 12 °C from three different dairy farms. Samples contained significantly different initial microbial counts. During storage the bacterial counts (BC), protease activity (PA), proteolysis (PL), and microbial diversity in raw milk were determined. One examined the effects of combined heating (75.0 ± 0.5 °C for 15 s) and refrigeration on controlling microorganisms' contamination. All samples showed increasing BC, PA, and PL as a function of

temperature, time, and initial BC, with significant increase in those criteria at ≥6 °C. During extended storage of raw milk at 4 °C, similar trends in BC, PA, and PL were observed. Both PA and PL showed strong correlation with the psychrotrophic proteolytic count (PPrBC: at ≥4 °C) and thermoduric psychotrophic count (TDPC: at ≥8 °C) as compared to the total plate count (TPC) and psychrotrophic bacterial count (PBC), which are often used as the industrial standard. When PPrBC and TDPC reached 5 × 104 cfu/mL and 1 × 104 cfu/mL, significant increases in PA and PL were observed and were defined as storage life for quality (S LQ), and storage life for safety (S LS) aspects, respectively. Storage conditions also affected significantly the microbial diversity, where Pseudomonas fluorescens and Bacillus cereus were found the most predominant isolates. However, for extending significantly S LQ and S LS of raw milk, deep cooling (2 °C) and combination of heating and refrigeration (≤4 °C) are required.

To decrease microbiological risks and to increase preservability, certain food products go thorough pasteurization process. Aggad *et al*. investigated some conformity criteria of pasteurized milk by physico-chemical and bacteriological tests (Aggad *et al*., 2010). Acidity, pH, density, total dry extract and stability at 6 °C were determined. Germs recommended by the national regulation (total aerobes at 30 °C; total fecal coliforms and Staphylococcus aureus) were analyzed. Since 93.5% of samples had insufficient density, pasteurized recombined milk appeared less conform with respect to physico-chemical criteria. Nevertheless, most samples became unstable after 4 days of storage. Pasteurized raw milk was contaminated mostly with 53.7% of unsatisfactory samples. To improve milk quality, one should apply hygiene rules in combination with better regulations.

Worldwide, all diary producers are willing to supply high quality dairy products. Nonetheless, presence of psychrotrophic bacteria in raw milk, generally comprising bacterial species of the genera Pseudomonas, Acinetobacter, Aeromonas, Serratia, Bacillus, Lactococcus, Microbacterium, and Staphylococcus are of special concern to dairy industry, as they can produce heat-stable enzymes, which may withstand various heat treatments during dairy processing. They cause defects in quality over the product storage period, leading worldwide to huge economic losses from product spoilage. Natural habitats, milking practices, and hygiene practices of farms in different countries is tightly linked to the levels and diversity of psychrotrophic bacteria in raw milk. Most of these bacteria form biofilms attached to various milk storage and processing equipment, which will provide the source of microbial contamination via bio transfer. Yuan and co-workers studied the diversity of psychrotrophic bacteria in raw milk, the spoilage potential of these bacteria, specific technological problems caused by biofilms and heat-resistant enzymes. They concluded that to avoid psychrotrophic bacterial cross-contamination, it is required to implement good hygienic practices during milking and milk processing (Yuan *et al*., 2019). Structural features and molecular characteristics of various heat-stable enzymes are also important issues and need to be addressed for the safety of processed or pasteurized milk.

Eneroth and his research team examined the sites where critical contamination may occur by gram-positive spore-forming bacteria, e.g., Bacillus and the gram-negative psychrotrophic bacterial groups, such as Pseudomonas, Enterobacteriaceae, and Aeromonas. All these bacteria have been traced in the production lines of pasteurized milk, in three dairy plants located in Sweden or Norway (Eneroth *et al*., 1998). Raw and pasteurized milk samples were collected from six sites along the line. These milk samples were incubated at 7 °C until the number of gram-positive spore-forming bacteria exceeded 104 cfu mL-1 or the aerobic plate count reached 106-107 cfu mL-1. Then, colonies were picked randomly and identified. Nearly all recontamination happened in the filling step, by gram-negatives. In about 40% of the sampled milk packages, gram-negative bacteria grew to high numbers over incubation. Pseudomonas were isolated from all these packages (100%), Enterobacteriaceae from 9% and Aeromonas from 3% of the packages. Therefore, these gram-negative bacteria constituted a major part of bacteria that spoiled milk upon prolonged storage. Gram-positive spore-forming bacteria like Bacillus spoiled the remaining 60% of packages. As the spores of Bacillus are present in raw milk and survive pasteurization, some indications were found for recontamination after pasteurization.

Somatic cells are known to serve as major defense components of mammary gland against diseases or intra-mammary infections. Four main cell types corresponding to somatic cells are macrophages, PMNs, lymphocytes, and epithelial cells. These are important components found naturally in milk. Somatic cell count is used as an indicator of udder health and milk quality. The role of somatic cells is ill-defined in dairy processes and products, as the presence of such cells in high number modifies the physicochemical properties of milk, bacterial count, and the udder inflammation. Li, Richoux *et al*. in 2014 reviewed the role of somatic cells and of endogenous enzymes secreted from somatic cells in milk, in dairy transformation processes, and in characteristics of final products. Authors surmounted bias originating from other factors. They considered primarily the immune function of somatic cells in the udder defense and their protective role in milk.

Discussed were different characteristics of milk, induced by various somatic cell counts, types, and their endogenous enzymes, which affect directly the technological properties of milk and the final quality of dairy products. A new approach has been suggested to evaluate the effective role of somatic cells on dairy processes and products. Explanation was provided for mechanisms involved in the release of the enzymes from somatic cells during dairy processes, particularly in cheese technologies. Milk is an ideal and suitable medium, allowing diverse microorganisms to grow and multiply, yielding early spoilage. Raw milk consumption should be discouraged, as numerous epidemiological outbreaks even death cases have been reported. Pasteurization is a widely adopted technology amongst various methods to render milk safe for human consumption. Microbiological quality of pasteurized milk depends on various factors, including quality of raw milk, heat-treatment employed, storage conditions, and the extent of post-pasteurizing contamination. Various factors affecting the microbiological quality of pasteurized milk are explored and hygienic practices are implemented for quality improvement. Sarkar stated that improvement in the microbiological quality of raw milk, proper pasteurization and prevention of post-pasteurization contamination is important to produce safe pasteurized milk (Sarkar, 2015). For complete removal of spores, introduction of microfiltration prior to pasteurization is suggested and, thereby, microbiological safety of pasteurized milk may be enhanced. Valeeva *et al*. studied the production chain of fluid pasteurized milk and important attributes of food safety improvement. The chain had 4 blocks: (i) "feed" (compound feed production and its transport), (ii) "farm" (dairy farm), (iii) "dairy processing" (transport and processing of raw milk, delivery of pasteurized milk), and (iv) "consumer" (retailer/catering establishment and pasteurized milk consumption) [34]. The concept of food safety improvement focuses on 2 main groups of hazards: chemical (antibiotics and dioxin) and microbiological (Salmonella, Escherichia coli, Mycobacterium paratuber-culosis, and Staphylococcus aureus). Individual experts' (n = 24) preference data on 101 attributes along the chain were collected in a computer-interactive mode. Experts obtained the attributes from the "feed" and "farm" blocks as they are vital for controlling chemical hazards; whereas attributes from "farm" and "dairy processing" were important for limiting microbiological hazards. The most important attributes considered were "identification of treated cows" and "quality assurance system of compound feed manufacturers" which identified chemical hazards. Attributes for the microbiological hazards were "manure supply source" and "action in salmonellosis and M. paratuberculosis cases". This study helps in decision-making for private businesses along the chain and for the government, about food safety improvement of fluid pasteurized milk.

Conclusions

Raw or unpackaged milk contain various valuable vitamins, enzymes, and microorganisms, which are beneficial to humans. Milk prevents various chronic diseases, like diabetes, cardiovascular diseases (CVDs), obesity, and some forms of cancer, but at the same time, it shows some negative reactions to humans, namely lactose mal-absorption symptoms and cow milk protein allergy. Major risks of consuming raw or unpackaged milk are related to their possible content of various viable pathogens, like Listeria monocytogenes, Campylobacter jejuni, Salmonella species, Brucella species, and Escherichia coli. When present in milk, these pathogens represent serious health hazards to individuals.

Because of unhygienic practices over the entire dairy chain, raw milk contains many impurities, including manure, dust, and strands of hair. It also contains several adulterants, such as extraneous water, foreign proteins, whey proteins, melamine and urea, vegetable or animal fats, formaldehyde, hydrogen peroxide, hypochlorite, detergents, rice flour, salt, cane sugar, and toxic elements, which are added on purpose for economic benefits.

For pasteurized or packaged milk conflict arises from the pasteurization process, which may kill or destroy valuable nutrients, enzymes, and microorganisms by the applied heat treatment. Nonetheless, if one considers the benefits of consuming pasteurized milk, the above risks are minimal, as proper pasteurization kills all pathogenic bacteria present in raw milk, which is beneficial and safe. Adulterants concentration is lower in pasteurized milk than in raw milk, as a result of tests performed in several stages of the dairy processing chain.

Consuming pasteurized milk poses some risks and health hazards, as well, including contamination by thermostable (heat resistant) and psychrotrophic (cold resistant) bacteria, because of ineffective heat treatment during pasteurization or post pasteurization preservation.

As shown in this review paper, there are many pros and cons of consuming raw (unpackaged) and pasteurized (packaged) milk, if one considers risks and benefits simultaneously. One can conclude that pasteurized milk is more appropriate for consumption as compared to the lower quality raw milk. For manufacturing high quality pasteurized milk, one should implement good hygienic practices, proper pasteurization process, as well as pre and post pasteurization preservation.

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