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Review on Improving Milk Quality

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SUMMARY

Milk is sterile when secreted into the alveoli of the udder. Microbial contamination occurs mainly during and after milking. Different microorganisms have different origins; microorganisms in bulk tank milk originate from the interior of teats, the farm environment and surfaces of the milking equipment. Microorganisms are mainly transferred from the farm environment to milk via feces, bedding and soil attached to the exterior of teats; in addition, microorganisms attached to the exterior of the teats can enter the teat canal and cause mastitis. Aerial contamination is insignificant under normal production conditions .The concentration of microorganisms in bulk tank milk /farm storage can further increase due to their growth. The microbial population in farm storage consists of a variety of bacterial species. Most species have a specific origin. For example, the presence of *Staphylococcus aurous* in farm storage will, generally, be traced back to cows suffering from mastitis, and silage is the most likely origin of spores of butyric acid bacteria in bulk tank milk. Human microbial pathogens that can be found in raw milk include Listeria monocytogenes, Salmonella spp. and Campylobacter. In addition to their significance for public health, a very good microbial quality of raw milk is also important to prevent production losses and to achieve an optimal shelf life of dairy products. In addition, hygienic milk production by dairy farmers is important with respect to animal welfare and the image of the dairy sector. Pathogenic microorganisms can infect cows (e.g. gastrointestinal tract, udder tissue), and result in reduced milk yields and even the death of animals. Thus, in summary control of all the above problems at the dairy farm resulting in on-farm hygienic milk production is important for all elements of the dairy production chain.

Keywords: Milk, Milk Quality, Dairy Management

INTRODUCTION

The public health experts have defined milk as to be "the lacteal secretion of the mammary glands of a mammal, practically free from cholesterol, obtained by the complete milking of one or more healthy cows which contains not less than 8.25% milk solids-not-fat, and less than 3.25% milk fat" (Woldecherkos and Yitayal, 2003) [1].

It is used to nourish the young from birth to weaning, and it is the most complete food product of animal origin providing more essential

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nutrients in significant amounts than any other single food (Mirkena, 2010) [2]. The use of milk and milk products as human food has got a very long history. The milk as it is meant to be the first and sole food for offspring of mammals - is an almost complete food. (Pandey and Voskuil 2011) [3].

Milk is highly nutritious and an important part of diets across the globe, but is also a perfect medium for the growth of several pathogens of public health significance (Kenny, 2013) [4]. Quality and safety is also a valid indicator of overall postharvest losses (post-milking waste) (Weaver and Kim, 2001) [5]. Good hygienic conditions are required to produce safe milk products of acceptable quality for the consumer (O'Connor, 1995; Angelidis, 2015) [6,7].

Quality and safety is also a valid indicator of overall postharvest losses (post-milking waste) (Weaver and Kim, 2001) [5]. Good product quality facilitates marketing and is a necessity to intensify production and to attain food security (Francesconi and Ruben, 2012) [8].

Unsafe food products with poor nutritional values may create disease and malnutrition. Therefore, milk safety needs to be considered as it is one of the challenges to intensification (process) as a main global public health and livelihood issue. Raw milk is also associated with pathogenic bacteria, which nausea milk – bone disease such as tuberculosis or typhoid fever, among others. Hygienic milk production, proper handling and storage of milk, and appropriate heat treatment can reduce or eliminate pathogens in milk (Akam, & Quick, A.J. (1989) [9].

Milk is the most perishable of all farm produce. Unlike other animal products, such as meat, milk is frequently harvested in very unhygienic conditions, where all too frequently, the current practices of cleaning and sterilizing the containers used for its collection and transportation leave much to be desired. Not only is bacterial contamination in buckets and milk cans a major problem, but, because the tropical environment encourages rapid growth of these bacteria, the prolonged time delays in cooling the milk to 4°C, reduce its quality even further (Yirsaw, W. (2004) [10].

Therefore, the objective of this review is:

❖ To give highlight on improving milk quality.

❖ **SOURCE OF CONTAMINATION OF MILK**

It is generally accepted that milk drawn from healthy cows under hygienic milking conditions contains relatively few organisms. However, during milking, it may be subjected to many sources of microbial contamination such as the atmosphere (e.g. dust), dirty udders, unclean equipment and pipelines.

Environment

As mentioned elsewhere, the most common microbial sources in the farm environment are feeds, feces, bedding material and soil. Microorganisms from these sources are transferred to milk in a number of steps. The consecutive steps from source to milk are referred to as the contamination pathway. A crucial step in the contamination pathway is the transmission of dirt, composed of, for example, feces, bedding and/or soil, to milk. Microorganisms from transmitted dirt dilute in the milk and pass the filter of the milking system (Akam et al., 1989) [9]. Dirt is mainly transmitted to milk when it is attached to the exterior of teats and rinses off during the milking operations (Stadhouders & Jørgensen, 1990; Murphy & Boor, 2000) [11,12]. Additional dirt and microorganisms can be transmitted from the farm environment to bulk tank milk when the tea cups (that fall on the ground or are kicked off the teats) get contaminated or even suck up dirt from the milking parlour floor (Stadhouders & Jørgensen, 1990) [11]. The mass of transmitted dirt per unit of volume can be calculated using a marker method (Stadhouders & Jørgensen, 1990) [11].

The strains and concentrations of microorganisms transmitted from the farm environment to milk via the exterior of teats depends on the composition of the attached dirt and microbial concentration in the dirt. When cows are at pasture, the teats are predominantly contaminated with soil, whereas teats of cows housed in the barn are mainly contaminated with feces and bedding material (Christiansson et al., 1999; Magnusson et al., 2007) [13,14]. The contamination of teats with soil during the grazing period is considered to be the main cause of elevated concentrations of spores of B. cereus in bulk tank milk (Slaghuis et al., 1997; Vissers et al., 2007) [15,16].

Spore concentrations in feces are between 2 and 10 times as high as the concentration in the ration of the cows (Hengeveld, 1983) [17]. This increase is explained by digestion of feed components while spores pass the gastrointestinal tract unaffected. Different materials are used for bedding in barns, for example, straw, sawdust, wood shavings and shredded paper. Fresh bedding contains a large variety of microorganisms. Microbial concentrations in fresh bedding are usually much lower than concentrations in used bedding (Hogan et al., 1990; Te Giffel et al., 1995; Hogan & Smith, 1997; Slaghuis et al., 1997) [15,18-20]. Especially, during the first day when the bedding is laid down, the concentrations in bedding material seem to increase significantly due to contamination with feces and microbial growth (Hogan et al., 1990, 1999; Hogan & Smith, 1997) [18,20]. However, high coliforms counts (7–9 log10 cfu g^{-1}) have also been measured in unused bedding material (Knappstein et al., 2004) [21].

Animal Feed

Feeds introduce a large variety of microorganisms to the farm environment, and subsequently to milk. The impact of feed as a hazard of microbial contaminants of raw milk is twofold: firstly, feed can be a source or transmission vehicle of pathogens causing infection in cattle, and secondly, feed is an important source of bacterial spores in raw milk. Basically, the diet of high-yielding dairy cows consists of two categories of feedstuffs, roughages and concentrate. The former feed provides the animal with dietary fiber, which is essential for the normal functioning of the cow's rumen. The most important roughage crops are grass, maize and lucerne (Wilkinson & Toivonen, 2003) [22].

Ensiling and haymaking are the two most common methods to conserve the nutritional value after harvesting. A special situation exists for grass, for example during the growing season, it is usually fed fresh, and outside the growing season, it usually fed as silage or hay. To meet the high nutritional requirements of high-yielding dairy cows, roughage-based diets are supplemented with concentrate feeds, which are high in energy and/or protein. Some examples include cereal grains, bran of cereals and pulses and by-products of the processing of soybeans, rapeseed and other oilseeds. These feeds have low moisture content and may be fed as individual ingredients or blended into particular formulations by compound feed manufacturers. In addition, concentrate feeds with high moisture content are also utilised (e.g. sugar beet pulp, brewers' grains and other co-products of crop-processing industries). These products are usually supplied directly by the processor to the farmer and, subsequently, conserved as silage (European Commission (2004) [23].

Animal pathogens associated with feed include *L. monocytogenes*, *E. coli* O157:H7 and Salmonella enterica. Outbreaks of listeriosis in cattle herds have been associated with the feeding of poorly conserved silages contaminated with *L. monocytogenes* (Fenlon, 1988; Wiedmann et al., 1996) [24,25]. Furthermore, there is evidence supporting a role of silage in the contamination of raw milk with *L. monocytogenes* (Sanaa et al., 1993) [26]. In addition, recent studies suggest that cattle feed can be a vehicle for transmission of *E. coli* O157:H7 and *S. enterica* (Fenlon & Wilson, 2000; Davis et al., 2003; Dodd et al., 2003; Dargatz et al.,2005) [27-30].

COW DEIT AND MILK QUALITY

Cow nutrition can have important effects on milk composition. Proteins are relatively unaffected provided the cow has an adequate level of nutrition; however, the milk fat is very considerably affected by diet composition (Murphy, S.C. & Boor, K.J. (2000) [11].

Differences between Milks from Pasture-fed and Concentrate-fed Cows

There are two quite distinct ways of managing dairy cows, which dictate the way they are fed and consequently affect the characteristics of the milk and dairy products. Pastoral farming, where the cows spend their time outdoors grazing pasture, is practiced almost exclusively in New Zealand, most of Australia, and for a large part of the year in Ireland. In contrast, most of the dairy cows in North America and a large part of Europe are housed indoors for most of the time and are fed on concentrates and rations largely based on grains. These differences in feeding affect milk yield and the composition and other qualities of the milk. In a parallel trial, small herds of Friesian and Holstein cows were fed either on pasture or on total mixed rations (TMR). The pasture-fed cows produced milk with higher concentrations of milk fat, whereas the cows fed on

Total mixed ration produced greater volumes of milk and higher concentrations of lactose (Auldist et al., 2000; Kolver et al., 2000, 2002) [31,32]. Some data are shows Milks from pasture-fed and ration-fed cows also show significant differences in fatty acid composition (Palmquist et al., 1993; White et al.,2001; Taylor and MacGibbon, 2002) [33-35], though these differences are confounded with seasonal effects on milk fat from pasture-fed cows (Taylor and MacGibbon, 2002) [35].

ANIMAL HEALTH MANGEMENT

Animal health management is extremely important for hygienic milk production. Mastitis infections lead to contamination of milk via the interior of teats, and gastrointestinal infections will increase the contamination via the exterior of teats. Furthermore, regulations of the European Union require that raw milk comes from animals that do not show any symptoms of infectious diseases that are communicable to humans via milk, and are in a good state of health and do not have udder wounds likely to affect milk; separation of milk of animals treated with authorized treatment products is also required (European Commission, 2004) [23].

Basically, animal health management is aimed at achieving and sustaining a disease-free herd (Hillerton, 2004) [36]. This can be achieved when infected animals are cured or removed (e.g. culling) from the herd, and new infections are prevented. A closed herd, i.e. no import of animals from other farms, is an important measure to sustain a disease-free herd. Treatment and separation of infected animals from the rest of the herd prevents transmission of pathogens from cow to cow (Hillerton, 2004) [36].

Effect of Udder Health

Generally, micrococci and streptococci are the main bacteria within the udder and on the teat skin (Slaghuis, 1996) [37]. Udder health is particularly important in maintaining milk composition. The effects of mastitis on milk composition have been reviewed recently by Auldist and Hubble (1998) [31]. In mastitis, high numbers of environmental bacteria such as Str. uberis, *E. coli*, coliforms and Pseudomonas spp. may contaminate teats especially if udders are wet and exposed to mud and manure. Counts of streptococci, staphylococci or coliforms in individual milks can be very high (up to 107 cfu mL^{-1}) and similar to the total plate count. The bulk milk count from these sources may be up to 105 cfu mL^{-1} under certain circumstances. Therefore, ineffective cleaning of teats before milking can contribute to high populations of fermentative bacteria in raw milk (Bramley & McKinnon, 1990) [38].

Lactic acid bacteria are normal inhabitants of the skin and streak canal of the cow's teat. Consequently, all raw milk contains at least low numbers of these organisms (Bramley & McKinnon, 1990) [38]. A strong correlation between decreasing somatic cell count and increasing casein content in milk received at the factory has been observed (Bob Franks, personal communication, referred to in Lacy-Hulbert and Auldist, 2002) [39]. Mastitis has three important adverse effects on milk production, even at sub-clinical levels (Lacy-Hulbert and Auldist, 2002) [40]. First, bacterial toxins and the inflammatory response cause damage to mammary epithelial cells, leading to a reduction in mammary-synthesized components. Second, the inflammation of the mammary gland leads to leakiness of the tight junctions, leading to higher leakage of serum proteins, particularly serum albumin, immunoglobulin and, importantly, plasminogen, which can be activated to the proteolytic enzyme plasmin. Third, the bacteria causing the infection produce extracellular proteases and lipases that break down milk proteins and fats, particularly casein, which is more susceptible to enzyme action than globular proteins, because of its extended structure. Plasminogen can also be activated to plasmin by bacterial enzymes, causing further protein hydrolysis. The net result of all this is to produce milk with a lower casein number and poorer cheese making properties (Barbano, 1994) [41]. Lipolysis can also lead to flavor defects from release of short chain fatty acids. Milk fat is affected by increased lipolysis in some mastitis milks, leading to increased levels of free fatty acids which can have adverse flavor effects. Whether this is due to bacterial lipases or animal origin lipases may vary depending on the species of bacterial infection. It is also likely that many mastitis infections lead to fragility of the milk fat globule membrane, making the fat more susceptible to release and hydrolysis by endogenous lipases (Deeth and FitzGerald, 1995) [42].

Exterior of the Udder

When cows are housed, bedding material and feedstuffs can be contamination sources. Plant material such as grass, hay, barley and oats used for animal feed may contain from 5 × 105 to 2 × 108 cfu of psychrotrophs g^{-1} (Cousin, 1982) [43]. Lactic acid bacteria are also associated with silage and other animal feeds (Bramley&McKinnon, 1990) [38]. Contamination of bedding material can be very high due to absorption of urine and feces. For mastitis-causing bacteria, bedding materials can be a vehicle of contamination. Teats of straw-bedded cows contain higher levels of streptococci than those of cows bedded on sawdust and shavings (Slaghuis, 1996) [37].

The groups of microorganisms on teats which enter milk during milking are mainly aerobic spore-formers and micrococci. The aerobic thermoduric organisms on teat surfaces are almost entirely Bacillus spores, with spore counts ranging from 102 to 105 per teat depending on environmental conditions (Underwood et al., 1974; Muir, 1996; Slaghuis, 1996) [37,44,45].

Soil and feces on teat surfaces are the major contamination sources, although other sources such as water and silage can play a role in increasing the spore content of raw milk (Cook & Sandeman, 2000) [46]. Bramley & McKinnon (1990) [38] stated that wood shavings, straw and sand bedding can harbor Bacillus spores between 1.5 × 105 and 5.4 × 106 cfu g^{-1}(Yirsaw, W. (2004) [10].

Weather-related factors, particularly those affecting the moisture of the soil, are important for contamination of milk with spores of B. cereus during the grazing period (Christiansson et al. 1996) [47]. Although the total spore count of milk in summer is markedly lower than in winter, the psychotropic spore count remains the same because the proportion of psychrotrophs within the total spore population increases. The psychotropic spore counting summer is mainly derived from soil contaminating the teat surface. As a result, the udder becomes contaminated, resulting in the transfer of these organisms to the raw milk (Giffelet al., 1996) [48].

IMPROVING MILK QUALITY ON PROCESSING UNIT

Milk and dairy products are major components of the human diet in Western countries, providing about 30% of dietary proteins and lipids and about 80% of dietary calcium. Current annual production of milk is _ 600 _ 106 tons, of which _85%, 11%, 2% and 2% are bovine, buffalo, caprine and ovine, respectively. Although some raw milk is still consumed, the vast majority of milk is processed to at least some extent. Liquid (beverage) milk is a major food item in all developed dairying countries, representing _40% of total milk production. The remainder is processed into one of several thousand products. The dairy industry is probably the most diverse and flexible sector of the food industry (Matthew man RW (1993) [49].

Most of reported cases of dairy-related illness are of bacterial origin, mainly due to consumption of unpasteurized milk (Brady etal. 2014) [50]. Good product quality facilitates marketing and is a necessity to intensify production and to attain food security (Francesconi and Ruben, 2012) [8].

OTHER CONTAMINANTS

Industrially Derived Contaminants

Lactating ruminants tend to consume extensively grown forage and be relatively long-lived, with resultant potential for bioaccumulation of any environmental contaminants present (Rabinowitz et al., 2005) [51]. Examples include dioxins, furans, polychlorinated biphenols (PCBs), elemental 'heavy' metals and radionuclides. In general terms, the risk to public health arises through chronic exposure and build-up of contaminants partitioning into tissues harvested for food. In contrast, and somewhat non-intuitively, acute toxicity with overt clinical disease in the animal represents a lower risk to public health due to likelihood of detection and exclusion of those animals from food production (Sharpe & Livesey, 2006) [52]. Dioxins are a group of chemical compounds (congeners) inadvertently produced by many anthropogenic industrial activities, including metallurgical works, incineration and paper mulch bleaching. PCBs are a group of molecules purposefully synthesized for incorporation into, for example, industrial coolants, or plastic compounds. Dioxins and PCBs demonstrate remarkable resilience to environmental degradation, along with potential for lipophilic bioaccumulation in animal tissues. Consumption of food of animal origin represents the principal route of human exposure to dioxins and PCBs (Furst et al., 1992) [53].

Consumption of cow's milk has been implicated as a significant source of human exposure to lipophilic contaminants, such as dioxins. The risk of such contaminants bio-accumulating in lactating animals leading to high levels in milk is directly related to the potential for exposure from emitters in the geographic area of feed production. Contamination of feed after it has been harvested has also been described, e.g. contaminated storage containers (Bernard et al., 2002) [54] or inadvertent contaminant production in the manufacture of feed supplements. Contamination of animal feed with heavy metals has been linked to local industrial activity, such as mining, as well as farming practices, such as the application of sewage sludge to agricultural land. Radionuclide emissions present similar potential for bioaccumulation in foods derived from grazing animals, following fallout over a feed-producing area. Potential emitting industries should engage in environmental impact assessment prior to beginning production. Ongoing emission monitoring should be supplemented with surveillance of contaminant concentrations in tissues of animal sentinels, to verify total environmental load, and assess the attendant risk to public health in high-risk areas Jansen KE (2003) [55].

Biologically Derived Contaminants

Some potential chemical contaminants of milk arise from biological processes in the feed of the lactating animals, with subsequent potential for secretion into milk. Mycotoxin is a term used to refer to a group of secondary metabolites of fungi with toxic effects in animals or man. Fungi growing on plants may produce such toxins as the plant is growing, or after harvest of the plants during storage prior to utilization as animal feed (Driehuis & Oude Elferink, 2000) [56]. Mycotoxin ingestion can result in animal disease with overt clinical syndromes, as is the case with aflatoxicoses of turkeys (turkey X disease) or may be associated with a chronic insidious loss of productivity in food animals. Various factors, particularly mycotoxin load and animal age, and synergism amongst mycotoxins, may permit apparently health animals to shed mycotoxins in their milk (Yiannikouris & Juany, 2002) [57].

Aflatoxins produced by Aspergillus species of fungi are well studied, with biological transformation prior to shedding of a specific milk derivative, Alfatoxin M1, with carcinogenic and hepatotoxic potential (Sweeney et al., 2000). Several other mycotoxins, particularly Ochratoxin, are effectively detoxified in the ruminant fore stomach and, hence, are low risk in milk derived from ruminant animals. The risk of mycotoxin accumulation is higher when animals are consuming feed which has been stored following harvesting. Monitoring of mycotoxins in stored feed represents an important risk management strategy. Approaches to keeping fungal growth and toxin elaboration low include maintaining low aw of feed, use of fungal inhibitors, such as organic acid, and cultivation of resistant plant varieties. Potential carcinogenicity of Aflatoxin M1 has resulted in zero-tolerance in many regulatory frameworks (Sraïri MT, Benhouda H, Kuper M, Le Gal PY (2009) [58].

Phytotoxins are naturally expressed substances in plants. Toxicity in grazing animals is well described in cases, such as pyrrolizidine in ragworth, ptaquiloside in bracken, or glucosinolate in brassicas. Potential for these toxins to arise in milk of lactating animals consuming these plants represents a poorly understood risk (Panter & James, 1990; EFSA, 2007) [59,60]. One specific example is a hepatotoxicity syndrome of 'milk sickness' described in people in southern and mid-western USA, which is associated with milk borne tremetol and tremetone toxins due to the consumption of plants, such as white snakeroot or rayless goldenrod. The highest risk of phytotoxins of public health significance arises when animals are relatively resistant, as in the case of sheep and pyrrolizidine. Similarly, point-source milk supply and subsistence agriculture with one animal supplying all milk, for example to one family, presents opportunity for potentially high exposure for a small number of individuals. The grazing management and dilution effects involved in modern intensive dairying minimize phytotoxic milk borne risks IDF (2006) [61]. All milks contain a certain amount of somatic cells represented by polymorphonuclear cells (PMN), lymphocytes and macrophages. In bacterial infection and other inflammation processes affecting the mammary tissue, the number of somatic cells in milk increases, especially the PMN level (Atroshi et al., 2002) [62]. Milk contains several groups of nutrients. Organic substances are present in about equal quantity and are divided into elements builders, proteins, and energy components, carbohydrates and lipids. It also comprises functional elements, such as traces of vitamins, enzymes and dissolved gases, and contains dissolved salts, especially in the form of phosphates, nitrates and chlorides of calcium, magnesium, potassium and sodium (Sweeny et al., 2000) [63].

CONCLUSION AND RECOMMENDATIONS

Milk is the main output of a dairy farm and it is source of income and nutrition for the farm owner. Thus, dairy farmer must ensure that milk produced in clean and hygienic way to improve the benefits from the farm. Otherwise, wider ranges of issues are a rising such as from the public health point out of view, milk is a very good media for bacterial and other microorganisms development so that can easily be predisposed by infected milk during production, handing, transporting and marketing. Above the conclusions the recommendations are forwarded:

- Quality of dairy product is affected by many factors such as preservation, transportation mechanism, type and quality of milking utensils and poor personal sanitation. So improvement mechanism on such attribute should be made.
- Extension service for producers should be given on the improvement of milk quality and handling practice.
- Handling of dairy product could be improved by replacing traditional equipment's with improved one by giving training for those peoples participating in milk handling practice.

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