World Journal of Dairy & Food Sciences 15 (1): 21-31, 2020
ISSN 1817-308X

DOI: 10.5829/idosi.wjdfs.2020.21.31

Milk Quality and Sources of Microbiological Contamination: A Review

Temesgen Zekarias

Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia

Abstract: Milk has a high nutritional value and it is a good diet composes water, fat (milk lipids or butter fat), solids-not-fat (SNF), protein (casein, whey), lactose, minerals (micronutrients such as Zinc, Iron and Copper as well as macronutrients such as Calcium, Phosphate, Magnesium, Sodium, Potassium, Citrate and Chlorine). This group also includes sulphate, bicarbonate, acids (citrate, formate, acetate, lactate and oxalate), enzymes (peroxidase, catalase, phosphatase and lipase), gases (oxygen and nitrogen) and vitamins A, C, D, Thiamine and Riboflavin. In addition, milk is a good source of many other vitamins such as B6, B12, K, E, niacin, biotin, folates and pantothenic acid. Milk has an outstanding nutritional quality but is also an excellent medium for bacterial growth and an important source of bacterial infection when consumed without pasteurization. Milk can be contaminated with large number of bacteria. This is because milk is obtained from animals with unknown health status, good milking and handling practices are to a large extent not observed and marketing and distribution are done mostly in informal channels. These factors are potential causes of milk-borne diseases and milk quality loss. Failure to observe high hygiene during milking and milk handling will expose milk to potential risk of microbial contamination. Udder of the lactating animal is the highest source of contributor to milk contamination immediately it leaves the animal. Effective udder cleaning and observation of high personal hygiene of the milking hands may reduce the risk of microbial contamination in different systems of milk production. Most important is the need to train farmers and farm employees on the importance of farm hygiene especially where hand milking is involved. Animal husbandry practices should be improved to control microorganisms from lactating animals, environment and equipment by adhering to general hygiene practices and environmental cleanliness. All actors along the milk value chain should be organized and educated to increase their awareness on management of animals, general milk handling, milk hygiene and commercialization of milk.

Key words: Milk · Food Safety · Food-Borne Disease · Contamination

INTRODUCTION

Milk is of great importance particularly in the rural communities of Africa as a source of micro- and macronutrients that improve the nutritional status of individuals and populations. Also, it is one of the pathways out of poverty for millions of people in these communities [1]. In Africa consumption of milk and milk products will continue to increase from their current levels as a result of population increase, economic growth and urbanization [2].

Milk and milk products play an important role in human nutrition throughout the world. Therefore, it is essential to ensure its quality and safety at every step in the process, from the farm to the consumer [3]. This is required since milk is a suitable substrate for microbial growth and development. The fluid or semi-fluid nature of milk and its chemical composition renders it one of the ideal culture media for microbial growth and multiplication [4].

In developing countries like Ethiopia, the production of milk and various dairy products take place under rather unsanitary conditions and poor production practices [5]. According to Coorevits *et al*. [6], sources of bacterial contamination of raw milk can originate from air, milking equipment, feed, soil, faeces and grass. The health and hygiene of the cow, the environment in which the cow is housed and milked and the procedures used in cleaning and sanitizing the milking and storage equipment are all also key factors in influencing the level of microbial contamination of raw milk. All these factors will influence the total bacteria count and the types of bacteria present

Corresponding Author: Temesgen Zekarias, Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia P.O. Box: 2003, Tel: +251912844964.

in bulk raw milk [7]. The differences in feeding and housing strategies of cows may also influence the microbial quality of milk [6]. Bacteria in raw milk can affect the quality, safety and consumer acceptance of dairy products [8].

The presence of microorganisms in milk and milk products has important ramifications for safety, quality, regulations and public health. As a result, many countries have milk quality regulations, including limits on the total number of bacteria in raw milk, to ensure the quality and safety of the final product. Hygienic quality control of milk and milk products in Ethiopia is not usually conducted on routine basis. The studies conducted to assess the bacteriological quality of raw milk in Ethiopia mostly focused on mastitis causing pathogens [9] and only few studies attempted to assess along the milk production and processing chains [10].

Pathogenic bacteria pose a serious threat to human health and constitute about 90% of all dairy- related diseases [11]. Recent studies have established the emergence of new milk-borne bacterial pathogens such as *Escherichia coli* O157:H7 with more serious challenges for public health and the dairy industry [12]. To protect public health against milk-borne infections, there are regulations that require proper hygienic handling of milk and its pasteurization. However, such regulations are not usually adhered to in developing countries, making milk-borne health risk higher in developing countries. There is a deficiency in information on the microbiological quality of risk factors pointing out the most responsible source of contamination of milk with spoilage microorganisms. Therefore the aim of this review was to assess nutritional value and sources of contamination of milk & its public health implication.

Milk Quality

Milk Composition and its Nutritional Value: On average 87.4 % of the cow's liquid milk is water, 3.7% is milk fat (milk lipids or butter fat), 8.9% is solids-not-fat (SNF), 3.4% is protein (2.8% casein, 0.6% whey protein), 4.8% is lactose, 0.7% includes minerals (micronutrients such as Zinc, Iron and Copper as well as macronutrients such as Calcium, Phosphate, Magnesium, Sodium, Potassium, Citrate and Chlorine). This group also includes sulphate, bicarbonate, acids (citrate, formate, acetate, lactate and oxalate), enzymes (peroxidase, catalase, phosphatase and lipase), gases (oxygen and nitrogen) and vitamins A, C, D, Thiamine and Riboflavin [13, 14]. In addition, milk is a good source of many other vitamins such as B6, B12, K, E, niacin, biotin, folates and pantothenic acid [15].

Theoretically, milk that is secreted in the udder of healthy cow should be free of microorganisms. However, freshly drawn milk is generally not free of microorganisms. Numbers of several hundred to several thousand cfu/ml are often found in freshly drawn milk and they represent the movement up the teat canal of some and the presence of others at the lower ends of teats. Fresh milk has neutral or slightly alkaline pH but on souring it becomes acidic because of the lactic acid forming by bacterial action on lactose. It has a water content of 88% and 12% of solids which constitute of 4.8% sugars, 3.5% fats, 3.1% protein and 0.6% salts. It has a wide range of positive nutritional benefits and supplies a variety of nutrients including protein for body building, vitamins, minerals (especially calcium), fat and carbohydrate for energy [16].

There are numerous proteins found in milk. The major groups of milk proteins are caseins and whey proteins. Milk provides easily digested protein of a high nutritional value and is a rich source of essential amino acids which also supports the growth of bacteria. In addition casein is the principal protein of cow's milk. Also whey proteins are now well known for high nutritional value for bacteria and versatile functional properties in food products [16]. Many trace elements essential for health and growth of microorganisms present in milk. Na, Ca, K, P and some of the trace minerals are, Zn, Co, I, Fe, etc. Also vitamins are important both for bacterial growth and humans such as vitamin A, vitamin D, vitamin E, vitamin K, vitamins B complex, vitamin C [16].

In general, milk has a high nutritional value and it is a good diet for the children [17]. It provides nourishment and immunological protection [18]. However, if not handled properly, milk can be easily destroyed through contaminations and bacterial growth and becomes unfit for human consumption. Some of the microbial contaminants are responsible for milk spoilage while others are pathogenic with potential health effects to cause milk borne diseases [19]. Bacterial count in milk is influenced by the temperature at which milk is stored and the time that elapses since milking. Once the milk is cooled to 4°C within 2–3 hours after milking, it preserves its original quality and remains safe for processing and consumption [20]. East African countries (EAC) have harmonized standards for some products including milk. Standards are reference points and tools for ensuring quality and safety. East African Standard (EAS 67) prescribes quality requirements for raw, normal cow's milk. It covers bacteriological quality. It is important that all players in the milk value chain implement standard at their level of operation to protect the consumer [21].

Fermentation of Milk and Milk Products: Fermentations provide a way to preserve food products, to enhance nutritive value, to destroy undesirable factors, to make a safe product, to improve the appearance and test of some foods and to reduce the energy required for cooking [22]. Besides this, fermentation is relatively a low energy preservation that promotes the shelf life of products [23]. Traditional methods of preparing fermented foods are not complicated and do not require expensive equipment [24]. Fermentation of indigenous foods is, therefore, considered by many to be an effective, inexpensive and nutritionally beneficial household technology for communities with food scarcity and malnutrition [25].

The rural peoples in Ethiopia produce fermented milk by traditional methods and *ergo* are the major fermented milk products produced by smallholder farmers. *Ergo* is a traditional naturally fermented milk product, which has some resemblance to yogurt and is a thick and smooth with uniform appearance and usually has a white milk color when prepared carefully. The product is semi solid and has a pleasant odor and taste. Depending on the storage temperature, it can be stored for 15-20 days [26]. As the major fermented dairy product, *Ergo* is popular and is consumed in all part of the country and by every member of the family. *Ergo* fermentation is usually natural, with no starter cultures used to initiate it. This is made possible only through the proliferation of the initial milk flora. In most urban homes, no attempt seems to be made to control the fermentation. Raw milk is either left at ambient temperatures or kept in warmer places to be fermented. Incubation temperature does not usually vary significantly and the test of the fermented product may, in general, be more or less uniform [27]. Gonfa *et al.* [28] reported that “Ergo” fermentation is carried out by lactic acid bacteria belonging to the genera *Lactococcus, Streptococcus, Luconostoc* and *Lactobacillus.* They also observed that *Micrococcus* spp., coliforms and spore-formers were also present in fairly high numbers during the first 12-14 hr of fermentation. Their population decreased substantial thereafter, which implies an antimicrobial activity besides low pH in the fermented milk.

Lactic acid bacteria (LAB) are widely utilized to produce fermented foods contributing to flavor development and safe metabolic activities while growing in foods using available sugar in the milk for the production of organic acids and other metabolites [29]. Several metabolic products produced by these bacteria have antimicrobial effects, including organic acids, fatty acids, hydrogen peroxide and diacetyl. However, attention has focused on the ability of LAB to produce specific proteinaceaus substances, bacteriocins that inhibit the growth of pathogens, such as *Listeria, Clostridium, Staphylococcus, Bacillus* spp. and *Enterococcus* spp., Therefore they enhance the shelf life of the food [30].

Sources of Microbiological Contamination of Milk: Microbial contamination of milk in the value chain can originate from a diseased cow, unhygienic milking practice, poor personal hygiene, unsanitary utensils and/or milking equipment and water supplied in sanitary activities [31, 32, 33]. A cow with an infectious disease can shed pathogens from its blood into the milk. Findings by Streeter *et al*. [34] indicate that infected cows with clinical disease and subclinical infections shed *Mycobacterium avium* subspecies paratuberculosis in both milk and faeces. Detectable levels of the organism were observed in milk from both clinically infected and asymptomatic carrier animals. Also, infected mammary quarters or cows and the environment, in which animals are kept, are known to be chief sources of bacteria that cause udder infections in a herd. Transmission of infectious bacteria to teats of uninfected mammary quarters or cows occurs mostly at milking [32]. Appropriate milking hygiene practices reduce the rate of new infections during milking [35]. The use of pre- and post-milking teat disinfectants is an effective measure in reducing the risk of new infections. Pre-dipping reduces the resident teat skin bacterial population, which is the main source of infection for the mammary gland. It can reduce new environmental streptococcal infections and E. coli by 50%. Post-dipping prevents the transmission of contagious bacteria such as S. aureus [36]. All individuals involved in the milk value chain should maintain hygiene and must be in sound health because microbes may drop from hands, clothing, nose and mouth and from sneezing and coughing. It is important for them to be in good health to avoid becoming a source of infectious diseases [37]. Other bacterial sources are from air, drugs or chemicals used during treatment of animal and from contaminated water used for adulteration by unscrupulous and unfaithful workers/sellers may cause additional health problems [38].

Sources of Bacterial Contamination of Raw Milk: Milk is synthesized in specialized cells of the mammary gland and is virtually sterile when secreted into the alveoli of the udder. Beyond this stage of milk production, microbial contamination can generally occur from three main sources from within the udder, from the exterior of the udder and from the surface of milk handling and storage equipment [39]. The health and hygiene of the cow, the environment in which the cow is housed and milked and the procedures used in cleaning and sanitizing the milking and storage equipment are all important in influencing the level of microbial contamination of raw milk. Equally important are the temperature and length of time of storage, which allow microbial contaminants to multiply and increase in numbers. The water used for cleaning purposes is considered also as the source of milk contamination [3].

Interior of the Udder: For many years, it was believed that milk drawn directly from the udder of a healthy cow was a sterile fluid, that is, it contained no living microorganisms. It has been demonstrated conclusively that freshly drawn milk usually contains bacteria. It is found that the first milk withdrawn from the udder (foremilk) usually has a higher bacterial content than that drawn later in the milking process, while the strippings may show a somewhat higher count than the latter [40].

Raw milk as it leaves the udder of healthy cows normally contains very low numbers of microorganisms and generally will contain less than 1000 total bacteria per ml [41]. Natural microflora within the udder of healthy animals is not considered to contribute significantly to the total numbers of microorganisms in the bulk milk, nor the potential increase in bacterial numbers during refrigerated storage. Natural floras of the cow generally have little influence on standard plate counts (SPC) [42].

In case of mastitis, counts of *Streptococci*, *Staphylococci* or coliforms will be as high as the total plate count and can be very high up to 10^7 cfu/ml. Bulk milk count may even increase to 10^5cfu/ml under certain circumstances [43].

Exterior of the Udder: The exterior of the udder can be an important source of contamination. But the exterior of the udder is influenced by the environment of the cows, in which cows are housed and milked [42].

Housing Conditions: In temperate regions, cows are housed in winter and pastured in summer. Differences in teat contamination can be found between housing and pasturing. Both total plate and aerobic spore counts are lower when cows are at pasture. When cows are housed, bedding material and feed stuffs can be contamination sources. In both cases (housing and pasturing) feces and dung are important contamination sources. Contamination of bedding material can be very high due to absorption of urine and feces [43].

Teat Contamination: The groups of microorganisms isolated from teats are mainly *Microcoocci* and aerobic spore formers. The method of sampling teats can give different results but in general most bacteria found are aerobic spore formers. This can be a problem in producing milk in that the spores may survive pasteurization temperatures and spoil the milk and milk products during storage(*Bacillus* spores) and semi-hard cheese during ripening (*Clostridial* spores). Teat surfaces are also sources of *Clostridial* spores in milk. Sources of these spores are feed stuff, silage and bedding. The number declines markedly when cows go out to pasture because the pasture environment is cleaner than housing conditions [43].

Udder Preparation: Careful cleaning of the cow prior to milking significantly reduces contamination. Clipping the flanks, escutcheon and udder reduces contamination from hair and adhering debris [44]. A maximum reduction of teat contamination of 90 % can be achieved with good udder preparation (washing with disinfectant and drying with towel) before milking. This depends on the initial level of contamination and the way of udder preparation. So with high initial contamination levels this 90 % reduction might not be achieved [42].

Milking and Storage Equipment: During milking, the major source of bacteria in milk is the milk contact surfaces of milking equipment and milk cans or bulk tanks [4]. In practice, the contribution of milking equipment to the microflora of the milk can't be accurately obtained by bacteriological counts on the milk produced, because of the variability in numbers and types of bacteria derived from cow's udder [44, 42].

Cleaning and Disinfections of Equipment: Cleaning and disinfection of equipment after each milking is important for reduction of milk contamination from the equipment. Rinsing of milking equipment can reduce about 10 % of the number of bacteria found in milk [42]. In most cases, all bacteria are not removed and killed during cleaning and disinfections. Also outgrowth of remaining bacteria fixed in the wall of the container between two milking is supposed [45]. A milk can that is improperly washed, inadequately sanitized or sterilized or insufficiently dried, may contribute millions of bacteria to every milliliter of milk placed in it [42].

Storage of Raw Milk: Raw milk stored in cans should be transported to the dairy plant on the same day, because storage temperatures are rather high. Spoilage of this raw milk is due to Streptococci and coliforms resulting in souring of the milk. Milk storage and transport are aimed at having good quality milk available where and when needed for processing [40].

Miscellaneous Sources of Bacteria in Raw Milk: Although the air of the milking environment rarely contributes a significant number of the total microbial count of milk, extremely dusty conditions may increase the counts. Milk handling personnel may contribute various organisms including pathogens especially when they are careless, uninformed, or willfully negligent, directly to milk [4]. Polluted water may also cause entry of pathogens into milk [3]. The soils (while the cows are in pasture), manure, the animal coats, tails etc. are some of the possible sources of contamination of milk [46]. Substances such as salt and water added to various dairy products may be a source of microorganisms in large or small numbers and of harmless or harmful types [40, 42].

Bacteria in Milk

Zoonotic Bacteria in Milk: Milk, either raw or processed, is a well-known vehicle for a number of human pathogens. Milk and milk products have, therefore, pose a health risk to consumers if it is contaminated by any pathogens and subjected to high temperature where these organisms can multiply to high counts and may produce toxins [47]. In countries where foodborne illness are investigated and documented, the relative importance of pathogens like *Staphyloccocus aureus*, *E. coli*, *Salmonella* species and *Listeria* species are well known [41]. The following are the most important disease causing organisms that can be found in milk and targeted during this study.

***Salmonella* Species:** Most foodborne salmonellosis outbreaks have been implicated to food containing eggs or poultry products. Nevertheless, there have been several outbreaks of salmonellas for which milk or milk products were responsible. Natural infections of the udder may occur very rarely and therefore don't play any role in human infections. There are a lot of case reports about epidemics by consumption of raw milk, however, mostly from the seventies and eighties. Contamination of raw milk mostly is due to infected persons and to environment [48].

***Escherchia coli*:** This is frequently contaminating organism and is an indicator of fecal contamination generally in sanitary conditions of food including milk and its products [30]. Recovery of *E. coli* from food is an indicative of possible presence of entero-pathogenic and/or toxigenic microorganisms, which could constitute a public health hazard. *Escherchia coli* are frequently occurring organisms in milk whenever the methods of production, transportation, handling and sale of milk are unhygienic. The milk sold in raw forms and because of possibilities of contamination with *E. coli* poses a great hazard to public health [49].

***Staphylococcus aureus*:** It is the leading cause of foodborne illness throughout the world. Milk and milk products can become contaminated unless a good hygienic (including mastitis) control measure occurs on farms. The milk should be adequately pasteurized and precautions should be taken to prevent contamination and subsequent growth of *Staphylococci* during the manufacturing process and the finished product. The pathogenicity of *Staphylococcus aureus* has been recognized for many years and it may cause mastitis or skin disease in milk producing animals or lead to foodborne intoxication in milk and milk products [50]. Human carriers can also contaminate milk. Five serologically distinct enterotoxins (A, B, C, D and E) are recognized, with enterotoxin A most frequently involved in food poisoning outbreaks. The minimal intoxication dose is 100 nanogram and sometimes less [50].

***Streptococcus pyogenes*:** This pathogen is directly responsible for a variety of inflammatory and supurative conditions in humans such as sore throat, scarlet fever, cellulitis, erysipelas, impetigo, puerperal sepsis, otitis media, septicemia and wound infections; it is indirectly associated with rheumatic fever, glomerulonephritis and erythema nodosum. It is also found in the throat or nasal cavity in a proportion of apparently healthy carrier people [51].

Spoilage Organisms in Milk: Spoilage organisms are organisms that are capable of hydrolyzing milk component such as protein, fat and lactose in order to yield compounds suitable for their growth which can lead to spoilage of milk, manifested as off-flavors and odours and change in texture and appearance [52]. The number of spoilage bacteria in raw milk depends on the level of hygiene during milking and the cleanliness of the vessels used for storing and transporting the milk. During the first 2–3 hours after milking, raw milk is protected from spoilage by inherent natural antibacterial substances that inhibit the growth of spoilage bacteria. However, if the milk is not cooled, these antibacterial substances break down causing bacteria to multiply rapidly. Cooling milk to less than 10°C may prevent spoilage for up to three days. High storage temperatures result in faster microbial growth and hence faster milk spoilage [53].

Bacteria that cause food to spoil are classified in three groups on the basis of temperatures for optimal replications: psychrophilic, mesophilic and thermophilic [44].

Psychrophilic Organisms: Psychrophilic bacteria are primary spoilage bacteria because of their ability to multiply at low temperatures [44]. Psychrophilic organisms can even grow at refrigeration temperatures. These are of interest to those storing milk at low temperatures. These bacteria grow slowly and mostly feed by breaking down protein (proteolysis) and fats (lipolysis). They can develop in raw milk during cold storage and high numbers can produce enough enzymes to cause flavour defects. The psychrotrophic bacteria are killed by pasteurization, however, the enzymes they produce can survive. Since most strains of psychrotrophic bacteria and in particular Pseudomonas, produce lipases and proteases that critically affect the sensory and physical quality of raw milk. Although most strains produce lipases or proteases, some strains have been shown to produce both enzymes [16]. Protease attacks proteins and cause the development of bitter flavor or gelatin in milk while lipase produce rancid flavor in milk and milk products due to its action on milk fats [40].

They are ubiquitous in nature and are major contaminants of milk. Poorly cleaned and sanitized dairy farm and processing plant equipment probably constitute major sources for contamination of milk with psychrophiles [45]. Bacteria such as *Pseudomonas putrifaciense* can rapidly grow at refrigeration temperatures between 2 and 10°C and is an example of apsychrophiles [44]. Other Gram-negative bacteria most commonly found to contain psychrophilic species are *Achromobacter*, *Alcaligenes, Flavobacterium, Escherichia* and *Enterobacter* spp [44].

Mesophilic Organisms: Mesophilic bacteria are the groups, which grow best at normal temperature ranging from about 20 to 40°C. They are characterized by the lactobacilli that can attack the milk sugar lactose and convert it to lactic acid. Their uncontrolled growth gives rise to the souring and even curdling of milk stored at ambient temperatures [16].

Thermophilic Organisms: Thermophilic organisms although they are less harmful to humans, they are responsible for changes in organoleptic properties of milk products [44]. They can tolerate heat and survive pasteurization [16]. By far the largest groups and those with which we are concerned are called mesophiles because their optimum growth temperature falls between 20°C and 40°C, the range between normal room temperature and just slightly above normal body temperature. This group mostly contains pathogenic microorganisms [54].

Bacteriological Milk Quality Tests: Sanitary methods of handling milk must be strictly followed in order to provide safe milk for human consumption. Furthermore, since milk is a good growth medium, even a small number of non-pathogens can multiply considerably if the milk is not kept refrigerated. Because the consumer has no way of knowing whether or not the milk delivered to the home or purchased in the store is contaminated, a number of standard tests are carried out periodically on milk [55].

Standard Plate Count (SPC): The standard plate count of raw milk gives an indication of the total number of aerobic bacteria present in the milk at the time of pick up. Obviously, very clean milk will have lower bacterial counts than milk collected or handled under unsanitary conditions. The standard plate count is a basis for grading milk [55]. It is indicated that total bacterial count is a good indicator for monitoring the sanitary conditions practiced during production, collection and handling of raw milk [56]. Milk samples are plated on standard plate count agar media and then incubated for 48 hrs. at 32°C to encourage bacterial growth. Single bacteria or clusters grow to become visible colonies that are then counted. All plate counts are expressed as the number of colony forming units (CFU) per milliliter of milk [42]. This method is used mainly to estimate the bacterial population of raw milk prior to heat treatment. It has a limited value in that it doesn't indicate the quality of microbial populations in terms of pathogens and non-pathogens [46]. The standard plate count is generally accepted as the most accurate and informative method of testing bacteriological quality of milk [57]. It is sensitive but also labor intensive and is inaccurate for high count milks [43]. Plate count standards have been developed to ensure satisfactory production hygiene and that the product is safe. The plate count method has been conducted as a valuable adjunct to guide sanitarians in correcting sanitation failures and improving milk quality [58].

Coliform Bacteria in Raw Milk: Coliforms are group of bacteria, which inhabit the intestinal tracts of human and animals. They are excreted in large number with human excreta and animal droppings. They may be found in the soil, on vegetables and in untreated water [46]. It includes all aerobic and facultative anaerobic, Gram-negative, non-spore forming rods able to ferment lactose with the production of acid and gas at 35°C within 48 hours. Most of them belong to the genera *Escherichia, Enterobacter* and *Klebsiella* [41]. The presence of coliforms in milk indicates unsanitary conditions of production, processing or storage. Hence their presence in large number in dairy products is an indication that the products are potentially hazardous to the consumers' health [41]. Coliform organisms contaminate raw milk from unclean milker's hands, improperly cleaned and un sanitized milk utensils, faulty sterilization of raw milk utensils especially churns, milking machines, improper preparation of the cows' flecks or dirt, manure, hair dropping into milk during milking, udder washed with unclean water, dirty towels and udder not dried before milking [59].

Public Health Standards for Milk: As food safety and quality are a growing concern all over the world, different organizations in many countries implement quality control programs and established quality standards for all food items including animal products to ensure the health of the consumer. Health hazards to the consumer are often grouped into microbiological, physical and chemical. A microbial criteria specify that a type of microorganism, groups of microorganisms, toxin produced by a microorganism must either not be present at all, be present in only a limited number of samples, or be present at less than a specified number or amount in a given quantity of a food ingredient [60].

High initial microbial count in milk of $>10^5$ cfu/ml is evidence of serious faults in milk production hygiene, whereas production of milk having counts consistently below 10^5 cfu/ml reflects good hygiene practices [59]. A standard plate count of $1x10^5$cfu/ml has been widely adopted for good quality raw milk intended for treatment before liquid consumption. However, some other countries have adopted different standards suited to local conditions. For example, the standard plate count for America is not more than $4x10^5$cfu/ml, while the standard for Kenya is not more than $2x10^6$ cfu/ml [59].

Coliform count provides an indication of unsanitary production practices and/or mastitis infection. Coliforms can rapidly build up in moist, milky residues in milking equipment, which then becomes the major source of contamination of milk produced. Coliform counts regularly greater than 150 cfu/ml are considered generally as evidence of unsatisfactory production hygiene. However, relatively low coliform counts in milk don't necessarily indicate effectively cleaned and disinfected equipment [59]. The coliform count and total bacterial counts in milk for Common Market for Eastern and Southern Africa as sited by Muriuki [61] beyond $4x10^5$ and $5x10^5$ is considered as unacceptable to be consumed as raw.

Measure to Reduce Bacterial Contamination of Raw Milk

Cleaning and Sanitation: In order to reduce contamination by spoilage and pathogenic organisms from the farm to dairy plant, the cows teats and surrounding udder area and all utensils and equipments used during milking and processing should be properly cleaned. The standard of hygiene is a more factor contributing to difference in the quality of milk produced by different milk processors. The degree of sanitation and cleaning can influence the type of *Pseudomonads,* which contaminate milk [62].

Cooling Milk Storage: Rapid cooling of milk after collection is vital, since contamination of the product with psychrophilic bacteria is unavoidable. This is a major challenge for the farm equipment and storage systems [63]. Storage of raw milk at 2°C is effective for shelf life extension compared with storage at 4 and 7°C [64]. The storage temperature of raw milk influence the quality of the resulting product; the result of ultra-high temperature treated milk is much longer when processed from raw milk stored at 2°C than when processed from raw milk stored at 6°C [65].

To prevent or transport to the processing plant, it is essential to cool the fresh milk as quickly as possible [41]. Although milk is known to possess several natural antimicrobial agents which retards the growth of bacteria in milk and to maintain its quality for domestic consumption, bacterial numbers will double in less than 4 hours in unchilled milk. The rate of microbial growth will depend on initial numbers of bacteria and the temperature at which milk is held after milking and thereafter [57]. In the tropical countries of Africa with high ambient temperatures, lack of refrigeration facilities at the farm and household level imply that raw milk will acidify very fast unless and otherwise protected [41]. Therefore the collection systems must be designed to move the milk to the cooling and/or processing center in shortest possible time. In addition every effort should be made to use available systems such as water cooling, air circulation or shaded areas to reduce milk temperature [66].

Addition of Carbon Dioxide: Carbon dioxide can be added as a preservative in milk. When the air in a sealed container is replaced with carbon dioxide, the bicarbonate ion is produced, which has antimicrobial properties against psychrotrophic, lactic acid and coliform bacteria [67].

Thermal Treatment: A range of thermal treatments is used to reduce the bacterial population of milk. These include theorization, batch and HTST pasteurization, high temperature pasteurization (ESL), UHT treatment and in-container sterilization [68]

Non-Thermal Treatment: Several non-thermal treatments can be used to remove microorganisms in foods. These include high pressure treatment, pulse electric field technology, ultrasonication, centrifugation and microfiltration; however only centrifugation and microfiltration are used commercially for milk [69].

CONCLUSION AND RECOMMENDATION

Milk is important as a valuable diet, but due to its nutritional value and perishable product it serves as an ideal medium for development of various microorganisms under suitable conditions, hence it is a staple food in epidemiology linked to zoonotic pathogens. The lactating animal, the milking and milk handling procedures at the farm level may expose the milk to potential risk of contamination with spoilage microorganisms. Milk contamination if not prevented will lead to milk losses along the dairy value chain and zoonosis. Poor milk quality, unhygienic practices, poor animal husbandry practices, organization of milk supply chains and dysfunction of the regulatory authorities predispose the public to risk of contracting milk-borne infections. Training on animal husbandry practices and public education on general milk hygiene are recommended. Also, sector policies, organizational structures, support services and research into public health risks in milk must be given close consideration. There is the need for instituting effective control measures including improved hygienic handling of milk and its pasteurization to protect public health.

REFERENCES

1. Food and Agriculture Organization (FAO), 2013. Milk and Dairy Products in Human Nutrition, edited by E. Muehlhoff, A. Bennett and D. McMahon, United Nations, Rome, Italy.
2. Tschirley, D., T. Reardon, M. Dolislager and J. Snyder, 2014. The rise of a middle class in East and Southern Africa: implications for food system transformation, Working Paper 119, World Institute for Development Economics Research (WIDER), Helsinki, Finland.
3. De Graaf, T., Z.J. Romero, M. Cabalellero and R.H. Dwinger, 1997. Microbiological quality aspects of cow's milk at a smallholder cooperative in Turrialba, Costa Rica. Revue Elev. Med. Vet. Pays Trop., 50: 57-64.
4. Ashenafi, M. and F. Beyene, 1994. Microbial load, microflora and keeping quality of raw and pasteurized milk from a dairy Farm. Bulletin of Animal Health Production in Africa, 42: 55-59.
5. Yilma, Z. and B. Faye, 2006. Handling and microbial load of cow's milk and irgo- fermented milk collected from different shops and producers in central highlands of Ethiopia. Ethiopian Journal of Animal Production, 6: 67-82.
6. Coorevits, A., V. De Jonghe, J. Vandroemme, R. Reekmans, J. Heyrman, W.Messens, P. De Vos and M. Heyndrickx, 2008. Comparative analysis of the diversity of aerobic-spore-forming bacteria in raw milk from organic and conventional dairy farms. Syst. Appl. Microbiol., 31: 126-140.
7. Murphy, S.C. and K.J. Boor, 2000. Trouble-shooting sources and causes of high bacteria counts in raw milk. Dairy, Food and Environmental Sanitation, 20: 606-611.
8. Jayarao, B.M., S.C. Donaldson, B.A. Straley, A.A. Sawant, N.V. Hegde and J.L. Brown, 2006. A survey of food borne pathogens in bulk tank milk and raw milk consumption among farm families in Pennsylvania. Journal of Dairy Science, 89: 2451-2458.
9. Abebe, G., A.C. Ike, M. Siegmund-Schultze, A. Mane-Bielfeldt and A. Valle Zarate, 2010. Prevalence of mastitis and brucellosis in cattle in Awassa and the peri-urban areas of two smaller towns. Zoonoses and Public Health, 57: 367-374.
10. Garedew, L., A. Berhanu, D. Mengesha and G. Tsegay, 2012. Identification of gram-negative bacteria from critical control points of raw and pasteurized cow milk consumed at Gondar town and its suburbs, Ethiopia. BMC Public Health, 12: 950. [DOI: 10.1186/1471-2458-12-950].
11. Ryser, E.T., 1998. Public Health Concerns. In: Applied Dairy Microbiology; Steele Edition. Mercell Dekker, Inc New York, pp: 263-404.

12. Sivapalasingams, S., C.R. Friedman, L. Cohen and R.V. Tauxe, 2004. Fresh produce: a growing cause of outbreaks of foodborne illness in the United States. J. Food Protect, 67: 2342-2353.
13. Nangwala, S.W., 1996. Effect of mastitis on milk yield response to improved feeding. Dissertation for Award of MSc Degree at Sokoine University of Agriculture. Morogoro, Tanzania.
14. Tesha, Y.C., 2010. Effect of feeding different concentrates to Ayrshire and Friesian cows on milk yield and Fatty Acid composition of Butter Fat. Dissertation for Award of MSc. Degree at Sokoine University of Agriculture. Morogoro, Tanzania.
15. Goff, H.D. and A.R. Hill, 1993. Chemistry and physics. In Y. H. Hui (Ed.), Dairy Science and Technology Handbook. Principles and properties, Vol. 1. VCH Publishers, New York. NY: John Wiley and Sons, pp: 1-82.
16. Harding, F., 1999. Milk Quality. 2nd Edition, Gaithers burg, Maryland and Aspen, pp: 25-105.
17. FAO, 2005. Developing Countries and the Global Dairy Sector. Part I – Global Overview, by V. Knips. Rome, Italy.
18. Bauman, D.E., 2004. The enhancement of milk fat with fatty acids of importance in human health maintenances and diseases prevention. [http//vivo.cornell.edu/entity?home=&id=5502]. Site visited on 25/8/2013.
19. Kivaria, F.M., J.P.T.M. Noordhuizen and A.M. Kapanga, 2006. Evaluation of the hygienic quality and associated public health hazards of raw milk marketed by smallholder dairy producers in the Dar es Salaam region, Tanzania. Journal of Tropical Animal Health Production, 38: 185-194.
20. Omore, A., T. Lore, S. Staal, J. Kutwa, R. Ouma, S. Arimi and E. Kang'ethe, 2005. Addressing the public health and quality concerns towards marketed milk in Kenya SDP Research and Development Report No. 3 Smallholder Dairy (R&D) Project, pp: 1-45.
21. EAS (East African Community Standard), 2006. EAS 67: 2000. Raw cow milk-Specification[http://www.dairyafrica.com/documents/EAS%2067%20raw%20milk%20cleaned.doc]. Site visited on 24/8/2013.
22. Lopez, U.P., 1992. Nutrition and safety consideration. In: Applications of biotechnology to traditional fermented foods. National academic press, Washington, DC, pp: 153-158.
23. Cooke, R.D., D.R. Twiddy and P.J.A. Reilly, 1987. Lactic acid fermentation as a low cost means of food preservation in tropical countries. FEMS Microbiol. Rev., 46: 369-379.
24. Nigatu, A., 1992. Lactic acid bacteria of fermented Tef dough and fermented Kocho and their inhibitory effect on certain food-borne pathogens or spoilage organisems. MSc thesis department of Biology, Addis Ababa University, Ethiopia.
25. Jay, J.M., 1994. Modern Food Microbiology, 4th edition. Van Nostrand Rainhold, New York. Biophysics, 204: 13-29.
26. Gonfa, A., H.A. Foster and W.H. Holzapfel, 2001. Field survey and literature review on traditional fermented milk products of Ethiopia. International Journal of Food Microbiology, 68: 173-186.
27. Ashenafi, M., 2002. The microbiology of Ethiopian foods and beverages: A review. SENET: Ethiopian Journal of Science, 25: 97-140.
28. Almaz, G., F. Alemu, U. Kelbessa and A. Berhanu, 1999. Microbiological aspects of 'Ergo' ('Ititu') fermentation. SINET: Ethiop. J. Sci., 22: 283-289.
29. Nigatu, A., 1998. Systematics of *Lactobacillus* and *Pediococcus* isolates from fermented tef (*Eragrostis tef*) and kocho (*Ensete ventricosum*) and microbiological status of the baked products. Ph.D. dissertation, Department of Biology, Addis Ababa University, Ethiopia.
30. Soomro, A.H., M.A. Arain, M. Khaskheli and B. Bhuto, 2002a. Isolation of E. coli from raw milk and milk products in relation to public health sold under market conditions at Tandonjam, Pakistan. Journal of Nutrition, 1: 151-152.
31. Parekh, T.S. and R. Subhash, 2008. Molecular and Bacteriological examination of milk from different milch animals with special reference to Coliforms. Journal of Current Research in Bacteriology, 1: 56-63.
32. Kilango, K.G., 2011. Food Safety in Milk Markets of Smallholder Farmers in Tanzania: A Case of Peri Urban Wards in Temeke Municipality. Dissertation for Award of MSc. Degree at Sokoine University of Agriculture, Morogoro, Tanzania.
33. Lubote, R., F. Shahada and A. Matemu, 2014. Prevalence of *Salmonella* spp. and *Escherichia coli* in raw milk value chain in Arusha, Tanzania. American Journal of Research Communication, 2: 1-13.

34. Streeter, R.N., G.F. Hoffsis, S. Bech-Nielsen, W.P. Shulaw and D.M. Rings, 1995. Isolation of *Mycobacterium paratuberculosis* from colostrum and milk of subclinically infected cows. American Journal of Veterinary Research, 56: 1322-1324.
35. Robert, J.H., 1996. Controlling Contagious Mastitis National Mastitis Council Regional Meeting Proceedings, pp: 11.
36. NADIS (National Animal Disease Information Service), 2013. Mastitis Control and Management. Mastitis part 7 – Teat Disinfection, by R. Laven. UK. [http://www.nadis.org.uk/bulletins/mastitis-control-and-anagement/mastitispart-7-teat-disinfection.aspx?alt Template =PDF] Site visited on 23/08/2013.
37. Kurwijila, L.R., 1998. Dairy Processing marketing in Tanzania: Lessons and Future Challenges. Tanzania Veterinary Journal, 18: 192-208.
38. Karimuribo, E.D., L.J. Kusiluka, R.H. Mdegela, A.M. Kapaga, C. Sindato and D.M. Kambarage, 2005. Studies on mastitis, milk quality and health risks associated with consumption of milk from pastoral herds in Dodoma and Morogoro regions, Tanzania. Journal of Veterinary Science, 6: 213-221.
39. Bramley, A.J. and C.H. McKinnon. 1990. The microbiology of raw milk. In Dairy Microbiology, Robinson, R.K. (ed.) Elsevir Science Publishers, London, 1: 163-208.
40. Walstra, P., T.J. Geurts, A. Omen, D. Jellema and M.A.J.S. Van Boekel, 1999. Dairy Technology Principles of Milk Properties and Processes, Marcel Dekker Inc, New York, NY, USA.
41. Godefay, B. and B. Molla, 2000. Bacteriological quality of raw milk from four dairy farms and milk collection center in and around Addis Ababa. Berl. Munch. Tierarzt. Wschr., 113: 1-3.
42. Murphy, S.C., 1996. Sources and Causes of High Bacteria Count in Raw Milk: an Abbreviated Review. Cornell University, Ithaca, N.Y., pp: 1-4.
43. Slaghuis, B., 1996. Source and significance of contaminants on different levels of raw milk production. Research Station for Cattle, Sheep and Horse Husbandry, Lelystad, Netherlands.
44. Hagstad, H.V. and W.T. Hubbert, 1986. Food Quality Control, Foods of Animal Origin. 1st Edition, the IWA State University Press/Ames, 52: 87-88.
45. Mehari, T., 1988. Thermoduric and psychrophilic bacteria from raw milk. MSc Thesis, Faculty of Science, Addis Ababa University, Addis Ababa, Ethiopia.
46. Teka, G., 1997. Food Hygiene principles and food borne disease control with special reference to Ethiopia. Faculty of Medicine, Department of Community Health, Addis Ababa University, pp: 73-86.
47. Radiostits, O.M., D.C. Blood and C.C. Gay, 1994. Veterinary Medicine Text Book of the Disease of Cattle, Sheep, Pigs, Goats and Horses. 8th Edition., Baillière Tindall, pp: 563-574.
48. Vlaemynck, G., 1994. *Salmonella*. In: The Significance of Pathogenic Micro-organisms in Raw Milk. International Dairy Federation. IDF, Brussels, Beljium, pp: 78-90.
49. Rea, M. and M.G. Fleming, 1994. *Escherichia coli* (ETEC). In: The Significance of Pathogenic Microorganisms in Raw Milk, International Dairy Federation. IDF, Brussels, Belgium, pp: 91-100.
50. Asperger, H., 1994. *Stapylococcus aureus*. In: The Significance of Pathogenic Microorganisms in Raw Milk, International Dairy Federation. IDF, Brussels, Belgium, pp: 24-42.
51. Collee, J.G., J.P. Duguid, A.G. Fraser and B.P. Marmion, 1989. Practical Medical Microbiology. 13th ed., United Kingdom, 2: 28-379.
52. Frank, J.F. and A.N. Hassan, 2003. Microorganisms associated with milk. In: Roginski, H., Fuquay, J.W. & Fox, P.F. (Eds.). Encyclopedia of dairy sciences. London, UK. Academic Press, Elsevier Science, pp: 1786-1796.
53. Kurwijila, L.R., 2006. Hygienic milk handling, processing and marketing: reference guide for training and certification of small-scale milk traders in Eastern Africa. ILRI (International Livestock Research Institute), Nairobi, Kenya, pp: 1-12.
54. Hagstad, H.V. and W.T. Hubbert, 1986. Food Quality control, Foods of Animal origin 1st Edition, The IVVA State University Press/Ames, 52: 87-88.
55. Volk, W.A. and M.F. Wheeler, 1980. Basic Microbiology. 4th edition, United States of America, Philadelphia, pp: 266-269.
56. Fatine, H., E. Abdelmoula, B. Doha and H. Hinde, 2012. Bacterial Quality of Informally Marketed Raw Milk in Kenitra City, Morocco. Pakistan Journal of Nutrition, 11: 662-669.
57. Kurwijila, R.L., K.K. Hansen, I.E. Macha, K. Abdallah and H.J.S. Kadigi, 1992. The bacteriological quality of milk from hand and machine milked dairy herds in Morongo, Tanzania, Journal of African Livestock Research, 2: 59-67.

58. IDF, 1990. IDF expert committee on methods for assessing the bacteriological quality of raw milk from the farm. Brussels, Belgium. Bulletin: IDF, pp: 4-8.
59. Ombui, J.N., S.M. Arimi, J.J. Mcdermott, S.K. Mbugua, A.A. Githua and J. Muthoni, 1995. Quality of raw milk collected and marketed by dairy cooperative societies in Kiambu District, Kenya. Bulletin Animal H ealth Production in Africa, 43: 277-284.
60. NRC, 1985. An evaluation on microbiological criteria for foods and food ingredients. Subcommittee on microbiological criteria, Committee on Food Protection, National Research Council (NRC), Ethiopia.
61. Muriuk, H.G., 2011. Dairy development in Kenya, Food and Agricultural Organization, Rome, Italy.
62. Craven, H.M. and B.J. Macauley, 1992. Microorganism in pasteurized milks after refrigerated storage 3. Effect of milk processor. Australian Journal of Dairy Technology, 47: 50-55.
63. Frank, J.F., 1997. Milk and dairy products. In: Food Microbiology: Fundamentals and Frontiers (eds M.P. Doyle, L.R. Beuchat & T.J. Montiville), ASM Press, Washington, DC.
64. Muir, D.D., 1996. The shelf-life of dairy products: 1. Factors influencing raw milk and fresh products. J. Soc. Dairy Technol., 49: 24-32.
65. Griffiths, M.W., J.D. Phillips, I.G. West, A.W.M. Sweetsur and D.D. Muir, 1988. The quality of skim-milk powder produced from raw milk stored at 2°C. Food Microbiology, 5: 89-96.
66. DelloCastillo, L.B., 1990. Introduction. In: Handbook on Milk Collection in Warm Developing Countries. Brussels, Belgium, pp: 9-14.
67. Champagne, C.P., R.R. Laing, D. Roy, A.A. Mafu and M.W. Griffiths, 1994. Psychrotrophs in dairy products: their effects and their control. Crit. Rev. Food Sci. Nutr., 34: 1.
68. Kelly, A., N. Datta and H.C. Deeth, 2005. Thermal processing of dairy products. In: Thermal Food Processing: New Technologies and Quality Issues (ed. D.W. Sun), Taylor & Francis, Boca Raton, FL. pp: 265-298.
69. Deeth, H.C. and N. Datta, 2002. Pulsed electric technologies. In: H. Roginski, J.W. Fuquay, P.F. Fox, editors. Encyclopedia of Dairy Science. Academic Press, London, pp: 1333-1339.