World Journal of Agronomy, Food Science & Technology
Vol. 1, No. 1, January 2014, PP: 01-10
Available online at www.wjafst.com

Review Paper

Assessing the Microbiological quality of milk

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Abstract

Milk is one of the food products which are used as vehicle of disease transmission to human being. This paper is to assess the quality of both raw and pasteurized milk produced by the milk processing plants. Microorganisms may contaminate milk at various stages of milk procurement, processing and distribution. The health of the cow and its environment, improperly cleaned and sanitized milk handling equipment, and workers who milk cows come in contact with milk due to a number of reasons could serve as sources of microbial contamination of milk. Pathogenic or disease causing microorganisms may be shed in to milk even by healthy cows. Raw milk collection and its transportation to the processing centers present a number of technical, economical and organizational problems in most developing countries in tropical regions. Hygienic quality control of raw milk and milk products in Ethiopia is not usually conducted on routine basis. Milk is one of the food products which is used as a vehicle of disease transmission. Tuberculosis, typhoid fever, dysentery, diphtheria, septic sore throat and other streptococcal infections, staphylococcal toxins, salmonella gastroenteritis, and brucellosis are some of the diseases transmitted by milk.

Key Words: Aerobic Plate Count, E. coli, Fecal Coliforms, Pasteurization

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1. Introduction

Milk is the lacteal secretion of the mammary glands of a mammal. It is the first natural food of all young mammals during the period immediately after birth (Gebra-Emanuel Teka, 1997). 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 nutrients in significant amounts than any other single food (O'Mahony, 1988). Man has consumed milk and milk products even before the

dawn of civilization. Because of its nutritive value, milk is considered as one of the most important diet items of many people (Mehari, 1998). Nutritionally, milk has been defined as "the most nearly perfect food". Milk is an outstanding source of calcium and phosphorus for bones and teeth, and contains vitamin B6, A and B1 in significant amounts. It also contains vitamin B12 (O'Mahony, 1988).

As milk products play an important role in human nutrition throughout the world, consequently, the products must be of high quality. In less developed areas and especially I hot tropics high quality of safe product is most important but not easily accomplished (DeGraaf et al., 1997). This is required since milk is also 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 (Soomrow et al., 2002). 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 i.e., within the udder, the exterior of the udder and the surface of the milk handling and storage equipment (Godefay and Molla, 2000).

Pathogenic or disease causing microorganisms may be shed in to milk even by healthy cows. (AVMA, 2005). Further, milk handling procedures on the dairy farms may introduce pathogenic microorganisms in to the milk. Milk is an excellent growth medium and when stored improperly will allow the rapid proliferation of pathogens. A recent survey b (Jayarao, et al., 2006) identified several food borne pathogenic bacteria, including Campylobacter jejuni, Escherichia coli, Listeria monocytogens, Salmonella serovars and Yersinia enterocolitica associated with raw milk.

Microorganisms may contaminate milk at various stages of milk procurement, processing and distribution. The health of the cow and its environment, improperly cleaned and sanitized milk handling equipment, and workers who milk cows come in contact with milk due to a number of reasons could serve as sources of microbial contamination of milk .Use of non potable water may also cause entry of pathogens in to milk. It is known that tropical conditions which have a hot, humid climate for much of the year are ideal for quick milk deterioration so pose particular problems because the temperature is ideal for growth and multiplication of many bacteria (Godefay and Molla, 2000).

Although milk is known to posses several antimicrobial systems, bacterial numbers will double in less than 3 hours in unchilled milk. The rate of microbial growth will depend on initial numbers and the temperature at which milk is held after milking and thereafter (Kurwijila et al., 1992).

The increase in urban population during the present century and improvements in method of milk preservation have led to large scale transportation of milk from the producer to the consumer areas (Linton,1982). Raw milk collection and its transportation to the processing centers present a number of technical, economical and organizational problems in most developing countries in tropical regions. These have inevitably increased the risk of

infection of many people from a common source. Lack of refrigeration facilities at the farm and household level, with high ambient temperature implies that raw milk will easily be spoiled during storage and transportation (Gilmour, 1999). Diseases that commonly spread from the milk to human beings are tuberculosis, brucellosis, salmonellosis, listeriosis, campylobacteriosis, yersinoses, and other bacterial pathogens transmitted to humans include streptococcus agalactaciae, staphylococcus aures and Escherichia coli (Hahn, 1996).

Milk in most places in Ethiopia is consumed raw. Milk products such as yoghurt and butter are also produced using raw milk as a starting material. Hence, there exists the possibility o consuming milk, which has been contaminated with disease causing organisms (Mehari, 1998). Hygienic quality control of raw milk and milk products in Ethiopia is not usually conducted on routine basis. Apart from this, door to door raw milk delivery in the urban and peri-urban areas is commonly practiced with virtually no quality control at all levels (Godefay and Molla, 2000). So this study was conducted to identify the microbiological contamination of raw and pasteurized milks from the selected milk processing plants.

2. Literature Review

Milk, a natural liquid food is one of our most nutritionally complete food, adding high quality protein, fat, milk sugar, essential minerals, and vitamins to our diet. However, milk contains bacteria that- when improperly handled may create conditions where bacteria can multiply. Most of the bacteria in fresh milk from a healthy animal are either harmless or beneficial. But, rapid changes in the health of an animal, or the milk handler, or contaminants from polluted water, dirt, manure, vermin, cuts, and wounds can make raw milk potentially dangerous (USDA,1981).

Food - borne diseases are caused by a wide range of agents and can result in mild indispositions or life threatening illnesses. The true scale of their impact on health remains unknown since only a small proportions of cases come to the notice of health services and even fewer are investigated. In many developing countries reliable quantitative data are by and large lacking (WHO, 1992).

Bovine tuberculosis is transmitted by the ingestion of unpasteurized milk or dairy products from tuberculoses cows, by air borne infection in barns and by handling of contaminated animal products. Transmission of tuberculosis from human origin through milk is usually the result of unhygienic handling of milk by infected persons or exposure of milk to flies or dust. Typhoid, dysentery, and salmonella organisms may reach milk from the unclean hands of milkier or other dairy employees who are carriers or in the early stages of illness (Ehlers, 1976). A recent systematic review in New Zealand investigated the strength of evidence to support casual links between food borne illness and consumption of raw milk products. The report findings indicated moderate evidence exists to support a causal link between consumption of raw milk products and *salmonella* serovars, *E.coli* species, *Listeria monocytogens*, *Campylobacter species* (Jaros et al., 2008). Several foods borne disease outbreaks have been linked to pasteurized milk traced to in adequate pasteurization or post pasteurization contamination (ICMSF, 1998).

The detection of coliform bacteria and pathogens in milk indicates a possible contamination of bacteria either from the udder, milk utensils or water supply used (Bonfoh et al., 2003). Entrance of micro organism is through hair, udder, and teats of dairy cows and can move up the teat canal. Some of these germs cause an inflammatory disease of the udder known as mastitis while other enter the milk without causing any disease symptoms in animals. In addition, organisms can enter the milk supply during the milking process when equipment used in milking, transporting, and storing the raw milk is not properly cleaned and sanitized (Namminga,1999).

2.1. Bacteriological quality of raw milk

Due to its complex biochemical composition and high water activity, milk serve as an excellent culture medium for the growth and multiplication of many kinds of microorganisms (Ashenafi and Beyene, 1994). Presence and multiplication of saprophytic bacteria in raw milk might change the milk composition and influence the quality of the product (Godefay and Molla, 2000). Moreover, the flavor of the raw milk may be adversely affected and heat stable bacterial enzymes may continue to act in the product, particularly during long storage and adversely affect stability and/or flavor of cream and upper treated milk (Heeschen, 1994).

2.2. Sources and significance of bacterial contamination

The bacterial contamination in milk emanates from a number of sources including mastitis, external udder surfaces and from the milking plant (Hagstad and Hubert, 1986).Inadequate cooling of the milk, improper udder preparation methods, unclean milking equipment and the water used for cleaning purposes are considered as the main source of milk contamination (DeGraaf et al., 1997). The conditions necessary for bacterial multiplication are moisture, suitable temperature, air and nutriment. During milking, the major source of bacteria in milk is the milk contact surfaces of milking equipment and milk cans or bulk tanks (Ashenafi and Beyene, 1994).In practice, the contribution of milking equipment to the micro flora 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 (Hagstad and Hubbert 1986).

Cleaning and disinfections of equipment after each milking is important for reduction of contamination of milk from the equipment and with rinsing, about 10% of the number of bacteria found in milk can be reduced (Murphy, 1996). In most cases not all bacteria are removed and killed during cleaning and disinfections. Also outgrowth of remaining bacteria fixed in the wall of the container between two milking period is supposed (Mehari, 1998). 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 (Murphy, 1996).

After production, milk can be stored in cans and in bulk tanks before collection. 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 (Walstra et al., 1999)

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 (milkier, butter maker, cheese maker, etc.) may contribute various organisms including pathogens especially when they are careless, uninformed , or willfully negligent, directly to milk(Ashenafi and Beyene,1994).The soils, while the cows are in pasture, manure, the animal tails etc. are some of the possible sources of contamination of milk(Gebra Emanuel Teka,1997).

To prevent or retard growth of bacteria in milk and to maintain its quality for domestic consumption or during transport to the processing plant, it is essential to cool the fresh milk as quickly as possible (Godefay and Molla, 2000). Although milk is known to posses several natural antimicrobial systems, bacterial numbers will double in less than 4 hours in unchilled milk. The rate of microbial growth will depend on initial numbers and the temperature at which milk is held after milking and thereafter (Kurwijiila et al., 1992).

2.2.1. 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 found in the soil, on vegetables and untreated water (Gebra-Emanuel Teka, 1997). It includes all aerobic and facultatively anaerobic, gram-negative, none 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 coli*, *Enterobacter* and *Klebsiella* (Godefay and Molla,
2000).

Coliform organisms contaminate raw milk from unclean milker's hands, improperly cleaned and unsanitized or faulty sterilization of raw milk utensils especially churns, milking machines, improper preparation of the cow's flecks or dirt, manure, hair dropping in to milk during milking, udder washed with unclean water, dirty towels and udder not dried before milking(Ombui et al., 1995). The presence of coliform organisms 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(Godefay and Molla,2000).

The following are the most important disease causing organisms that can be found in milk; Salmonella species: Many strains of salmonella can cause food borne illness in humans,
and all strains exhibit the same symptoms such as gastroenteritis (vomiting and diarrhea). Pasteurization destroys the salmonella organism, and although pasteurized milk , powdered milk, and cheese have been implicated in salmonellosis outbreaks, in these cases, the pasteurized milk was contaminated during further processing(USDA,1981). Most food borne salmonellosis outbreaks have been implicated to food containing eggs or poultry products. Nevertheless, there have been several outbreaks of salmonella for which milk or milk products were responsible (Vlaemynck, 1994). *Staphylococcus aures*: is a common cause of mastitis in dairy cattle and can

enter the milk supply from sores on the teats of cows or from the hands and nasal discharges of dairy farmers and workers. The Staphylococcus organism produces an enterotoxin (toxins causing vomiting and diarrhea) in raw milk when it is held at temperatures above 50 degree Fahrenheit. Sufficient amounts of enterotoxin in foods can cause illness. The incidence of staphylococcal intoxication has been greatly reduced by pasteurization (USDA, 1994).

The pathogenicity of Staphylococcus aures has been recognized for many years and it may cause mastitis of skin disease in milk producing animals or lead to food borne intoxication in milk and milk products (Asperger, 1994).

Escherichia coli, It is a frequently contaminating organism and is reliable indicator of fecal pollution generally in sanitary conditions of water, food and milk and other dairy products (Soomro et al., 2002).

Listeria Monocytogens; this widespread organism is found principally in soil. *Listeriosis* in humans may cause serious illness and is specially dangerous to pregnant women, causing stillbirths or infant death soon after birth (USDA,1994).

Campylobacter jejuni; this organism, isolated in raw milk and meat, can cause mastitis in dairy cattle. It has also been isolated in the feces of many species including dogs, cats, rodents, cattle, sheep, swine, and poultry. Symptoms include vomiting, cramps, bloody diarrhea, mild enteritis, or severe enterocolitis. Individuals who have recovered from the disease may suffer a relapse. *Campylobacter jejuni* is destroyed by pasteurization (USDA, 1981).

Mycobacterium bovis; causes tuberculosis in both human and domestic animals. The disease is important from the point of public health as well as its detrimental effects on animal production. When raw milk is consumed, it acts as a vector by which M. bovis is transmitted to man. Human tuberculosis due to *M.bovis* is rare in countries that have adopted pasteurization and extensive veterinary control measures but even in those countries the disease is not extinct (Sinha, 1994).

Yersinia entrocolitica; among the yersinia species in food hygiene, only Yersinia enterocolitica is of predominant importance. Obviously, milk and milk products as a source or vehicle for human yersiniosis are not as important as for example with campylobacter infections. Because Yersinia enterocolitica is surely inactivated by pasteurization, only raw milk and milk products or recontaminated ones may be dangerous (Hahn, 1994).

Streptococcus agalactiae; Milk borne Streptococcus agalactiae infections are usually acquired by drinking milk from an infected cow. The organisms enter through the teats and teat canal and cause inflammation of the teats and udder of the cow. The infected cow secretes with the milk viable organisms, which eventually reach the consumers (Gebra-Emanuel Teka, 1997).

Mycobacterium tuberculosis; causes tuberculosis in humans, the organisms get access to milk primarily from infected humans or animals at post secretary stage. Human tubercle bacilli apparently cause transient infections in cattle. In such cases, cattle may excrete the bacilli in their milk from apparently normal udders. There have been few reports of symptomless cows excreting virulent M. tuberculosis in their milk following inoculation and natural infection (Sinha, 1994b).

2.3. Public Health importance of raw 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 temperature abuse where these organisms can multiply to high counts and may produce toxins (Radostitis et al., 1994). In countries where food borne illness are investigated and documented, the relative importance of pathogens like staphylococcus aures, E.coli, salmonella species and listeria species is well known (Godefay and Molla, 2000).

2.4. Public Health Standards for milk

The microorganisms present can originate from interior of the udder, its exterior and/or milking equipment. High initial microbial count in milk of >105 Cfu/ml is evidence of serious faults in milk production hygiene, where as production of milk having counts consistently below 105 Cfu/ml reflects good hygiene practices . Coliforms can rapidly build up in moist milking equipment, which then becomes the major source of contamination of milk produced. Coliform counts regularly in excess of 150 Cfu/ml are considered generally as evidence of unsatisfactory hygienic production. However, relatively low coliform counts in milk don't necessarily indicate effectively cleaned and disinfected equipment (Ombui et al., 1995).

Milk has a high nutritive value, not only for the new-born mammal and for the human consumer, but also for microbes. The quality and safety of market milk begins with milk producer (farmers).Even with higher levels of quality, some consumer groups challenge and question the microbial safety of the milk supply which affects the milk producer's profits and staying power(Hayes et al., 2001).The microorganism ,which may gain entry to milk, can multiply and bring about either spoilage or render them unsafe due to potential health hazards(Chye et al.,2004).

Pasteurization; a process applied to a milk product with the object of minimizing possible health hazards arising from pathogenic microorganisms associated with milk, by heat treatment which is consistent with chemical, physical and organoleptic change to the product (Harding,1999). The objective of pasteurization is to ensure that all pathogenic and spoilage microorganisms, commonly found in milk are completely destroyed, to safeguard the food value of milk, to ensure that other non pathogenic bacteria and certain undesirable enzymes, which may cause spoilage, are inactivated or reduced to optimal levels (Gebra-Emanuel Teka, 1997). This requires heating the milk to

a specific temperature, holding it for a specified period and subsequent cooling of the product rapidly below 10ºc (Linton, 1982).

2.5. Importance of hygienic quality of milk

Milk is an ideal balanced diet for human beings. It is not surprising therefore that it also provides an ideal medium for growth of bacteria. Bacteria find accidental access to milk may give rise to consumer's health problems or product faults. Bacteria produce enzymes, which attack fat, protein or lactose and some of these enzymes even survive in milk after the bacteria have been killed by heat treatment, hence affecting the quality of pasteurized milk, can all be minimized by starting the manufacturing process with raw milk of good hygienic quality (Harding, 1999).

Pasteurization

Pasteurization is the process of heating milk for a predetermined time at a predetermined temperature to destroy pathogens. The thermal destruction process is logarithmic, and bacteria are killed at a rate that is proportional to the number of bacteria present. Pasteurization improves the safety and lengthens the shelf life of a product by destroying pathogenic and spoilage organisms (Jeffrey et al, 2009). It was named after Louis Pasteur who discovered that spoilage organisms could be inactivated in wine by applying heat at temperatures below its boiling points. The process was later applied to milk and remains the most important operation in the processing of milk (Namminga, 1999). Pasteurization destroys most disease producing organisms and limits fermentation in milk , beer, and other liquids by partial or complete sterilization. The pasteurization process heats milk to 161 degree Fahrenheit (72 ºc) for 15 seconds, inactivating or killing organisms that grow rapidly in milk. Pasteurization does not destroy organisms that grow rapidly in milk and also does not destroy organisms that grow slowly or produce spores. While pasteurization destroys many microorganisms in milk, improper handling after pasteurization can re-contaminate milk. (UDSS, 2006)

Further research must be conducted on the milking procedure, milking equipment and temporary storage of milk to decrease early contamination. Regular inspection of milk hygiene must be conducted by Ministry of Health and respective Regional Bureaus for corrective action. Detailed study of microbiological safety of milk in Ethiopia is recommended to be carried out on large scale.

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