Chuka University
info@chuka.ac.ke | 020 231 0512 / 020 231 0518

A REVIEW OF BACTERIAL PATHOGENS FOUND IN RAW MILK AND THEIR HEALTH SIGNIFICANCE

[1]Margaret Faith Atieno, [1]Ogolla O.Fredrick and [2]RuthNyakinywa
[1]Department of Biological Sciences, [2]Department of Plant Sciences, Chuka University, P. O. Box 109-60400, Chuka, Kenya
Email: oogahfaith@gmail.com, ogolla.fredy@gmail.com, ruthnyakinywa@gmail.com
fogolla@chuka.ac.ke

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ABSTRACT
Raw milk has benefits such as maintenance of healthy bones due to the combination of nutrients helping prevent diseases such as osteoporosis, high protein content in milk making people full for a longer period of time thus reducing obesity, nutritional benefits due to the presence of nutrients, beneficial microflora and antibacterial systems and protection against the development of allergies. Milk is composed of water, fat, protein, lactose, enzymes, minerals and vitamins in different proportions. Milk is an excellent culture and protective medium thereby creating a conducive environment for pathogenic bacteria such as *Salmonella, E. coli*, *Campylobacter* spp, *Staphylococcus aureus*, *Streptococcus* spp and *Listeria* to thrive in. Thus, intake of raw milk has been associated with health complications such as typhoid fever, infantile gastroenteritis, campylobacteriosis, pneumonia, listeriosis and food poisoning. Pathogens contaminate milk through infested cattle faeces, udder, handler and utensil, mastitic milk and infertility as in the case of listeriosis. Thus, the objective of this paper was to review on bacteria pathogens associated with raw milk and their health significance. *Salmonella* has two species but only *S. enterica* is pathogenic and causes salmonellosis with nausea, vomiting, abdominal cramps, diarrhea, fever, chills, headache and blood in the stool as its symptoms. Pathogenic *E. coli* are of six types causing infertile gastroenteritis, hemolytic and uremic syndrome associated with symptoms of severe intestinal and extra intestinal diseases, diarrhea, abdominal cramp and vomiting. *Streptococcus* has *S. pneumoniae*, *S. pyogenes* and *S. agalactiae* as the pathogenic species causing pneumonia, sore throat and scarlet fever. *Campylobacter* has seven pathogenic species but only C*ampylobacter jejuni* and *Campylobacter coli* are the most common pathogens causing campylobacteriosis. *Staphylococcus aureus* is the main bacteria responsible for causing foodborne poisoning in human due to its production of exotoxins. *Listeria* has *L. monocytogenes* and *L. ivanovii* as the pathogenic species responsible for septicemia, circling disease, encephalitis, abortion and still births. Proper handling of milk may alleviate health complications associated with pathogens contaminants. Practices such as pasteurization and sterilization of equipment are necessary to ensure milk safety.
Keywords: Milk, Bacteria-Pathogen, Contaminants

INTRODUCTION
Milk is a whitish liquid secreted by the mammary secretory cells of females to nourish their young ones for a period beginning immediately after birth and it is one of the defining characteristics of mammals. It is produced by the glands which is contained in the udder (Oftedal, 2002) . The milk that is produced few days after parturition called colostrum designed to provide the calf with the necessary nutrients and biologically active ingredients (Kehoe *et al.*,2007). Milk is produced by all species of mammal for the purpose of feeding their infants. Examples of these mammals include cows, buffaloes, sheep, goats and camels. Raw milk is milk that has not undergone any heat treatment. Milk is composed of water, fat, protein, lactose, enzymes, minerals, vitamins and dissolved gases. Raw milk has the following benefits; provides nutrients, has beneficial microflora and antibacterial systems, maintains healthy bones, helps in weight loss and prevent gaining of weight and lastly raw milk is lactose intolerance. Raw milk contains disease causing microorganisms called pathogens. They include; *Salmonella* spp, *Mycobacterium* spp, *Staphylococcus* sp., *Campylobacter* spp, *Listeria* spp, *Escherichia coli*, and coliforms (Olatunji *et al.*, 2009; Fadaei, 2014). Pathogen present in milk is due to direct contact with contaminated sources in the dairy farm (Oliver, *et al.*,

2005). Persistence of these pathogens in biofilms may occur due to the entry of foodborne pathogens contaminated raw milk into the dairy food processing. Some pathogens survive and thrive in post-paxsteurization environments thereby leading to recontamination.

Composition of milk

Composition of milk varies depending on a number of factors such as health, nutrition and environment (Tyasi et al., 2015). The components of milk are water, fat, protein, lactose, enzymes, minerals, vitamins, and dissolved gasses (Mourad et al., 2014). Milk is a good source of water in the diet since it has approximately 87% of water. Water does not provide nutritional benefits in the same manner as other components of milk but is essential in human metabolism (Górska-Warsewicz et al., 2019). Milk also has carbohydrates in the lactose form and it takes 4.9%.

Lactose is a disaccharide made up of glucose and galactose bonded together. Fat is 3.4% of milk contents and are structural component of cell membranes and hormones. Milk fat has fatty acids that have been estimated to be 6% polyunsaturated, 65% saturated and 29% monounsaturated (Hanuš et al., 2018). The polyunsaturated fatty acids are the small amounts of the essential fatty acids, linoleic and linolenic. Milk has 3.3% of protein and contains the essential amino acids. Milk protein consists of approximately 82% casein and 18% whey proteins (Górska-Warsewicz et al.,2019). Vitamin A is a fat soluble vitamin found in milk. The compounds with vitamin A activity are referred to as retinoid and are found in foods in different forms. Milk contains retinol, retinyl esters, and ß-carotene which are from both plants and animals foods (CombsJr. & McClung, 2017).

Health benefits of components in raw milk

Milk is a good source of nutrients like minerals and vitamins (Górska-Warsewicz et al., 2019). Raw milk is healthy due to the presence of good bacteria e.g. lactic acid bacteria which is considered to be a probiotic (Lucey, 2015). Probiotic bacteria such as Bifidobacteria and lactobacillus do not compete well with the common types of lactic acid bacteria therefore they should be present in low numbers. This is not the case as Bifidobacteria are found at high numbers in the gastrointestinal tract of cows and humans, and their presence has been used as indicators of fecal contamination (Beerens *et al*., 2000). Probiotic cultures conveys health benefits when used at high levels in commercial products. Milk has antimicrobial systems which include lactoferrin, lactoperoxidase, bacteriocins, oligosaccharides, and xanthine oxidase (Griffiths, 2010:) that are unable to prevent pathogen growth in raw milk.

Drinking raw milk also helps in the maintenance of healthy bones because of the combination of nutrients such as calcium, phosphorus, potassium, protein and vitamin K2 that is found in milk. All of these nutrients are essential for maintaining strong, healthy bones. Roughly 99% of the calcium found in the body is stored in the bones and teeth (Górska-Warsewicz et al., 2019). Addition of milk to the diet prevents bone diseases such as osteoporosis. Raw milk intake helps in reducing obesity. It has components that contribute to weight loss and prevent weight gain e.g. the high-protein content makes people feel full for a longer period of time, which may prevent overeating. Conjugated linoleic acid in raw milk has the ability to boost weight loss by promoting fat breakdown and inhibiting fat production (Marangoni, et al., 2018).

Pathogens of raw milk

Milk can be contaminated with pathogenic bacteria or bacterial toxins which may cause health implications such as diarrhea, food poisoning, tuberculosis and salmonellosis (Uddin *et al*., 2011). Food-borne diseases is caused by numerous microorganism some of which include; *Staphylococcus* spp., *Escherichia coli* and *Salmonella spp* (Haque *et al.,* 2018). Milk is an excellent culture and protective medium for certain pathogenic micro-organisms (Marshall & Tamime, 1997; Adams & Moss, 2008; Quigley *et al*., 2013; Sarkar, 2016; Berhe *et al*, 2020), particularly bacterial pathogens such as *Salmonella and E. coli.* Such pathogens may serve *as the* source of infection (Arqués, et al., 2015). Bacteria such as *Mycobacterium, Brucella, and Leptospir* found in milk though pathogenic, they however do not multiply freely in milk unlike *Salmonella and E.coli* (Velázquez-Ordoñez *et al*., 2019). The sources of milk contamination with pathogens include; feces of infected cattle, through handlers'(milkers) dirty hands and coughs, through environment from dirty milking equipment, dirty water, dirt(dust borne infection)and manure, contaminated skin, infected and dirty udders, feed and from animal insects (Bergonier *et al*., 2003; Coorevits *et al.,* 2008; Callon *et al*., 2008).

Salmonella

Salmonella is a gram negative bacteria which is rod shape that has higher chances of contaminating milk (Riyaz-Ul-Hassan *et al*., 2013; Ashurst, *et al*., 2020). Mostly, contamination of milk by the *Salmonella* spp emanates from infected persons and surroundings and rarely from udder (Grimaud *et al*., 2009). It causes salmonellosis or typhoid fever and has two species *Salmonella enterica* and *S. bongori*, out of these only *S. enterica* is pathogenic, having six subspecies (*enterica*, *salamae*, *arizonae*, *diarizonae*, *houtenae*, and *induce)* (Shu-Kee *et al*., 2015) . It causes dysentery in human being and also cause diarrhea which is transmitted via consumption of contaminated dairy products (Vignaud *et al.*, 2017) which may be unpasteurized or partially pasteurized milk (De Valk *et al*., 2000; Ahmed & Shimamoto, 2014). (Radke *et al*., 2002) reported that in some regions contamination of milk by *Salmonella spp.* may occur from fecal material of healthy cows that shed numerous bacteria and this can be controlled by pasteurization and proper hygiene (Bankole *et al.,* 2011; Ahmed & Shimamoto, 2014). Gould et al., (2014) revealed that outbreaks due to cheese made from raw milk are caused by *salmonella*, and food borne outbreaks with human salmonellosis is the most reported zoonosis in the European union (Wuyts, et al., 2013).

Possible signs and symptoms include: Nausea, vomiting, abdominal cramps, diarrhea, fever, chills, headache and blood in the stool. Most of the symptoms last two to seven days but diarrhea may last up to 10 days but may take several months before bowels return to normal. A few varieties of salmonella bacteria result in typhoid fever a deadly disease that is more common in developing countries. Salmonellosis must be controlled both in farm and during processing so that safe and wholesome milk reaches to the consumer. Omar *et al*., 2018 used two hundred samples composing of 100 raw milk (market and bulk farm, 50 each) and 100 dairy products (pickled white cheese, fresh soft cheese, Kareish cheese and ice cream, 25 each) and the total occurrence of biochemically identified salmonella from dairy products and raw milk on XLD was 29% ranging from 52%(26/50), 14%(7/50), 0%(0/25), 20%(5/25), 8%(2/25) and 72%(18/25)) among market milk, bulk farm milk, pickled white cheese, fresh soft cheese, Kareish cheese and ice cream, respectively. The incidence of human salmonellosis can be reduced substantially by control measures such as; strict observance of personal hygiene, proper sewage disposal, proper handling of foods to avoid cross-contamination and milk pasteurization is required for prevention of salmonellosis (Yesigat, et al.,2020). In animals it can be controlled by good hygiene and management at the farm.

Escherichia coli

Escherichia coli is the major coliform organism of concern which is responsible for many milk borne infection in infant causing infantile gastroenteritis. Pathogenic *E.coli* are of six types depending on the pathogenicity of the disease and presence of virulence factors ; enteropathogenic *E. coli* (EPEC), enterotoxigenic *E. coli* (ETEC), enteroinvasive *E. coli* (EIEC), Shiga toxin-producing E.coli (STEC), diffusely adherent E.coli(DAEC) and enterohaemorrhagic *E. coli* (EHEC) (Kaper, et al.,2004; Allocati, et al.,2013; Beauchamp & Sofos, 2010). *E. coli* responsible for hemolytic and uremic syndrome in man can also get access to the milk through contaminated faeces of cattle, udder, handler and utensil. Raw milk is thereby associated with diarrheagenic *E. coli* (Serrano, et al., 2018). Some E.coli outbreaks that causes diarrhea are due to consumption of unpasteurized milk (Mylius, et al., 2018) and their prevalence have been reported in several countries worlwide (Omarak, et al., 2016).

Several studies have revealed the occurrence of pathogenic E.coli in milk e.g. a report where 30 milk samples were collected from 5 dairy cattle farms where two farms had 0% occurrence while the other three had 33.3%, 50% and 83.3% the same prevalence was a witnessed from raw milk samples in India (Nanu *et al*.,2007) and a much higher prevalence of 65.5% in Malaysia (Chye *et al*., 2004). Previous studies have also provided evidence of the occurrence of E.coli in raw milk with methods of production, transportation, handling and sale of milk contributing highly to contamination. The studies have shown that 13 out 50 samples of milk (32.5%) become contaminated with E. coli (Ahmed & Sallam, 1991; Adesiyun, 1994). A report revealed that out 24 milk samples that were collected, 16 were E.coli positive (66.67%) which was as a result of the presence of STEC (shiga toxin-producing E.coli) in milking water (Marti & Beutin, 2011) that led to the milk contamination and that this could be avoided by effective hygienic practices and water quality to avoid transmission of pathogenic organisms to humans via ingestion of raw milk. A research by (Bali *et al.,* 2013) revealed the contamination of milk by *E.coli* using milk samples from El Amra and Esaadi where 5 out of ten samples were contaminated, Menzel Cheker with 2 out of 10 samples contaminated and lastly Nakta with 1 out of 10 samples contaminated with coliform bacteria and *E.coli.*

Another study carried out in Pantnagar (Kumar & Prasad, 2010) with a total of 135 milk samples from dairy farm, milk vendors and houses were used to determine the prevalence of *E.coli* the results showed high contamination in the milk samples with 26.6% from milk samples from vendors, 20% from the dairy farm milk samples and 6.6% from house milk. The major contribution for this contamination was unhygienic handling and preparation. A research done using 22 milk samples showed the prevalence of E.coli in 14 samples having the highest coliform to be 8x106 cfu/ml and the lowest to be 1.0 x104 cfu/ml (Uddin *et al*., 2011). Another one done by (Megersa et al., 2019) in central Ethiopia using sample size of 50 resulted to 20 samples testing positive for *E.coli* with a prevalence of 42%. Research carried out in western Ethiopia by (Disassa, et al., 2017) using 380 raw cow milk samples resulted in 129 (33.9%) of E.coli being isolated and this was based on morphological and biochemical tests. This prevalence compared to other reports like (Shunda *et al.,* 2013) from makelle town, (Ali, 2011) from Britain, (Lingathurai & Vellathurai, 2013) from South India and (Chye *et al*., 2004) () from Malaysia was much lower as they ranged from 44.4%, 63%, 70% and 65% respectively.

Symptoms of *E. coli* infection include severe intestinal and extra intestinal diseases in man (Kaper, et al., 2004), diarrhea (Bali *et al*., 2001), abdominal cramp and vomiting. Infections caused by *E. coli* (EPEC, ETEC) are particularly prevalent and are major cause of malnutrition. EPEC is a common cause of childhood diarrhea majorly in the developing countries and this is because it has the ability to adhere to the intestinal mucosa, resulting in nutrient malabsorption. This is due to formation of lesions which decreases the capacity of absorption in the intestinal mucosa thereby leading to diarrhea (Clarke, et al., 2003)which results from ion secretion, increased intestinal permeability, loss of absorption surface and intestinal inflammation (Shaw, et al., 2005). Contamination of milk with E.coli includes the use of contaminated utensils, use of contaminated water for cleaning udder,contamination of milk with faeces, improper storage conditions, unhygienic equipments and dirty hands (Bagré, et al., 2014). The following can be done to control E.coli infections;good farm practices to controll coliform, hygienic practices such as regular washing and sterilization of dairy equipments, utensils, milkers hands and animals udders, pasteurization of milk before ditribution and getting rid of diseeased animals to reduce the spread of contaminated material to animals(Bali *et al.,* 2013).

Table 1. Comparison in the prevalence of E.coli in milk from diferent regions

Year	Prevalence in %	Referrence
2004	65	(Chye et al., 2004)
2011	66.67	(Marti & Beutin, 2011)
2013	70	(Lingathurai & Vellathurai, 2013)
2017	33.9	(Disassa et al., 2017)
2019	40	(Megersa et al.,2019)

Campylobacter species

These are bacteria which are slender, rod shaped, spiral shaped with or without flagella and gram negative (Acke, 2018) belonging to a distinct group of specialized bacteria designated rRNA superfamily VI of Class proteobacteria (Allos, 2001). *Campylobacter* species are indole negative, oxidase positive, catalase positive, nitrate positive and glucose utilization negative (Pal, 2017). *Campylobacter* species cause infections, with varying symptoms, ranging from asymptomatic to severe chronic illness. Campylobacteriosis is mainly considered to be a food borne disease (Man, 2011)having its main source infection to be raw milk and milk products which acts as vehicles in food borne outbreaks of *Campylobacter enteritis* (Richter *et al.,* 1992). The species of Campylobacter that cause infections include; Ca*mpylobacter jejuni, Campylobacter coli, C. upsaliensis, C. fetus, C. hyointestinalis, C. laridis* and *C. ureolyticus* but the most common are Ca*mpylobacter jejuni* and *Campylobacter coli* (CDC, 2005; Yan *et al*., 2005).

Sources of contamination *Campylobacter* spp include secondary fecal contamination during the milking process (Oliver *et al.,* 2005), poor pretreatment of the teats and infection in the udder. Symptoms of the infection include; abdominal pain, fever, nausea and diarrhea which can vary from slight to profuse watery diarrhea sometimes containing mucous or blood. Chronic health consequences may occur in 2 – 10% of cases of campylobacteriosis. These include reactive arthritis, meningitis, cholecystitis, endocarditic (Alnimr, 2014), abortion and neonatal sepsis. The reservoir for *Campylobacter* is livestock (pigs, cattle and sheep) (Humphrey *et al.,* 2007), birds and polluted water. Campylobacteriosis is majorly transmitted through ingestion of contaminated milk and the main food source is raw milk which is contaminated with the bacterium. The bacteria can be transmitted to other foods by cross contamination, or contamination with untreated water and its prevalence has been revealed in various researches.

A study by (El-Kholy *et al*., 2016) with a total of 100 raw milk samples resulted in 13 isolates of *Campylobacter* spp at 13% in which 2 isolates were *C. jejuni* at 2% and that the higher percentages of campylobacter spp is due to inadequate milk pasteurization, persistence of pathogens in biofilms, lack of general hygiene and poor control of salt addition (Truzyan, 2003; Nasr *et al*., 2004; Latorre *et al*., 2010). This result was close to those obtained by (Khanzadi *et al*., 2010; Giacometti *et al.,* 2013). There were lower percentages of *campylobacter* prevalence as recorded by (Modi *et al*., 2015; Barakat *et a*l., 2015) as opposed to the higher percentages revealed by (Martin *et al.*, 2007; Mabotel *et al.*, 2011). Other researchers also failed to detect the occurrence of *campylobcter* spp in raw milk (Singh *et al*., 2009). Another study by (Saad, Ahmed, & Nassife) using 150 samples of raw milk resulted in 19 isolates of *campylobacte*r spp (12.7%) which were identified as *C.jejuni* (7), *C.coli* (6), *C.laridis* (3), *C.fetus* (2) and *C.hyointestinalis* (1) these results were compared to other studies in which there were lower percentages recorded by (DuzGun *et al*., 2000) and higher percentages in reports presented by (Roshdy, 2000). Infections caused by campylobacter spp can be prevented by pasteurization/sterilization of milk.

Staphylococcus aureus

Staphylococcus aureus are cocci shaped, Gram-positive and non-spore forming spherical bacterium that belongs to the Staphylococcus genus. The Staphylococcus genus is subdivided into 32 species and subspecies (Montville & Matthews, 2008) arranged in clusters (Taylor & Unakal, 2020). Invitro, Staphylococcus aureus is able of growing media constituted with up to 10% salt concentration. Colonies of Staphylococcus aureus appears as golden or yellowish. Temperatures of between 18- 40◦C favors aerobically or anaerobically growth of Staphylococcus aureus (Stewart, 2003; Taylor & Unakal, 2020). Staphylococcus aureus has been documented as the main bacteria responsible for causing foodborne poisoning in human due to its production of exotoxins. The enterotoxin is heat stable both in storage and also not destroyed by normal pasteurization or boiling. Thus, enterotoxins may cause fatalities even in absence of viable S. aureus cell (Kadariya *et al.*, 2014). Approximately 50% enterotoxin producing *S. aureus* strains produces enterotoxins that cause food poisoning (Musser, et al., 1990).

Milk is an excellent medium for growth of the bacterium (Marshall & Tamime, 1997; Quigley *et al*., 2013; Sarkar, 2016; Berhe *et al,* 2020). Production of exotoxins in milk by the *Staphylococcus aureus* is initiated when its' population density approaches $10^{6.5}$ cfu/ml (Salgado-Pabón *et al*., 2013). According to (Argudín et al., 2010), illness in human may be caused by small amount of enterotoxin of about 100 to 200 ng. In milk the accepted concentration of *Staph aureus* in the milk should be > 10^5/g (Baird-Parker, 2000; Boynukara, et al., 2008). Infection of human with *S. aureus* from milk inquired by ingestion *of milk infested with Staphylococcus aureus* leading to food poisoning to occurrence of preformed enterotoxins. Initial symptoms associated with *S. aureus* poisoning are nausea, vomiting and diarrhea (Jablonski and Bohach, 1997). According to (Khanna *et al*. 2008), continous assessment of milk is neccessary to monitor the occurrence and distribution of MSSA and MRSA. Such assessment also helps in detecting the emergence of new clonal types. There is an increase in the incidence of pathogenic Staphylococcal in milk as reported in different studies.

A study by (Jørgensen *et al.,* 2005) reported existence of *Staphylococcus aureus* in more than two samples from ten cows with four cows having *S.aureus* positive milk samples at levels between 5 and 1250 cfu/ml. (Deepak et al., 2020) using a sample size of 258 raw milk samples to find out the occurrence of *S.aureus* isolated *S.aureus* from 89 samples (34.49%) this was similar to a prevalence of 39.09% from 110 raw milk samples by (Sudhanthiramani *et al*., 2015) while (Bhati *et al*., 2018) isolated *S.aureus* from 107 (54.31%)from a sample size of 197. In turkey in a research by (Gundogan & Avci, 2014) reported 56% prevalence of *S.aureus* from raw milk whereas in India in reports documented by (Akriti *et al.,* 2019; Sarkar et al., 2014) there was higher prevalence of *S.aureus* of 66.66% and 74.5% respectively.

Another study carried out by (Kashoma *et al.,* 2015) in Tanzania using 100 samples of raw milk isolated 49(49%) of staphylococcus aureus and this study was compared to similar studies from Morocco with a prevalence of 40% (Bendahou *et al.,* 2008), Brazil having a prevalence of 63.3% (Dittmann, et al., 2017), Ethiopia with 48.75% prevalence (Daka *et al*., 2012) and finally in Kenya by (Shitandi & Sternesjö, 2004) with a prevalence of 30.6%. A research by (Omwenga *et al.*, 2019) in kenya to show the prevalence of *S.aureus* led to isolation of 85 samples out of 603 samples from different mammals e.g. goats, camels, cows etc.

Table 2. Prevalence of *S.aureus* in milk from different regions

Country	Year	Prevalence in percentage(%)	Referrence
Kenya	2004	30.6	(Shitandi & Sternesjö, 2004)
Morocco	2008	40	(Bendahou et al., 2008)
Ethiopia	2012	48.75	(Daka et al., 2012)
India	2014	74.5	(Sarkar et al.,2014)
Turkey	2014	56	(Gundogan & Avci, 2014)
Tanzania	2015	49	(Kashoma et al., 2015)
Kenya	2019	14	(Omwenga, et al., 2019)
India	2019	66.66	(Akriti, Diwakar, & Gaurav, 2019)

Table 3. Occurrence of S.aureus in milk

Year	Number of samples	Positive samples	Reference
2005	10	4	(Jørgensen et al., 2005)
2015	110	40	(Sudhanthiramani et al., 2015)
2020	258	89	(Deepak, et al., 2020)

Streptococcus

Streptococcus is a Gram-positive, non-motile, non-spore forming and catalase-negative coccus which occurs in pairs and most are facultative anaerobes whilst others are strict anaerobes (Patterson, 1996). Pathogenic species of streptococcus include *S. pneumoniae*, *S. pyogenes* and *S. agalactiae* (Krzyściak *et al.,* 2013). Milk get contaminated from mastitic milk or by infected human being, the organism does not cause any major human disease but milk borne streptococcal infections are responsible for the outbreaks of infections discussed above. According to WHO, *S. pneumoniae is the major cause of pneumonia all over the world. Streptococcus agalactiae is* an etiologic agent of neonatal disease and is a Gram-positive bacteria whose pathogenicity is associated with mastitis in bovine (Agger *et al.,* 1994; Barkema et al., 2009) leading to severe milk loss in dairy animals and financial losses to the dairy industries (Gonen *et al*., 2008; Richards *et al*., 2013). Several reports have shown that out 10-30% pregnant women are infected with *S. agalactiae* (Brzychczy-Włoch *et al*., 2012; Szwabowicz & Panasiuk, 2012). Streptococcus is responsible for sore throat and scarlet fever (associated with Streptococcus pyogenes pharyngitis in school-age and adolescent children) by generating an endotoxin responsible for the skin manifestation of the infection. The organism usually gets destroyed from pasteurization.

Listeria

This is a gram positive motile rod shaped bacterium having different species of which *L. monocytogenes* and *L. ivanovii* are the only pathogenic species responsible for disease in man and animals. It causes listeriosis or the circling disease having a mortality rate of 20-30% (Sleator, et al., 2009). *L. monocytogenes* is mainly zoonotic with 95% of human cases (McLauchlin *et al.,* 2004) and only few cases are by *L. ivanovii* which is basically a pathogen of animal. Since they are tolerant to extreme pH, temperature and salt concentrations, *Listeria* species habits in soil, water, effluents and foods (Liu, 2006; Hawker *et al.,* 2012). Listeriosis is the least notifiable disease among the food borne diseases with a high rate of fatality and *L.monocytogenes* survives in extreme environments posing a high risk of human infection. It causes septicemia, circling disease and abortion in late term in animals. In man it causes food borne illness with diarrheal symptom leading to encephalitis and causes abortion in pregnant women and still births since the infection is passed from the mother to the fetus through the placenta (MAČVANIN, 2004). A report from India shows two cases of human listeriosis and four cases of abortion in women with prevalence of the disease varying from 2.77% to 7.0% (Kaur *et al.,* 2007). The pathogen has also been recovered from repeat breeding, infertility and mastitis cases in animals (Malik *et al*., 2002).

Table 4. Occurrence of *L.monocytogenes* in milk and milk products

SN	**Country**	**Reference**	**Positive samples**
1	Raw milk	5	2
2	Pasteurized milk	5	0
3	cheese	5	0
4	yoghurt	5	0
5	butter	5	1

Prevalence of Listeria varies as reported by (Fox *et al.,* 2011) 6% in Ireland, (Latorre *et al,* e2009)19.7% in USA, (Mahmoodi, 2010) 1.7% in Iran, (Vázquez-Salinas *et al.,* 2001) 13% in México and lastly (Aygun & Pehlivanlar, 2006)2.2% in Turkey. (Mansouri *et al.,* 2015) documented the presence of *L.monocytogenes* in 100 raw milk samples from dairy farms and out of 100 only 5 isolates were found to be *L.monocytogenes*. Another study by (Seyoum *et al.,* 2015) reported that out of 443 samples of milk and milk products from Ethiopia, 28.4% were contaminated with Listeria spp sorted as 60% in cheese, 40% in pasteurized milk samples, 18.9% in raw milk and 5% in yoghurt. These results indicate that contamination is due to inadequate cooling, unhygienic handling of food by food handlers, improper packing and storage. (Muthulakshmi *et al.,* 2018). (Chandio *et al*., 2007) conducted a study with 200 milk samples of 50 each from mastitic milk,market milk, buffalo and cow milk and identified all the isolates as *L.monocytogenes* with a prevalence of 12%, 10%, 8% and 6% respectively.

In order to lower the incidence of *Listeria* spp. in raw food materials and farm-raised animals, it is important to adapt appropriate farming and husbandry practices that lessen *Listeria* contamination. Healthy cows can serve as reservoirs for *L. monocytogenes* and secrete the organism in milk. Contamination of milk may also occur through accidental contact with faeces and silage. Listeriosis can be controlled by Culling of infected animals, care in use and preparation of silage since the pathogen grows luxuriantly at pH greater than 5, taking care during handling the abortion cases in humans as well as in animals, avoiding consumption of contaminated food-stuffs and avoiding cross-infections especially in hospitals among infants. Proper handling, adequate cooling and proper storage conditions are some of the ways to control *L.monocytogenes*

CONCLUSION

Raw milk is an excellent culture medium thereby harboring pathogenic microorganisms which gets into the milk majorly through direct contact with contaminated sources, infected and dirty udders and dirty water used in milking. The pathogenic bacteria and their toxins contaminate milk leading to human implications such as salmonellosis and tuberculosis.

RECOMMENDATION

Reducing the level of milk contamination by microorganisms majorly depends on the hygiene of the environment, equipment used and that of the cow. The following are some of the ways in which contamination can be mitigated; keeping the cows healthy and clean to reduce the level of microbial contamination and udder infection. This includes clipping the udders of the cows to avoid trapping dirt from the environment which is then drawn into the milk during milking, washing and sanitizing the teats prior to milking. After washing and sanitization, the teats should be dried using towels as this creates a non-conducive environment for microbial growth. The other thing that can be done is dipping the teats to decrease the chances of bacterial growth and reduced incidence of new infections. Equipment used during milking should be washed with clean water and sanitized. Lastly, the parlor and its environments should be kept clean and dry since bacteria cannot survive in dry conditions. Having a clean environment also reduces the risk of contaminating the udder and milking equipment leading to production of milk with good quality and reduced number of bacteria.

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