Review on Listeriosis and its Public Health Significance

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Abstract

Listeriosis is an infectious and fatal disease of animals, birds, fish, crustaceans, and humans. It is an important food-borne zoonosis caused by *Listeria monocytogenes*, an intracellular pathogen with unique potential to spread from cell to cell, thereby crossing blood-brain, intestinal and placental barriers. The organism possesses a pile of virulence factors that help to infect the host and evade from host immune machinery. Though disease occurrence is sporadic throughout the world, it can result in severe damage during an outbreak. Listeriosis is characterized by septicaemia, encephalitis, meningitis, meningoencephalitis, abortion, stillbirth, perinatal infections, and gastroenteritis with the incubation period varying with the form of infection. *L. monocytogenes* primarily affects older, pregnant women, newborns, and adults with weakened immune systems; and it has been recovered from the soil, dust, water, sewage, decaying vegetation, etc. Due focus has also been given regarding appropriate prevention and control strategies to be adapted for better management of this zoonotic disease. The working group made recommendations for action by public health authorities and by the food industry in order to control and prevent these infections.

Keywords: *Listeria monocytogenes*, Listeriosis, Food contaminants, Ready to eat food, Zoonosis.

1. Introduction

Listeriosis, a disease of humans and animals, is one of the important emerging bacterial zoonotic diseases worldwide (Pal, 2007; Gebretsadik et al., 2011; Desai et al., 2015). Among the genus *Listeria*, which causes the infection of listeriosis in both animal and man, *Listeria monocytogenes* is a major pathogenic microorganism (Aygun and Pehlivanlar, 2006). *L. monocytogenes* is gram positive, facultative food borne pathogen of humans and animals (Dhama et al., 2013). Listeriosis is of great public health concern because of its high mortality (20 to 30%) and its common source epidemic potential. The most important aspect in food hygiene is the ability of the bacteria to survive in a wide range of temperatures and to make biofilms on various environmental surfaces, which serve as natural habitats or reservoirs (Duggan and Phillips, 1998). Many outbreaks of Listeriosis were associated with consumption of raw milk and dairy products worldwide (Kasalica et al., 2011). Due to poor measures of quality control during food processing/handling and packaging, contamination of *L. monocytogenes* may occur (Carpentier and Cerf, 2011), raising concerns for public health (Dhama et al., 2013a; Dhama et al., 2013b). Human infections primarily result from eating contaminated food and may lead to serious and potentially life-threatening listeriosis (Posfay-Barbe and Wald, 2004; Mane et al., 2017). Listeriosis, caused by *Listeria monocytogenes*, is an infection of great public-health concern due to its clinical severity, which may lead to meningitis or bacteraemia with high fatality. The infection is found mostly in neonates, pregnant women, the elderly and immunocompromised patients. Recent epidemiological investigations have shown that retail foods, especially ready-to-eat foods contaminated with *L. monocytogenes*, may cause large outbreaks of infection in populations (Tompkin, 2002). Objective of this paper is to; Review on the study of listeriosis and its public health significance, inform veterinarian their role to control *Listeria* zoonosis.

2. Etiology

Listeriosis is a serious illness caused by eating food contaminated with the *Listeria*, which is a Gram positive, psychrotropic, facultative anaerobic, nonsporulating, motile, small rod (Pal, 2007). While there are seven species within the genus *Listeria* (*L. monocytogenes*, *L. ivanovii*, *L. innocua*, *L. seeligeri*, *L.
welshimeri, L. grayii and L. murrayi), only two, L. monocytogenes and L. ivanovii, are pathogenic, the former causing disease in both humans and animals, and the latter causing disease predominantly in sheep. Human listeriosis is a significant health threat primarily to immunosuppressed individuals and is overwhelmingly a foodborne disease; estimated that 99% of all human listeriosis cases are caused by consumption of contaminated food product (Mead et al., 1999). There are four lineages in L. monocytogenes named as I, II, III and IV, and there exist several differences among these lineages. Lineage I comprising serotypes 1/2b and 4b is mostly concerned with human infections and a few subsets of this lineage code listeriolysin S which is not present in other lineages. Lineage II includes serotype 1/2a and other serotypes, which are also involved in human infections, and carry several plasmids that are resistant to heavy metals (Orsi et al., 2011).

3. Morphology and Growth Characteristics of Listeria

Microscopically Listeria appears as regular, short rods with rounded ends, 0.4-0.5 micrometer in diameter, and 0.5-2 micrometer in length. Sometimes it is arranged in Y or V forms but usually it occurs singly or in short chains. Listeria is motile with peritrichous flagella when cultured at room temperature (20-22ºC). Listeria rotates around its long axis with the help of actin-based motility; average time per rotation is 507±106 micrometer per sec and average distance perrotation being 29.4±11.8 micrometer (Robbins and Theriot, 2003). Listeria is aerobic and facultatively anaerobic. After 24 hours, incubation colonies on nutrient agar are round, 0.5-1.5 mm in diameter, translucent, smooth, with glistening surface (S forms). Prolonged incubation makes colonies rough (R forms). Colonies show hemolytic activity on blood agar, which distinguishes L. monocytogenes from some other species of genus Listeria. Stabbed in semisolid medium, inverted “pine tree” like growth appears below3 to 5 mm of the surface. L. monocytogenes exhibit positive CAMP reaction on sheep blood agar (5% v/v) with Staphylococcus aureus but not with Rhodococcus equi (Robbins and Theriot, 2003).

4. Epidemiology

4.1 Source of Infection

Nevertheless, various foods and environmental samples have been implicated in the spread of L. monocytogenes. Thus the pathogen is repeatedly found in meat and meat products, raw milk, soft cheese and pasteurized dairy products, vegetables, and fish and fish products. For example, L. monocytogenes has been isolated from sheep, goat and cow milk (Rahimi et al., 2010). (Barbudhe and Trinad, 2009) reported that the natural habitat of Listeria monocytogenes is thought to be decomposing plant matter, in which they live as saprophytes. Nevertheless, L. monocytogenes can be found in the intestinal tract of animals such as cattle, goats, sheep, poultry, fish, rabbits, mice, pets, and wild animals. They may also occur in soils, water, effluents, plants, vegetables, and feces of animals and humans. It has been reported that one out of five percent healthy humans serves as a carrier of this pathogen (Arun, 2008). L. monocytogenes can also colonize various inert surfaces and can form biofilms on food-processing surfaces (Roberts and Wiedman, 2003). Raw meat products showed a high level of contamination with Listeria species and it was generally assumed that such products could not be kept free from Listeria because of unhygienic slaughter methods, evisceration technique, and food processing methods that allowed greater chance for contamination (Bayleyegn et al., 2004).

4.2 Modes of Transmission

Soil contamination and ingestion of contaminated feed are the primary modes of transmission of Listeria (Fentahun and Fressebhiat, 2012). The most common route of infection of humans is consumption of foods contaminated by L. monocytogenes (Pal, 2007). Several reports indicate the importance of carriers in transmission of the disease under field conditions. Eveleth et al. (1952) observed that the disease often appeared in a new flock following introduction of apparently normal sheep from infected flocks. The most widely accepted estimate of food borne transmission is 85-95% of all Listeria cases. The mode of transmission of Listeria to the fetus is either Trans placental via the maternal blood stream or ascending from a colonized genital tract. Infections during pregnancy can cause premature delivery, miscarriage, stillbirth, or serious health problems for the newborn (Bennett, 2000; Pal, 2007).

4.3 Risk Factors

4.3.1 Host Risk Factor

Regarding sensitivity, virtually all wild or domestic animals are susceptible to infection caused by Listeria (Kiiyukia, 2003). Listeriosis in cattle may develop sporadically or enzootic, having a stationary character, without tendency to disseminate in the outbreak.

4.3.2 Management Risk Factor
Several factors may predispose animals to infection with pathogenic Listeria. It has been shown in sheep and goats that abrupt changes in feed, concurrent disease, changes in dentition, damage to the epithelial lining of the digestive tract, overcrowding, heavy rains, or extreme cold, as well as the addition of new animals to a herd may predispose to *L. monocytogenes* infection. Most likely, these predisposing factors act by weakening the animal’s physical and immunological defenses. Physical damage to the mouth, teeth, and gastrointestinal tract may make it easier for pathogenic *Listeria* to invade the body, while stress caused by inclement weather or changes in herd routine may weaken an animal’s immune response. In addition, pregnancy, parturition, lactation, and extended transportation are believed to lower resistance to listeriosis in cattle. Poor general management practices, poor nutrition, and particularly the feeding of poor-quality silage may also predispose a farm animal to listeriosis (Wesley, 1999).

### 4.3.3 Pathogen Risk Factor

There are several pathogen-specific factors that influence the outcome of human and animal infection with a pathogenic *Listeria* strain. These can be grouped into the general categories of (i) virulence genes, or those genes that are essential for pathogenesis, and (ii) virulence-related genes, or those genes that are not essential for pathogenesis, but can enhance it. A virulence gene can be broadly defined according to ‘molecular Koch’s postulates’. These postulates require that true virulence genes fulfill the following criteria: First, the gene must be present in pathogenic strains and absent (or at least mutated or not expressed) in nonpathogenic strains; second, disrupting the gene should reduce its virulence and third, the gene should be expressed when the pathogen is in the host environment (Finlay and Falkow, 1989).

### 4.4 Host Range

*L. monocytogenes* can infect a wide variety of animal species, including mammals and birds, and has been isolated from fish and crustaceans. The animals most commonly infected, however, include ruminants such as cattle, sheep, and goats (Wesley, 1999).

### 4.5 Disease Status in Ethiopia

However, in most African countries, there are a few reports on *Listeria* and listeriosis, when compared to the Europe and USA. This could be associated with lack of awareness of laboratory technicians or lack of diagnostic facilities and limited resources together with the presence of other disease epidemics that claim more priority than listeriosis in developing countries including Ethiopia. In Ethiopia, data regarding the prevalence of *L. monocytogenes* is limited. A study conducted in Addis Ababa city showed the prevalence of *Listeria spp.* to be 32.6% and that of *L. monocytogenes* to be 5.1% in some foods such as meat, cheese, fish, pork, poultry and ice cream (Molla et al., 2004). In Ethiopia study, conducted from 384 food samples showed a 25% prevalence of *L. monocytogenes* among which some isolates were multi-drug resistant (penicillin, nalidixic acid, tetracycline and chloramphenicol) emphasizing the need for adopting hygienic practices in food processing industries (Garedew et al., 2015). In recent study, Mulu and Pal (2016) reported the overall prevalence of *L. monocytogenes* to be 4.1%; and the prevalence of 2.1%, 5.5%, and 6.7% was recorded from abattoir, butcher shops, and equipments, respectively.

### 5. Pathogenesis

*Listeria* possesses unique virulence factors to invade host, evade immune cells and to cause infection (Camejo et al., 2011). *L. monocytogenes* is capable of multiplying extracellularly and intracellularly, within macrophage after phagocytosis or within parenchymal cells after induced phagocytosis, and then spread to hepatocytes of the liver, causing cell disruption. It is internalized by phagocytic and non-phagocytic cells and can deliver antigen to both endogenous and exogenous antigen processing and presentation pathways. *Listeria* attach onto receptors on the host cells and are then engulfed and remain as a membrane-bound vesicle, but *Listeria* soon escapes into the cytosol (Rocourt and Cossart, 1997). *L. monocytogenes* has got the ability of crossing intestinal, blood-brain and fetoplacental barriers. Once the gastrointestinal tract is invaded, there is internalization of the bacterium within epithelial cells of the host (via phagocytosis) followed by multiplication and subsequent infection. Various stages are involved in harboring and conquering of host cells by *Listeria* that includes adhesion, invasion, lysis of vacuoles, multiplication, and evasion of the host defense mechanisms and cell-to-cell spread (Camejo et al., 2011). *Listeria monocytogenes* uses various proteins, including some internalins to adhere and to invade the host cells. Once in the intracellular phagocytic vacuole, bacteria secrete listeriolysins and phospholipases that allow it to lyse the vacuolar membrane and avoid intracellular killing. Upon being released into the cytoplasm, *L. monocytogenes* can multiply and induce the formation of act in filaments that will allow it to move in the cytoplasm until it reaches the plasma membrane. Subsequently, adjacent cells are invaded through plasma membrane protrusions and cell-to-cell spread. Through this cycle *L. monocytogenes* can move from one host cell to another cell, without being in the...
extra cellular environment, thus escaping from the human T-cell immune system, and invading other tissues and organs (Pizarro-Cerd´a and Cossart, 2006).

6. Clinical Signs
Myocardial degeneration, necrosis, and inflammation are often extensive in nature. Whole carcass congestion and petechial hemorrhage on serosa are observed in the acute form of disease. The encephalitic form is seen with nervous signs of depression, incoordination, ataxia, torticollis and opisthotonus condition. It shows no predominant gross lesions in the brain, except gliosis and satellitosis in the cerebellum, and microabscesses with presence of gram-positive bacteria in the midbrain and medulla (Kurazono et al., 2003).

7. Listeriosis in Animals
Listeriosis is of major veterinary importance in the three farm ruminant species i.e. cattle, sheep, and goats, not only by virtue of significant economical losses in livestock production due to morbidity and high mortality in animals, but also with regard to food safety and public health representing a possible link between the environment and human infection (Low and Donachie, 1997).

Sheep can be severely affected by listeriosis and the signs include encephalitis (i.e. circling disease) with brainstem and cranial nerve dysfunction, abortion with placenta in the last trimester (from 12 weeks on) and gastroenteritis with septicaemia (Rawool et al., 2007; OIE, 2014). Young lambs (under 5 weeks of age) might develop the septicaemic form while the encephalitic form is noticed in older lambs (4-8 months). Sheep vary with Signs between individual; however, incoordination, head deviation sometimes with tilting of head, walking in circles, propelling themselves forward till getting a solid object like wall or gate and unilateral facial paralysis (causing drooling of saliva, drooping of eyelid and ear) are observed (Scott, 2013). Death occurs in 2-3 days due to respiratory failure. Goats and cattle exhibit similar signs like sheep (OIE, 2014).

8. Disease in Humans
First human case of listeriosis was reported by Nyfeldt in 1929. Today, listeriosis is regarded as a food-borne disease of serious public health concern due to the great mortality rate (20-30%). A minimal infective dose has not been determined in human infection studies and estimates vary from 10° colony-forming units (cfu) to 10³ cfu, depending on the immunological status of the host. The incubation period for the disease varies from 11 to 70 days (median 21 days) in humans. Most countries within the European Union have an annual incidence of listeriosis of between two and ten reported cases per million per year. Because of its high case fatality rate, listeriosis ranks among the most frequent causes of death due to food-borne illness. Reports from the USA show that L. monocytogenes infections are responsible for the highest hospitalization rates (91%) amongst known food-borne pathogens (Mead, 1999). Fatal outbreak has been recorded in the USA during 2011, where 33 deaths were reported out of 147 infected persons. Epidemiological data regarding listeriosis infection in humans are not available from many developing countries.

Genital listeriosis is very common in India. However, exact epidemiological data are not available due to under-reporting and poor diagnostic facilities. Studies regarding status of Listeria infection in various parts of developing countries are needed to know the exact status of disease throughout the world (DeNoordhout et al., 2014). Humans can acquire listeric infections from contact with infected poultry/birds, consumption of contaminated poultry meat or meat products (pre-cooked and ready-to-eat products) and food-chain by faecal-oral route (Vivant et al., 2013). Direct contact with animals/birds is of lesser significance in the transmission/spread of Listeria, excluding highly susceptible individuals. Person-to-person transmission is not generally observed. Proper cooking of the food is valuable in terms of killing the organism. The most frequent manifestation in immunocompromised individuals is the bacteremia with no obvious focus; and therefore it is very difficult to suspect and consequently to diagnose a bacteremia by L. monocytogenes. Clinical manifestations of bacteremia in this kind of patients are not easy to diagnose, because usually the host factors do not permit expressing the illness in immunocompromised patients as healthy inhabitants. It is very important to make a good history and complete exploration. It is also recommended when the medical record to the patient is performed to classify the severity of the illness in accordance with the inflammatory response syndrome definition and sepsis criteria above all, if the patient presents risk factors for invasive infection by L. monocytogenes (Pontello et al., 2000-2010).

In non-pregnancy-associated cases, listeriosis mainly manifests as meningoencephalitis or septicaemia. The median incubation period is estimated to be 3 weeks. Outbreak cases have occurred 3-70 days following a single exposure to an implicated product. The onset of meningoencephalitis, which is rare in pregnant women, can be sudden, with fever, intense headache, nausea, vomiting, and signs of meningeal
irritation, or may be subacute, particularly in an immunocompromised or elderly host. Rhombencephalitis involving the brainstem is an unusual form of listeriosis. *L. monocytogenes* can also produce a wide variety of focal infections; cases of conjunctivitis, skin infection, lymphadenitis, hepatic abscess, brain abscess, cholecystitis, peritonitis, splenic abscess, pleuropulmonary infection, joint infection, osteomyelitis, pericarditis, myocarditis, arteritis, necrotizing fasciitis and endophthalmitis have been described (Allerberger, 2007). Cases of conjunctivitis in poultry workers at processing plants have been documented while handling of apparently normal but *Listeria*-carrying chickens. Disease onset is rapid and death within 24-48 hours may occur. More recently, *listeria* has also been recovered from a patient who suffered from spontaneous bacterial peritonitis, which is a rare occurrence as *listeria* is not a common organism causing it (How et al., 2015).

9. Necropsy Findings

Post-mortem findings and histopathology in affected animals depend upon clinical presentation. Changes in cerebrospinal fluid are noticed in the encephalitic form with cloudy fluid and congestion of meningeal vessels. No gross pathological lesions of the brain have been observed other than discoloration of the brain stem with softening and abscessation of the medulla noticed in some cases. Histopathology is pathognomonic of disease, consisting of micro-abscesses in the brainstem, spinal myelitis, perivascular lymphocytic cuffing, vasculitis, edema and hemorrhages (Rocha et al., 2013). Most commonly, there is involvement of medulla and pons. Multiple foci of necrosis in the liver and spleen are seen less frequently in the septicemia form.

10. Diagnostic Techniques

10.1 Tentative Diagnosis

The diseases can be tentatively diagnosed based on clinical signs and its confirmation is achieved by isolating the pathogen from appropriate specimens. Characteristic neurological signs or abortion in association with silage feeding may suggest listeriosis (Quinn, 2002).

10.2 Laboratory Diagnosis

A number of methods are available for the detection of *Listeria* species. However, culture is the best method, with detection power of about 10^5 CFU/ml. The most widely used selective media is OXA (Oxford agar) agar which was developed in 1989. Most literatures recommended to use OXA agar and either one of the following media; PALCAM (Polymixin Acriflavine, Lithium chloride, Ceftazidime Aesculine Mannitol), MOX (Modified Oxford Agar), and LPM (Lithium Chloride Phenyl ethanol Moxacalatam medium) with escline and ferric iron (Kiyukia, 2003).

In recent study (Kumar et al., 2014) reported that the two step enrichment procedure using UVM and PALCAM media combination yielded maximum isolates (4.04 percent) followed by two step enrichment using UVM and plating to Oxford media (3.35 percent), single step enrichment using BLEB and plating to PALCAM (2.02 percent) and finally, single step enrichment using BLEB and plating to Oxford agar (1.91 percent).

10.3 Direct Microscopy

10.3.1 Isolation and Identification

The CAMP reaction is useful for identifying *Listeria* species. This test uses horse blood agar and streaks of hemolytic *Staphylococcus aureus* and *Rodococcus equi* in combination with *Listeria* isolates. *L. monocytogenes* and *L. seeligeri* hemolytic reactions are enhanced in the zone influenced by the *S. aureus* streak, while the other species remain non-hemolytic in this zone. In contrast, the hemolytic reaction of *L. ivanovii* is enhanced in the zone influenced by R. equi (Hitchins, 2002). For confirmed and specification, different standard biochemical tests can be used. These are motility test medium (motility), blood agar (hemolysis), mannitol, rhamnose, galactose, xylose, Hippuratehydrolysis and xylose broths for carbohydrate fermentation testing (James M Jay et al., 2005).

10.3.2 Molecular Methods

As molecular methods are accurate, sensitive and specific, they are increasingly used in Identification of *L. monocytogenes* form foods. Various molecular methods used are DNA hybridization, polymerase chain reaction and real time PCR (RT PCR) (Hein et al., 2001; Hough et al., 2002).

11. Public Health Significance

Many food-borne zoonosis are of serious public health concerns with long-term sequel to various organs. Owing to change in food habits towards ready-to-eat products, food production systems, processing and supply, refrigeration for food preservation, interest in organic and natural products, interest in free-range birds and awareness towards better health, listeriosis is now considered as an emerging food-borne zoonosis of increased public health significance (Dhama et al., 2013). Although exposure and colonization may occur
in any person, those patients without predisposing factors represent less than 20% of the cases (H DiMaio, 2000). Humans can acquire listeric infections from contact with infected poultry/birds, consumption of contaminated poultry meat or meat products (pre-cooked and ready-to-eat products) and food chain by fecal-oral route (Vivant et al., 2013). During the early stages of infection, human listeriosis often displays non-specific flu-like symptoms like chills, fatigue, headache, and muscular and joint pain and gastroenteritis. However, without appropriate antibiotic treatment, it can develop into septicaemia, meningitis, encephalitis, abortion and, in some cases, death (Pal, 2007).

11.1 People at Risk

Healthy adults and children occasionally get infected with *L. monocytogenes*, but they rarely become seriously ill. The body’s defense against *L. monocytogenes* is called “cell-mediated immunity” because it depends on our cells, especially lymphocytes called “T-cells.” Therefore, individuals whose cell-mediated immunity is suppressed are more susceptible to the devastating effects of listeriosis (Galanis et al., 2008).

11.1.1 Pregnancy

Pregnant women naturally have a depressed cell-mediated immune system. In addition, the systems of fetuses and newborns are very immature and are extremely susceptible to these types of infections (Richard et al., 2008).

11.1.2 Age

The major age at risk of listeriosis is newborn babies and the elderly with age, starting around age 65 or 70 years. In elderly as age increase risk of infection also increase (Galanis et al., 2008).

11.1.3 Medication and Immuno Compromised

The majority of cases in adults and juveniles occur amongst the immunosuppressed i.e., patients receiving steroid therapy. Other at risk groups includes patients with AIDS, diabetics, elderly people and individuals with alcoholic liver disease. *Listeriosis* in pregnancy manifests as severe systemic infection in the unborn or newly delivered infants. Infection can occur at any stage of pregnancy (Kumar, 2011).

12. Treatment

Treatment of listeriosis may be a difficult task because *L. monocytogenes* can invade virtually all cell types. Time of treatment may vary according to the level of infection. In livestock and human beings, antibiotics have been used since long time for treatment of listeriosis. Usually, treatment in sheep and goat has little value soon after the appearance of neurological signs or in the chronic form. Sulphonamides, penicillin, and tetracycline may be used as prophylactics (Radostits et al., 2008).

However, the cure rate in the immunocompromised host is low. Drugs of choice for human listeriosis are erythromycin and ampicillin. Chlorotetracycline at 10 mg/kg BW per day administered for 5 days intravenously is effective in encephalitis cases of cattle. Penicillin at 44,000 IU/kg BW IM can be given daily for 7 days along with supportive therapies such as rehydration with electrolytes. Treatment of listerialiritis involves systemic antibiotics in early stages coupled with sub palpebral corticosteroid and atropine to dilate the pupil (Sturic et al., 2008).

13. Prevention and Control

The control of *Listeria* in foods relies largely on a HACCP approach and the establishment of effective critical control points in the process. The careful design and layout of processing equipment in conjunction with the implementation of regular, thorough cleaning regimes of the processing environment can significantly reduce the level of *Listeria* contamination in many processed foods. However, because of its ubiquitous nature it is virtually impossible to totally eliminate the pathogen from many food products. Vulnerable individuals, especially pregnant women, the elderly, and the immunosuppressed are advised to avoid consuming unpasteurized dairy products to reduce the risk from listeriosis (Pal, 2007; Richard et al., 2008). Strategies to reduce *L. monocytogenes* in foods and consequently listeriosis will depend much on hygienic and sanitary production and processing practices. This is to reduce the colonization, transmission and cross contamination of *L. monocytogenes* among foods and the environment. An effective control measure for this pathogen has to target the farm, processing plants and the environments. At these all these stages, strict adherence to standard operating measures must be practiced. In farming, livestock’s should be reared in clean dry environments. Soils in particular should not be moist or damp as that will provide a conducive environment for the growth of this pathogen. Livestock houses should be thoroughly cleaned, and disinfected on regularly basis. Prevent entering of wild animals (which may serve as reservoirs) into the farm especially in areas where feeds are stored. In processing plants, there is the need for each company to set up processing and environmental monitoring plans for *L. monocytogenes*. Such plans must be specified in the HACCP plan of the company. Monitoring plans should lay emphasize on sanitation...
practices, processing and packaging operations, personnel hygiene, and routine testing programs for *L. monocytogenes*. If the pathogen is found during monitoring, investigations must be carried out immediately to determine the source to prevent further transmissions. The management needs to set clear policies and train employees so that they understand the importance of proper sanitary practices. Practices such as moving people and equipment from raw material areas to finished product areas, not wearing clean gloves, handling unsanitary utensils or equipment and then touching finished products should be avoided. Cooling units should have dehumidifying properties in order to limit moisture in this area. Packing materials should also be palletized and covered until used. In retail display, temperatures of refrigerators should be monitored on regular basis, avoid mixing products from different sources, and products should be well packaged for display. Expired products should be -

![Diagram of potential routes of transmission of *Listeria monocytogenes* among habitats and host populations along the dairy food supply chain (Sources: Ryser, 2007; Swaminathan et al., 2007; Allerberger and Wagner, 2010).](image)

![Diagram of clinical signs of *Listeriosis* in Animals and Humans (Pron, B et al., 2001).](image)
disposed off immediately. Further education of consumers on food safety issue is recommended. Also foods should be well cooked or heated (in case of ready-to-eat foods) before being eaten. The use of bio protective meat starter cultures such as *L. rhamnosus* E-97800, *L. rhamnosus* LC-705 and *L. plantarum* ALC01 in some sausages could help reduce the number of *L. monocytogenes* if they are present (Työppönen et al., 2003).

### 13. Conclusion and Recommendation

*L. monocytogenes* has gained recognition as a global human pathogen because of the increasing incidence, diagnosis of infections, and it is widespread in nature, lives naturally in plants and soil environments, and has potential to introduce listeriosis outbreaks in different countries of the world. The consumption of raw milk or products made of raw milk and meats has caused several listeriosis outbreaks resulting in several hundred cases. Raw milk and raw meat products are therefore, clear risk factors and people that are susceptible for acquiring listeriosis should not consume such products. Good manufacturing and hygiene practices, particularly maintaining hygiene of processing machines, are the keys in preventing *L. monocytogenes* contamination. It is also equally important to notice that highly immunocompromised individuals should properly reheat products, which may be subjected to post processing contamination, before consumption in order to eliminate possible contamination. A food safety management system based on the principles HACCP with regular reviews should be developed and implemented in dairy plant. Then having the above conclusions I recommended that public health authorities should:

a) Actively promote research to determine ways in which (a) *L. monocytogenes* can be reduced or eliminated from the raw food supply and, the contamination of processed food in areas of greatest public health impact (e.g., delicatessens and restaurants) can be lessened.

b) Commence or continue public education programmes to help consumers to protect themselves from *L. monocytogenes* in raw foods.

c) Cooperate with the food industry, universities and research institutes to coordinate essential research on this organism;

d) Promote the HACCP approach and ensure the safety of food products, by education and motivation of all those working in the food industry;

e) Carry out or promote research to seek new ways of eliminating or limiting the growth of *L. monocytogenes* in foods using natural or synthetic inhibitors;

f) Withdraw from the market any foods which have been demonstrated to be causally associated with human and animal cases of listeriosis.

### References


monocytogenes infection in poultry and its public health importance with special reference to food borne zoonoses. *Pakistan Journal of Biological Sciences*, 16(7): 301-308.


Rawool DB, Malik SVS, Shakuntala I, Sahare AM and Barbudelle SB (2007). Detection of multiple virulence-associated genes in *Listeria monocytogenes* isolated
from bovine mastitis cases. *International Journal of Food Microbiology*, 113: 201-207.


