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Review Article

Listeria monocytogenes in Food Production and Food Safety: A Review

Adebesin IO[1], Amoka SO[1]*, Olomoko CR[1], Olubunmi OH[2] and Balogun AO[1]

[1]Department of Microbiology, Faculty of Life Sciences, University of Ilorin, Nigeria

[2]Department of Microbiology, Faculty of Life Sciences, Landmark University, Nigeria

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***Corresponding author:** Amoka Sherifat Onayi, Department of Microbiology, Faculty of Life Sciences, University of Ilorin, Nigeria, E-mail: dawnysherifat@gmail.com

ORCiD: https://orcid.org/0009-0003-0157-3636

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Abstract

In the current world of global food distribution and marketing, the outbreak of a particular foodborne disease in a region may eventually occur in another part of the world at the same time. Foodborne diseases are estimated to cause over 600 million illnesses and 420,000 deaths each year. Listeriosis, a zoonotic bacterial disease caused by *Listeria* spp. has been reported in various parts of the world's disease outbreak and incidence. The highest number of diseases and outbreaks is caused by *Listeria monocytogenes* and is highly predominant among elderly persons, immunocompromised individuals, pregnant women, and infants. This bacterium possesses the ability to survive and multiply under refrigeration temperature, a wide range of pH (4.1 - 9.6), and high salt (≤ 10%). The disease can be minimal (non-invasive/febrile gastroenteritis) and the pathogen possesses the ability to cross the epithelium and infect sterile organs (invasive). Outside food contamination, resistance to antibiotics by *Listeria monocytogenes* poses major public health concerns as this bacterium has developed resistance to various antibiotics in use. In addition to food, *Listeria* species have been isolated from the soil, water, plants, fruits, and vegetables coupled with the long incubation period (11 - 70 days), which poses a challenge to infection source identification and trace back principle. Controlling *Listeria* in foods can be achieved by practicing a Hazard Analysis and Critical Control Point (HACCP) strategy in the food industry, improving hygiene measures, and avoiding the consumption of contaminated foods. Also, susceptible individuals should be educated on the risks associated with the consumption of contaminated foods.

Introduction

Foodborne diseases are a major cause of illness and death worldwide, affecting people of all ages and genders. They result in more than 600 million illnesses and over 420,000 deaths annually on a global scale [1]. These diseases have diverse causes and are prevalent in both developed and developing countries. Due to global food distribution and marketing, contaminated products can affect multiple countries at the same time. The discovery of one contaminated ingredient or product can lead to massive recalls of food products, causing substantial illness, diseases, economic losses, trade embargoes, and impacting the tourism industry. Despite improvements in food production, the incidence of foodborne diseases has increased over the past decades. There are over 250 different types of foodborne illnesses caused by various pathogens or toxins [2]. While most cases are mild and resolve on their own, severe instances can lead to high mortality and morbidity, especially among vulnerable groups such as infants, young children, the elderly, and those with weakened immune systems [3].

Foodborne illnesses arise from consuming contaminated foods, which can be contaminated by pathogens (such as bacteria, viruses, and parasites), chemicals, or toxins at various stages of production and preparation. According to the WHO, approximately 550 million people fall ill and 230,000 die annually due to diarrheal diseases associated with consuming contaminated food with 220 million children and 96000 deaths per year [4]. Developing countries are particularly vulnerable due to factors such as inadequate access to potable water for drinking and food preparation, improper food transportation, preservation and storage practices, and lack of awareness regarding safe food handling practices. Additionally, many developing countries lack the resources to enforce food safety

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regulations, conduct effective surveillance, and implement educational programs on food hygiene [5]. Despite causing considerable illness in developed countries, the greatest impact of foodborne diseases is felt in developing nations. These diseases pose a growing public health challenge in both developed and developing countries. One notable emerging foodborne illness is Listeriosis caused by *Listeria monocytogenes* primarily affects vulnerable populations such as pregnant women, newborns, the elderly, and individuals with weakened immune systems. Healthy individuals may experience no symptoms or mild gastrointestinal issues.

Listeria monocytogenes is one of the major causative agents that accounts for serious diseases in humans and animals through the consumption of contaminated foods. Identified as a human pathogen in 1929, its transmission route became evident in the 1980s following several outbreaks linked directly to food [6]. *L. monocytogenes* is a Gram-positive bacterium, anaerobic facultative, non-spore-forming, facultative intracellular, catalase positive, non-capsulated, L-Rhamnose positive, oxidase negative, motile at 10 °C to 25 °C and rod-shaped bacteria capable to grow in temperatures between 0 and 45 °C [7]. This bacterium tolerates high salinity (up to 10%) and wide pH range (4.1 to 9.6) [8]. *Listeria monocytogenes* is a foodborne bacterium that can be found in natural environments such as water, soil, and decaying vegetation, and animal reservoirs such as cattle, sheep, and fowl. Humans may also act as reservoirs and asymptomatic fecal carriage has been reported in humans, particularly abattoir workers and laboratory workers exposed to *L. monocytogenes* culture [9]. Transmission of *L. monocytogenes* is principally via the fecal-oral route through the consumption of contaminated food. Serotyping based on the somatic (O) and flagellar (H) antigens, revealed more than 13 serotypes of *L. monocytogenes* comprising 1/2a, 1/2b, 1/2c, 3a, 3b, 3c, 4a, 4ab, 4b, 4c, 4d, 4e, and 7, with only four of them (1/2a, 1/2b, 1/2c and 4b) are responsible for the majority of global listeriosis cases [7,10].

Listeriosis

The incubation period ranges from 11 to 70 days after exposure to the contaminated food, with an average of 31 days [11]. Following ingestion, the bacteria that survive/resist the stomach acidity enter the small intestine, breach the epithelial barrier, and then disseminate to organs such as the liver, spleen, central nervous system, and fetus. The mortality rate among individuals infected with *Listeria* averages around 20-30%, even with appropriate antimicrobial treatment [12]. Despite its relatively low incidence compared to diseases like salmonellosis and campylobacteriosis, listeriosis is recognized as a significant foodborne pathogen due to its persistent mortality rates over the years [13].

Most healthy individuals infected with listeriosis experience no symptoms or only mild febrile illness. Symptomatic infection is common in pregnant women, infants, the elderly, and those with weakened immune systems. High-risk individuals primarily include those with chronic debilitating conditions that compromise their immune system, such as cancer, diabetes, or alcoholism; HIV/AIDS; individuals taking immunosuppressive medications and those over the age of 60 - 65, especially those with pre-existing medical conditions. Healthy children and immunocompetent adults have a low risk of severe *L. monocytogenes* infection. In severely immunocompromised patients, the fatality rate may reach as high as 75% [14]. Clinical manifestations of listeriosis can be categorized into invasive, where the bacteria spread beyond the gastrointestinal tract, and non-invasive forms.

Invasive listeriosis occurs when *L. monocytogenes* that initially infect the intestinal tissue subsequently invade the sterile system and organs of the body such as the pregnant uterus, the central nervous system, and the bloodstream. *L. monocytogenes* can evade the phagosome, and immune defense mechanism, and multiply within the cell. The possibility of *L. monocytogenes* to evade intestinal defense mechanisms and establish infection depends on the number of bacteria ingested, the susceptibility of the host, and the strain. This infection can be life-threatening, with hospital fatality rates ranging from 20% to 30% CDC reported *L. monocytogenes* as having the second-highest case fatality rate (21%) and the highest hospitalization rate (90.5%) among foodborne pathogens it tracked in 2000 [15]. In adults, the syndromes of invasive Listeriosis include bacteremia, meningitis, encephalitis, and gastrointestinal symptoms accompanied by fever while pregnant women often experience an influenza-like illness with bacteremia, which can lead to infection of the fetal and fetal membranes and result in abortion, stillbirth, or premature birth.

Non-invasive listeriosis, also known as febrile listerial gastroenteritis, typically occurs during outbreaks where individuals experience symptoms such as chills, diarrhea, fever, headache, abdominal pain, nausea, vomiting, fatigue, joint and muscle pain, and myalgia shortly after being exposed to high doses of *L. monocytogenes*. Symptoms typically appear within 9 to 48 hours after exposure to the bacteria. Healthy individuals with robust immune systems are generally at lower risk of developing severe complications from non-invasive listeriosis. However, vulnerable populations are at greater risk of developing invasive forms of the infection.

Prevalence of *L. monocytogenes*

In 1983, Fleming, et al. documented the first instance of *L. monocytogenes* in 2% of pasteurized milk samples in Massachusetts [16]. Earlier, *L. monocytogenes* had been identified as the causative agent of mastitis in dairy cows, leading to contamination of the milk they produce [17]. Since then, numerous studies have investigated and revealed the presence of *L. monocytogenes* in milk, fresh produce, meat, fish, dairy products, vegetables, food processing environments, ready-to-eat meats, etc. as shown in Table 1. 100% occurrence of *L. monocytogenes* was found in spiked soft cheeses [18]. The detection of *L. monocytogenes* in both frozen and pasteurized samples demonstrates its ability to survive under refrigeration, highlighting the complexity of producing *Listeria*-free foods, especially under suboptimal processing and handling conditions.

In 2004, a study in the Czech Republic reported a 2.6%

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contamination rate of *L. monocytogenes* in milk samples, attributed to soil contamination before pasteurization [19]. Although pasteurization reduces the risk of infection, it does not eliminate it; a Finnish report indicated that milk could be contaminated in stages following pasteurization [20]. A study in Iran found that the prevalence of *Listeria* species in raw milk, ice cream, cream, and porridge was 5.49%, 19.04%, 11.11%, and 4%, respectively and no *Listeria* was detected in yogurt, butter, kashk, or cheese. Also, Sayevand, et al. identified *L. innocua* and *L. monocytogenes* as the dominant species, with prevalences of 5.44% and 1.36%, respectively [21].

Most of the research on *L. monocytogenes* has focused on milk and dairy products, meat and meat products, and ready-to-eat foods as shown in Table 1. However, fewer studies have examined environmental and processing equipment, which are also critical vectors for *L. monocytogenes* transmission and should not be neglected. It was discovered that *L. monocytogenes* can persist in food processing environments (e.g., meat and dairy facilities), particularly in cool, damp areas such as conveyors, floors, and drains, even with rigorous sanitation protocols [22]. Raw foods like milk and meat can be directly contaminated with the pathogen at the farm and during slaughter.

Table 1: Prevalence of *Listeria monocytogenes* in various Food.

Sample	No. Analyzed	No. Positive	% Positive	Reference
Chicken wieners	101	3	3	[29]
Roast beef	101	0	0	
Raw ground beef	100	52	52	
Raw chicken legs	100	34	34	
Raw pork chops	98	24	24	
Fermented sausage	100	4	4	
Turkey breast	100	3	3	
Beef wieners	100	5	5	
Frozen vegetable	1750	31	2	[30]
Cured meats	345	23	7	
Raw chicken	158	57	36	
Cooked meats	396	35	9	
Raw sheep milk	202	6	3	
Raw meats	295	103	35	
Raw cow milk (culturing)	340	23	7	
Raw whole milk (culturing)	81	13	16	[31]
Raw whole milk (RT-PCR)	81	21	26	
Milk samples	2060	105	5	[32]
Commercial ice cream	28	0	0	[33]
Traditional ice cream	40	2	5	
Commercial cheese	30	0	0	
Traditional cheese	60	9	15	
Commercial doogh	10	0	0	
Traditional doogh	20	0	0	
Raw sheep milk	62	4	6	
Raw cow milk	90	1	1	
Raw goat milk	60	1	2	
Cheese	280	7	2.5	[34]
Raw milk	307	50	16.2	[35]
Milk and milk products	36	9	25	[36]
Raw milk	173	14	8.3	[37]
Raw milk	8716	145	1.66	[38]
Raw milk	446	18	4	[39]
Traditional dairy products	288	17	5.9	[40]
Mexican-fresh cheeses	200	18	9	[41]
Domestic cheese	123	15	12.1	[42]
Pottery cheese	279	44	15.7	[43]
Turkey and Chicken	100	56	56	[44]
RTE food	201	17	8.5	[45]

In a review on the burden of bacterial meningitis, about 10% of the causative agents of bacterial meningitis were unconfirmed in Africa and about 36% of the bacterial cause of meningitis in Angola were unconfirmed [23,24]. It can be inferred that these unconfirmed cases could potentially be a result of less monitored pathogens like *L. monocytogenes*. Out of 290 raw vegetable samples collected from raw produce arriving at frozen food manufacturing facilities, 96 and 17 samples were positive for *Listeria* spp. (33.1%) and *L. monocytogenes* (5.9%) respectively in which 82 samples had greater than 100 MPN of *Listeria* spp. per g and 14 samples had less than 100 MPN *Listeria* spp. per g [25]. Gombas, et al. examined 31,705 samples from retail markets across the USA and discovered an overall *L. monocytogenes* prevalence of 1.82%, among the product categories tested showing prevalence rates between 0.17% and 4.7% [26]. Bacteriological examination of 400 random samples of muscles, liver, spleen, and kidneys taken from 100 diseased chickens from different poultry farms and markets in El Gharbia Governorate showed 13.25% (53) were contaminated with *Listeria monocytogenes* [27]. Eight (7.4%) out of 108 fresh croaker samples collected from retail outlets in Lagos, Nigeria were positive for *L. monocytogenes* identified by colony morphology, sugar fermentation, PCR incorporating 16S rRNA, and hemolytic properties [28].

Outbreak of listeriosis

The outbreak of *Listeria* is relatively low when compared with pathogens such as *E. coli* and *Salmonella* in various regions of the world. In 2001, listeriosis was added to the list of nationally notifiable diseases by the CDC's National Center for Zoonotic, Vector-Borne, and Enteric Diseases. In a meta-analysis, it was found that approximately 23,150 cases of listeriosis occurred globally in 2010, leading to 5,463 deaths. The majority of reported listeriosis outbreaks were documented in Europe, Canada, the United States, Australia, and New Zealand [46]. Table 2 shows the listeria outbreak in the USA, Europe, South Africa, and Canada

Research indicates that the annual infection rate in the USA is about 1795-1860 cases per 100,000 people [47]. The mortality rate can be as high as 30% in some parts of the country. The number of reported cases in the United States dropped from 7.7 per million people in 1990 to 3.1 per million by 2003. The 2024 outbreak in the USA that resulted in 26 illnesses, 23 hospitalizations, and 2 deaths in 11 states was linked to the consumption of contaminated Quesco fresco and Cotija cheese [48]. In 2006, US public health officials noted that only one out of 884 foodborne pathogen outbreaks were due to *Listeria*; however, in the following year, the CDC recorded 122 Listeria outbreaks globally, which increased to 158 by 2008. Despite this, the incidence of *Listeria* infections showed a 42% decline compared to 1998 [49]. *Listeria*

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Table 2: Cases of Listeriosis Outbreak in Different Countries.

Year	Country	Food Type	No. Of Cases	Death cases	Reference
1987	UK	Pate	>300	-	[56]
1992	France	Pork tongue in aspic	279	85	[57]
2002	USA	Deli meat	54	11	[58]
2003	England	Butter	17	4	[53]
2005	Switzerland	Soft cheese	10	3	[59]
2006	Germany	Cheese	189	-	[60]
2007	Norway	Raw milk/soft cheese	21	5	[61]
2007	USA	Milk	5	3	[62]
2008	Quebec	Cheese	38	2	[63]
2008	USA	Tuna Salad	5	3	[62]
2011	US	Cantaloupe	147	33	[64]
2011	USA	Romaine lettuce	84	15	[13]
2013	Denmark	Smoked fish	20	7	[65]
2017	South Africa	RTE meat	1060	193	[66]
2018	ADFSU	Frozen corn	47	9	[52]
2018	USA	Pork	4	0	[62]
2018-2023	USA	Leafy greens, lettuce, and packaged salad	19	0	[67]
2022	USA	Enoki Mushroom	5	0	[68]

ADFSU: Austria, Denmark, Finland, Sweden, and the United Kingdom; RTE: Ready To Eat

outbreaks are also occasionally connected to the consumption of fruits, vegetables, and ice cream as depicted in Table 2. For instance, a *Listeria* outbreak due to contaminated cantaloupe was reported in 2011. Low contamination levels have been found in ice cream samples, indicating a lower infectious dose. The health status of individuals significantly affects the likelihood of *L. monocytogenes* infection, with higher infection rates possibly in immunocompromised individuals. The most common serotypes of *Listeria* in foods and environments are 1/2a and 1/2b. However, serotype 4b is responsible for 50% of human *Listeria* outbreaks, while serotype 1/2a accounts for 27% of clinical listeriosis cases [50]. The 2015 *Listeria* outbreak in the USA linked with ice cream consumption was distinguished by three *Listeria* serotypes: 1/2b, 3b, and 1/2a.

In Europe, the incidence decreased from 4.5 to 3.4 per million between 1999 and 2003. ECDC reported 30 EU/EEA countries confirmed 2575, 2652, 1931, 2268, and 2770, listeriosis cases in 2018, 2019, 2020, 2021, and 2022 respectively [51]. In 2013, the European Food Safety Authority (EFSA) reported 1760 human cases of listeriosis, with 99.1% of these cases requiring hospitalization [52]. From 2010 to 2017, Germany and Denmark reported four significant *L. monocytogenes* outbreaks associated with fish and fishery products to EFSA. Germany reported one outbreak in 2010, and Denmark reported three outbreaks in 2010, 2014, and 2017, totaling 44 cases. In 2015, the Netherlands reported an outbreak with weak evidence connecting smoked salmon consumption to three human cases. The 2017 Danish outbreak, caused by *L. monocytogenes* ST8 (CC8), was part of a larger multi-country outbreak involving 12 cases in Denmark, France, and Germany, all linked to ready-to-eat cold-smoked salmon produced in Poland [52]. Between 2013 and 2017, 30 EU/EEA countries reported between 1,905 and 2,527 listeriosis cases annually to The European Surveillance System (TESSy). Germany, France, and Spain accounted for 26%, 17%, and 10% of these cases, respectively. Severe *L. monocytogenes* infections were more prevalent in males (54%) and in individuals over 65 years old (65% of cases) across both genders. The vast majority of cases (98%) were of domestic origin. In England and Wales, Gillespie, et al. documented 48 listeriosis cases linked to the consumption of butter and hospital sandwiches [53]. In France, de Valk, et al. identified listeriosis in 42 individuals associated with eating pork rillettes and jellied pork tongue [54].

August 2023, the Government of Canada announced the outbreak of listeriosis linked to recalled plant-based refrigerated beverages resulting in 9 hospitalizations and 2 deaths in the 12 cases reported in Ontario, Quebec, and Scotia provinces as of July 17, 2024 [55]. In Japan, Makino, et al. documented 38 cases related to cheese consumption [42] (Table 2).

Qualitative and quantitative methods of detecting *L. monocytogenes*

L. monocytogenes occurs in very low numbers in the environment, food, and food processing facilities, and its growth can be suppressed by competing organisms. To counter this, inhibitory agents such as nalidixic acid and acriflavine are incorporated into their culture media. Standard culturing involves enriching the samples in one or two enrichment media such as Fraser broth, University of Vermont Media, *Listeria* enrichment medium, etc. The International Standard (ISO 11290) and United States Department of Agriculture (USDA) standards involve a two-step enrichment process using Fraser broth and University of Vermont Media (UVM), respectively. These standards take 4-5 days before inoculation into selective media. Alternatively, the One-broth *Listeria* method requires the use of one enrichment broth, less incubation time, and generates results within two days [69]. There are several methods to qualitatively and quantitatively detect *L. monocytogenes* in food, water, environment, and clinical samples.

Conventional method

Culture-based methods: In the laboratory, culture-based methods are usually utilized. These methods are time-consuming and occur in two stages. To isolate *L. monocytogenes* from food samples, there is a need to enrich their growth to sufficient numbers and suppress the growth of other possible pathogens present in the food. The enrichment step dilutes inhibiting substances in the samples, provides nourishment for the bacteria to grow, hydrates the bacteria, and activates injured cells. This step is followed by inoculation onto selective media such as PLACAM, Chromogenic agar, ALOA agar, and Oxford agar, which contain different salts and antibiotics to suppress the growth of competing organisms and support the growth of the target bacteria under favorable temperature and duration of growth. The growth of *L. monocytogenes* on these selective media in a defined morphology and color indicates a positive result. This pathogen can further be isolated for confirmatory testing using appropriate morphological, biochemical, and serological tests.

Selective media enhances accuracy by inhibiting unwanted

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competing microflora and enabling the appearance of *L. monocytogenes* in predetermined color without the need for subculturing or biochemical tests to confirm the pathogen. However, some selective media such as PLACAM and Oxoid agar have limitations in differentiating between pathogenic and non-pathogenic *Listeria* spp. [70]. Chromogenic media are effective in isolating pathogenic virulence factors of *L. monocytogenes* after 24 hours [71]. Incubation in both the enrichment and agar plates occurs at 30 °C - 35 °C for 24 hours - 48 hours under aerobic conditions. *L. monocytogenes*, a non-hemolytic species, can be differentiated from hemolytic species based on the fermentation of xylose in Rapid L' mono agar [71]. *L. ivanovii*, a hemolytic species, ferments xylose with blue colonies and yellow halo zones on Rapid L' mono, while *L. monocytogenes* do not ferment xylose

Gran's staining and biochemicatests: These tests are used following the isolation of pure culture on selective media for the confirmation of *Listeria* spp. Gram staining is used to differentiate between Gram-positive (cell-walled bacteria) and Gram-negative bacteria (non-cell-walled bacteria). *Listeria* spp. are Gram-positive bacteria and are stained purple under a microscope. Biochemical tests such as catalase, oxidase, hemolytic, Voges-Paskeur, and coagulase are also used to identify bacterial species. While these tests are useful for identification, they can sometimes produce false-positive results.

Rapid diagnostic method

Several rapid diagnostic methods have been developed to detect *L. monocytogenes* in food, laboratories, food processing environments, etc. within a shorter time. They are faster than conventional culture, Gram staining, and biochemical test methods. These methods include immunoassays/antibody-based methods, bacteriophage-based detection methods, biosensors, gene/nucleic acid amplification methods, ribotyping, esterase typing, etc.

Biosensors: Biosensors are devices that convert biological responses into electrical signals, enabling the detection of target pathogens and biomolecules. They integrate biological components with physicochemical detectors to detect analytes such as proteins, cells, nucleic acids, and enzymes associated with pathogens and diseases. Initially developed in the 1960s for glucose detection, biosensors have evolved significantly through nanotechnological advancements, becoming portable, rapid, and capable of detecting multiple organisms simultaneously. These biosensors typically consist of three components: a detector element, a reading device, and a biologically sensitive element. They are used for detecting biomarkers in various samples such as food, body fluids, saliva, urine, stool, and environmental samples. The technology has been applied extensively in studying various pathogens, including *Ebola* virus, HIV, Hantavirus, *Escherichia coli, Neisseria meningitides*, *Zika* virus, *Pseudomonas aeruginosa*, and *Salmonella* [72,73]

In medical diagnostics, biosensors play a crucial role in detecting cancer/tumor biomarkers, allergic responses, and cardiovascular disease markers. For instance, biosensors have been developed with high sensitivity, such as detecting *Mycobacterium tuberculosis* with a Limit of Detection (LOD) as low as 8.948×10^{-13} [74]. Specific biosensor technologies include voltammetric DNA biosensors for *L. monocytogenes* detection and quartz crystal microbalance-based methods for detecting *L. monocytogenes* in contaminated foodstuffs [75,76]. Additionally, e-Nose techniques have been employed to detect a range of pathogens including *E. coli*, *Enterococcus faecalis*, *Staphylococcus lentus*, *Staphylococcus aureus*, *Bacillus cereus*, *Salmonella enterica*, *L. monocytogenes*, *Salmonella typhi,* and *Listeria innocua* [77].

Bacteriophages: Bacteriophages, also known as phages, are viruses that infect and replicate within bacteria and archaea, utilizing proteins to encapsulate DNA or RNA genomes. These viruses have found application as bio-receptors in the detection and control of pathogenic microorganisms. Phages possess the ability to bind to bacterial bio-receptors on the surface, injecting their genetic material into the host cell. Xu, et al. utilized wild-type T4 bacteriophage as bio-receptors in nanoelectronic devices, distinguishing between viable and dead bacteria cells in contaminated water samples [78]. The T4 phage showed specific and sensitive detection capabilities for both types of cells. In clinical settings, Park, et al. employed phage amplification techniques to detect *Mycobacterium tuberculosis* in patient sputum, demonstrating effective detection within 1hour - 3 hours of infection before applying a virucidal agent [79]. Oliveira, et al. developed a bacteriophage amplification technique using A511 listeriophage, capable of quantitatively detecting viable *L. monocytogenes* cells across different serotypes [80]. Ahmadi, et al. highlighted the efficacy of listeriophage A511 as a biocontrol agent, effectively reducing *L. monocytogenes* contamination on meat product surfaces [81]. Stambach, et al. integrated A511 bacteriophage with surface-enhanced Raman Spectroscopy and lateral flow immunochromatography for rapid *Listeria* detection, demonstrating a decrease in viable *L. monocytogenes* counts after incubation [82]. Studies have shown that phages have no adverse effects on humans or lower animals, addressing concerns about their use in food safety and biocontrol. For instance, studies on oral toxicity in rats exposed to Listeria phages P100 found no side effects [83]. Beyond their role in pathogen detection, bacteriophages serve as effective biocontrol by lysing pathogens, thereby reducing viable cell counts. These multifaceted applications underscore the potential of phages in enhancing food safety and clinical diagnostics.

Immunoassays: A range of immunoassay methods have been developed for the detection of *Listeria monocytogenes*, a highly invasive food pathogen in food. These methods or types of immunoassays include competitive fluorescence immunoassays, Enzyme-linked immunoassays, immuno-magnetic assays, lateral flow immunoassays, and an immunochromatographic assay. These assays are specific and sensitive, with the potential for rapid and simple detection of *L. monocytogenes* in various food products and environments. These methods are based on the specific ability of the antibody to bind to an antigen. There are two types of antibodies in

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immunoassays: monoclonal antibodies detect single epitopes, and polyclonal antibodies detect several epitopes on the antigens. In a study by Beauchamp, et al. a specific and highly conserved peptide of 11 amino acids from the p60 protein of *L. monocytogenes* was used to produce monoclonal anti-p60 antibodies, enabling the detection of as low as 1 CFU of *L. monocytogenes* in food samples [84]. This antibody increased the fluorescence signal of the eluate, indicating a positive result, and showed no cross-reactivity with non-pathogenic *Listeria* spp.

A collaborative study evaluated the efficiency of *Listeria*-TekTM, an enzyme-linked immunosorbent assay (ELISA), for detecting *L. monocytogenes* and other *Listeria* spp. in six different food samples (frankfurter, roast beef, Brie cheese, 2% milk, raw shrimps, and crab meat) inoculated with *Listeria* spp. [85]. *L. monocytogenes* was detected in 593 samples by ELISA compared to 574 by culture method, demonstrating the superiority of immunoassay over culture-based detection. In Brazil, a point-of-care test containing anti-Internalin A and B antibodies and a biotin-streptavidin system was used to detect pathogens in artificially contaminated foods [86]. This test, with a limit of detection (LOD) of 1000 CFU/ml or /25 g of contaminated food samples, showed 100% specificity when tested with pure cultures of various food pathogens used in the study.

Ueda, et al. developed an immunochromatographic assay based on gold-labeled monoclonal antibodies directed against *L. monocytogenes* antigens [87]. The assay demonstrated a positive reaction to all *L. monocytogenes* strains but negative reactions to other Gram-positive and Gram-negative bacteria, providing results within 30 minutes of the assay. Kim, et al. isolated five monoclonal antibodies (MAbs) purified from *L. monocytogenes* 4b, which showed specific reactions to *Listeria* and no cross-reactivity with other bacteria, such as *E. coli* O157and *Salmonella enteritidis* tested in the experiment after 48 hours of culturing [88]. Couture, et al. developed a sandwich ELISA for detecting the p60 protein secreted by *L. monocytogenes*, addressing both rapidity and specificity. The ELISA detected 10^3 CFU/ml of *L. monocytogenes* after 18 hours of incubation without cross-reacting with *Listeria innocua, S. aureus, E. coli,* and *S. typhi* [89].

PCR amplification: Understanding the ecology of *L. monocytogenes* in food, food facilities, and the environment is crucial for developing effective strategies to control and detect its presence. Norton, et al. applied commercial PCR-based detection strategies and molecular typing methods in the smoked fish industry to explore the ecology of *L. monocytogenes* in food and the food environment. Their application demonstrated that PCR-based screening reliably and efficiently detected the pathogen in various food samples, raw materials, and environmental samples [90].

Several studies have underscored the effectiveness of PCR in detecting *L. monocytogenes* in food. In a comparative study, Ennaji, et al. evaluated the efficiency of PCR versus the Official ISO procedure, ISO 11290-1, for *L. monocytogenes* isolation from different food samples [91]. PCR was able to detect approximately 15 CFU/25g of samples in less than 36 hours, whereas culture-based methods detected lesser counts and required 7 days - 10 days. It also highlighted PCR as a rapid and sensitive method, emphasizing its ability to effectively eliminate false-positive results and detect all instances of *L. monocytogenes* in food samples [92].

Antibiotic resistance in *Listeria monocytogenes*

Currently, there is significant concern over the increasing prevalence of antibiotic-resistant bacteria, which poses a critical global issue. Historically, *L. monocytogenes* has generally been susceptible to most antibiotics used to treat Gram-positive bacterial infections. However, in recent years, there has been a noticeable rise in antibiotic resistance within this bacterial species isolated from various sources. Monitoring antibiotic resistance in food systems, environment, and clinical settings helps identify trends in resistance prevalence and allows for the planning and evaluation of strategies to prevent its spread. The challenge posed by pathogenic *L. monocytogenes* and other food-borne microorganisms extends beyond food contamination; it also includes the ability to resist commonly used antibiotics for infection treatment. Most *Listeria* spp. is sensitive to conventional antibiotics. However, exposure to pH, cold, and salt stresses can increase their resistance. The ability to form biofilms, efflux pump expression, hydrolysis, and mobile genetic elements are primary causes of antibiotic resistance in *Listeria*. The most common treatment for listeriosis is penicillin or ampicillin combined with aminoglycosides [12]. Other antibiotics like vancomycin, trimethoprim, sulfamethoxazole, and rifampicin have also been used to treat the infection successfully [93]. There are reports of *L. monocytogenes* resistance to penicillin, ampicillin, tetracycline, streptomycin, clindamycin, oxacillin, and vancomycin [94].

Two major efflux pumps, MdrL and Lde, are present in almost all *L. monocytogenes* serotypes. The MdrL pump detoxifies macrolides, cefotaxime, heavy metals, and EtBr, while the Lde pump detoxifies fluoroquinolone antibiotics and dyes such as EtBr and acridine orange [95]. Resistance to fluoroquinolones involves three plasmid-mediated mechanisms (PMQR) and chromosomal mutations that alter the amino acid sequences of topoisomerase II and IV subunits. In *Listeria* spp., resistance to macrolides like erythromycin is linked to the presence of the ermB and ermC genes, which encode methyltransferases that modify 23S rRNA. Five determinants of tetracycline resistance genes have been identified: tet(K), tet(L), tet(M), tet(S), and tet(T). The tet(M), tet(S), and tet(T) genes encode cytoplasmic proteins that protect ribosomes from antibiotics, while tet(L) and tet(K) encode membrane proteins that expel the antibiotic from the cell.

Byren, et al. demonstrated that 50% of *Listeria* spp. isolated from vegetables were resistant to penicillin G (PEG) and tetracycline (TET) [96]. The antibiotic susceptibility of 194 *L. monocytogenes* isolates recovered from common South African ready-to-eat foods against 22 antibiotics showed only two (1%) of the isolates did not exhibit phenotypic resistance against all the antibiotics screened, and 53.1%, 56.2%, 59.3%, 61.9%, 62.9%, and 62.9% were resistant to ceftriaxone, trimethoprim, streptomycin, sulfamethoxazole, vancomycin,

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and oxytetracyclines respectively [97]. Thirty of the isolates (15.5%) were resistant to only one or two antibiotics, whereas 162 (83.5%) exhibited phenotypic multiple antibiotic resistance. A study on 163 *L. monocytogenes* isolates obtained from 100 samples of fresh poultry in North-Western Spain showed multiple antibiotic resistance indices between 4 and 11, accounting for 49.1% of *L. monocytogenes* isolated [44]. The antimicrobial sensitivity test of 53 *L. monocytogenes* obtained from 400 random samples of muscles, liver, spleen, and kidneys showed that 91.6%, 83.3%, 83.3%, 83.3%, 83.3%, 66%, 50%, and 50% were resistant to sulfamethoxazole-trimethoprim, ampicillin, gentamycin, vancomycin, chloramphenicol, ciprofloxacin, erythromycin, and tetracycline, respectively, while all the isolated strains were completely resistant to cephalothin [27].

Food regulations and safety standards relating to *L. monocytogenes*

Microbiological food safety standards provide a protective and regulatory guide that assures consumer protection against food safety hazards relating to food consumption. The World Health Organization (FAO/WHO) and the Food and Agriculture Organization held a joint regional conference on food safety for Africa aimed at identifying the agencies and bodies responsible for food safety in various countries in Africa.

Despite the biggest listeriosis outbreak recorded in South Africa in 2018, there is little awareness and monitoring relating to *L. monocytogenes* in other African countries and this has led to the availability of little information on the outbreak Only a few African countries have standards on *L. monocytogenes* in their food safety legislation. This standard varies in terms of allowable limits and types of food (raw and RTE food). Some countries adopt the absence of any pathogenic microbes such as *L. monocytogenes* and *Escherichia coli* in food (Nigeria, Egypt, Kenya) while some adopt the absence in five 25 g samples taken before the product left the establishment (Seychelles, Saint Helena, Tunisia), or less than 100 CFU/g before the end of the product shelf-life (Mauritania, Mauritius, Madagascar, Djibouti). With the daily increase in vulnerable groups (immunocompromised, infant, pregnant people), and consumption of high-risk raw and RTE foods, there is a great need for all African countries to develop strict safety standards and monitoring schemes. The implementation of such standards would provide a significant level of consumer protection against *L. monocytogenes* incidence and potential outbreaks. South Africa Dairy Standard Agency (DSA) has guidelines related to *L. monocytogenes* in raw milk, pasteurized milk, cream, and salted butter [98]. The guideline recommends the absence of *L. monocytogenes* in 25 g of raw milk for consumption and in other products.

In Europe, there exists a set of microbiological standards that foods with *L. monocytogenes* possible presence or contamination must comply with, Regulation (EC) No 2073/2005. This regulation possesses different criteria depending on the ability of the food product to support the growth of *L. monocytogenes*. This criterion has replaced the zero-tolerance requirement in Ready-To-Eat (RTE) foods unable to support the growth of *L. monocytogenes* (foods with a pH of 4.4 and a water activity [aw] of 0.92, or a pH of #5.0 and an aw of #0.94, or a shelf life of 5 days) [99]. Less than 100 cfu/g throughout the shelf-life of the product (5 x 25 g) must be met in ready-to-eat foods and food products that can support *L. monocytogenes* growth while no *L. monocytogenes* must be present in 5 x 25 g samples at the time of leaving the production plant for food that support *L. monocytogenes* growth. Countries such as Germany, the Netherlands, and France have set a tolerance level not above 100 CFU of *L. monocytogenes* per gram of food at the time of consumption while Italy possesses different criteria of total absence of *L. monocytogenes* in 25 g of food [14]. The Food Safety Standard of Ireland prescribed the absence of *L. monocytogenes* in 25 g of RTE food and food products intended for infant consumption and special food for medical purposes in up to 10 collected food samples. Also, the criteria states that *L. monocytogenes* should be absent in 25 g of RTE food after production or the microbial load should not exceed 100 CFU per gram of food throughout its shelf life placed on the market, in up to 5 collected food samples [91].

In 2014, Food Standards Australia-New Zealand prescribed two sets of criteria for *L. monocytogenes* based on the food's ability to support or does not support the growth of bacteria. Such include fewer than 100 CFU of *L. monocytogenes* per gram of food that does not support the growth of *L. monocytogenes* and that *L. monocytogenes* should not be detected in 25 g of food likely to support the growth [100].

In 1987, the USDA initiated testing for *L. monocytogenes* in Ready-To-Eat (RTE) meat and poultry products. The current US policy considers the detectable presence (≥ 1 CFU in a 25-gram sample) of *L. monocytogenes* in RTE food to be a health hazard [99]. The agency established a "zero tolerance" policy for *L. monocytogenes* in food and the processing environment (no detectable level of viable organisms allowed). However, studies have shown that low numbers of *L. monocytogenes* represent no considerable health risk for most consumers as this bacterium can multiply at refrigeration temperatures, an initially low number of *L. monocytogenes* in food can replicate to levels that could cause an illness even in properly stored food [101].

Risk Reduction in *L. monocytogenes*

L. monocytogenes is prevalent in food processing environments and can survive for extended periods in foods, processing plants, households, or the environment, especially at refrigeration or frozen storage temperatures. Implementing the Hazard Analysis and Critical Control Points (HACCP) is a crucial risk prevention program throughout the food processing environment in high and low-risk environments.

Although *L. monocytogenes* is frequently found in raw foods of both plant and animal origin, it can also be present in cooked foods due to post-processing contamination if handled after cooking. The bacterium is often isolated from cool and wet food processing environments and has been found in foods such as raw and pasteurized fluid milk, cheeses, ice cream, raw vegetables, fermented raw meat and cooked sausages, raw and

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cooked poultry, raw meats, and raw and smoked seafood [37]. Even when initially present at low levels in contaminated food, *L. monocytogenes* can grow during refrigerated storage, leading to increased levels in foods that support its growth.

Foodborne pathogens like *Listeria* are primarily associated with fecal contamination from infected animals or humans. To reduce contamination levels, a primary strategy in food processing environments is to decrease the fecal carriage of *Listeria* in livestock. Maintaining hygienic practices, especially during milking and slaughtering, can lower the risk of *Listeria* contamination. Animal manure and contaminated irrigation water introduce a pre-harvest contamination route for field crops such as fruits and vegetables. Despite the risk of contamination in raw foods, many human listeriosis outbreaks result from contaminated processed ready-to-eat foods [102].

Cold stress adaptation and biofilm formation are key attributes of *L. monocytogenes* that facilitate its dissemination in food environments. This attachment to food products leads to significant concern and economic losses due to food spoilage. Biofilms formed by *Listeria* are particularly resistant to detergents, disinfectants, antimicrobial agents, and sanitizers, necessitating greater effort to mitigate risks compared to less resilient microorganisms. The application of antimicrobial agents and ultraviolet radiation has been successfully used to reduce microbial loads in fresh produce [13]. Despite this measure, *L. monocytogenes* may not be inactivated due to its ability to survive in adverse conditions.

Prevention and control of *L. monocytogenes*

Strategies to reduce *L. monocytogenes* contamination in foods and mitigate the risk of listeriosis heavily rely on stringent hygienic and sanitary practices throughout farming, processing, and environmental management. Early detection and timely reporting of a listeriosis outbreak are crucial for halting its spread. Once food becomes contaminated with *Listeria*, refrigerator temperatures may not sufficiently inhibit bacterial survival due to its cold tolerance and biofilm formation. Therefore, implementing the HACCP approach and establishing effective critical control points in food processing plants is essential. Individuals at risk should refrain from consuming raw animal products, raw milk, soft cheeses, and refrigerated ready-to-eat foods that have not been heated to a high temperature.

Total eradication of *L. monocytogenes* in food and food production is unlikely as this pathogen is ubiquitous and found mostly in the animal intestine. Various sources have been identified as sources of contaminating food produce at various stages of the food chain, including contaminated incoming raw materials, inefficient cleaning and poor hygiene, inadequate processing, and factory workers acting as carriers of *L. monocytogenes*. The prevention and control of *L. monocytogenes* contamination in raw and Ready-To-Eat (RTE) foods are paramount in protecting consumers against listeria disease.

Good hygiene practices, such as careful preparation and cooking of food, and interventions like pasteurization, organic acid washes, and steam vacuuming, along with the use of antimicrobial solutions (e.g., dilute lactic acid and chlorine), can effectively eliminate pathogens from food. Proper sampling of a processing environment should include several areas where contamination is likely, including both food contact and non-food contact surfaces. One of the most common areas susceptible to contamination is floor drains, where *L. monocytogenes* can persist as a harbor site [103]. Continuous monitoring and testing of food processing plants and environments for the presence of *L. monocytogenes* and other foodborne pathogens are effective practices for their control.

A study on the efficacy of X-ray treatment for reducing inoculated *L. monocytogenes* and other pathogens on shredded iceberg lettuce revealed that treatment with X-rays at doses of 1.0 and 2.0 kGy significantly reduced the *L. monocytogenes* population under both conditions [104]. Importantly, this method did not adversely affect the sensory quality, particularly the visual color, of the lettuce leaves during subsequent storage, suggesting X-ray treatment as a viable approach for pathogen reduction in lettuce. Various strategies, including the use of bioprotective meat starter cultures like *L. rhamnosus* E-97800, *L. rhamnosus* LC-705, and *L. plantarum* ALC01 in sausages, have demonstrated antibacterial activity, contributing to reducing *L. monocytogenes* levels in contaminated foods [105]. Combined treatments such as ozone and organic acids have proven efficacy in reducing initial pathogen populations on foods like mushrooms [106] Nitrite has also been identified as a substance that can injure *Listeria*, potentially reducing their numbers [107]. Steam treatment systems and Ultra-High-Pressure Homogenization (UHPH) have rendered *L. monocytogenes* undetectable in grape juice due to their disruptive effect on bacterial cells [108].

Various medicinal plant species have been found to possess compounds with antimicrobial, anti-inflammatory, and anti-diarrheal properties, making them potential candidates for listeriosis treatment [109-111]. These extracts often contain bioactive compounds like tannins, flavonoids, alkaloids, and essential oils, which can inhibit the growth of diarrheagenic bacteria, reduce intestinal inflammation, and regulate bowel movements. Clinical studies and trials continue to explore the efficacy and safety of plant extracts for disease treatment, aiming to integrate traditional knowledge with modern medical practices. This approach not only seeks to provide effective treatments but also supports sustainable and accessible healthcare solutions globally. These diverse approaches underscore the importance of multifaceted strategies in ensuring food safety and reducing the risk of *L. monocytogenes* contamination throughout the food chain.

Conclusion

Despite the achievement of developed countries in reporting, curtailing, diagnosing, and monitoring the incidence and outbreak of Listeriosis, many developing countries are yet to have a defined system. The biology, the ubiquitous nature, and the ability of the pathogen to overcome various stresses could make it persist in food and food processing environments for

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a long period, hence the need for good hygiene practices and Good Manufacturing Practices (GMP) from raw material to food consumption. The application of Hazard Analysis Critical Control Points (HACCP) at various stages of food production will reduce the risk of food contamination. One health approach aimed at promoting effective collaboration, coordination, and communication among relevant stakeholders will provide a comprehensive and proactive strategy to tackle zoonotic diseases, mitigate risks, and promote the well-being of both animals and humans while preserving the health of the environment. Proper awareness for the vulnerable group on the risk of eating contaminated food will reduce the disease burden, outbreak, fatality, and morbidity rate. Also, the identification of all the stakeholders involved in the food chain and ensuring proper Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP), and food safety management practices will reduce the disease burden. The manufacturing industries should take proper corrective actions once *Listeria* spp. is found in the environment and monitor the effectiveness of the corrective actions.

References

1. Pal M. Importance of zoonoses in public health. Indian J Anim Sci. 2005; 75:586-591. Available from: https://epubs.icar.org.in/index.php/IJAnS/article/view/9539
2. Linscott AJ. Food-Borne Illnesses. Clin Microbiol Newsl. 2011; 33(6):41-45. Available from: https://doi.org/10.1016/j.clinmicnews.2011.02.004
3. Fleury MD, Stratton J, Tinga C, Charron DF, Aramini J. A descriptive analysis of hospitalization due to acute gastrointestinal illness in Canada, 1995-2004. Can J Public Health. 2008; 99(6):489-493. Available from: https://doi.org/10.1007%2FBF03403783
4. World Health Organization. WHO's first-ever global estimates of foodborne diseases find children under 5 account for almost one-third of deaths. 2021.
5. World Health Organization. Food Safety. 2011 Jun 26, 2011.
6. Painter J, Slutsker L. Listeriosis in Humans. In: Ryser ET, Marth EH, eds. Listeria, listeriosis, and food safety. 3rd ed. Boca Raton, FL: CRC Press; 2007;85-109.
7. Arun KB. Listeria monocytogenes. In: Foodborne Microbial Pathogens. New York, NY: Springer; 2008. p. 165-182. Available from: https://link.springer.com/chapter/10.1007/978-0-387-74537-4_9
8. Fallah AA, Saei-Dehkordi SS, Mahzounieh M. Occurrence and antibiotic resistance profiles of Listeria monocytogenes isolated from seafood products and market and processing environments in Iran. Food Control. 2013; 34:630-636. Available from: https://doi.org/10.1016/j.foodcont.2013.06.015
9. Heymann DL. Control of communicable diseases manual. 18th ed. Washington: American Public Health Association; 2004. Available from: https://www.scirp.org/reference/referencespapers?referenceid=3225878
10. Wu S, Wu Q, Zhang J, Chen M, Hu H. Listeria monocytogenes prevalence and characteristics in retail raw foods in China. PLoS One. 2015;10. Available from: https://doi.org/10.1371/journal.pone.0136682
11. Ramaswamy V, Cresence VM, Rejitha JS, Lekshmi MU, Dharsana KS, Prasad SP, et al. Listeria--review of epidemiology and pathogenesis. J Microbiol Immunol Infect. 2007; 40(1):4-13. Available from: https://pubmed.ncbi.nlm.nih.gov/17332901/
12. Johnsen BO, Lingaas E, Torfoss D, Strom EH, Nordoy I. A large outbreak of Listeria monocytogenes infection with a short incubation period in a tertiary care hospital. J Infect. 2010; 61:465-470. Available from: https://doi.org/10.1016/j.jinf.2010.08.007
13. Hussain MA, Gooneratne R, Zhu Q. Listeria monocytogenes in Fresh Produce: Outbreaks, Prevalence and Contamination Levels. Foods. 2017; 6(3):21. Available from: https://doi.org/10.3390/foods6030021
14. Nørrung B. Microbiological criteria for Listeria monocytogenes in foods under special consideration of risk assessment approaches. Int J Food Microbiol. 2000; 62(3):217-221. Available from: https://doi.org/10.1016/s0168-1605(00)00338-x
15. CDC. 2000. FoodNet 2000. Foodborne Diseases Active Surveillance Network. CDC's Emerging Infections Program. 1999 surveillance results. Preliminary report. Available from: https://stacks.cdc.gov/view/cdc/152194
16. Fleming DW, Cochi SL, Macdonald KL, Brondum J, Hayes PS, Plikaytis BD, et al. Pasteurized milk as a vehicle of infection in an outbreak of listeriosis. N Engl J Med. 1985; 312:404-407. Available from: https://doi.org/10.1056/nejm198502143120704
17. Weis J. The incidence of Listeria monocytogenes on plants and in soil. In: Problems of listeriosis. Proceedings of 6th International Symposium, Leicester University Press, Leicester. 1975; 61-65.
18. Johansson T. Enhanced detection and enumeration of Listeria monocytogenes from foodstuffs and food-processing environments. Int J Food Microbiol. 1998; 40(1-2):77-85. Available from: https://doi.org/10.1016/s0168-1605(98)00022-1
19. Navratilov P, Schlegelova J, Sustackova A, Napravnikova E, Lukasova J, Klimova E. Prevalence of Listeria monocytogenes in milk, meat and foodstuff of animal origin and the phenotype of antibiotic resistance of isolated strains. Vet Med (Praha). 2004. Available from: https://vetmed.agriculturejournals.cz/artkey/vet-200407-0003_prevalence-of-listeria-monocytogenes-in-milk-meat-and-foodstuff-of-animal-origin-and-the-phenotype-of-antibiot.php
20. Lyytikäinen O, Nakari U, Lukinmaa S, Kela E, Minh NNT, Siitonen A. Surveillance of listeriosis in Finland. Euro Surveill. 2006; 11:82-85. Available from: https://pubmed.ncbi.nlm.nih.gov/16801696/
21. Sayevand HR, Bakhtiary F, Pointner A, Remely M, Hippe B, Hosseini H, et al. Bacterial diversity in traditional doogh in comparison to industrial doogh. Curr Microbiol. 2018;75:386-393. Available from: https://doi.org/10.1007%2Fs00284-017-1392-x
22. Slade PJ. Monitoring Listeria in the food production environment. I. Detection of Listeria in processing plants and isolation methodology. Food Res Int. 1992;25(1):45-56. Available from: https://doi.org/10.1016/0963-9969%2892%2990025-Z
23. Peltola H. Burden of meningitis and other severe bacterial infections of children in Africa: implications for prevention. Clin Infect Dis. 2001;31:64-75. Available from: https://doi.org/10.1086/317534
24. Peltola H, Roine I, Kallio M, Pelkonen T. Outcome of childhood bacterial meningitis on three continents. Sci Rep. 2021;11:21593. Available from: https://www.nature.com/articles/s41598-021-01085-w
25. Brittany FM, Gummalla S, Garren D, Thippareddi H, Berrang ME, Harrison MA. Prevalence of Listeria Species and Listeria monocytogenes on Raw Produce Arriving at Frozen Food Manufacturing Facilities. J Food Prot. 2021;84(11):1898-1903. Available from: https://doi.org/10.4315/jfp-21-064
26. Gombas DE, Chen Y, Clavero RS, Scott VN. Survey of Listeria monocytogenes in Ready-to-Eat Foods. J Food Prot. 2003;66(4):559-569. Available from: https://doi.org/10.4315/0362-028X-66.4.559
27. Abd El-Tawab AA, Homouda SN, El-Haw S.E. Prevalence and molecular studies on Listeria monocytogenes isolated from chicken in El-Gharbia Governorate. Benha Vet Med J. 2018;34(1):430-442. Available from: https://doi.org/10.21608/bvmj.2018.54506
28. Amusan EE, Sanni AI. Isolation and Identification of Listeria monocytogenes in Fresh Croaker (Pseudotolithus senegalensis). 8th International Biotechnology Conference, Exhibition and Workshop. IOP Conf. Series: Earth and Environmental Science. 2019;210:012004. Available from: https://iopscience.iop.org/article/10.1088/1755-1315/210/1/012004/pdf
29. Bohaychuk VM, Gensler EG, King RK, Manninen KI, Sorensen O, Wu JT, et al.

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Occurrence of pathogens in raw and ready-to-eat meat and poultry products collected from the retail marketplace in Edmonton, Alberta, Canada. J Food Prot. 2006;69(9):2176-2182. Available from: https://doi.org/10.4315/0362-028X-69.9.2176

30. Vitas AI, Aguado V, Garcia-Jalon E.L. Occurrence of Listeria monocytogenes in fresh and processed foods in Navarra (Spain). Int J Food Microbiol. 2004;90:349-356. Available from: https://doi.org/10.1016/S0168-1605(03)00314-3

31. Vanegas MC, Vásquez E, Martinez AJ, Rueda AM. Detection of Listeria monocytogenes in raw whole milk for human consumption in Colombia by real-time PCR. Food Control. 2009;20(4):430-432. Available from: https://doi.org/10.1016/j.foodcont.2008.07.007

32. Kalorey DR, Warke SR, Kurkure NV, Rawool DB, Barbuddhe SB. Listeria species in bovine raw milk: A large survey of Central India. Food Control. 2008;19(2):109-112. Available from: https://doi.org/10.1016/j.foodcont.2007.02.006

33. Rahimi E, Ameri M, Momtaz H. Prevalence and antimicrobial resistance of Listeria species isolated from milk and dairy products in Iran. Food Control. 2010;21(11):1448-1452.

34. Kahraman T, Ozmen G, Ozinan B, Goksoy E. Prevalence of Salmonella spp. and Listeria monocytogenes in different cheese types produced in Turkey. Br Food J. 2010;112:1230-1236. Available from: https://www.emerald.com/insight/content/doi/10.1108/00070701011088214/full/html

35. Karthikeyan R, Gunasekaran P, Rajendhran J. Molecular serotyping and pathogenic potential of Listeria monocytogenes isolated from milk and milk products in Tamil Nadu, India. Foodborne Pathog Dis. 2015;12:522-528. Available from: https://doi.org/10.1089/fpd.2014.1872

36. Usman U, Kwaga J, Kabir J, Olonitola O. Isolation and antimicrobial susceptibility of Listeria monocytogenes from raw milk and milk products in Northern Kaduna State, Nigeria. Appl Environ Microbiol. 2016;4:46-54. Available from: https://pubs.sciepub.com/jaem/4/3/1/index.html

37. Usman U, Kwaga J, Kabir J, Olonitola O, Radu S, Bande F. Molecular characterization and phylogenetic analysis of Listeria monocytogenes isolated from milk and milk products in Kaduna, Nigeria. Can J Infect Dis Med Microbiol. 2016;4:52-58. Available from: https://doi.org/10.1155/2016/4313827

38. Dalzini E, Bernini V, Bertasi B, Daminelli P, Losio MN, Varisco G. Survey of prevalence and seasonal variability of Listeria monocytogenes in raw cow milk from Northern Italy. Food Control. 2016;60:466-470. Available from: https://doi.org/10.1016/j.foodcont.2015.08.019

39. Jamali H, Radmehr B, Thong KL. Prevalence, characterization, and antimicrobial resistance of Listeria species and Listeria monocytogenes isolates from raw milk in farm bulk tanks. Food Control. 2013;34:121-125. Available from: https://doi.org/10.1016/j.foodcont.2013.04.023

40. El Marnissi B, Bennani L, Cohen N, Lalami AEO, Belkhou R. Presence of Listeria monocytogenes in raw milk and traditional dairy products marketed in the north-central region of Morocco. Afr J Food Sci. 2013;7:87-91. Available from: https://doi.org/10.5897/AJFS2013.0992

41. Torres-Vitela M, Mendoza-Bernardo M, Castro-Rosas J, Gomez-Aldapa C, Garay-Martinez L, Navarro-Hidalgo V, et al. Incidence of Salmonella, Listeria monocytogenes, Escherichia coli O157, and staphylococcal enterotoxin in two types of Mexican fresh cheeses. J Food Prot. 2012;75:79-84. Available from: https://doi.org/10.4315/0362-028X.JFP-11-258

42. Makin SI, Kawamoto K, Takeshi K, Okada Y, Yamasaki M, Yamamoto S, et al. An outbreak of food-borne listeriosis due to cheese in Japan, during 2001. Int J Food Microbiol. 2005;104:189-196. Available from: https://doi.org/10.1016/j.ijfoodmicro.2005.02.009

43. Kaptan B. Prevalence of Listeria spp and L. monocytogenes in homemade pottery cheese. Food J. 2016;112:1230-1236. Available from: https://www.semanticscholar.org/paper/Prevalence-of-Listeria-spp-and-L.-monocytogenes-in-Kaptan/ba70099afedc0aa34997dc4c39c8b51feb35bcfa

44. Panera-Martínez S, Rodríguez-Melcón C, Serrano-Galán V, Alonso-Calleja C, Capita R. Prevalence, quantification and antibiotic resistance of Listeria monocytogenes in poultry preparations. Food Control. 2022;135:108608. Available from: https://doi.org/10.1016/j.foodcont.2021.108608

45. Sanlıbaba P, Tezel BU, Çakmak GA. Prevalence and Antibiotic Resistance of Listeria Monocytogenes Isolated from Ready-to-Eat Foods in Turkey. J Food Qual. 2018;1. Available from: http://dx.doi.org/10.1155/2018/7693782

46. de Noordhout CM, Devleesschauwer B, Angulo FJ, Verbeke G, Haagsma J, Kirk M. The global burden of listeriosis: a systematic review and meta-analysis. Lancet Infect Dis. 2014;14:1073-1082. Available from: https://doi.org/10.1016/S1473-3099(14)70870-9

47. Clark. About Listeria.(2015-2017).

48. CDC. Listeria Outbreak Linked to Queso Fresco and Cotija Cheese. 2024.

49. Chen Y, Ross WH, Gray MJ, Wiedmann M, Whiting R, Scott VN. Attributing risk to Listeria monocytogenes subgroups: dose response in relation to genetic lineages. J Food Prot. 2006;69:335-344. Available from: https://doi.org/10.4315/0362-028X-69.2.335

50. Burall LS, Grim CJ, Datta AR. A clade of Listeria monocytogenes serotype 4b variant strains linked to recent listeriosis outbreaks associated with produce from a defined geographic region in the US. PLoS One. 2017;12. Available from: https://doi.org/10.1371/journal.pone.0176912

51. European Centre for Disease Prevention and Control. Listeriosis. In: ECDC. Annual Epidemiological Report for 2022. Stockholm: ECDC. Available from: https://www.ecdc.europa.eu/en/publications-data/listeriosis-annual-epidemiological-report-2022

52. European Centre for Disease Prevention and Control/European Food Safety Authority. The multicountry outbreak of Listeria monocytogenes serogroup IVb, multi-locus sequence type 6, infections linked to frozen corn and possibly to other frozen vegetables – first update. 3 July 2018 ECDC; Stockholm. Available from: https://doi.org/10.2903/sp.efsa.2018.EN-1448

53. Gillespie IA, McLauchlin J, Grant KA, Little CL, Mithani V, Penman C, Lane C, Regan M. Changing pattern of human listeriosis, England and Wales, 2001-2004. Emerg Infect Dis. 2006;12(9):1361-1366. Available from: https://wwwnc.cdc.gov/eid/article/12/09/05-1657_article

54. de Valk H, Vaillant V, Jacquet C, Rocourt J, Le Querrec F, Stainer F, et al. Two consecutive nationwide outbreaks of listeriosis in France, October 1999-February 2000. Am J Epidemiol. 2001;154(10):944-950. Available from: https://doi.org/10.1093/aje/154.10.944

55. Public Health Agency of Canada. Public Health Notice: Outbreak of Listeria infections linked to recalled plant-based refrigerated beverages. 2024. Available from: https://www.canada.ca/en/public-health/services/public-health-notices/2024/outbreak-listeria-infections-recalled-refrigerated-plant-based-beverages.html

56. McLauchlin J, Greenwood MH, Pini PN. The occurrence of Listeria monocytogenes in cheese from a manufacturer is associated with a case of listeriosis. Int J Food Microbiol. 1990;10:255–262. Available from: https://doi.org/10.1016/0168-1605(90)90073-E

57. Goulet VA, Lepoutre J, Rocourt AL, Courtieu P, Dehaumont-Veit P. Listeriosis epidemic in France—final assessment and results of the epidemiological investigation. Bull Epidemiol Weekly. 1993;4:13–14.

58. Gottlieb SL, Newben EC, Griffin PM, Graves LM, Hoekstra RM, Baker NL. Multistate outbreak of listeriosis linked to Turkey deli meat and subsequent changes in US regulatory policy. Clin Infect Dis. 2006;42:29-36. Available from: https://doi.org/10.1086/498113

59. Bille J, Blanc DS, Schmid H, Boubaker K, Baumgartner A, Siegrist HH, et al. Outbreak of human listeriosis associated with tomme cheese in northwest Switzerland, 2005. Euro Surveill. 2006;11(6):633. Available from: https://www.eurosurveillance.org/content/10.2807/esm.11.06.00633-en

60. Koch J, Dworak R, Prager R, Becker B, Brockmann S, Wicke A, et al. Large listeriosis outbreak linked to cheese made from pasteurized milk, Germany, 2006-2007. Foodborne Pathog Dis. 2010 Dec;7(12):1581-4. Available from: https://doi.org/10.1089/fpd.2010.0631

Citation: Adebesin IO, Amoka SO, Olomoko CR, Olubunmi OH, Balogun AO. *Listeria monocytogenes* in Food Production and Food Safety: A Review. Food Sci Nutr The. 2024;10(1): 057-068. Available from: https://dx.doi.org/10.17352/jfsnt.000050

61. Helwigh B, Korsgaar H, Chriél M. The Community Summary Report on Food-borne Outbreaks in the European Union in 2007. 2009. Available from: https://doi.org/10.2903/j.efsa.2009.271r

62. Cartwright EJ, Jackson KA, Johnson SD, Graves LM, Silk BJ, Mahon BE. Listeriosis outbreaks and associated food vehicles, United States, 1998–2008. Emerg Infect Dis. 2013;19(1):1. Available from: https://wwwnc.cdc.gov/eid/article/19/1/12-0393_article

63. Gilmour MW, Graham M, Van Domselaar G, Tyler S, Kent H, et al. High-throughput genome sequencing of two Listeria monocytogenes clinical isolates during a large foodborne outbreak. BMC Genomics. 2010;11:1. Available from: https://bmcgenomics.biomedcentral.com/articles/10.1186/1471-2164-11-120

64. McCollum JT, Cronquist AB, Silk BJ, Jackson KA, O'Connor KA, Cosgrove S, et al. Multistate outbreak of listeriosis associated with cantaloupe. N Engl J Med. 2013;369:944–953. Available from: https://www.nejm.org/doi/10.1056/NEJMoa1215837

65. Gillesberg-Lassen S, Ethelberg S, Björkman JT, Jensen T, Sørensen G, Kvistholm Jensen A, et al. Two Listeria outbreaks caused by smoked fish consumption—using whole-genome sequencing for outbreak investigations. Clin Microbiol Infect. 2016;22(7):620–624. Available from: https://doi.org/10.1016/j.cmi.2016.04.017

66. Thomas J, Govender N, McCarthy KM, Erasmus LK, Doyle TJ, Allam M, et al. Outbreak of listeriosis in South Africa associated with processed meat. The New England Journal of Medicine. 2020; 382:632–643. Available from: https://doi.org/10.1056/nejmoa1907462

67. Centers for Disease Control and Prevention (CDC). Listeria Outbreak Linked to Leafy Greens. 2023. Available from: https://www.cdc.gov/listeria/outbreaks/monocytogenes-02-23/index.html

68. US Food and Drug Administration (USFDA). Outbreak Investigation of Listeria monocytogenes: Enoki Mushrooms (November 2022). 2023. Available from: https://www.fda.gov/food/outbreaks-foodborne-illness/outbreak-investigation-listeria-monocytogenes-enoki-mushrooms-november-2022

69. Gómez D, McGuinness S, Reddington K, O'Grady J, Yangüela J, Barry T. Evaluation of a novel Listeria enrichment broth combined with a real-time PCR diagnostics assay for the specific detection of Listeria monocytogenes in RTE pork products. Int J Food Sci Technol. 2013;48:1103-1108. Available from: https://research-portal.uea.ac.uk/en/publications/evaluation-of-a-novel-listeria-enrichment-broth-combined-with-a-r

70. Aurora R, Prakash A, Prakash S. Genotypic characterization of Listeria monocytogenes isolated from milk and ready-to-eat indigenous milk products. Food Control. 2009;20(9):835-839. Available from: https://doi.org/10.1016/j.foodcont.2008.10.017

71. Shamloo E, Hosseini H, Abdi Moghadam Z, Halberg-Larsen M, Haslberger A, Alebouyeh M. Importance of Listeria monocytogenes in food safety: a review of its prevalence, detection, and antibiotic resistance. Iran J Vet Res. 2019;20(4):241-254. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6983307/

72. Ionescu RE. Biosensor Platforms for Rapid Detection of E. coli Bacteria. In: Samie A, editor. Recent Advances on Physiology, Pathogenesis and Biotechnological Applications. IntechOpen; 2007:67. Available from: https://www.intechopen.com/chapters/54261

73. Afsahi S, Lerner MB, Goldstein JM, Lee J, Tang X, Bagarozzi DA, et al. Novel graphene-based biosensor for early detection of Zika virus infection. Biosens Bioelectron. 2018;100:85-88. Available from: https://doi.org/10.1016/j.bios.2017.08.051

74. Mat MH, Abdullah J, Yusof NA, Sulaiman Y, Wasoh H, Noh MF, Issa R. PNA biosensor based on reduced graphene oxide/water-soluble quantum dots for the detection of Mycobacterium tuberculosis. Sens Actuators B Chem. 2017;241:1024-1034. Available from: https://doi.org/10.1016/j.snb.2016.10.045

75. Saini K, Kaushal A, Gupta S, Kumar D. PlcA-based nanofabricated electrochemical DNA biosensor for the detection of Listeria monocytogenes in raw milk samples. Biotech. 2020;10(7):327. Available from: https://link.springer.com/article/10.1007/s13205-020-02315-0

76. Wachiralurpan S, Chansiri K, Lieberzeit PA. Direct detection of Listeria monocytogenes DNA amplification products with quartz crystal microbalances at elevated temperatures. Sens Actuators B Chem. 2020;308: 127678. Available from: https://doi.org/10.1016/j.snb.2020.127678

77. Bonah E, Huang X, Aheto JH, Osae R. Application of the electronic nose as a non-invasive technique for odor fingerprinting and detection of bacterial foodborne pathogens: A review. J Food Sci Technol. 2020;57:1977-1990. Available from: https://link.springer.com/article/10.1007/s13197-019-04143-4

78. Xu J, Zhao C, Chau Y, Lee YK. The synergy of chemical immobilization and electrical orientation of T4 bacteriophage on a micro electrochemical sensor for low-level viable bacteria detection via Differential Pulse Voltammetry. Biosens Bioelectron. 2020;151:111914. Available from: https://doi.org/10.1016/j.bios.2019.111914

79. Park DJ, Drobniewsski FA, Meyer A, Wilson SM. Use of a phage-based assay for phenotypic detection of Mycobacteria directly from sputum. J Clin Microbiol. 2003;41:680–688. Available from: https://doi.org/10.1128/jcm.41.2.680-688.2003

80. Oliveira IC, Almeida RC, Hofer E, Almeida PF. Bacteriophage amplification assay for detection of Listeria spp. using virucidal laser treatment. Braz J Microbiol. 2012;43(3):1128-1136. Available from: https://doi.org/10.1590%2FS1517-83822012000300040

81. Ahmadi H, Barbut S, Lim L-T, Balamurugan S. Examination of the Use of Bacteriophage as an Additive and Determining Its Best Application Method to Control Listeria monocytogenes in a Cooked-Meat Model System. Front Microbiol. 2020;11:779. Available from: https://doi.org/10.3389/fmicb.2020.00779

82. Stambach NR, Carr SA, Cox CR, Voorhees KJ. Rapid Detection of Listeria by Bacteriophage Amplification and SERS-Lateral Flow Immunochromatography. Viruses. 2015;7(12):6631-6641. Available from: https://www.mdpi.com/1999-4915/7/12/2962

83. Carlton RM, Noordman WH, Biswas B, de Meester ED, Loessner MJ. Bacteriophage P100 for control of Listeria monocytogenes in foods: genome sequence, bioinformatic analyses, oral toxicity study, and application. Regul Toxicol Pharmacol. 2005;43:301–312. Available from: https://doi.org/10.1016/j.yrtph.2005.08.005

84. Beauchamp S, Auria S, Pennacchio A, Lacroix M. A new competitive fluorescence immunoassay for detection of Listeria monocytogenes. Anal Methods. 2012;4(12):4187-4192. Available from: https://pubs.rsc.org/en/content/articlelanding/2012/ay/c2ay25997d

85. Curiale MS, Lepper W, Robison B. Enzyme-Linked Immunoassay for Detection of Listeria monocytogenes in Dairy Products, Seafoods, and Meats: Collaborative Study. J AOAC Int. 1994;77(6):1472-1489. Available from: https://doi.org/10.1093/jaoac/77.6.1472

86. Lopes-Luz L, Mendonça M, Fogaça MBT, Bentivoglio-Silva BC, Conceição FR, Stefani MMA, et al. Detection of Listeria monocytogenes using an immunochromatographic point of care test based on anti-internalin A and B antibodies and a nano-biotinylated detection complex. LWT. 2023;188:115336. Available from: http://dx.doi.org/10.1016/j.lwt.2023.115336

87. Ueda S, Iwase M, Kuwabara Y. Evaluation of immunochromatography for the rapid and specific identification of Listeria monocytogenes from food. Biocontrol Sci. 2013;18(3):157-161. Available from: https://doi.org/10.4265/bio.18.157

88. Kim SH, Park MK, Kim JY, Chuong PD, Lee YS, Yoon BS, et al. Development of a sandwich ELISA for the detection of Listeria spp. using specific flagella antibodies. J Vet Sci. 2005;6(1):41-46. Available from: https://doi.org/10.4142/jvs.2005.6.1.41

89. Couture J, Morissette C, d'Auria S, Lacroix M. Development of a highly specific sandwich ELISA for the detection of Listeria monocytogenes, an important foodborne pathogen. Microbiol Res Int. 2014;2(4):46-52. Available from: https://www.netjournals.org/pdf/MRI/2014/4/14-017.pdf

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90. Norton DM, Scarlett JM, Horton K, Sue D, Thimothe J, Boor KJ, et al. Characterization and pathogenic potential of Listeria monocytogenes isolates from the smoked fish industry. Appl Environ Microbiol. 2001;67:646-653. Available from: https://doi.org/10.1128/AEM.67.2.646-653.2001

91. Food Safety Authority of Ireland: Listeria monocytogenes. Microbial factsheet series Issue No 1 September 2011 [Internet]. 2016. [Accessed: February 13, 2018]. Available from: https://www.fsai.ie/publications/listeria-monocytogenes

92. Ennaji H, Timinouni M, Ennaji M, Mhand R, Hassar M, Cohen N. Rapid detection of Listeria monocytogenes in food by polymerase chain reaction. Cell Mol Biol. 2009;55(2):1104-1110. Available from: https://doi.org/10.1128/AEM.67.2.646-653.2001

93. Srinivasan V, Nam H, Nguyen L, Tamilselvam B, Murinda S, Oliver S. Prevalence of antimicrobial resistance genes in Listeria monocytogenes isolated from dairy farms. Foodborne Pathog Dis. 2005;2:201-211. Available from: https://doi.org/10.1089/fpd.2005.2.201

94. Troxler R, Von Graevenitz A, Funke G, Wiedemann B, Stock I. Natural antibiotic susceptibility of Listeria species: L grayi, L innocua, L ivanovii, L monocytogenes, L seeligeri, and L welshimeri strains. Clin Microbiol Infect. 2000;6:525-535. Available from: https://doi.org/10.1046/j.1469-0691.2000.00168.x

95. Mata M, Baquero F, Perez-Diaz JA. Multidrug efflux transporter in Listeria monocytogenes. FEMS Microbiol Lett. 2000;187:185-188. Available from: https://doi.org/10.1111/j.1574-6968.2000.tb09158.x

96. Byrne VDV, Hofer E, Vallim DC, Almeida RCDC. Occurrence and antimicrobial resistance patterns of Listeria monocytogenes isolated from vegetables. Braz J Microbiol. 2016;47:438-443. Available from: https://doi.org/10.1016/j.bjm.2015.11.033

97. Kayode AJ, Okoh AI. Antimicrobial-Resistant Listeria monocytogenes in Ready-to-Eat Foods: Implications for Food Safety and Risk Assessment. Foods. 2023;12:1346. Available from: https://doi.org/10.3390/foods12061346

98. Dairy Standards Agency 2012. Available at: Accessed 28/10/2015.

99. European Commission. Commission Regulation (EC) No 1441/2007 of 5 December 2007 amending Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs. Off J Eur Union. 2007;322:12-29. Available from: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:322:0012:0029:EN:PDF

100. Food Standards Australia–New Zealand (FSANZ). Criteria for Listeria monocytogenes-Microbiological Limits for Foods [Internet]. 2014. [Accessed: February 12, 2018].

101. Shank FR, Elliot EL, Wachsmuth IK, Losikoff ME. US position on Listeria monocytogenes in foods. Food Control. 1996;7(4-5):229-234. Available from: https://doi.org/10.1016/S0956-7135(96)00041-2

102. Fagerlund A, Langsrud S, Møretrø T. Microbial diversity and ecology of biofilms in food industry environments associated with Listeria monocytogenes persistence. Curr Opin Food Sci. 2021;37:171-178. Available from: https://doi.org/10.1016/j.cofs.2020.10.015

103. Gil MI, Truchado P, Tudela JA, Allende A. Environmental monitoring of three fresh-cut processing facilities reveals harborage sites for Listeria monocytogenes. Food Control. 2024;155:110093. Available from: http://dx.doi.org/10.1016/j.foodcont.2023.110093

104. Mahmoud BSM. Effects of X-ray radiation on Escherichia coli O157, Listeria monocytogenes, Salmonella enterica, and Shigella flexneri inoculated on shredded iceberg lettuce. Food Microbiol. 2010;27(1):109-114. Available from: https://doi.org/10.1016/j.fm.2010.07.009

105. Työppönen S, Markkula A, Petäjä E, Suihko ML, Mattila-Sandholm T. Survival of Listeria monocytogenes in North European type dry sausages fermented by bioprotective meat starter cultures. Food Control. 2003;14(13):181-185. Available from: https://doi.org/10.1016/S0956-7135(02)00086-5

106. Yu HG, Mee-Young Y, Jae-Won Y, Marshall DL, Oh D. Effect of combined ozone and organic acid treatment for control of Escherichia coli O157and Listeria monocytogenes on enoki mushroom. Food Control. 2007;18(5):548-553. Available from: http://dx.doi.org/10.1016/j.foodcont.2006.01.004

107. Nyachuba DG, Donnelly CW, Howard AB. Impact of Nitrite on Detection of Listeria Monocytogenes in Selected Ready-to-Eat (RTE) Meat and Seafood Products. J Food Sci. 2007;72(7). Available from: https://doi.org/10.1111/j.1750-3841.2007.00455.x

108. Velázquez-Estrada RM, Hernández-Herrero MM, Guamis-López B, Roig-Sagués AX. Impact of ultra-high-pressure homogenization on pectin methylesterase activity and microbial characteristics of orange juice: A comparative study against conventional heat pasteurization. Innov Food Sci Emerg Technol. 2012;13:100-106. Available from: https://doi.org/10.1016/j.ifset.2011.09.001

109. Adebesin IO, Sule IO, Ogunniyi DO, Amoka SO. Antibacterial activity of Vernonia amygdalina extracts against multi-drug resistant gram-positive and gram-negative bacteria. Int J Med Lab Res. 2022;7(3):1-8. Available from: https://doi.org/10.1016/j.ifset.2011.09.001

110. Adebesin IO, Kolapo KT, Amoka SO, Olubunmi OH, Olomoko CR, Balogun AO, et al. Phytochemical analysis and antibacterial efficacy of Ocimum gratissimum extracts on multi-drug resistant bacteria. Int J Med Lab Res. 2023;8(3):23-31. Available from: https://www.ijmlr.com/_files/ugd/19be9b_6055da271b434dc39f89bad87535bdde.pdf?index=true

111. Ceruso M, Clement JA, Todd MJ, Zhang F, Huang Z, Anastasio A, et al. The Inhibitory Effect of Plant Extracts on Growth of the Foodborne Pathogen, Listeria monocytogenes. Antibiotics. 2020;9(6):319. Available from: https://www.mdpi.com/2079-6382/9/6/319#

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