Received: 21 May 2023, Accepted: 03 July 2023

Review Article

Journal of Advanced Veterinary Research
(2023) Volume 13, Issue 7, 1487-1490

Prevalence of *Listeria monocytogenes* in Meat Products Retailed in Egypt and Worldwide: A Review

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Abstract

Meat products are regarded as major sources of essential amino acids, minerals, and vitamins. However, during all stages of the processing of meat products, including the slaughter of the animal, dressing, evisceration, and subsequent transportation and distribution, may expose the product to a wide range of bacteria. The microbial community of the final product may be influenced by handling and raw materials used in the production of the meat products. The microbiological condition of meat products may be affected by a number of factors, including worker hands, clothing, knives, cutting boards, slaughterhouse and meat processing plant environments, including walls, floors, washing water, etc. *Listeria monocytogenes* (*L. monocytogenes*) is considered as one important foodborne pathogen that is responsible for many cases of food poisoning among consumers worldwide. This study aimed to investigate the current scenario of the prevalence of *L. monocytogenes* in retailed meat products in Egypt and worldwide. The cited literatures in the current review demonstrated that effective sanitary practices should be used throughout all phases of handling meat to produce meat products with a high level of storage quality and free from *L. monocytogenes*.

KEYWORDS
L. monocytogenes, Meat products, Egypt

INTRODUCTION

Animal-derived protein is extremely important to humans in order to keep their bodies functioning normally. The main sources of red meat in Egypt and around the world are meat products (Saleh *et al*., 2017; Mahmoud, 2019; Mahmoud *et al*., 2021). They can supply humans with the vital fatty acids, carotenoids, zinc, calcium, and iron minerals, vitamin B complexes, and critical amino acids required to sustain good health. Red meat is, nevertheless, a common cause of food illness in many countries (Sallam and Morshdy, 2008; Darwish *et al*., 2016; Elabbasy *et al*., 2021; Abdallah *et al*., 2022; Elshafie *et al*., 2022).

The primary source of microbial contamination of the surfaces of animal carcasses is the presence of a wide range of microorganisms in the atmosphere of meat processing factories, slaughterhouses, and butcher shops (Morshdy *et al*., 2022; Darwish and Thompson, 2023). Various processing steps, such as animal slaughter, skinning, evisceration, de-boning, corpse transportation, and distribution, result in this cross-contamination. As a result, raw meat can become infected with a variety of bacteria, including ones that can cause food poisoning and have a negative impact on public health (Darwish *et al*., 2018; Morshdy *et al*., 2021).

One of the most significant food-borne diseases that can infect humans through contaminated food is *Listeria monocytogenes* (*L. monocytogenes*). Several listeriosis outbreaks associated to the intake of meat, poultry, dairy, fish, and vegetable products have been caused by *L. monocytogenes*, which has been isolated from a wide range of meat products as well. *L. monocytogenes* can reproduce at different rates during refrigerated storage depending on the kind of food product, both under aerobic and anaerobic circumstances, respond to disinfectants, and cling to different surfaces even when it originally exists in small numbers in a food product (Meloni, 2015). The presence of *L. monocytogenes* in ready-to-eat (RTE) foods, such as cooked, raw-cured, and dry-cured salted meat products, is particularly concerning because *L. monocytogenes* may multiply in a variety of foods at temperatures as low as 2 to 4 °C (Codex Alimentarius, 2007; Pradhan *et al*., 2009; Williams *et al*., 2011).

Despite the possibility of initial contamination, *L. monocytogenes* in RTE meat products are typically linked to either recontamination of the product prior to final packaging or to later handling, whether during commercialization or usage at home (Codex Alimentarius, 2007). It is well established that common cross-contamination sources include working surroundings, equipment, and surfaces that come into contact with food (Cogan *et al*., 2002). Food-contact surfaces may pose a serious risk, particularly if biofilms, or microbial aggregates, have developed on the surfaces (Domínguez *et al*., 2010). The capacity of *L. monocytogenes* to produce biofilms may play a significant role in its ability to survive in situations where food is processed (Meloni, 2015). In fact, a number of investigations have demonstrated that *L. monocytogenes* can attach to and create biofilms on surfaces in contact with food, including polyethylene, polyvinyl chloride,

ISSN: 2090-6277/2090-6269/

glass, and stainless steel (Blackman and Frank, 1996; Di Bonaventura *et al*., 2008).

Listeria monocytogenes is a significant foodborne pathogen that has been linked to high mortality and hospitalization, according to the World Health Organization. Listeriosis ranks among the most common causes of death from food-borne illness due to its high case fatality rate (Darwish *et al*., 2022).

This review aimed to highlight the current scenario of the prevalence of *L. monocytogenes* in retailed meat products in Egypt and worldwide.

Prevalence of *Listeria monocytogenes* in meat products retailed in Egypt

Meat and chicken products bought from Assuit, Egypt, retail supermarkets were examined for isolation of *Listeria* spp. Over a 7-month period, from January to July 2009, a total of 100 samples, including 25 samples of minced frozen beef, luncheon, frozen chicken legs, and frozen chicken breast fillets, were gathered and examined for the presence of *Listeria* spp. Additionally, 28 stool cultures from children hospitalized in the Assuit Pediatric University Hospital with fever or diarrhoea were tested for *Listeria* spp. The latter was found in 8 (32%) of the minced frozen beef, 8 (32%) of the luncheon, 13 (52%) of the frozen chicken leg, and 14 (56%) of the frozen chicken fillet samples out of the total 100 meat samples investigated. Two (7.14%) of the 28 stool cultures from children hospitalized with an underlying illness at the Assuit University hospital were confirmed to be positive for *Listeria* spp. With a total incidence of 5 isolates (5%) from the 100 food samples investigated, the PCR results showed that *L. monocytogenes* was confirmed in one of the minced imported frozen meat examined, two luncheon samples, and two frozen chicken legs (El-Malek *et al*., 2010). Besides, the presence of *Listeria* species was checked in street-vendor prepared food served in Egypt, including sandwiches and traditional culinary items. 24% of the 576 samples tested had *Listeria* species in them. *L. monocytogenes* and *L. innocua* were found to be present in 57% and 39%, respectively, of the contaminated samples. Less frequently, other *Listeria* spp., were found. In 7% of the total samples evaluated, *L. monocytogenes* (10^3 CFU/g) was found, accounting for 49% of the contaminated food samples (meat, poultry, fish, dairy products, and items of plant origin). The majority of the *L. monocytogenes*-contaminated samples showed high total viable bacterial counts (El-Shenawy *et al*., 2011). Likely, Awadallah and Suelam (2014) examined the presence of certain virulence genes in *L. monocytogenes* isolated from consumers and ready-to-eat (RTE) meat products in Cairo Province, Egypt. A total of 120 samples of beef luncheon, chicken luncheon, and frankfurter meat (40 samples each) were gathered from ten local businesses in the Egyptian city of Al-Salam. 40 people who frequently consumed RTE meat had their stools sampled. Using primers specific for the *inlA*, *inlC*, and *inlJ* genes, the putative *L. monocytogenes* isolates were put through a multiplex PCR for quick speciation and virulence assessment. All samples tested under culture on Oxford medium showed the presence of *L. monocytogenes* colonies in six beef luncheon (15%), four chicken luncheon (10%), one frankfurter beef (2.5%), and one human stool (2.5%) samples. Two out of six culture isolates from beef luncheon (5%), and one out of four culture isolates from chicken luncheon (2.5%) samples, were used to confirm the species identity of *L. monocytogenes*. They came to the conclusion that beef and chicken luncheons offered in Cairo, Egypt, are contaminated with *L. monocytogenes*. In addition, Ismaiel *et al*. (2014) collected 180 food samples in total, including dairy products (raw milk, Zabady, and Kareesh cheese) and meat (raw lean beef, frozen lean beef, and frozen chicken), were examined for *Listeria*. In frozen lean beef, the occurrence rate was the greatest (13.33%). Milk products and raw lean beef had an incidence rate of 6.67%. The samples of frozen chicken meat and Kareesh cheese had the lowest occurrence rate (3.33%). *L. monocytogenes* was isolated from a single frozen lean beef sample and had the lowest incidence rate (0.55%). Out of 4 samples, L. ivanovii and *L. grayi* had the greatest occurrence rate (2.22%). Three samples (1.67%) each tested positive for *L. innocua*, *L. seeligeri*, and *L. welshimeri*, while two samples (1.11%) did not. The virulence factors of *L. monocytogenes* and L. ivanovii were both positive. Depending on the method utilized *Listeria* spp., were isolated at rates between 24% and 36%, and with counts ranging from $16x10^2$ to $23x10^2$ CFU/g. *L. monocytogenes* was identified in all samples. All of the investigated Hawawshi sandwiches did not contain *Listeria* spp., with the exception of one positive sample discovered using chromogenic medium. According to the results, 62 out of 100 (62%) isolates from chromogenic medium and 37 out of 68 (54%) isolates from traditional selective conventional media were both positively identified as *L. monocytogenes*, suggesting that chromogenic medium may be preferable for isolating the pathogen from prepared meat and product sandwiches (Zaghloul *et al*., 2014). To screen for the presence of *L. monocytogenes*, 340 distinct samples were gathered from various locations around the El Giza Governorate in Egypt. 250 food samples, 40 refrigerator swabs, and 50 samples of diarrheal children's stools made up the collection of samples. The evaluated samples were used to isolate *L. monocytogenes* in accordance with the International Organization for Standardization. The isolates underwent biochemical testing with *Listeria* Microbact 12L and polymerase chain reaction confirmation. In contrast to sausage samples, which were all negative, beef burger samples had isolation rates of *L. monocytogenes* of 8%, 4%, and 4%, respectively. Only *Listeria grayi* (2.5%) was found in human stools (Reda *et al*., 2016). Moreover, Mohamed *et al*. (2016) collected a total of 150 samples of processed meat were gathered from the Egyptian governorate of Giza. Using PCR integrating the listeriolysin O virulence gene *hlyA* and DNA sequence analysis, *L. monocytogenes* were identified phenotypically and genotypically. In 4% of the beef burger, minced meat, and luncheon samples, *L. monocytogenes* was identified. With the exception of one Egyptian sample, which exhibited significant homology with an Indian isolate (EU840690), phylogenetic analysis revealed that all six Egyptian isolates have high homology with Colombian isolate (EF030606). These infections' importance for public health as well as suggested hygienic practices was discussed. In the years 2017 and 2018, 120 samples of raw meat items were gathered from various retail locations in the Qena Governorate of Egypt and tested for *Listeria* spp. contamination. *L. monocytogenes* was present in the minced meat, kofta, sausage, burger, luncheon and pasterma under examination at rates of 15%, 20%, 10%, 15%, 10% and 5%, respectively. Other *Listeria* species, including *Listeria ivanovii* (10.8%), *L. welshimeri* (6.6%), *L. innocua* (10.8%), *L. seeligeri* (4.1%), and *L. grayi* (1.6%), were also isolated and identified from the meat products described above (Mahmoud *et al*., 2019). Abdeen *et al*. (2021) detailed *L. monocytogenes* prevalence, antibiogram, virulence assessment, and genomic characterization from several food products. A total of 250 food samples were gathered from the Minoufyia governorate in Egypt, including 50 samples each of raw milk, ice cream, minced beef, fish fillet and sausage. *L. monocytogenes* was found in 17 (6.8%) of the food items examined, including raw milk (6%), minced meat (14%), and fish fillet (8%). Notably, every isolate of *L. monocytogenes* exhibited multidrug resistance.

Prevalence of *Listeria monocytogenes* in meat products retailed Worldwide

It is now known that *Listeria monocytogenes* infection (also known as Listeriosis) is a foodborne sickness that can cause invasive disease in people who are at risk for it. *Listeria* bacteremia and meningitis can be fatal, and they are more likely to affect older adults, pregnant women, and people with immunocompromized conditions. Listeriosis outbreaks and isolated cases have been linked to contaminated milk, soft cheese, beef and meat products, vegetables, seafood goods, and ready-to-eat meals (Gómez *et al*., 2014). Several studies were conducted to investigate the prevalence of *Listeria* spp., and particularly, *L. monocytogenes* in meat products worldwide. For instances, an investigation was conducted to find out the prevalence and quantity of *L. monocytogenes* in a range of meat products retailed in Belgium, including cooked meat items, raw cured meat items (whether dried or not), mayonnaise-based salads, and prepared meals. As anticipated, the contamination rates of *L. monocytogenes* in raw cured meat products were much higher than those in cooked meat products, 13.71% (113/824) and 4.90% (167/3405), respectively. Additionally, a higher percentage of the samples of raw cured beef products had a high initial concentration of the pathogen (>10 CFU/g). Cross-contamination was shown to occur more frequently in whole cooked meat products (such as cooked gammon and bacon) after slicing than before slicing, 6.65 and 1.56%, respectively (Uyttendaele *et al*., 1999). Moreover, the presence of *Listeria* spp. was examined in a total of 146 raw (minced, chicken, beef) and cooked (red meat, chicken) meat samples retailed in in Ankara, Turkey. According to Bergey's manual, the isolates were identified using morphological, cultural, and biochemical tests, and API-*Listeria* kit confirmation. Out of 146 meat samples, 79 (54.10%) were found to be contaminated with *Listeria* spp., with raw minced meat having the highest prevalence (86.4%). Of the 79 samples analysed, *L. monocytogenes* was isolated from 9 (6.16%). *L. innocua* 68 (46.57%), *L. welshimeri* one (0.68%), and L. murrayi one (0.68%) were among the additional species that were isolated (Yücel *et al*., 2005). The presence of *L. monocytogenes* in various ready-to-eat (RTE) meat products and in the surroundings of meat processing facilities in Greece. 110 samples of work surfaces and equipment and 129 samples of RTE meat items were all examined. In 6 out of 35 cooked items (17.14%), 21 out of 57 raw-cured products (36.84%), and 9 out of 37 dry-cured, salted products (24.32%), *L. monocytogenes* was found. From the manufacture date through half shelf life, and then again at the end of shelf life, the number of sample units that exceeded the food safety level of 100 CFU/g declined. On 25 of the 110 surfaces that came into touch with food (22.72%), *L. monocytogenes* was found (Angelidis and Koutsoumanis, 2006). Escolar *et al*. (2017) recovered a total of 50 *Listeria* strains, including 7 *L. monocytogenes* and 43 *Listeria innocua* strains, were identified from meat and dairy products, and their antimicrobial susceptibility to nine antimicrobials was examined. The antimicrobial resistance genes *tet* M, *tet* L, *mef* A, *msr* A, *erm* A, *erm* B, *lnu* A, and *lnu* B were examined in the strains using real-time PCR. 27 *Listeria* strains, including 4 *L. monocytogenes* strains, had multidrug resistance. In 45 different *Listeria* strains, clindamycin resistance was found to be the most prevalent resistance trait; however, the mechanisms behind this resistance are yet unknown.

Listeria monocytogenes at the human, food animal interface

Studies on *L. monocytogenes* at the human-food animal interface, particularly in high-risk human groups, have been done in the Arab countries. El-Gohary *et al*. (2018) found *Listeria* spp. in 11.1% (1/9) of stool samples from Mansoura governorate abortion victims in Egypt. Additionally, *L. monocytogenes* was found in 4% (8/200) of the feces of healthy pregnant Egyptian women, according to EL-Naenaeey *et al*. (2019). All of the isolates were found to have the inlA and inlB genes, which suggest that these isolates may be virulent. Seven cases of *L. monocytogenes* infection were documented in Tunisia between 2000 and 2008, according to a study by Elbeldi *et al*. (2010); two infants and five newborn children were among the affected. Clinical indicators in the two newborns included fever along with neurological and digestive symptoms, and cases of maternal-fetal infections were confirmed in those cases. Based on a single site (same hospital) analysis, Ramdani-Bouguessa and Rahal (2000) reported two listeriosis cases in infants in Algeria. Due to the considerable public health concern regarding listeriosis in pregnant women in Morocco, *L. monocytogenes* infection should be considered in any situation when a pregnant woman is admitted to the hospital with symptoms of a bacterial illness or an unidentified infection (Benabdejlil *et al*., 2015). In the Arab countries, there is a need to improve the surveillance of *L. monocytogenes* and other foodborne zoonoses in general.

In general, national food safety organizations should promote risk-based microbiological standards and find a balance between providing the industry with necessary protection while adhering to reasonable and attainable limitations. The Middle East's individual nations should also recognize the value of national surveillance and audit their current food testing facilities to uncover their flaws and streamline their operations to meet international standards (Habib *et al*., 2021).

CONCLUSION

The current review demonstrated the potential role of the meat products as a source of *L. monocytogenes*, and therefore, adoption of strict hygienic measures should be followed during the entire production cycle of meat products. Moreover, continuous screening programs should be followed in order to update our information about the prevalence of *L. monocytogenes*. Besides, finding ecofriendly additives with anti-*Listeria*l activities is highly targeted.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

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