Research Note

Incidence and Contamination Level of *Listeria monocytogenes* and Other *Listeria* spp. in Ready-to-Eat Meat Products in Jordan

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**ABSTRACT**

The objective of the present study was to investigate the incidence and contamination levels of different *Listeria monocytogenes* serovars in ready-to-eat meat products (RTE-MP) collected from different outlets and processing plants in Jordan in order (i) to provide information to Jordanian health authorities on the incidence of *L. monocytogenes* in RTE-MP sold and consumed in Jordan and (ii) to ascertain the risks of these products for consumers. Two hundred forty RTE-MP samples, 120 beef and 120 poultry, were analyzed. European International Organization for Standardization (EN ISO) 11290-1 and -2 standard protocols were used for detection and enumeration of *L. monocytogenes*. The identity of suspected *L. monocytogenes* was confirmed using PCR. Three *Listeria* spp., *L. monocytogenes*, *L. innocua*, and *L. welshimeri*, were isolated. *L. innocua* and *L. welshimeri* were the most and least frequently isolated with 56 and 36 samples, respectively. *L. monocytogenes* was isolated from 41 samples (17.1%): 23 from beef and 18 from poultry samples. The contamination levels of *L. monocytogenes* were ≤100 CFU/g in 97.5% (40 samples) of the positive samples. Only one beef sample with a count of >100 CFU/g was found. The *L. monocytogenes* strains isolated fell into two serotypes (1 and 4) and four different serovars (1/2a, 1/2b, 1/2c, and 4b).

In recent years the popularity of and demand for ready-to-eat meat products (RTE-MP) has greatly increased in Jordan and around the world; in response, meat processing companies have developed many new products. Part of the appeal of these products is their convenience, which comes largely from the fact that cooking is not needed prior to serving (7, 25).

Along with increased consumption has come a rise in incidence of illness resulting from contaminated RTE-MP (6, 21). *Escherichia coli* O157:H7, *Salmonella*, *Campylobacter* spp., and *Staphylococcus aureus* are among the most common foodborne pathogens associated with RTE-MP, but recently several outbreaks have occurred involving *L. monocytogenes* in RTE-MP (7, 28). The incidence of *L. monocytogenes* in RTE-MP has ranged from 2.7 to 20%, whereas the incidence of other *Listeria* spp. (i.e., *L. innocua*, *L. welshimeri*, *L. ivanovii*, *L. seeligeri*, and *L. grayi*) has ranged from 1.8 to 48.0% (3, 27).

*L. monocytogenes* is the causal agent of listeriosis, which is one of the most virulent foodborne diseases that regulatory agencies throughout the world have been trying to keep contained (33, 35). It is well established that foodborne listeriosis causes a range of manifestations including flulike symptoms such as fever, fatigue, nausea, vomiting, and diarrhea, and severe symptoms such as septicemia and meningitis. Listeriosis has an approximately 30% case-fatality rate that increases to 75% in high-risk groups, such as fetuses, neonates, persons ≥60 years of age, and immunocompromised adults (9, 18, 30).

Because *L. monocytogenes* is able to tolerate refrigeration, a wide pH range (as low as 4.4), salt concentrations as high as 40%, and water activity (?w) values as low as 0.90, its growth environment is similar to the processing and packaging conditions of many RTE-MP (12, 15). As a consequence, controlling this bacterium through standard control procedures may not be effective. For example, sodium chloride and nitrates do not inhibit the growth of *L. monocytogenes* under typical conditions (9, 14, 25).

Recently, European Commission Regulation (EC) No 1441/2007 (1) considered food products with pH ≤ 4.4 and ?w ≤ 0.92, products with pH ≤ 5.0 and ?w ≤ 0.94, and products with a shelf life of fewer than 5 days as products unable to support the growth of *L. monocytogenes* (1). There are various regulations concerning the microbiological level of *L. monocytogenes* in foods. In a number of countries, including the United States, the microbiological criterion is 0 CFU of *L. monocytogenes* per 25-g sample of RTE foods (10, 33). However, some European countries have microbiological criteria of 100 CFU/g of *L. monocytogenes* at the point of consumption for RTE foods unable to support the growth of *L. monocytogenes*, and for RTE foods able to support the growth of *L. monocytogenes*, microbiological criteria of 0 CFU/g before the food has left the immediate control of the food business operator or 100 CFU/g at the point of consumption.

There are a number of standard methods and selective media (i.e., Oxford, modified Oxford, LiCl-phenylethanol-
TABLE 1. Incidence of Listeria spp. and L. monocytogenes in beef and poultry ready-to-eat meat products by EN ISO protocol

<table>
<thead>
<tr>
<th>Type (no.) of samples</th>
<th>L. monocytogenes</th>
<th>E. innocua</th>
<th>L. welshimeri</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef RTE-MP (120)</td>
<td>23 (19.2)</td>
<td>29 (24)</td>
<td>17 (14.2)</td>
</tr>
<tr>
<td>Poultry RTE-MP (120)</td>
<td>18 (15)</td>
<td>27 (23)</td>
<td>19 (15.8)</td>
</tr>
<tr>
<td>Total (240)</td>
<td>41 (17.1)</td>
<td>56 (23)</td>
<td>36 (15)</td>
</tr>
</tbody>
</table>

moxalactam, and polymixin B, acriflavin, lithium chloride, ceftazidime, aesculin, D-mannitol media) that are used for L. monocytogenes enrichment, isolation, and identification. All of these standard protocols involve the detection of low numbers of L. monocytogenes from foods and environmental samples, where injured L. monocytogenes are likely to be present through the use of two-step selective enrichment cultures followed by selective plating (32, 34). All of these protocols are laborious and time-consuming. Because of these limitations, in recent years a number of selective chromogenic media for isolation of L. monocytogenes have been developed and marketed. For example, chromogenic culture media have been used to selectively detect and enumerate L. monocytogenes in 24 to 48 h (22, 23, 29).

In Jordan, the microbiological criteria of L. monocytogenes are not specified in the official standards for different types of foods. As a result, there is little information concerning the incidence and distribution of L. monocytogenes in foods, particularly high-risk foods (i.e., RTE-MP). Due to the potential health threat of this pathogen there is a need to develop a database of information concerning the incidence and distribution of L. monocytogenes in different Jordanian foods, so that possible outbreaks can be avoided. To begin to address this need, the aims of the study were to survey the incidence of L. monocytogenes and other Listeria spp. in Jordanian ready-to-eat meat products by EN ISO protocol and to survey the serotype groups of L. monocytogenes isolates.

MATERIALS AND METHODS

Food samples. A total of 240 RTE-MP samples, 120 beef and 120 poultry, were randomly collected during the period June 2006 to April 2007 from different markets and processing outlets in Amman, Jordan (Table 1). The analyzed products included processed RTE beef and poultry products. Samples were kept refrigerated until analyzed, which was within 24 h of purchase.

Chemical-physical analysis. For all samples, the pH and aw were determined. The potentiometric measurement of pH was carried out by inserting the pin electrode of a pH-meter GLP 21 (Crisson, Carpi, Modena, Italy) directly into each sample, and aw was determined using an Aqualab CX3 (Decagon, Pullman, WA).

Detection and enumeration of L. monocytogenes using EN ISO standard protocols. To isolate and identify L. monocytogenes in the food samples, EN International Organization for Standardization (ISO) standard protocols were employed (22, 23), using a two-step selective enrichment protocol to recover the maximum number of stressed cells of L. monocytogenes and other Listeria spp. L. monocytogenes (ATCC 7644; positive control) and L. innocua (ATCC 33090) and E. coli (ATCC 25922) (negative controls) were used in the detection and PCR procedures.

Detection of L. monocytogenes. L. monocytogenes was detected following EN ISO 11290-1:1997/Amendment 1:2004 (22). Twenty-five grams of each sample was added to 225 ml of primary enrichment broth (see below). The mixture was then homogenized for 60 s in a Stomacher 400 laboratory blender (Seward Medical, London, UK). Half Fraser broth was used as primary enrichment and Fraser broth as a secondary enrichment. Half Fraser broth was prepared using Fraser Broth Base (Oxoid, Basingstoke, Hampshire, UK) supplemented with a half of the Fraser Selective Supplement. Inoculated broth was incubated for 24 h at 30°C and then 0.1-ml samples were transferred to a tube containing 10 ml of the secondary selective Fraser enrichment. After 24 and 48 h of incubation at 30°C, a loopful was collected from secondary enrichment broth preparations and streaked onto both chromogenic Listeria agar (LCA) plates (Oxoid).

Purification and identification. After incubation at 37°C for 48 h, five characteristic colonies were selected from the LCA plates and streaked onto tryptone soy yeast glucose agar (TSAYE) plates for purification (22). On LCA, L. monocytogenes colonies typically appear as turquoise blue colonies with a white precipitation zone around the colony, whereas other nonpathogenic Listeria spp. colonies appear turquoise blue without precipitation zones (22, 23, 29). Isolates appearing as turquoise blue colonies with a white precipitation zone around the colony were presumptively considered L. monocytogenes, and isolates appearing as turquoise blue colonies without a white precipitation zone around the colony were presumptively considered as nonpathogenic Listeria spp. Isolates were tested for catalase, Gram reaction, motility test, hemolysis test on sheep blood agar (blood agar base no. 2, Oxoid; overlayed with the same medium containing 7% [vol/vol] sheep blood), carbohydrate utilization, and biochemical identification by API Listeria (bioMérieux, Marcy l’Etoile, France), which was performed according to manufacturer’s instructions.

Enumeration of L. monocytogenes. Samples positive for L. monocytogenes were tested by direct plating following EN ISO 11290-2:1998/Amendment 1:2005 (23). Twenty-five grams of each sample was placed in a sterile plastic bag with 225 ml of buffered peptone water (Oxoid), and this initial blend was stored for 1 h ± 5 min at 20 ± 2°C in order to recover stressed microorganisms. Decimal dilutions were prepared and plated in duplicate on LCA (Oxoid). In order to increase the sensitivity of the technique, 1 ml of the first decimal dilution was also plated (using one 140-mm plate or three 90-mm Petri dishes). The plates were incubated for 24 or 48 ± 2 h at 37 ± 1°C, and typical colonies were counted and isolated in TSAYE for further confirmation, as described in the previous section.

PCR identification of presumptive-positive L. monocytogenes. All presumptive-positive colonies identified by plating on selective agars and biochemical kits were subjected to a PCR procedure that amplified a specific DNA sequence of the 730-bp listeriolysin (hlyA) gene. The gene was identified using the following primer sequences: 5’-CATTAGTGGAAAGATGGAA-TG-3’ (primer A) and 5’-GTATCTCCAGAGTGATCGA-3’ (primer B) (Oligos, Midland Certified Reagent Co., Midland, TX). The primers are known to be highly specific for L. monocytogenes and do not amplify DNA present in any other Listeria spp. or non-Listeria organisms (5). L. monocytogenes ATCC 7644 and E. coli ATCC 25922 were used as positive and negative controls, respectively.
The extraction procedure was based on a protocol previously described by Blais and Phillippe (4) and Gouws and Liedemann (19) for the detection of L. monocytogenes in food products. L. monocytogenes strains were stored for long-term use in brain heart infusion medium with 10% sterile glycerol at −80°C. To recover strains, samples were streaked on brain heart infusion agar plates and grown overnight at 37°C. Cells were then scraped and resuspended in 50 μl of 1× PCR buffer in a 2-ml microcentrifuge tube with an interlocking cap. A solution of 2% Triton X (50 μl) was then added to this cell suspension and thoroughly mixed. This mixture was heated at 100°C for 10 min and then allowed to cool to room temperature. For PCR amplification, 5 μl of this crude cell lysate was used.

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PCR amplification. Amplification reaction mixtures were prepared using the primers at concentrations of 50 pmol/μl, 1 U of Taq polymerase, 1× reaction buffer (Fisher Scientific, Pittsburgh, PA), 0.2 mM each deoxynucleoside triphosphate (Oligos, Midland, TX), 2.5 mM MgCl2, and 2 μl of template DNA in a 25-μl reaction volume. PCR cycling conditions were as follows. Amplification conditions were optimized to the thermal cycler and were as follows: 80°C for 10 min, an initial denaturation at 94°C for 3 min, 30 cycles of denaturation at 94°C for 30 s, annealing at 55°C for 30 s and extension at 72°C for 30 s, then a final extension at 72°C for 2 min (Primus 96 Plus Thermal Cycler, MWG Biotech, High Point, NC). The amplified DNA was analyzed by gel electrophoresis on a 1.2% agarose gel stained with ethidium bromide (3 μl/100 ml). A 100-bp ladder (Promega, Madison, WI) was used as a reference marker. Tris-borane-EDTA (0.5×) was used as the running buffer and the gel was viewed using UV transillumination at a wavelength of 254 nm (19).

Survey of L. monocytogenes serotypes. Isolated L. monocytogenes were serotyped following the plan established by Seeliger and Hohne (31). Strains were serotyped using antisera against somatic (O) and flagellar (H) antigens according to the manufacturer’s instructions (Denka Seiken, Tokyo, Japan).

RESULTS

The results of the chemical-physical analysis of beef and poultry RTE products were as follows: pH values were 5.0 to 5.4 and 5.2 to 5.4 for the beef and poultry samples, respectively; aw values were 0.93 to 0.97 for both types of samples.

The incidence of L. monocytogenes and other Listeria spp. in the beef and poultry RTE-MP samples analyzed is shown in Table 1. The analyses used in this study isolated and identified three major Listeria spp.: L. monocytogenes, L. innocua, and L. welshimeri. L. innocua was the most frequently isolated Listeria sp., followed by L. monocytogenes and L. welshimeri. Of the 240 meat samples, L. monocytogenes was isolated from 41 (17.1%) samples, L. innocua from 56 (23.0%) samples, and L. welshimeri from 36 (15.0%) samples. Incidence of L. monocytogenes and other Listeria spp. was higher in beef samples than in poultry samples (Table 1). L. innocua was isolated from 29 samples from beef and 27 samples from poultry, L. monocytogenes from 23 beef samples and 18 poultry samples, and L. welshimeri from 17 beef samples and 19 poultry samples. Also, it is worth mentioning that cocontamination with different Listeria spp. was observed in several samples. L. monocytogenes plus L. innocua was the most frequent combination.

The high accuracy and sensitivity of EN ISO protocol in the detection and isolation of L. monocytogenes (Table 2) was notable. The ISO protocol was efficient in isolating L. monocytogenes from 41 samples. Plates of 62 samples were determined to contain the growth of typical colonies (i.e., turquoise blue colonies with and without halos around the colonies) of L. monocytogenes and other Listeria spp. Of the 62 plates with isolates, only 41 showed the growth of typical colonies of L. monocytogenes. All of the 41 isolates were confirmed as L. monocytogenes by biochemical kits and PCR (Table 2).

Results of the contamination levels of L. monocytogenes in the positive samples are shown in Table 3. In the 23 positive beef samples, 8 (35%) had counts <10 CFU/g, 14 (61%) had >10 to 100 CFU/g, and only 1 sample (4%) had >100 CFU/g. In the 18 positive poultry samples, 6 (33.3%) had counts <10 CFU/g and 12 (66.7%) had counts >10 to 100 CFU/g.

The 41 isolated L. monocytogenes strains fell into two serotypes (1 and 4) and into four different serovars (1/2a, 1/2b, 1/2c, and 4b). Serotype 1 comprised 83% and serotype 4 comprised 17% of isolated L. monocytogenes. Serovar 1/2a comprised 56.1%; serovar 1/2b, 17.1%; serovar 1/2c, 9.7%; and serovar 4b, 17.1% of isolated L. monocytogenes (Table 4).

DISCUSSION

Because of its virulence, the incidence of L. monocytogenes in RTE-MP, generally considered to be an indication of poor hygienic practices and conditions in food processing environments, is of great concern for both regulatory agencies and processors. According to the

### TABLE 2. PCR-confirmed L. monocytogenes of typical colonies on LCA

<table>
<thead>
<tr>
<th>Plates with typical nonpathogenic Listeria spp. growth*</th>
<th>Plates with typical L. monocytogenes colonies</th>
<th>No. (%) of PCR-confirmed L. monocytogenes isolates</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>41</td>
<td>41 (100)</td>
</tr>
</tbody>
</table>

* Turquoise blue colonies without halos.

### TABLE 3. Contamination levels of L. monocytogenes in beef and poultry ready-to-eat meat products

<table>
<thead>
<tr>
<th>Ready-to-eat meat products</th>
<th>No. of positive samples</th>
<th>No. (%) of positive samples by colony count (CFU/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&lt;10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;10–100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;100–1,000</td>
</tr>
<tr>
<td>Beef</td>
<td>23</td>
<td>8 (35)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 (61)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 (4)</td>
</tr>
<tr>
<td>Poultry</td>
<td>18</td>
<td>6 (33.3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 (66.7)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>41</td>
<td>14 (34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 (63.5)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 (2.5)</td>
</tr>
</tbody>
</table>

* Contamination level was determined by using EN ISO 11290-2:1998(Amd1:2005 with detection limits of 10 to 100 CFU/g sample.

Because of its virulence, the incidence of L. monocytogenes in RTE-MP, generally considered to be an indication of poor hygienic practices and conditions in food processing environments, is of great concern for both regulatory agencies and processors. According to the
Chemical-physical analysis of the samples showed mean values of pH and aw that were typical of products able to support the growth of *L. monocytogenes* (pH ≥ 4.4 or aw ≥ 0.92, or pH ≥ 5 and aw ≥ 0.94) (1, 26). Of 240 RTE-MP samples (120 beef and 120 poultry), 17.1% (n = 41) were identified as *L. monocytogenes* positive. The identified positive samples represented 19.2% and 15% of the beef and poultry sources, respectively. We also found *L. innocua* and *L. welshimeri* in 23 and 15% of 240 analyzed samples, respectively. Available data from literature indicated variable incidence rates of *L. monocytogenes* and other *Listeria* spp. in different RTE-MP. Incidence rates of *L. monocytogenes* ranged from as low as 2.7% to as high as 20% (26). Garrido et al. (16) and Vitas et al. (35) reported 8.5 and 10% incidence of *L. monocytogenes* in RTE-MP, respectively. Consistent with our findings, other studies have reported incidence rates of other *Listeria* spp. in RTE-MP ranging from 1.8 to 48.0% (3, 28, 35).

In accordance with our findings, Gudbjornsdottir et al. (20) and Vitas et al. (35) reported that *L. innocua* was the dominant *Listeria* species in RTE-MP, 9.3 and 11.4%, respectively. Comparable to our findings on the incidence of *L. welshimeri* in RTE-MP, Garrido et al. (16) reported 3.9% and Vitas et al. (35) reported 1.3% incidence rates of *L. welshimeri*. Our finding that *L. monocytogenes* and *L. innocua* is the most frequent cocontamination is also consistent with previous reports (20, 35).

Even though RTE-MP are subjected to heat treatment during processing sufficient to kill *L. monocytogenes* present in raw materials, this pathogen has been reported in finished products as a result of cross contamination or postprocessing contamination (6, 20). It is well known that *Listeria* spp., including *L. monocytogenes*, are widely distributed in nature as well as in food processing and storage environments. The processing environment and such operations as the peeling, slicing, cutting, and packaging of cooked meat have been reported to be critical points of recontamination and transfer of *L. monocytogenes* and other species to other uncontaminated meat products (6, 8, 17, 25).

One of the objectives of this study was to quantify contamination levels of *L. monocytogenes* in beef and poultry RTE-MP in order to estimate actual consumer exposure to the organism. Of the 41 positive beef and poultry samples, only one beef sample (2.5%) had a level of contamination >100 CFU/g and was thus in nonconformity with the food safety criteria provided for RTE foods able to support the growth of *L. monocytogenes*: 97.5% of the positive samples had contamination levels of ≤100 CFU/g and were in conformity with European Commission Regulation (EC) No 1441/2007 (1). The most recent Codex document on microbiological criteria for *L. monocytogenes* in RTE foods able to support the growth of *L. monocytogenes* (11) suggests a zero tolerance throughout the entire shelf life of the product. Application of this criterion could certainly prevent the consumption of high-risk RTE products, but it could also classify low-risk RTE products as unsatisfactory, especially towards the end of their shelf life (13).

Our results showed that 100% of *L. monocytogenes* detected by EN ISO protocol were identified and confirmed positive by PCR. The high sensitivity and accuracy of the EN ISO protocol in isolating and identifying *L. monocytogenes* as confirmed by PCR is consistent with Aurora et al. (2) and Gouws and Liedemann (19). Aurora et al. (2) reported a 93% correlation between chromogenic agar and PCR results for *L. monocytogenes* in different RTE foods, whereas Gouws and Liedemann (19) reported 84% correlations between RAPID*L. mono* chromogenic agar and PCR results. The ISO chromogenic agar’s ability to differentiate *L. monocytogenes* from other nonpathogenic *Listeria* spp. is based on the ability of *L. monocytogenes* to produce a very specific enzyme, phosphatidylinositol-phospholipase C (PI-PLC), which cleaves 1,2- or phosphatidylinositol as a substrate. Cleavage of this substrate by PI-PLC produces water-insoluble fatty acids around the colonies, with a distinct, opaque, halolike precipitation zone, combined with the chromogenic substrate 5-bromo-4-chloro-3-indoxyl-β-d-glucopyranoside for detection of β-d-glucosidase, which occurs in all *Listeria* spp. All *Listeria* spp. produce turquoise colonies on these media (29).

With respect to the serological results, our results were similar to those of Garrido et al. (16) and Vitas et al. (35). In our study, two serotypes were observed, serotypes 1 (83%) and 4 (17%). In the Garrido et al. (16) study, serotypes 1 and 4 made up 62 and 38% of isolates from RTE-MP, while in the Vitas et al. (35) study, the same serotypes comprised 75 and 25% of the isolates. The serovars usually involved in cases of listeriosis are 4b, 1/2a, and 1/2b, which were also the serovars isolated in our study. Notably, the serovar 1/2c has never been involved in foodborne listeriosis, although it is present in almost 10% of the food isolates in our study.

In Jordan, food processors and handlers may have limited awareness about the high risks associated with not

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**TABLE 4. Serotypes of *L. monocytogenes* isolated from beef and poultry ready-to-eat meat products**

<table>
<thead>
<tr>
<th>Source</th>
<th>No. (%) of serotype 1-positive samples</th>
<th>No. (%) of serotype 4-positive samples</th>
<th>No. (%) of serovar-positive samples</th>
<th>Total no. (%) of serovar-positive samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>19 (82.6)</td>
<td>4 (17.4)</td>
<td>13 (56.5)</td>
<td>23 (100)</td>
</tr>
<tr>
<td>Poultry</td>
<td>15 (83.3)</td>
<td>3 (16.7)</td>
<td>10 (55.6)</td>
<td>18 (100)</td>
</tr>
<tr>
<td>Total</td>
<td>34 (82.9)</td>
<td>7 (17.1)</td>
<td>23 (56.1)</td>
<td>41 (100)</td>
</tr>
</tbody>
</table>
decontaminating the processing environment sufficiently to ensure complete eradication of foodborne pathogens like L. monocytogenes. This might partly explain the high incidence of L. monocytogenes and other Listeria spp. in Jordanian-produced RTE-MP. Also, Johnson et al. (24) noted that though the majority of RTE-MP are labeled with a "use by" date and instructions to "store at 0 to 5°C," many retail and domestic refrigerators are too warm for the safe storage of food (reaching temperatures ≥9°C), which allows the growth of pathogens and spoilage organisms in a shorter time (15). Since storage time and temperature are important in controlling the growth of L. monocytogenes and preventing its counts from exceeding the microbiological criteria of RTE-MP, processors, retailers, and consumers need improved awareness and education concerning storage conditions. The findings from this study also suggest that they would benefit from increased knowledge of the pattern and levels of incidence of Listeria spp. in both raw materials and finished products, and the strict hygienic procedures needed to avoid and prevent recontamination. Greater knowledge and compliance could result in better control of L. monocytogenes and other Listeria spp. in RTE-MP sold and consumed in Jordan.

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REFERENCES


13. European Food Safety Authority. 2007. Scientific opinion of the panel on biological hazards on a request from the European Commission on Request for updating the former SCVPH opinion on Listeria monocytogenes risk related to ready to eat foods and scientific advice on different levels of Listeria monocytogenes in ready to eat foods and the related risk for human illness. EFSA J. 599:1–42.


