

Journal of the Hellenic Veterinary Medical Society

Vol 61, No 1 (2010)



Prevalence of *Listeria* spp. in freshwater *Tilapia* (*Oncorhynchus mykiss* and *Carassius gibelio*) and the environment of fish markets in Northern Greece

Th. PAPADOPOULOS (Θ. ΠΑΠΑΔΟΠΟΥΛΟΣ), A. ABRAHIM, D. SERGELIDIS (Δ. ΣΕΡΓΚΕΛΙΔΗΣ), I. KIRKLOUDIS (Ι. ΚΥΡΚΟΥΔΗΣ), K. BITCHAVA (Κ. ΜΠΙΤΧΑΒΑ)

doi: [10.12681/jhvms.14868](https://doi.org/10.12681/jhvms.14868)

To cite this article:

PAPADOPOULOS (Θ. ΠΑΠΑΔΟΠΟΥΛΟΣ) T., ABRAHIM, A., SERGELIDIS (Δ. ΣΕΡΓΚΕΛΙΔΗΣ) D., KIRKLOUDIS (Ι. ΚΥΡΚΟΥΔΗΣ) I., & BITCHAVA (Κ. ΜΠΙΤΧΑΒΑ) K. (2017). Prevalence of *Listeria* spp. in freshwater *Tilapia* (*Oncorhynchus mykiss* and *Carassius gibelio*) and the environment of fish markets in Northern Greece. *Journal of the Hellenic Veterinary Medical Society*, 61(1), 15–22. <https://doi.org/10.12681/jhvms.14868>

■ Prevalence of *Listeria* spp. in freshwater fish (*Oncorhynchus mykiss* and *Carassius gibelio*) and the environment of fish markets in Northern Greece

Papadopoulos Th.¹, DVM, MSc, Abraham A.², DVM, MSc, PhD, Sergelidis D.², DVM, PhD, Kirkoudis I.³, DVM, PhD, Bitchava K.⁴, DVM, PhD

¹Veterinary Centre of Amynteo, Prefecture of Florina

²Laboratory of Hygiene of Foods of Animal Origin, Department of Hygiene and Technology of Foods of Animal Origin, Faculty of Veterinary Medicine, Aristotle University of Thessaloniki

³Laboratory of Ecology-Wildlife Management, Department of Forestry and Environmental Management and Natural Resources, Democritus University of Thrace

⁴Laboratory of Ichthyology & Fish Pathology, Faculty of Veterinary Medicine, University of Thessaly

■ Παρουσία των *Listeria* spp. σε ψάρια του γλυκού νερού (*Oncorhynchus mykiss* και *Carassius gibelio*) και στο περιβάλλον ιχθυοπωλείων της Βόρειας Ελλάδας

Θ. Παπαδόπουλος¹, DVM, MSc, Α. Αμπραχίμ², DVM, MSc, PhD, Δ. Σεργκελίδης², DVM, PhD, Ι. Κιρκούδης³, DVM, PhD, Κ. Μπιτσαβά⁴, DVM, PhD

¹Κτηνιατρικό Κέντρο Αμυνταίου, Νομαρχία Φλώρινας

²Εργαστήριο Υγιεινής Τροφίμων Ζωικής Προέλευσης, Τομέας Υγιεινής και Τεχνολογίας Τροφίμων Ζωικής Προέλευσης, Κτηνιατρική Σχολή, Αριστοτέλειο Πανεπιστήμιο Θεσσαλονίκης

³Εργαστήριο Οικολογίας-Διαχείρισης Άγριας Ζωής, Τμήμα Δασολογίας και Διαχείρισης Περιβάλλοντος και Φυσικών Πόρων, Δημοκρίτειο Πανεπιστήμιο Θράκης

⁴Εργαστήριο Ιχθυολογίας και Ιχθυοπαθολογίας, Κτηνιατρική Σχολή, Πανεπιστήμιο Θεσσαλίας

Correspondence: Sergelidis D.

Laboratory of Hygiene of Foods of Animal Origin, Department of Hygiene and Technology of Foods of Animal Origin, Faculty of Veterinary Medicine, Aristotle University of Thessaloniki
University Campus, 541 24 Thessaloniki
Tel: +30 2310 999970, Fax: +30 2310 999833, E-mail:dsergkel@vet.auth.gr

Αλληλογραφία: Δ. Σεργκελίδης

Εργαστήριο Υγιεινής Τροφίμων Ζωικής Προέλευσης, Τομέας Υγιεινής και Τεχνολογίας Τροφίμων Ζωικής Προέλευσης, Κτηνιατρική Σχολή, Αριστοτέλειο Πανεπιστήμιο Θεσσαλονίκης,
541 24 Θεσσαλονίκη
Τηλ.: 2310 999970, Fax: 2310 999833, E-mail:dsergkel@vet.auth.gr

Submission date: 13.01.2010

Approval date: 19.04.2010

Ημερομηνία υποβολής: 13.01.2010

Ημερομηνία εγκρίσεως: 19.04.2010

ABSTRACT. In this study, a total of 405 samples from freshwater fish, personnel and environment were collected from retail fish markets in three cities in Northern Greece and they were examined for the presence of *Listeria* spp. They consisted of 136 samples from the skin and 136 from the flesh of 71 rainbow trout (*Oncorhynchus mykiss*) and 65 gibel carps (*Carassius gibelio*), 20 from workers' hands, 27 from workers' knives, 22 from working surfaces, 29 from wooden boxes, 15 from plastic boxes, 18 from floor surfaces and 2 from drainage lids. *Listeria* spp. was isolated from 10.62% of the samples, *L. monocytogenes* were 0.99%, 4.69% *L. seeligeri* and 4.94% *L. innocua*, respectively. *L. monocytogenes* was isolated from 3.54% of the environmental samples and none from fresh water fish and workers hands' samples. *Listeria* spp. was isolated from 1.54% of gibel carp flesh (1.54% *L. seeligeri*), from 18.46% of gibel carp skin (10.77% *L. seeligeri* and 7.69% *L. innocua*) and from 8.45% from rainbow trout skin samples (1.41% *L. seeligeri* and 7.04% *L. innocua*). The higher rate of isolation of *Listeria* spp. from the environmental samples emphasises the importance of sanitary conditions in order to reduce the risk of contamination by *L. monocytogenes* at the retail level.

Keywords: *Listeria* spp., fresh water fish, fish markets, environment

ΠΕΡΙΛΗΨΗ. Στην παρούσα μελέτη, 405 συνολικά δείγματα από ψάρια του γλυκού νερού, το προσωπικό και το περιβάλλον ιχθυοπωλείων τριών πόλεων της Β. Ελλάδας εξετάστηκαν για την παρουσία των *Listeria* spp. Τα δείγματα αυτά ελήφθησαν 136 από την επιδερμίδα και 136 από τη σάρκα 71 πεστροφών (*Oncorhynchus mykiss*) και 65 κυπρίνων (*Carassius gibelio*), 20 από τα χέρια του προσωπικού, 27 από τα μαχαίρια, 22 από τις επιφάνειες εργασίας, 29 από ξύλινες κάσες, 15 από πλαστικές κάσες, 18 από τα δάπεδα και 2 από καπάκια αποχετεύσεων. *Listeria* spp. απομονώθηκαν σε ποσοστό 10,62% των δειγμάτων, εκ των οποίων 0,99% ήταν *L. monocytogenes*, 6,69% *L. seeligeri* και 4,943% *L. innocua*, αντιστοίχως. *L. monocytogenes* απομονώθηκε σε ποσοστό 3,54% των δειγμάτων του περιβάλλοντος και σε κανένα από τα δείγματα των ψαριών του γλυκού νερού και των χεριών του προσωπικού. *Listeria* spp. απομονώθηκε σε ποσοστό 1,54% των δειγμάτων από τη σάρκα των κυπρίνων (1,54% *L. seeligeri*), 18,46% των δειγμάτων από την επιδερμίδα των κυπρίνων (10,77% *L. seeligeri* και 7,69% *L. innocua*) και 8,45% των δειγμάτων από την επιδερμίδα των πεστροφών (1,41% *L. seeligeri* και 7,04% *L. innocua*). Το υψηλότερο ποσοστό απομόνωσης των *Listeria* spp. από τα δείγματα του περιβάλλοντος τονίζουν τη σημασία των συνθηκών υγιεινής ώστε να ελαττωθεί ο κίνδυνος μόλυνσης με *L. monocytogenes* στο επίπεδο λιανικής πώλησης.

Λέξεις ευρετηγίωσης: *Listeria* spp., ψάρια του γλυκού νερού, ιχθυοπωλεία, περιβάλλον

INTRODUCTION

Listeriosis is a disease caused by bacteria of the genus *Listeria* and it usually affects immunosuppressed persons, causing meningitis, septicaemia and perinatal disease (Newman et al. 1979, Lamont et al. 1988, Ahmed 1991, Koch and Stark 2006). *L. monocytogenes* is a pathogenic species in both animals and humans (McLauchlin and Jones 1999). However, in a few cases of human infections, *L. ivanovii* (Cummins et al. 1994, Lessing et al. 1994) and *L. seeligeri* (Rocourt et al. 1986) have been incriminated as causative agents.

Although an average of five to nine exposures to *L. monocytogenes* occur per person per year (Grif et al. 2003), listeriosis is a rather rare disease (Gerner-Smidt et al. 2005), but it is associated with a mortality rate of approximately 20% to 40% (Farber and Peterkin 1991, De Valk et al. 2005).

Elderly people, aged 65 years and older, pregnant women, unborn infants and neonates are the risk groups that are affected by the pathogen, due to which, during the last decade, a new form of the disease has been recognized with short incubation period, characterized by mild disorders of the

gastrointestinal system (FAO 1999).

L. monocytogenes is ubiquitous in nature (Donnelly 1994) and it has been isolated from many different foods of animal and plant origin and ready-to-eat products in Greece and Europe (Abraham et al. 1998, Angelidis and Koutsoumanis 2006, EFSA 2006). Decaying vegetation and soil, animal faeces, sewage, silage and water have been found to harbour this pathogen (Jay 2000). It has, also, been isolated from a range of fishery products, including frozen seafood, ready-to-eat shrimp, crabmeat and cold- and hot-smoked salmon, gravid salmon, surimi-based products, marinated fish, fermented fish and fish salads (Weagant et al. 1988, Jemmi 1990, Farber 1991, Ben Embarek 1994, Gudbjornsdottir et al. 2004).

Fish and fish products have been epidemiologically linked as vectors for outbreaks of listeriosis (Farber and Peterkin 1991, Madden 1994). Contaminated fishery products, such as cold-smoked salmon, smoked cod roe, shrimp, mussels and undercooked fish, have been assumed to be sources or sporadic cases of listeriosis (Ericson et al. 1997, Brett et al. 1998, Miettinen et al. 1999).

Lennon et al. (1984) observed a cluster of 22 perinatal listeriosis cases and a relationship between them and the consumption of contaminated raw fish and shell fish. Facinelli et al. (1989) reported a case of listeriosis due to consumption of undercooked fish, which was confirmed by phage typing and DNA fingerprinting. These cases of listeriosis emphasize the need for additional information on the behaviour and epidemiology of *L. monocytogenes* in fish and seafood and, moreover, about the routes of transmission to ready-to-eat fishery products, especially the minimum processed ones.

The prevalence of *Listeria* spp. has been reported in some marine fish in Greece (Soultois et al. 2006, Papadopoulou et al. 2006). However, scanty information is available on isolation from freshwater fish and the environment of the fish markets (Papadopoulou et al. 2006). Thus, the purpose of the present study was to investigate the presence of *Listeria* spp. in freshwater fish, the personnel and the environment of fish markets in Northern Greece.

MATERIALS AND METHODS

Sampling

Seventy one rainbow trout (*Oncorhynchus mykiss*) and 65 gibel carp (*Carassius gibelio*), with mean weight 340 ± 10 g and 490 ± 12 g respectively, were examined from fish markets from three cities in Northern Greece. Gibel carp originated from three nearby lakes and rainbow trout from fish farms located in streams near these lakes. The fish were brought to the markets covered with ice within the fishing day. The fish were collected in sterile stomacher bags and brought to the laboratory for examination in portable insulated boxes. In the laboratory, flesh and skin were sampled from each fish.

Moreover, 133 environmental and personnel swabbed samples were examined from the fish markets. Twenty of them were taken from workers' hands, 27 from workers' knives, 22 from work surfaces (wooden board), 29 from wooden boxes, 15 from plastic boxes, 18 from floor surfaces and 2 from drainage lids. For this purpose, about 100 cm² of plane surfaces, workers' hands and knives' surfaces were swabbed 2-5 times by the wet-dry double swab technique (Anonymous 2001), using sterile cotton swabs moistened with 0.1% peptone water containing

0.85% NaCl followed by a second swabbing using a dry swab. The 2-5 swabs were pooled as one sample. Swabbing was carried out in the middle of a working day. They were transported to the laboratory inside portable insulated boxes at 4°C and processed within 3 hours of collection.

The kind of retail markets investigated were super markets, fish markets and open air fish markets.

Isolation of *Listeria* spp.

Isolation of *Listeria* spp. was based on EN ISO 11290-1:1997 (Anonymous 1997). Immediately after the arrival of the fish in the laboratory, their skin surfaces were swabbed using the same technique that is described for environmental sampling. In this case, the sterile cotton swabs were moistened in tubes containing 10 ml of sterile half Frazier broth (4 swabs per sample). Gills were included in the swabbing area. In addition, 25-g samples of flesh of the fish were taken from the anterior-dorsal region, after aseptically skinned, and they were placed into sterile stomacher bags containing 225 ml of half Frazier broth; the samples were blended for 2 minutes in a stomacher (Lab Blender 400, A. J. Seward and Co. Ltd., London).

All fish, personnel and environmental swabbed samples were placed into half Fraser broth and incubated at 30°C for 24 hours. An aliquot of 0.1 ml of these primary enrichments were transferred into tubes containing 10 ml of full Fraser broth and incubated for secondary enrichment at 35°C for 24-48 hours. After incubation, a loopful of them was streaked onto Oxford agar (LAB M, Hal 10 UK) and ALOA agar (LAB M, Hal 10 UK) and it was incubated at 37°C for 24-48 h.

Identification of *Listeria* spp.

Three to four suspected colonies from ALOA and Oxford agar were subcultured to tryptone soy agar supplemented with 0.6% yeast extract (TSA-YE, Lab M) for purity and they were incubated at 37°C for 24 hours. All isolates were identified based on the criteria suggested by Seeliger and Jones (1986) and Lovett (Lovett 1988). In addition, the isolates of *L. monocytogenes* and *Listeria* spp. were identified using the Microgen™ *Listeria* ID MID-67 (Microgen Bioproducts Ltd., UK).

Statistical analysis

All statistical analysis was performed by a Student's t-test.

Table 1. Incidence of *Listeria* spp. in fresh water fish, personnel and environment of fish markets.

Origin of sample	Number of samples	Number and % of samples positive for			
		<i>Listeria</i> spp.	<i>L. monocytogenes</i>	<i>L. seeligeri</i>	<i>L. innocua</i>
Gibel carp flesh	65	1 (1.54%)	–	1 (1.54%)	–
Rainbow trout flesh	71	–	–	–	–
Gibel carp skin	65	12 (18.46%)	–	7 (10.77%)	5 (7.69%)
Rainbow trout skin	71	6 (8.45%)	–	1 (1.41%)	5 (7.04%)
Workers' hands	20	3 (15%)	–	2 (10%)	1 (5%)
Environment	113	21 (18.58%)	4 (3.54%)	8 (7.08%)	9 (7.96%)
Total	405	43 (10.61%)	4 (0.99%)	19 (4.69%)	20 (4.94%)

RESULTS

Listeria spp. was isolated from 43 of the total 405 samples (10.62%). From these isolates, 4/405 (0.99%) were *L. monocytogenes*, 19/405 (4.69%) *L. seeligeri* and 20/405 (4.94%) *L. innocua*, respectively (Table 1).

Only *L. seeligeri* was isolated from 1/65 samples (1.54%) from gibel carp flesh (Table 1). *Listeria* spp. was isolated from 12/65 (18.46%) of the gibel carp skin and from 6/71 (8.45%) rainbow trout skin samples, respectively. *L. seeligeri* and *L. innocua* were isolated from 7/65 (10.77%) and 5/65 (7.69%) of the gibel carp and 1/71 (1.41%) and 5/71 (7.04%) rainbow trout samples. *L. monocytogenes* did not detected in any of the fish samples (Table 1).

As it is shown in table 1, *L. seeligeri* was isolated in 2/20 (10%) samples from workers' hands and *L. innocua* in 1/20 (5%).

Listeria spp. was isolated from 21/113 (18.58%) of the environmental samples, from 4/27 (14.81%) of the knives' samples, from 6/29 (20.69%) of wooden boxes, from 2/15 (13.30%) of plastic boxes, from 4/22 (18.18%) of work surfaces (wooden board), from 3/18 (16.67%) of floor samples and from 2/2 (100%) of the drainage lids samples. *L. monocytogenes*, *L. seeligeri* and *L. innocua* were isolated from 4/113 (3.54%), 8/113 (7.08%) and 9/113 (7.96%) of the environmental samples, respectively. *L. monocytogenes* was detected in 2/29 (6.90%) samples taken from wooden boxes, from 1/18 (5.55%) of floor samples and 1/2 (50%) of the drainage lids samples (Table 2).

As it is shown in table 3, the incidence of *Listeria*

spp. was higher ($P \leq 0.05$) in the environment and the personnel of fish markets and open air markets (20% and 19.51%, respectively) than that of super markets (9.52%).

DISCUSSION

In the present study *L. monocytogenes* was not isolated from any of the freshwater fish samples examined. *L. innocua* and *L. seeligeri* were the dominant strains isolated from fish skin. Similar results were reported by Papadopoulou et al. (2006). They isolated *Listeria innocua* from 1% of trout (*Salmo trutta*) samples from retail markets in Greece. These two *Listeria* species were also detected in trout (*Oncorhynchus mykiss*) in Great Britain and Portugal. In Great Britain, 1 out 30 samples from fresh water fish was positive to *L. monocytogenes* (Davies et al. 2001).

Gonzalez-Rodriguez et al. (2002) reported that listeriae were not detected in salmon slices. The same authors found on trout fillets, recovered from eight different lots, 11 strains of *L. innocua*, after 4 days storage at 3°C. One of the examined fillets was contaminated with *L. monocytogenes*.

Panda and Garg (2003) isolated *Listeria* spp. from 28 out of 120 (23.33%) samples in fresh water fish in India. These included *L. monocytogenes* from 2 (1.66%) and *L. innocua* from 26 (21.66%) samples. In another study, also in India, Jallewar et al. (2007) isolated *Listeria* spp. from 20% of freshwater fish samples (walking catfish). Of these samples, 67%, 21%, 8% and 2% were *L. monocytogenes*, *L. seeligeri*, *L. grayi* and *L. welshimeti*, respectively. 33 % of the

Table 2. Incidence of *Listeria* spp. in environmental samples.

Location	Number of samples	Number and % of samples positive for			
		<i>Listeria</i> spp.	<i>L. monocytogenes</i>	<i>L. seeligeri</i>	<i>L. innocua</i>
Workers' knives	27	4 (14.81%)	–	2 (7.41%)	2 (7.41%)
Containers (wooden boxes)	29	6 (20.69%)	2 (6.90%)	3 (10.34%)	1(3.45%)
Containers (plastic boxes)	15	2 (13.3%)	–	1 (6.67%)	1 (6.67%)
Working surfaces (wooden board)	22	4 (18.18%)	–	2 (9.09%)	2 (9.09%)
Floor surfaces	18	3 (16.67%)	1 (5.56%)	–	2 (11.11%)
Drainage lids	2	2 (100%)	1 (50%)		1 (50%)
Total	113	21 (18.58%)	4 (3.54%)	8 (7.08%)	9 (7.96%)

Table 3. Incidence of *Listeria* spp. in environmental and personnel samples by the kind of retail markets' origin.

Location	Number of samples	Number and % of samples positive for			
		<i>Listeria</i> spp.	<i>L. monocytogenes</i>	<i>L. seeligeri</i>	<i>L. innocua</i>
Super markets	21	2 (9.52%)	1 (4.76%)	–	1 (4.76%)
Fish markets	30	6 (20%)	1 (3.33%)	4 (13.33%)	2 (6.67%)
Open air markets	82	16 (19.51%)	2 (2.44%)	6 (7.32%)	7 (8.54%)
Total	133	24 (18.04)	4 (3.01%)	10 (7.52%)	10 (7.52%)

positive to *L. monocytogenes* samples were muscle fish samples. *L. monocytogenes* was not detected in any marine and freshwater fish samples, which were obtained from local retail market in India, although 33% of the samples harboured *Listeria* spp. (Fucks and Surendran 1989).

L. monocytogenes was detected in 2 out of 20 trout (*Oncorhynchus mykiss*) samples from Great Britain, but neither was detected in samples from France and Portugal (Davies et al. 2001).

According to Miettinen and Wirtanen (2005), the prevalence of *L. monocytogenes* varied greatly between different fish farms of rainbow trout in Finland, from 0 to 100% in pooled samples and from 0 to 75%, according to individually studied fish samples. The prevalence of *L. monocytogenes*, *L. innocua*, *L. seeligeri* and *L. welshimeri* was 27.8%, 33.3%, 22.2% and 5.6%, respectively. Only 4.4% of the *L. monocytogenes*

positive samples were obtained from skin or viscera in this study.

Hansen et al. (2006) isolated *L. monocytogenes* from 8% of rainbow trout samples in Denmark and Vaz-Velho et al. (2000) isolated *L. monocytogenes* from one fresh salmon trout and one from swordfish out of 234 fish samples examined in Portugal.

The prevalence of the pathogen in raw salmon from Chile, Norway and the west coast of the US has been reported to be 8.0%, 21% and 29.5%, respectively (Hoffman et al. 2003). In other studies the prevalence of *L. monocytogenes* has been found to be 7.8% for salmon in the USA (Norton et al. 2001) and 7.4% in Denmark (Fonnesbech et al. 2001). *L. monocytogenes* was isolated in rainbow trout from retail markets in USA from 54% of the 74 samples examined (Draughon et al. 1999). In Turkey, *Listeria* spp. was isolated from 6.6% of the samples taken from

the intestinal content of fresh water fish (Ertas and Seker 2005).

According to the reported results in the literature, there is a broad range of *L. monocytogenes* prevalence in fresh water fish. Potential contamination sources may be polluted waters, soiled surfaces, ice, boxes, as well as human and avian sources (Parihar et al. 2008). Since *L. monocytogenes* is found in coastal waters and in surface waters of lakes, fish living or cultivated in these areas may possibly carry this pathogen (FAO 1999).

In the present study, the incidence of *Listeria* spp. and *L. monocytogenes* in the samples from personnel and the market environment was higher ($p \leq 0.05$) than that from fish samples. Hansen et al. (2006), in a study in Denmark on prevalence and survival of *L. monocytogenes* in Danish aquatic and fish processing environments, reported that the prevalence increased with the degree of human activity. It was not detected in a freshwater stream, it was 2% in the seawater fish farms, 10% in freshwater fish farms, 16% in fish slaughterhouses and 68% in fish smokehouses. During salmon filleting process, *L. monocytogenes* can be transferred from the flesh to cut surfaces, slicing machines and tables, contaminating 60% of these apparatuses, which become potential sources of contamination (Duffes 1999). The incidence of *L. monocytogenes* in boxes and floor surfaces may have serious impact on cross-contamination of fish and it may pose a health risk.

Vogel et al. (2001) reported that the RAPD (random amplified polymorphic DNA) profile of *L. monocytogenes* that was detected in cold-smoked salmon was identical to types that were isolated on the processing equipment and in the processing environment and not to the types isolated from raw fish. It seemed that contamination of the final product was due to contamination during processing rather than to contamination from raw fish. These findings do not minimize the importance of raw fish as a source of contamination to the processing environment and the final product.

The low incidence of listeriae in the fish skin

compared to inorganic surfaces seems to be a consequence of the nature of the skin and mucus as part of the fish immune system containing antimicrobial substances (Greenlee et al. 1991, Fernandes and Smith 2002).

The presence of *L. monocytogenes* and other *Listeria* spp. in personnel and environmental samples from fish and open-air markets proves that contamination of boxes and floor samples is due to bad hygienic practices during processing of fresh fish. *Listeria* spp. was not detected in any of the super market personnel samples and, at a lower than the other markets' rate, from their environmental samples ($P \leq 0.05$), probably because super markets follow good hygienic practices and comply with food safety regulations (Table 3).

A common practice in retail fish markets is evisceration and scalding of fish before they are given to the consumers. This practice seems to contribute to the expansion of the contamination to fish, utensils, personnel and the environment of the retail market, if handling is not in accordance with the hygienic rules.

A very important prerequisite for control of *L. monocytogenes* is knowledge, concerning its niches during processing, especially for minimally processed products, such as cold-smoked fish, which have been a major delicatessen commodity. It is reported that *L. monocytogenes* was detected in 10-40% of samples from freshly produced cold-smoked fish (Autio et al. 1999, Jorgensen and Huss 1998).

Contaminated fish may be potential vectors for this psychrotrophic pathogen and they may cause contamination of the refrigerators' and kitchen's environment and thus cross-contamination of other foods, especially ready-to-eat foods that do not need additional thermal processing before consumption. Moreover, diligent enforcement of sanitary conditions of food contact surfaces and handling areas and personal hygiene practices may contribute to the reduction of potential contamination of fishery products by *Listeria monocytogenes* at the retail level. ■

REFERENCES

- Abraham A, Papa A, Soutlos N, Ambrosiadis I, Antoniadis A. (1998) Antibiotic resistance of *Salmonella* spp. and *Listeria* spp. isolates from traditionally made fresh sausages in Greece. J Food Prot 61:1378-1380.
- Ahmed FE (1991) Seafood safety. Committee on evaluation of the safety of fish products. National Academy Press. Washington, D. C., pp. 57.
- Angelidis AS, Koutsoumanis K (2006) Prevalence and concentration of *Listeria monocytogenes* in sliced ready-to-eat meat products in the Hellenic retail market. J. Food Prot 69: 938-942.
- Anonymous (1997) Microbiology of food animal feedstuffs-horizontal method for the detection and enumeration of *L. monocytogenes*. BS EN ISO 11290-1:1997. BS5763: Part 18:1997. London: British Standard Institute.
- Anonymous (2001) Commission Decision of 8 June 2001 (2001/471/EC). Official Journal of the European Communities L 165: 48-53.
- Autio T, Hielm S, Miettinen M, Sjöberg AM, Aarnisalo K, Björkroth J, Mattila-Sandholm T, Korkeala H (1999) Sources of *Listeria monocytogenes* contamination in a cold-smoked rainbow trout processing plant detected by pulsed-field gel electrophoresis typing. Appl Environ Microbiol 65:150-155.
- Ben Embarek PK (1994) Presence, detection and growth of *Listeria monocytogenes* in seafoods. A review. Int J Food Microbiol 23:17-34.
- Brett M, Short P, McLauchlin J (1998) A small outbreak of listeriosis associated with smoked mussels. Int J Food Microbiol 43:223-229.
- Cummins AJ, Fielding AK, McLauchlin J (1994) *Listeria ivanovii* infection in a patient with AIDS. J Infect 28:89-91.
- Davies AR, Capell C, Jehanno D, Nychas JE, Kirby RM, (2001) Incidence of foodborne pathogens on European fish. Food Control 12:67-71.
- De Valk H, Jacquet C, Goylet V, Vaillant V, Perra A, Smon F, Desenclos JC, Martin P (2005) Surveillance of *Listeria* infections in Europe. Eurosurveillance 10:251-255.
- Donnelly CW (1994) *Listeria monocytogenes*. In: Foodborne disease Handbook Diseases caused by bacteria (Hui YH, Gorham JR, Murrell KD, Cliver DO eds.) Marcel Dekker, Inc. New York, pp 215-216.
- Draughon FA, Antony BA, Denton ME (1999) *Listeria* species in fresh rainbow trout purchased from retail markets. Dairy Food Environ Sanit 19:90-94.
- Duffes F (1999) Improving the control of *Listeria monocytogenes* in cold smoked salmon. Food Science Technol 10:211-216.
- EFSA (2006) The Community Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents, Antimicrobial resistance and Foodborne outbreaks in the European Union in 2006. Available from: http://www.efsa.europa.eu/EFSA/DocumentSet/Zoon_report_2006_en.pdf.
- Ericson H, Elkow A, Danielsoon-Them M, Loncarevic W, Mentzing L, Person I, Unnerstad H, Tham W (1997) An outbreak of listeriosis suspected to have been caused by rainbow trout. J Clinical Microbiol 35:2904-2907.
- Ertas HB, Seker E (2005) Isolation *Listeria monocytogenes* from fish intestines and RAPD analysis. Turk J. Vet Anim Sci 29:1007-1011. View Record in Scopus | Cited By in Scopus (1).
- FAO (1999) Report of the FAO expert consultation on the trade impact of *Listeria* in fish products. FAO Fisheries Report No 64. FIIU/ESNS/R604, Amherst, MA, United States.
- Facinelli B, Varaldo PE, Toni M, Casolari C, Fabio U (1989) Ignorance about *Listeria*. Br Med J 299, 738.
- Farber JM (1991) *Listeria monocytogenes* in fish products. J Food Prot 54:922-924.
- Farber JM, Peterkin PI (1991) *Listeria monocytogenes*, a foodborne pathogen. Microbiol Rev 55:476-511.
- Fernandes JMO, Smith VJ (2002) A novel antimicrobial function for a ribosomal peptide from rainbow trout skin. Biochem Biophys Research Communication 296:167-171.
- Fonnesbech VB, Huss HH, Ojenyi B, Ahrens P, Gram L (2001) Elucidation of *Listeria monocytogenes* contamination routes in cold-smoked salmon processing plants detected by DNA-based typing methods. Appl Environ Microbiol 67:2586-2595.
- Fucks RS, Surendran PK (1989) Incidence of *Listeria* in tropical fish and fishery products. Lett Appl Microbiol 9:49-51.
- Gerner-Smidt P, Ethelberg W, Schiellerup P, Christensen JJ, Engeberg J, Fussing V, Jensen A, Petersen AM, Bruun BG (2005) Invasive listeriosis in Denmark 1994-2003: a review of 299 cases with special emphasis on risk factors for mortality. Clin Microbiol Infect 11:618-624.
- Grenlee AR, Brown RA, Ristow SS (1991) Non specific cytotoxic cell of rainbow trout (*Oncorhynchus mykiss*) kill YAC-1 targets by both necrotic and apoptic mechanisms. Develop Compar Immunol 15:153-164.
- Grif K, Patscheider F, Dierich MP (2003) Incidence of fecal carriage of *Listeria monocytogenes* in three healthy volunteers: a one-year prospective stool survey. Eur J Clin Microbiol Infect Dis 22:16-20.
- Gonzalez-Rondriques MN, Sanz JJ, Santos JA, Otero A, Garcia-Lopez ML (2002) Foodborne pathogenic bacteria in prepackaged fresh retail portions of farmed rainbow trout and salmon stored at 30 °C. Int. J Food Microbiol 76:135-141.
- Gudbjornsdottir B, Suiko ML, Gustavsson P, Thorkelsson G, Salo S, Sjöberg AM (2004) The incidence of *L. monocytogenes* in meat, poultry and seafood plants in Nordic Countries. Food Microbiol 21:217-225.
- Hansen CH, Vogel BF, Gram L (2006). Prevalence and survival of *Listeria monocytogenes* in Danish aquatic and fish-processing environments. J Food Prot 69:2113-2122.
- Hoffman A, Gall KL, Norton DM, Wiedmann M (2003) *Listeria monocytogenes* contamination patterns for he smoked fish processing environment and for raw fish. J. Food Prot 66:52-60.
- Jallewar PK, Kalorey DR, Kurkure NV, Pande VV, Barbuddhe SB (2007) Genotypic characterization of *Listeria* spp. isolated from freshwater fish. Int J Food Microbiol 114:120-123.
- Jay JM (2000) Modern Food Microbiology. An Aspen Publication and Aspen publishers, Inc. Gaithersburg, Maryland.
- Jemmi T (1990) Actual knowledge of *Listeria* in meat and fish products. Mitt Geb Lebensmittel Hyg 81:144-157.
- Jorgensen LV, Huss HH (1998) Prevalence and growth of *Listeria monocytogenes* in naturally contaminated seafood. Int J Food Microbiol 42:127-131.
- Koch J, Stark K (2006) Significant increase of listeriosis in Germany-Epidemiological patterns 2001-2005. Eurosurveillance, 11:85-8. Available from: <http://www.eurosurveillance.org/em/v11n6/1106-224.asp>.
- Lamont RJ, Postelthwaite R, Maggowan AP (1988) *Listeria monocytogenes* and its role in human infection. J Infect 17:7-28.

- Lennon D, Lewis B, Mantell C, Becroft D, Dove B, Faemer K, Tonkin S, Yeates N, Stamp R, Mickleson K (1984) Epidemic perinatal listeriosis. *Pediatr Infect Dis* 3:30-34.
- Lessing MPA, Curtis GDW, Bowler ICJ (1994) *Listeria ivanovii* infection. *J. Infect* 29:230-231.
- Lovett J (1988) Isolation and enumeration of *Listeria monocytogenes*. *Food Technol* 42:162-175.
- Madden JM (1994) Concerns regarding the occurrence of *Listeria monocytogenes*, *Campylobacter jejuni* and *Escherichia coli* 0157:H7 in foods regulated by the U.S. Food and Drug Administration. *Dairy Food Environ Sanit* 14:262-267.
- McLauchlin J, Jones D (1999) *Erysipelothrix* and *Listeria*. In: *Microbiology and Microbial Infections* (Borriello SP, Duerden BI eds.), Topley and Wilson's *Systematic Bacteriology*, London, UK.
- Miettinen MK, Siitonen A., Heiskanen P, Haajanen H, Bjorkroth KJ, Korkeala HJ (1999) Molecular epidemiology of an outbreak of febrile gastroenteritis caused by *Listeria monocytogenes* in cold-smoked rainbow trout. *J Clin Microbiol* 37:2358-2360.
- Miettinen H, Wirtanen G (2005) Prevalence and location of *Listeria monocytogenes* in farmed rainbow trout. *Int J Food Microbiol* 104:135-143.
- Newman JJ, Waycott S, Cooney LM (1979) Arthritis due to *Listeria monocytogenes*. *Arthritis Rheumatism* 22:1139-1140.
- Norton DM, McCamey MA, Gall KL, Scarlett JM, Boor KJ, Wiedmann M (2001) Molecular studies on the ecology of *Listeria monocytogenes* in the smoked fish processing industry. *Appl Environ Microbiol* 67:198-205.
- Pand AK, Garg SR (2003) Prevalence of *Listeria* in foods of animal origin. *Indian J Anim Science* 73:967-968.
- Papadopoulou C, Economou E, Zakas G, Salamoura C, Dontorou C, Apostolou J (2006) Microbiological and pathogenic contaminants of seafood in Greece. *J Food Quality* 30:28-42.
- Parihar VS, Barbudhe SB, Danielsson-Tham ML, Tham W (2008) Isolation and characterization of *Listeria* species from tropical seafoods. *Food Control* 19:566-569.
- Rocourt J, Hof H, Schrettenbrunner A, Malinverni R, Bille J (1986). Acute purulent *Listeria seeligeri* meningitis in an immunocompetent adult. *Schweiz Med Wochenshr* 116:248-251.
- Seeliger HPR, Jones D (1986) *Bergey's Manual of Systematic Bacteriology*. Regular, Nonsporing Gram-positive Rods. In: *Genus Listeria* (O. Kandler and N. Weiss eds.). Williams & Wilkins, Baltimore, pp 1235-1245.
- Soultos N, Abraham A, Papageorgiou K, Steris V (2006) Incidence of *Listeria* spp. in fish and environment of fish markets in Northern Greece. *Food Control* 18:554-557.
- Vaz-Velho M, Duarte G, Gibbs P (2000). Evaluation of mini-VIDAS rapid test for detection of *Listeria monocytogenes* from production lines of fresh to cold-smoked fish. *J Microbiol Methods* 40:147-151.
- Vogel BFL, Jorgensen V, Ojenyi B, Huss HH, Gram L (2001). Diversity of *Listeria monocytogenes* contamination routes in cold smoked salmon produced in different smoke houses as assessed by random amplified polymorphic DNA analyses. *Int J Food Microbiol* 67:83-92.
- Weagant SD, Sado PN, Colburn KG, Torkelson JD, Stanley FA, Krane MH, Shields SC, Thayer CF (1988) The incidence of *Listeria* species in frozen seafood products. *J Food Prot* 51:655-657.

