Risk from Listeria monocytogenes in ready to eat smoked fish: Hazard identification

Listeria monocytogenes is a ubiquitous Gram-positive bacterium which occurs naturally in terrestrial and aquatic (fresh and salt water) environments (Thomas et al., 2012). Smoked fish has been identified as a vehicle for *L. monocytogenes* due to a combination of specific factors including a relatively high prevalence of initial contamination on fish, processing which may not fully eliminate contamination which is present, a production process with multiple opportunities for contamination or recontamination and a final product which can support the growth of the bacterium over its relatively extended shelf life (FAO and WHO, 2006; Ricci et al., 2017).

Listeriosis is an illness that is caused by infection with the bacterium *L. monocytogenes*, and while it usually presents as self-limiting mild gastroenteritis in immunocompetent people, it can cause serious illness (invasive listeriosis) in vulnerable people such as people aged over 65, pregnant women and those with impaired immunity (Thomas et al., 2012). The difficulty in eliminating *L. monocytogenes* from RTE products which can support its growth, and the very low relative risk to the population as a whole, is recognised in the Microbiological Criteria for Foodstuffs Regulation 2073/2005 which states that businesses must demonstrate that *L. monocytogenes* will not exceed the limit of 100 CFU/g throughout shelf life or, where the FBO is unable to demonstrate to the satisfaction of the Competent Authority that the product will not exceed 100 CFU/g at the end of shelf life, absence in 25 g before the product has left the immediate control of the FBO. A number of techniques can be used to determine shelf life, including shelf-life studies and historical data, predictive (computer) modelling and challenge testing. Any studies must be carried out using realistic parameters that the food will be subjected to, including the conditions during manufacture, transport, retail and in the consumer's home.

There are 17 species in the genus Listeria with two (*L. monocytogenes* and *L. ivanovii*) considered pathogens of any species (Orsi and Wiedmann, 2016). *L. ivanovii* is generally considered a pathogen of ruminants which may opportunistically infect humans, whereas *L. monocytogenes* is an important human foodborne pathogen (Guillet et al., 2010; Orsi and Wiedmann, 2016). As well as environmental testing for *L. monocytogenes,* businesses may also test for *Listeria spp.* in their processing environment as an indicator organism to ensure the efficacy of their cleaning protocol (Thomas et al., 2012; Townsend et al., 2021).

Microbial description

L. monocytogenes is a species of Gram positive, facultatively anaerobic, rod-shaped bacteria, which are non-spore forming. It can grow over a wide range of temperatures (-0.4 – 50°C) (Farber and Peterkin, 1991). There are many reservoirs of *L. monocytogenes,* as it can infect and cause listeriosis in ruminants (Walland et al., 2015) and, unlike many other foodborne pathogens, can live and grow in the natural environment without the need to grow within an animal host (Chasseignaux et al., 2001). Environmental cross-contamination is a major issue with respect to *L. monocytogenes.* It can occur through direct contact with raw materials, personnel, aerosols and contaminated utensils, equipment, etc. Cross-contamination can occur at any step where the product is exposed to the environment, including processing, transportation, retail, catering and in

the home. *L. monocytogenes* is tolerant to various environmental conditions, such as low oxygen, refrigeration temperatures (even freezing temperature -20°C), high salt (NaCl up to 10%) or acidity (pH ? 4 to 5) which results in survival for long periods (up to years) in the environment, on foods, in the processing plant, and in household refrigerators (Miller, 1992; Liu et al., 2005).