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Survey of the microbiological safety of pre-packaged dried herbs and spices (17NS3)

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Survey of the microbiological safety of pre-packaged dried herbs and spices (17NS3)

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Glossary

Acronym/abbreviation	Term
EHOs	Environmental Health Officers
EHS	Environmental Health Service
EU	European Union
FSAI	Food Safety Authority of Ireland
HSE	Health Service Executive
ICMSF	International Commission on Microbiological Specifications for Foods
Listeria	*L. monocytogenes* and *Listeria* species
NSSF	National Sample Submission Form
NSSLRL	National Salmonella, Shigella and *Listeria* Reference Laboratory
OFMLG	Official Food Microbiology Laboratory Group
RASFF	Rapid Alert System for Food & Feed
RTE	Ready to eat
STEC	Shiga toxin-producing *Escherichia coli*

Summary

Between the 1 August and 30 November 2017, the Food Safety Authority of Ireland (FSAI) in collaboration with the Environmental Health Service (EHS) and the Official Food Microbiology Laboratory Group (OFMLG) of the Health Service Executive (HSE), carried out a national survey to investigate the microbiological safety of dried herbs and spices. In total, 855 samples were collected by environmental health officers (EHOs). The naturally high levels of mould occurring in dried herbs and spices presented the laboratories with significant technical challenges in obtaining a result for some samples in which an overgrowth of mould had occurred. Therefore, results were not available for every test conducted. Samples were tested for *Listeria* (*L*. *monocytogenes* and *Listeria* species), *Salmonella,* presumptive *Bacillus cereus*, Shiga toxin-producing *Escherichia coli* (STEC), and the indicators; *Escherichia coli* and *Enterobacteriaceae*. In addition, environmental health officers (EHOs) were asked to ascertain if the dried herbs and spices had been irradiated. The results for *L*. *monocytogenes* were assessed against legal criteria (Commission Regulation (EC) No 2073/2005 as amended) while the results for all other tests were assessed against national guidelines (FSAI Guidance Note 3).

All 768 single and 73 batch[1] samples tested for *Listeria monocytogenes* were satisfactory. In addition, all 164 samples tested for STEC were satisfactory.

Four samples (0.5%) were unsatisfactory for *Salmonella,* out of a total of 790 single samples tested. *Salmonella* Infantis was detected in dill and *Salmonella* with unknown serotypes were detected in basil, ginger and dhaniya (coriander) powder. The contaminated dried basil sample originated in Egypt and was imported *via* the United Kingdom (UK), the ground ginger originated from Poland with raw materials from the Netherlands, the dill originated from Egypt and was imported *via* Germany and Lithuania while the coriander was packed and imported from the UK but its country of origin is unknown. All four *Salmonella* positive samples were removed from the Irish market.

For presumptive *B. cereus,* out of a total of 828 single samples tested, 22 samples (2.7%) were unsatisfactory while 79 samples (9.5%) were borderline. Black pepper, turmeric and basil were among the most frequently reported foods to be unsatisfactory or borderline for the limits for

[1] Single samples consist of a single sample unit (n=1) per sample whereas batch samples consist of 5 sample units (n=5) per sample.

presumptive *B. cereus*. The high level of non-compliance for presumptive *B. cereus* may be due to *Bacillus* spores being naturally present on fresh herbs and spices which are then concentrated by the drying process.

For hygiene indicators, 5 samples (0.7%) were found to be unsatisfactory for *E. coli* out of a total of 748 single samples tested while 33 (4.4%) were unsatisfactory for *Enterobacteriaceae* out of a total of 755 single samples. In addition, 5 (0.7%) *E. coli* and 87 (11.5%) *Enterobacteriaceae* samples were reported as borderline. Similar to presumptive *B. cereus*, the high number of borderline and unsatisfactory *Enterobacteriaceae* results may be due to *Enterobacteriaceae* being naturally present on fresh herbs and spices which are then concentrated by the drying process.

This survey showed that, whilst the majority of dried herbs and spices are microbiologically safe, a small percentage may be contaminated with pathogens. This has important implications for food safety if herbs and spices are used raw on ready-to-eat foods. In addition, this survey showed that dried herbs and spices are typically not decontaminated using irradiation.

Acknowledgements

The FSAI thanks those that participated in this survey including the environmental health officers, the laboratory staff of the seven official food microbiology laboratories (OFMLs) of the HSE[2]; the National *Salmonella*, *Shigella* and *Listeria* Reference Laboratory, University Hospital Galway, Newcastle Road, Galway (NSSLRL); the Department of Agriculture, Food and the Marine, Dairy Science Laboratory (National Reference Laboratory), Backweston, Celbridge, Co. Kildare; and the National VTEC Reference Laboratory, Health Service Executive Dublin Mid-Leinster, Cherry Orchard Hospital, Dublin 10.

[2] (i) Public Health Laboratory, Limerick; (ii) Public Health Laboratory, Sligo General Hospital, Sligo; (iii) Public Health Laboratory, Waterford Regional Hospital, Waterford; (iv) Public Analyst`s Laboratory, Sir Patrick Duns Hospital, Grand Canal Street, Dublin; (v) Public Health Microbiology Laboratory, St Finbarr's Hospital, Cork; (vi) Public Health Microbiology Laboratory, Cherry Orchard Hospital, Dublin; and (vii) Public Health Microbiology Laboratory, Galway University Hospitals

Introduction

Dried herbs and spices have low water activity ($a_w \leq 0.92$) that inhibit pathogens from growing but can allow some to survive. As dried herbs and spices are frequently eaten raw or used as ingredients in ready-to-eat foods (RTE) such as salads or as garnishes, contamination with pathogens, even in low numbers, has the potential to cause illness. Both fresh and dried herbs and spices have been implicated in foodborne outbreaks, particularly salmonellosis outbreaks (Appendix 1).

During 2016, the EU Rapid Alert System for Food and Feed (RASFF) issued 40 notifications reporting 54 microorganisms in herbs and spices[3], of which *Salmonella* followed by *E. coli* were the most frequently reported (**Figure 1**). *Salmonella* and *E. coli* were reported in a wide range of herbs and spices such as fresh mint, fresh parsley, dried parsley, mixed spices, ground cumin, ground coriander, peppermint, betel leaves, curry leaves, chilli powder, fresh basil, perilla, and piper lolot. *B. cereus* was reported in ground organic cinnamon, *L. monocytogenes* was reported in fresh thyme and STEC in fresh basil and fresh mint. Since 2002, the FSAI has issued four food alerts relating to *Salmonella* in herbs or salads containing herbs (FSAI, 2004; FSAI, 2007; FSAI, 2011; FSAI, 2015b). In 2016, the FSAI issued one food alert to recall spices due to the presence of *Salmonella* in coriander powder (FSAI, 2016b).

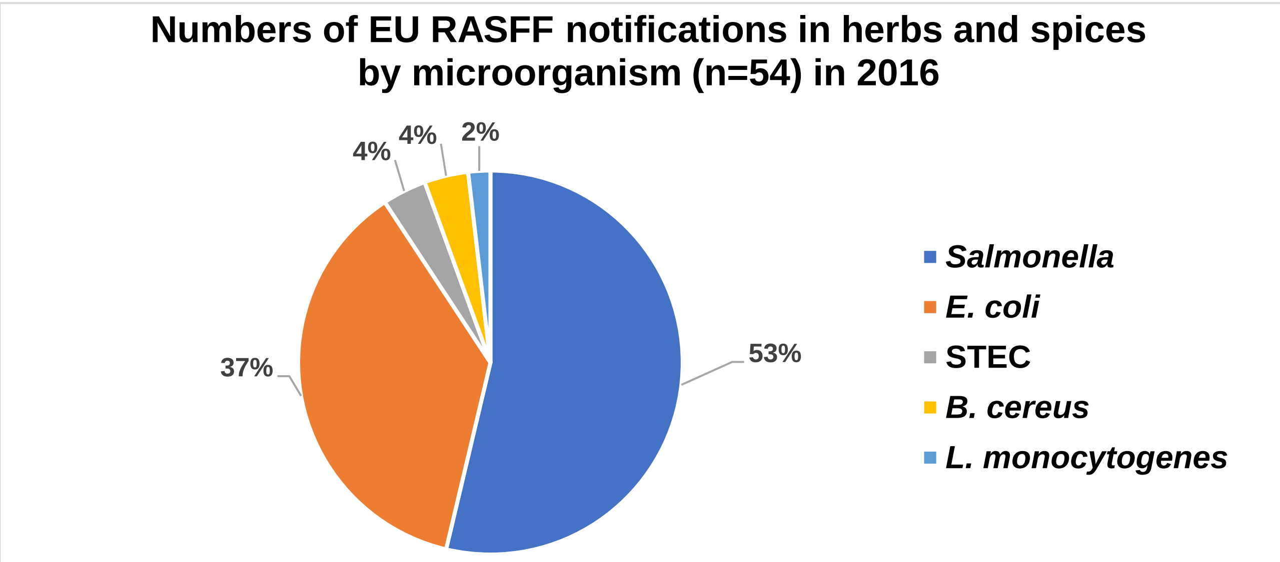

Figure 1 numbers of EU RASFF notifications in herbs and spices by microorganism (n=54) in 2016**.**

[3] Source: RASFF portal https://webgate.ec.europa.eu/rasff-window/portal/?event=SearchForm&cleanSearch=1

Prevalence

Dried herbs and spices can become contaminated with pathogens during growth, harvesting or processing and also, at retail level, if sold loose. A survey conducted by the FSAI and the HSE in 2004 on the “bacteriological and toxicological safety of dried herbs and spices” found 0.9% of samples were contaminated with *Salmonella* species (n=6/647), while 0.3% of single samples (n=2/647) and 4% of batch samples (n=1/25) were unsatisfactory for presumptive *B. cereus* (FSAI, 2004b). *Salmonella* was detected in sesame seeds (n=1), curry powder (n=1), extra hot chilli pepper (n=1), dried chilli powder (n=1) and turmeric (n=2). Unsatisfactory levels of presumptive *B. cereus* were detected in ground ginger (n=1), curry (n=1) and garlic powder (n=1). A further survey carried out by FSAI and HSE in 2013 on the “microbiological safety of ready-to-eat, pre-cut and pre-packaged fresh herbs and salad leaves” detected *Salmonella* (n=1) in one bag of rocket leaves (FSAI, 2015) but did not detect *Salmonella* in fresh herb samples.

Other prevalence studies carried out on fresh and dried herbs and spices show that they are frequently contaminated with low levels of pathogens. *Salmonella*, *B*. *cereus*, *E*. *coli*, *Shigella* and *C*. *perfringens* have all been detected at low levels (Appendix 2). Sagoo *et al.* (2009) isolated *B. cereus*, *Salmonella*, *C. perfringens* and *E. coli* from a wide range of dried herbs and spices such as fennel, cumin, black pepper, chilli, turmeric, mint, sage, coriander and fenugreek in the United Kingdom. Urabe *et al.* (2008) found that *Salmonella* survived on black and red pepper for 7 to 28 days depending on the species. The study also found that *Salmonella* was able to grow in cooked foods held at room temperature once contaminated spices were added. These studies indicate that herbs and spices may be subjected to contamination, which may persist throughout the food chain.

Outbreaks

Investigations of outbreaks of foodborne illness involving herbs, spices and food products used as ingredients, have indicated that *Salmonella* did not need to be present in high numbers in order to cause illness (Elviss *et al*., 2009; Lehmacher *et al.*, 1995). Outbreaks involving foodborne pathogens in dried herbs or spices may also be under-reported, given that they are added as minor ingredients or garnishes to a dish and therefore patients may not report eating them. In 2013, a large salmonellosis outbreak involving 413 people occurred at the Newcastle spice festival in the UK, due to the addition of contaminated raw curry leaves used as an ingredient in chutney (Public Health England, 2013). In 2010, the US Centers for Disease Control and Prevention (CDC) reported an outbreak of salmonellosis affecting 272 people that was linked to contaminated black and red pepper being added to salami slices after the salami had undergone heat treatment (CDC, 2010).

Outbreaks of illness linked to the consumption of herbs and spices or products containing them as ingredients have primarily been associated with *Salmonella*. In the outbreaks examined, the number of reported cases of illness ranged between 40 to 1,000 people while vehicles of transmission included aniseed containing tea, black and red pepper, paprika and paprika covered potato chips, white pepper, basil and cilantro (coriander) (Appendix 1). Lehmacher *et al.* (1995) reported that the attack rate for *Salmonella* in a paprika-powdered potato chips outbreak which affected over 1,000 people, was 1 in 10,000 exposed persons. The infective dose was estimated to be between 4 to 45 organisms.

Sources of contamination

Contamination of ready-to-eat dried herbs and spices could arise from a number of possible sources such as direct contact with animal or human faeces. In addition, dried herbs and spices can indirectly come into contact with faecal contamination through land spreading of manure/slurry or biosolids and/or the use of contaminated irrigation water. Lapidot and Yaron (2009) found *Salmonella* was still present on harvested fresh parsley plants three weeks after being sprayed with contaminated irrigation water. Similarly, Islam *et al*. (2004) found that *Salmonella* persisted in soils sprayed with contaminated irrigation water for up to 231 days. Zweifel & Stephen (2012) found that due to its high desiccation tolerance, *Salmonella* can survive for extended periods of time on dried herbs and spices.

Control of pathogens

Irradiation is an approved treatment within the European Union (EU) to control pathogens such as *Salmonella* in dried herbs and spices (European Commission, 1999a; b). Other treatments, such as fumigation with ethylene oxide, are not approved for treatment of herbs and spices sold in the EU.

Aim of the survey

The aim of this survey was to investigate the microbiological safety of ready-to-eat, pre-packaged dried herbs and dried spices sampled from retail establishments in Ireland.

Methods

Sample collection

Between 1 August and 30 November 2017 (inclusive), EHOs from the HSE collected 768 single and 73 batch samples[Error! Bookmark not defined.] of ready-to-eat dried herbs and dried spices from the f ollowing establishments:

- Supermarkets and corner shops (from retail shelves only, not the deli counter)
- Green grocers
- Market stalls (those selling dried herbs and spices, that are not sold loose, not packaged by the business themselves and not using them as part of food service activities)
- Health food shops
- Discount retailers
- Manufacturers, packers, distributors and wholesalers
- Catering establishments (those selling dried herbs and spices, that are not sold loose, not packaged by the business themselves and not using them as part of food service activities).

All samples were fully enclosed in sealed packaging, so that in the event of an unsatisfactory test result, it would be clear that the product was contaminated at the production/packaging stage and not during the distribution or retail stages. The ready-to-eat status of foods was assessed in line with the decision tree in Appendix 5**Figure 1** , which comes from the FSAI's Guidance Note 27 (Figure 1; FSAI, 2014).

Irradiation status

EHOs were asked to indicate whether the sample collected was irradiated or non-irradiated in the sample description field of the National Sample Submission Form (NSSF). If no information appeared on the label indicating that the sample has been irradiated, then this sample was considered non-irradiated as this information is required to be stated on the label if the food had undergone irradiation as per the requirements of Regulation 1169/2011 and Directive 1999/2/EC (European Parliament 2011; European Commission 1999a).

Sample analysis

Samples were analysed for:

- Presence or absence of *Salmonella* species using EN/ISO 6579
- Presence or absence of Shiga toxin-producing *E. coli*[4] using CEN/ISO TS 13136
- Enumeration of *E. coli* using ISO 16649-1 or 16649-2
- Enumeration of *Enterobacteriaceae* using EN/ISO 21528-2
- Enumeration of presumptive *Bacillus cereus*[5] using EN/ISO 7932

Enumeration of *Listeria* species including *Listeria monocytogenes* using EN/ISO 11290-2

Typing of isolates

Isolates of *Salmonella* or *Listeria monocytogenes* obtained during the study were sent to the relevant reference laboratory for subtyping.

Interpretation of results

L. monocytogenes results were assessed against the criterion set in Commission Regulation (EC) No 2073/2005 as amended for food category 1.3 "RTE foods unable to support the growth of Listeria monocytogenes" (European Commission, 2005; Appendix 3).

As no legal criteria are set for *Salmonella*, presumptive *Bacillus cereus*, *Enterobacteriaceae*, *E. coli* or STEC in ready-to-eat dried herbs or dried spices in Commission Regulation (EC) No. 2073/2005, the guideline limits for a satisfactory result for "RTE food placed on the market" as laid out in FSAI Guidance Note 3 Revision 2 were used to assess compliance and safety (Appendix 4).

[4] Only samples sent to Public Health Laboratory, Cherry Orchard were tested for Shiga toxin-producing *Escherichia coli*

[5] Using the reference method ISO 7932, the result is reported as 'presumptive *B. cereus*'. The term 'presumptive' is used to acknowledge the fact that it is difficult to distinguish *B. cereus* from other closely related but less commonly encountered *Bacillus* species, such as *B. anthracis*, *B. thuringiensis*, *B. weilhenstephanensis* and *B. mycoides*

Results & Discussion

In total, 855 food samples were taken. 82% (n=698) of these were taken at retail level (Figure 2).

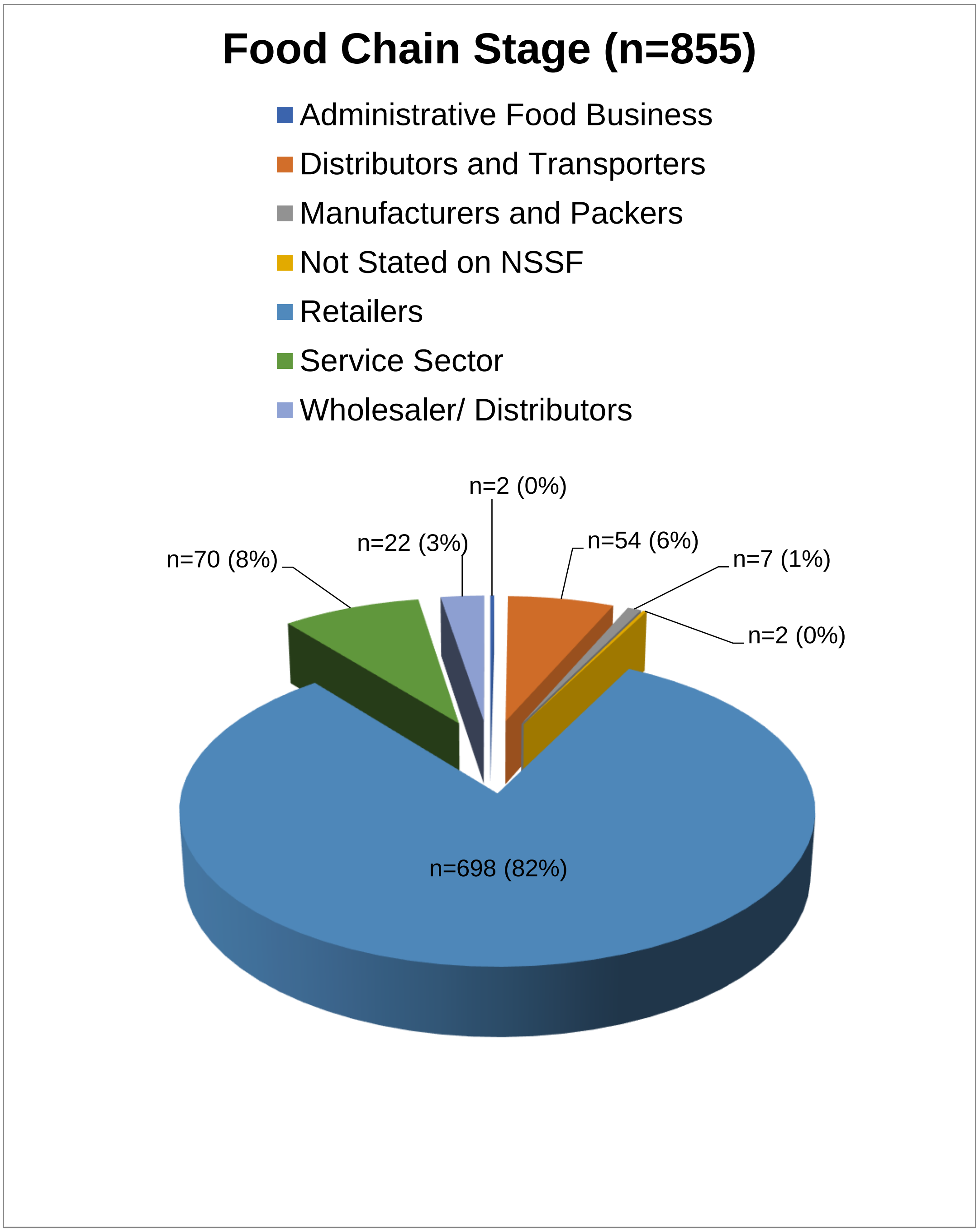

Figure 2 Breakdown of samples by food chain stage

Administrative food businesses include ‘food brokers, head offices/multiple chains and brand owners’.

NSSF: ‘National Sample Submission Form’

Irradiation status

Of the 855 food samples taken during the survey, only 1% of samples was reported to have been irradiated (Figure 3). Seventy six percent were reported as not irradiated and the remaining 23% did not have their irradiation status stated on the National Sample Submission Form. Irish and EU law requires that for foods that have undergone irradiation the words "irradiated or treated with ionising radiation" must appear on the label or packaging (European Commission 1999a; European Commission 1999b; S.I. 297/2000).

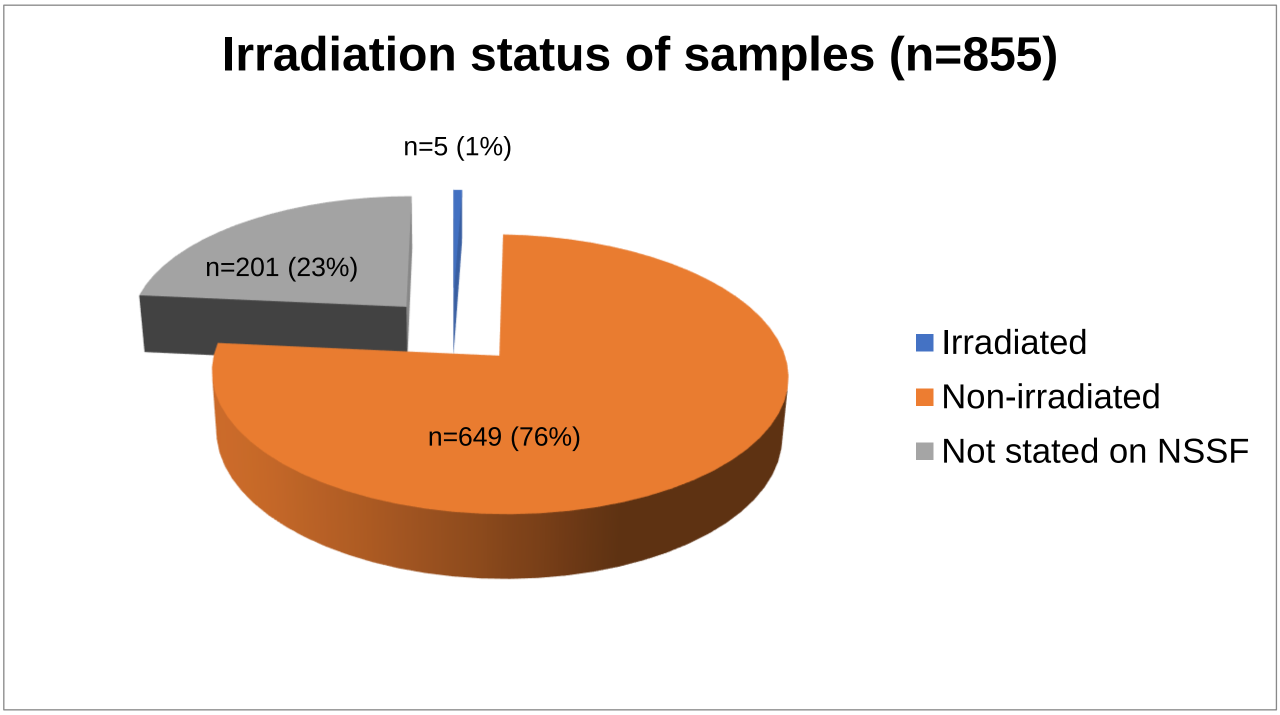

Figure 3 Breakdown of survey samples irradiation status

Microbiological Results

Results by organism are presented in Tables 1 and 2 and discussed in more detail below.

Table 1 Listeria monocytogenes results

	Satisfactory (%)	Unsatisfactory (%)	Total
Batch Samples[a]	73 (100%)	0 (0%)	73
	Compliant within the limit (%)	**Unsatisfactory (%)**	
Single Samples[b]	768 (100%)	0 (0%)	768

[a] Comprising n=5 sampling units

[b] Three detection tests were carried out for *Listeria* and all results were not detected.

Table 2 Results of other parameters

Parameter	Satisfactory (%)	Borderline (%)	Unsatisfactory (%)	Total
		Pathogens		
Presumptive Bacillus cereus	727 (87.8%)	79 (9.5%)	22 (2.7%)	828
Salmonella	786 (99.5%)	n/a	4 (0.5%)	790
STEC	164 (100%)	n/a	0 (0%)	164
		Hygiene Indicators		
Enterobacteriaceae	635 (84.1%)	87 (11.5%)	33 (4.4%)	755
Escherichia coli	738 (98.7%)	5 (0.7%)	5 (0.7%)	748
Listeria* non-*monocytogenes	823 (100%)	0 (0%)	0 (0%)	823

Listeria monocytogenes

Dried foods typically have low water activity ($a_w \leq 0.92$) which is below the threshold that will support the growth of *L. monocytogenes*. In total, 841 food samples; 768 single samples and 73 batch samples (each comprising 5 sample units), were tested for *L. monocytogenes* (Table 1). Of these, all single samples were compliant within the 100 colony forming unit per gram (CFU/g) legal limit for ready-to-eat foods unable to support the growth of *L. monocytogenes* and all batches were satisfactory under Regulation 2073/2005 (as amended). Finally, three detection tests were performed, and *Listeria* was not detected in any test. A study by Vitullo *et al.* (2011) examined dried herbs for the presence of *L. monocytogenes* and reported no positive result in 50 samples.

Salmonella

Salmonella was detected in 4 (0.5%) out of 790 food samples tested. All *Salmonella* positive samples were from non-irradiated food samples. These results were similar to the 2004 national survey on “Bacteriological and toxicological safety of dried herbs and spices” which found that 6 out of 647 (0.9%) samples were unsatisfactory for *Salmonella* (FSAI, 2004b).

Salmonella was detected in samples of ground coriander ‘dhaniya powder’, dried basil, organic ginger and in a sample of dill, which was also unsatisfactory for *Enterobacteriaceae*, *Salmonella* Infantis was detected in the sample of dill. *Salmonella* of unknown serotype was detected in the basil, ginger and in the dhaniya (coriander) powder. The unsatisfactory dried basil sample originated from Egypt and was imported *via* the United Kingdom (UK), the ground ginger originated from Poland with raw materials from the Netherlands, the dill originated from Egypt and was imported *via* Germany and Lithuania while the coriander was packed and imported from the UK but its country of origin is unknown.

Between June and July 2017 an outbreak involving a rare *Salmonella* serovar, *Salmonella* Adjame, involving 14 confirmed cases occurred in the United Kingdom. Seven people involved in the outbreak reported being vegetarian. Whilst an implicated food was never identified it was suspected to be a fresh product bought from an grocer. Herbs and spices such as pepper, turmeric, chilli powder, coriander and cinnamon were among the food items commonly consumed by the identified cases (Chandra *et al*., 2018). Interestingly there were two non-travel related Irish human clinical cases of *Salmonella* Adjame reported by the National Salmonella, Shigella and

Listeria Reference Laboratory[6] for 2017 (NSSLRL), however, the source of infection was never identified (NSSLRL, 2017).

In the case of the four contaminated survey samples, a recall was issued using point of sale notices by the food businesses in the stores in which the product was sold. In the cases of the dried basil, ground ginger and dill samples, as these products were imported from other European Member States; a European wide alert was issued through the EU's Rapid Alert System for Food & Feed (RASFF)[3]. RASFF numbers were 2017.1773 for the dried basil, 2017.1613 for the ground ginger and 2017.1333 for the dill sample respectively.

In the case of the contaminated coriander, FSAI notified the United Kingdom of the *Salmonella* positive result but no RASFF was issued. This was due to the sample being labelled as 'requires cooking before consumption'. However, as these instructions did not provide a validated target temperature-time combination to ensure a 6 $\log_{10}$ reduction in pathogen concentrations, FSAI considered this product 'ready-to-eat by default' (Appendix 5) as per page 32 of FSAI Guidance Note 27 (FSAI, 2014) resulting in the product being recalled locally.

Finally, the business where the contaminated ginger sample was taken reported that they would sprinkle the ginger directly onto ready-to-eat deserts without any cooking. Highlighting the belief that consumers consider these products as ready-to-eat. To FSAI's knowledge, no reported illnesses were linked to any of the *Salmonella* isolates obtained during the survey. Possible reasons for this may be that (i) the levels of contamination may have been too low to cause illness, (ii) symptoms of illness may not have been severe enough for the consumer to seek medical attention, (iii) where medical attention was sought either a clinical sample was not taken for microbiological analysis or by the time it was taken the patient was no longer shedding the organism.

Presumptive Bacillus cereus

In total, 828 food samples were tested for presumptive *B. cereus*[4]. Of these, 727 (87.8%) were satisfactory, 79 (9.5%) were borderline and 22 (2.7%) were unsatisfactory. A similar national survey in 2004 on dried herbs and spices found that only 2 out of 647 (0.3%) of samples were unsatisfactory for presumptive *B. cereus* (FSAI, 2004b). Table 3 shows all 22 samples that were

[6] The National Salmonella, Shigella and Listeria Reference Laboratory (NSSLRL). Department of Medical Microbiology. University College Hospital, Galway.

unsatisfactory for presumptive *Bacillus cereus*. Table 4 shows all 79 samples that were borderline for presumptive *B. cereus*. The irradiation status of all unsatisfactory and borderline samples was either non-irradiated or not stated.

Table 3 Foods that contained unsatisfactory levels of presumptive *Bacillus cereus* (n=number of unsatisfactory samples)

Foods that contained unsatisfactory levels of presumptive *Bacillus cereus*	
Black pepper (5)	Ground ginger (1)
Basil (3)	Cayenne pepper (1)
Mint (2)	Garlic granules (1)
Paprika (2)	Cardamom seeds (1)
Chilli powder (2)	Dill (1)
Garlic powder (2)	Fenugreek seeds (1)

Table 4 Foods that contained borderline levels of presumptive *Bacillus cereus* (n=number of borderline samples)

Foods that contained borderline levels of presumptive *Bacillus cereus*	
Black pepper (7)	Dill (2)
Turmeric (5)	Mustard seeds (2)
Coriander powder (5)	Basil (2)
Cumin powder (4)	Cayenne pepper (2)
Cinnamon (4)	Cajun spice (2)
Chilli powder (3)	Chives (2)
Ground cinnamon (3)	Fenugreek leaves (1)
Paprika (3)	Ginger powder (1)
Cardamom (3)	Herbal pepper (1)
Curry powder (3)	Nutmeg powder (1)
Oregano (3)	Spice mix (1)

Thyme (3)	Clove powder (1)
Coriander leaves (2)	Garlic granules (1)
Curry leaves (2)	Green cardamom powder (1)
Ground ginger (2)	Mint (1)
Sage (2)	Parsley (1)
Cumin (2)	Tarragon (1)

Bacillus cereus causes two distinct types of illness, an emetic (vomiting) type and a diarrhoeal type. The emetic (vomiting) intoxication is caused by the ingestion of a toxin known as cereulide that is preformed in the food, whilst the diarrhoeal form of illness is caused by the ingestion of bacterial cells which produce enterotoxin in the small intestine (FSAI, 2016c). The organism is ubiquitous in the environment and low levels are found on virtually all foods including vegetables, cereals, spices, meat, meat products pasteurised liquid egg, milk, dairy products and dried foods. The majority of cases are linked to heat treated foods which have been temperature abused during cooling, storage and handling, allowing the bacteria to multiply and form toxin. For example, products such as cooked rice which has been left for extended periods of time at room temperature (FSAI, 2016).

Outbreaks of illness involving *B. cereus* are typically small localised outbreaks e.g. within family units. Cases of illness are usually mild resulting in them not being reported; however, in extremely rare cases fatalities associated with liver failure caused by its emetic toxin have been reported (Dierick *et al*., 2005; Mahler *et al*. 1997). Mahler *et al*. (1997) reported that the emetic toxin inhibits hepatic mitochondrial fatty-acid oxidation, indicating that it caused liver failure and was responsible for the death of the patient.

A high number of samples were borderline and unsatisfactory for presumptive *Bacillus cereus*. These were unlikely to present a risk of foodborne illness if they were added to ready-to-eat food and consumed within 4 hours, or if the food was kept refrigerated throughout its shelf-life as the bacilli that are on herbs and spices are likely to be as spores in response to the stress of the drying process. However, they could pose a risk of illness if dried herbs and spices were added to cooked food which were then subsequently temperature abused, leading to outgrowth of spores and toxin formation. As the cereulide toxin is heat stable, any subsequent cooking would not remove the hazard.

In dried herbs and spices direct consumption of these products will not lead to foodborne illness from *B. cereus* because the water activity of these products is too low to support its growth. However, as stated previously herbs and spices are often added as flavourings to both ready-to-eat or cooked foods, this could potentially lead to foodborne illness if those foods are subsequently temperature abused.

Shiga toxin-producing Escherichia coli (STEC)

One laboratory carried out testing for STEC during the survey. In total, 164 samples were tested and STEC was not detected in any of the samples (Table 2).

Escherichia coli

In total, 748 samples were tested for the indicator *E. coli*. Of these, 738 (98.7%) were satisfactory, 5 (0.7%) were borderline and 5 (0.7%) were unsatisfactory. *E. coli* bacteria are hygiene indicators and their presence at unsatisfactory levels indicates potential contamination with faeces. Samples that were unsatisfactory for *E. coli* were dried basil (n=2), coriander (n=2) and mint (n=1) while the borderline samples were ground cumin (n=1), Bay leaves (n=1), organic mild curry (n=1), rubbed thyme (n=1) and scent leaves (n=1). The ground cumin sample that was borderline for *E. coli* was also borderline for *Enterobacteriaceae*.

Enterobacteriaceae

In total, 755 samples were tested for *Enterobacteriaceae*. Of these, 635 (84.1%) were satisfactory, 87 (11.5%) were borderline and 33 (4.4%) were unsatisfactory.

Enterobacteriaceae are hygiene indicators for post process contamination following a thermal treatment. Their presence at unsatisfactory levels indicates poor hygienic practices during production or processing. However, as *Enterobacteriaceae* are naturally present in high concentrations in fresh herbs and spices, they would only be an appropriate indicator of hygiene in dried herbs and spices if they have been irradiated. This is because the drying process used to dehydrate herbs and spices is not always sufficient to eliminate the natural microflora of these foods and can actually concentrate them (ICMSF, 2011).

In the EU, dried aromatic herbs, spices and vegetable seasonings are authorised for irradiation treatment under Directive 1999/3/EC ‘Community list of foods and food ingredients treated with ionising radiation’. Worldwide dried herbs and spices can also be decontaminated *via* fumigation with sulphur dioxide or ethylene oxide. However, placing dried herbs and spices treated with ethylene oxide on the EU market is banned under Directive 1999/3/EC due to the toxic potential of the residues from these practices (European Commission 1999b; European Parliament, 2014). The use of sulphur dioxide in dried herbs and spices imported into the EU is also prohibited under the additive's legislation due to the limits for maximum sulphite residues in herbs and spices (European Commission, 2008). The only exception is cinnamon, with a maximum limit of 150 mg/kg. The International Commission on Microbiological Specifications for Foods (ICMSF) recommends testing for *Enterobacteriaceae* in dried herbs and spices during the processing stage to verify process control if a kill step is used (ICMSF, 2011). Therefore, in dried herbs and spices *Enterobacteriaceae* would be an indicator for post-process contamination due to poor hygienic practices in dried herbs and spices that have undergone treatments such as irradiation, fumigation or cooking etc. However, *Enterobacteriaceae* may not be appropriate indicator for dried herbs and spices that have not undergone any kill step treatments during processing as they are naturally present in these foods and would be concentrated by the drying process. The ICMSF have stated previously that large quantities of herbs and spices are traded without further processing, apart from drying (ICMSF, 2005).

Only five samples (0.76%; n=654) on the National Sample Submission Form were stated to be irradiated. The high numbers of *Enterobacteriaceae* borderline and unsatisfactory results are likely to be due to the organisms being naturally present on herbs and spices, which are then being concentrated by the drying process. However, a large number of samples (n=201) had no irradiation status stated on the National Sample Submission Form, so the numbers of irradiated samples could potentially have been higher. The low number of irradiated samples could explain why 87 (11.28%) of *Enterobacteriaceae* samples were borderline and 33 (4.28%) were unsatisfactory compared with only 5 (0.66%) of the *E. coli* samples being borderline and 5 (0.66%) being unsatisfactory. A similar national survey in 2004 on the "Bacteriological and toxicological safety of dried herbs and spices" used *Enterobacteriaceae* as an indicator for irradiation or other similar treatments of these types of foods and found similar results (FSAI, 2004b). The 2004 survey reported that *Enterobacteriaceae* counts of >100 CFU/g were recorded for 26.1% (n=169/647) of single samples and 36% (n=9/25) of batch samples. For the purpose of that survey which formed part of an EU coordinated survey, the EU Commission stated that samples with an *Enterobacteriaceae* count ≤100 CFU/g should be suspected of having been irradiated or submitted to similar treatments

Dried herbs and spices are not produced in large quantities in Ireland or other Members States and are primarily imported into the EU from third countries. The high number of borderline and unsatisfactory samples in dried herbs and spices could be due to (i) poor process hygiene controls in importing third countries or, (ii) the dried herbs and spices are not being subjected to any decontamination treatments by producers in their country of origin prior to export meaning that the *Enterobacteriaceae* that are naturally present in these foods are being concentrated by the drying process (ICMSF, 2005; ICMSF, 2011), or (iii) a combination of both.

Listeria non-monocytogenes

All 823 sample results for *Listeria* non-*monocytogenes* were satisfactory.

Conclusion

This survey showed that, whilst the majority of dried herbs and spices are microbiologically safe, a small percentage may be contaminated with pathogens. This has important implications for public health if dried herbs and spices are used raw on ready to eat foods.

The results from this survey highlight that the vast majority of dried herbs and spices on the Irish market are not irradiated. With only five samples in this survey reported as having been 'irradiated', this highlights the importance to food safety of producing these foods under good hygienic conditions. Particularly, given that pathogenic microorganisms such as *Salmonella* can survive the drying process and survive on dehydrated foods for extended periods of time. If dried herbs and spices are not produced under hygienic conditions, they pose a risk of foodborne illness to the consumer as they frequently receive no further bactericidal treatment effective to eliminate pathogenic microorganisms of concern prior to consumption. Finally, while the dried nature of these foods inhibit the ability of pathogens to grow, if dried herbs and spices with contamination levels below those capable of causing illness, are added to RTE foods that undergo no further bactericidal treatment, they may grow to concentrations capable of causing illness.

Recommendations

The following recommendations are made on the basis of this survey's results:

- Food businesses should be aware that dried herbs and spices are a potential source of microbial hazard which needs to be controlled by their food safety management system.
- Food businesses should source dried herbs and spices from reputable suppliers who can provide evidence that adequate hygiene controls are in place during production and processing.
- Food businesses adding dried herbs and spices to foods that are to be cooked should ensure the food is cooled to 5°C within 2 hours or consumed within 4 hours.
- Dried herbs and spices should be sampled during routine official controls.

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Appendix 1: Selected outbreaks associated with herbs and spices

Table 5 Table of selected outbreaks associated with herbs and spices

Vehicle	Dried or fresh	Pathogen	Year	Country	Number of cases	Reference
Spices						
Spice mix	Dried	*S. Enteritidis*	2015	Sweden	174	(Jernberg *et al.*, 2015)
Black and red pepper	Dried	*S. Montevideo*	2009-2010	United States	272	(CDC, 2010)
White pepper	Dried	*S. Rissen*	2009	United States	87	(Kennelly, 2010)
Aniseed-containing herbal tea	Dried	*S. Agona*	2002-2003	Germany	42	(Koch *et al.*, 2005)
Paprika and paprika-powdered potato chips	Dried	*S. Saintpaul*, *S. Rubislaw*, *S. Javiana* + multiple other serovars	1993	Germany	>1000	(Lehmacher *et al.*, 1995)
Curry leaves	Fresh	*Salmonella* multiple strains	2013	England	413	(Public Health England, 2013)
Herbs						
Basil	Fresh	*S. Senftenberg*	2007	England, Wales, Scotland, Denmark, Netherlands and USA	51	(Elviss *et al.*, 2009; Pezzoli *et al.*, 2008)
Basil	Fresh	*S. Anatum* *E. coli*	2006	Denmark	>200	(Pakalniskiene *et al.*, 2009)
Cilantro (coriander)	Fresh	*S. Thompson*	1999	United States	76	(Campell *et al.*, 2001)

Appendix 2: Prevalence studies for pathogens in herbs and spices.

Table 6 Prevalence studies for pathogens in herbs and spices

Food product	Dried, fresh or unspecified	Pathogen	Number positive / number tested	% positive	Country	Reference
Spices						
Dried Cumin, fennel, garam masala, chilli, black pepper, turmeric, cayenne, all spice, cinnamon, curry and okra	Dried	*Salmonella*	23/2199	1.0	United Kingdom	(Sagoo *et al.*, 2009)
		B. cereus	195/2199	8.9		
		C. perfringens	58/2199	2.6		
		E. coli	71/2199	3.2		
Black pepper and cumin	Dried	*Salmonella*	13/233	5.6	Brazil	(Moreira *et al.*, 2009)
Saffron	Dried	*Salmonella*	0/79	0	Spain, Greece, Iran, Morocco and Italy	(Cosano *et al.*, 2009)
		B. cereus	3/79	3.8		
		C. perfringens	37/79	46.8		
		E. coli	5/79	6.3		
Black and red pepper	Dried	*Salmonella*	2/259	0.8	Japan	(Hara-Kudo *et al.*, 2006)
Ground red pepper	Dried	*C. perfringens*	4/115	3.5	Argentina	(Aguilera *et al.*, 2005)
Ginger and poppy seed	Dried	*Salmonella*	2/154	1.3	India	(Banerjee & Sarkar, 2003)
Spices	Dried	*Salmonella*	1/750	0.1	United Kingdom	(Little *et al.*, 2003)
Oregano, garlic, cumin and pepper	Dried	*Salmonella*	0/304	0	Mexico	(Garcìa *et al.*, 2001)

Spices unspecified	Unspecified	*Salmonella*	1/200	0.5	Republic of Trinidad	Rampersad *et al*. (1999)
Black pepper	Dried	*Salmonella*	1/160	0.6	Austria	Kneifel & Berger, (1994)
Cayenne pepper, chili powder, cinnamon, garlic powder, mustard powder and oregano	Dried	*B. cereus*	51/99	51.5	United States	(Powers *et al.,* 1976)
Cinnamon, cayenne pepper and oregano	Dried	*C. perfringens*	3/52	5.8	United States	(Powers *et al.,* 1975)
Herbs						
Basil, cilantro (coriander) and parsley	Fresh	*Salmonella*	1/133	0.7	United States	(Levy *et al*., 2015)
		E. coli	32/133	24.1		
Melissa officinalis, Salvia officinalis, Malva sylvestris, Matricaria chamomilla, Alchemilla vulgaris and Centaurea cyanus	Dried	*Salmonella*	0/51	0	Ireland	(Vitullo *et al.*, 2011).
		S. aureus	0/51	0		
		L. monocytogenes	0/51	0		
Dried Coriander, fenugreek, mint, sage	Dried	*Salmonella*	10/766	1.3	United Kingdom	(Sagoo *et al.*, 2009)
		B. cereus	65/766	8.5		
		C. perfringens	48/766	6.3		
		E. coli	80/766	10.4		
Basil, cilantro (coriander), curry leaves, mint,	Fresh	*Salmonella*	18/3760	0.5	United Kingdom	(Elviss *et al.*, 2009)
		E. coli	137/3760	3.6		

parsley and walleria						
Basil, cilantro (coriander) and curry leaves	Fresh	*Salmonella*	5/298	1.7	United Kingdom	(Surman-Lee *et al.*, 2008)
Cilantro (coriander) and parsley	Fresh	*Salmonella*	0/222	0	Mexico and United States	(Johnston *et al.*, 2006)
Sage	Unspecified	*C. perfringens*	10/115	8.7	Argentin a	(Aguilera *et al.*, 2005)
Garlic	Fresh	*E. coli*	1/154	0.6	India	(Banerjee & Sarkar, 2003)
Cilantro (coriander) and parsley	Fresh	*Salmonella*	1/175	0.6	United States	(FDA, 2003)
		Shigella	1/175	0.6		
Cilantro (coriander), culantro and parsley	Fresh	*Salmonella*	23/273	8.4	United States	(FDA, 2001)
		Shigella	1/273	0.4		
Parsley, dill and unspecified growing herbs	Fresh	*Salmonella*	0/230	0	Norway	(Johannesse n *et al.*, 2002)
		E. coli O:157	0/230	0		
		Listeria monocytogene s	0/230	0		
Bay leaves and unspecified herbs	Unspecified	*Salmonella*	0/304	0	Mexico	(Garcìa *et al.*, 2001)
Bay Leaves	Dried	*B. cereus*	7/11	63.6	United States	(Powers *et al.,* 1976)
Bay leaves	Dried	*C. perfringens*	1/11	9.1	United States	(Powers *et al.,* 1975)
Black and red pepper	Dried	*Salmonella*	0/30	0	United States	(Christensen *et al.*, 1967).

Appendix 3: Interpretation of survey results for Listeria monocytogenes.

Table 7 Interpretation of survey results for Listeria monocytogenes

Criteria in Regulation 2073/2005, as amended					
Listeria monocytogenes **enumeration**					
Sample Size	***L. monocytogenes*** **result**	**Test result designation**	**Test result designation basis**	**Sample designation**	**Sample designation basis**
n = 5	≤100 CFU/g in all 5 sample units	Compliant		**Satisfactory**	Regulation (EC) No. 2073/2005 as amended
n = 1	≤100 CFU/g	Compliant	**Category 1.2 & 1.3** **Regulation (EC) No. 2073/2005 as amended**	**Not designated**	This single sample was taken for monitoring and surveillance purposes; therefore this single sample cannot be designated under Regulation (EC) No. 2073/2005
n = 5	≥100 CFU/g in all 5 sample units	Exceeds the limit		**Unsatisfactory**	Regulation (EC) No.

					2073/2005 as amended
n = 1	>100 CFU/g	Exceeds the limit		**Unsatisfactory**	Regulation (EC) No. 2073/2005 as amended
***Listeria monocytogenes* detection**					
n = 5	Absence in 25g in all 5 sample units	Compliant	**Category 1.2** **Regulation (EC) No. 2073/2005 as amended**	**Satisfactory**	Regulation (EC) No. 2073/2005 as amended
n = 5	Presence in 25 g in at least 1 out of 5 sample units	Exceeds the limit		**Unsatisfactory**	Regulation (EC) No. 2073/2005 as amended

Appendix 4: Interpretation of survey results for Salmonella, B. cereus, STEC, E. coli, Enterobacteriaceae, and Listeria species except monocytogenes.

Table 8 Interpretation of survey results for Salmonella, B. cereus, STEC, E. coli, Enterobacteriaceae, and Listeria species except monocytogenes

National microbiological criteria (FSAI Guidance Note 3, Revision 2) (FSAI, 2016)	
Salmonella species *****	▪ Method: EN/ISO 6579 ▪ Test: **Presence/Absence in 25 g (n=1)** ▪ Interpretation of results and sample designation: - **Satisfactory**: Absence in 25 g - **Unsatisfactory**: Presence in 25 g
Bacillus cereus	▪ Method: EN/ISO 79325 ▪ Test: **Enumeration (n=1)** ▪ Interpretation of results and sample designation: - **Satisfactory**: $<10^3$ CFU/g - **Borderline**: 10^3 - $\leq 10^5$ CFU/g - **Unsatisfactory**: $>10^5$ CFU/g
STEC	▪ Method: CEN/ISO TS 13136 ▪ Test: **Presence/Absence in 25 g (n=1)** ▪ Interpretation of results and sample designation: - **Satisfactory:** Absence in 25 g - **Unsatisfactory:** Presence in 25 g
Escherichia coli	▪ Method: ISO 16649-1 or 2 ▪ Test: **Enumeration (n=1)** ▪ Interpretation of results and sample designation: - **Satisfactory:** <20 CFU/g

	- **Borderline:** 20–≤10^2 CFU/g - **Unsatisfactory:** >10^2 CFU/g
Enterobacteriaceae	▪ Method: ISO 21528-2 ▪ Test: **Enumeration (n=1)** ▪ Interpretation of results and sample designation: - **Satisfactory:** <10^2 CFU/g - **Borderline**: 10^2–≤10^4 CFU/g - **Unsatisfactory**: >10^4 CFU/g
Listeria species* except *monocytogenes* in foods that cannot support the growth of *Listeria species	▪ Method: ISO 11290-2 ▪ Test: **Enumeration (n=1)** ▪ Interpretation of results and sample designation: - **Satisfactory**: <10^2 CFU/g - **Borderline**: 10^2–≤10^4 CFU/g - **Unsatisfactory**: >10^4 CFU/g

*If isolated, OFMLS forwarded the isolate to the NSSLRL for typing.

Appendix 5: Food business operator's decision tree for determining the ready-to-eat status of the food they produce, manufacture or package.

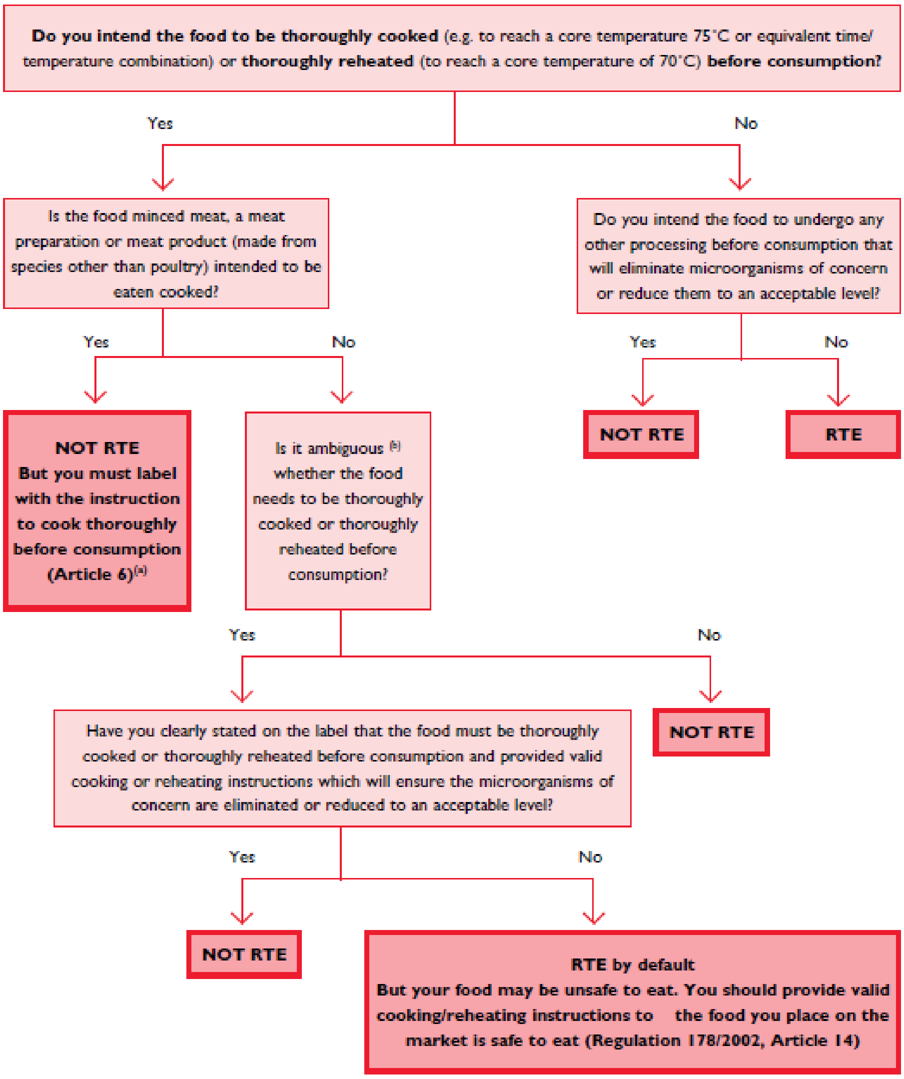

Figure 1: Food business operator's decision tree for determining the ready-to-eat status of the food they produce, manufacture or package

(a) Although the labelling requirement in Regulation 2073/2005 does not apply to minced poultry, poultry preparations and poultry products intended to be eaten cooked, the FSAI recommends that these products are also labelled with the instruction to cook thoroughly before consumption. See Q15 for more information on the Regulation's labelling requirements

(b) Consumers or other food business may believe that some foods are ready-to-eat because of their appearance, e.g. flash fried chicken nuggets

Figure 4 Food business operator's decision tree for determining the ready-to-eat status of the food they produce, manufacture or package

Source: FSAI Guidance Note 27 (page 32).

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