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# National Microbiological Survey and Consumer Habits in relation to Frozen Vegetables, Fruits and Herbs (19NS6)

MONITORING & SURVEILLANCE SERIES



# **National Microbiological Survey and Consumer Habits in Relation to Frozen Vegetables, Fruits and Herbs**

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## Glossary

<b>a<sub>w</sub></b>	water activity
<b>CC</b>	clonal complex
<b>CC MLST</b>	clonal complex multi-locus sequence typing
<b>CDC</b>	Centers for Disease Control and Prevention (United States)
<b>cgMLST</b>	core genome multi-locus sequence typing
<b>CE</b>	Calculation Engine
<b>cfu</b>	colony forming unit
<b>CSO</b>	Central Statistics Office
<b>DAFM</b>	Department of Agriculture, Food and the Marine
<b>ECDC</b>	European Centre for Disease Prevention and Control
<b>EFSA</b>	European Food Safety Authority
<b>EHO</b>	Environmental Health Officer
<b>EHS</b>	Environmental Health Service
<b>EN ISO</b>	European Standard International Organization for Standardization
<b>FSAI</b>	Food Safety Authority of Ireland
<b>HSE</b>	Health Service Executive
<b>INAB</b>	Irish National Accreditation Board
<b>MST</b>	minimum spanning tree
<b>n</b>	number of sample units
<b>non-RTE</b>	non-ready-to-eat
<b>NRL</b>	National Reference Laboratory
<b>OFMLs</b>	Official Food Microbiology Laboratories
<b>PCR</b>	polymerase chain reaction
<b>PROFEL</b>	European Association of Fruit and Vegetable Processors
<b>RASFF</b>	Rapid Alert System for Food and Feed
<b>RTE</b>	ready-to-eat
<b>WGS</b>	whole genome sequencing



## Summary

Following a multi-country listeriosis outbreak in Europe traced to the consumption of uncooked non-ready-to-eat (non-RTE) frozen sweetcorn and possibly to other frozen vegetables (ECDC-EFSA, 2018), a national microbiological survey was undertaken between August and November 2019 by the Food Safety Authority of Ireland (FSAI) in conjunction with the Environmental Health Service (EHS) and the Health Service Executive (HSE) Official Food Microbiology Laboratories (OFMLs) to gain a better understanding of the microbiological quality of ready-to-eat (RTE) and non-RTE frozen vegetables, fruits and herbs placed on the market in Ireland.

To complement the results of the national microbiological survey, a consumer survey was undertaken in conjunction with the all-island food safety promotion board, **safefood**, between January and March 2020 to further understand the consumption habits of adults living on the island of Ireland in relation to uncooked RTE and non-RTE frozen vegetables, fruits and herbs. The results of both the FSAI national microbiological survey and the **safefood** consumer survey are co-published in this report.

## National microbiological survey

Between 1 August and 30 November 2019, 907 samples of frozen vegetables, fruits and herbs were collected by Environmental Health Officers (EHOs) for the national microbiological survey. Most of these were single samples (n=882). Five batch samples, each comprising five individual sample units, were taken at the manufacturing and packing stage (n=25 samples in total). Five hundred and one of the samples collected were RTE and 366 samples were non-RTE. The RTE status was not provided for 40 of the samples collected. The samples were assessed for the microbiological parameters of *Listeria monocytogenes*, *Salmonella*, *Listeria* spp. and *Escherichia coli*.

The *L. monocytogenes* detection method was used to test 906<sup>2</sup> samples, while the *L. monocytogenes* enumeration method was used to test 907 samples. Of the 906 samples tested for *L. monocytogenes* using the detection method, 3% (n=27) were positive, the majority of which were non-RTE frozen vegetables (n=21). *L. monocytogenes* was detected in four samples of RTE frozen fruits and two samples of RTE frozen vegetables. The *L. monocytogenes* results of 907

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<sup>2</sup> The *L. monocytogenes* detection method was not used to test one sample of RTE frozen sour cherries. The same sample of RTE frozen sour cherries was tested using the *L. monocytogenes* enumeration method and had a test result of <10 cfu/g.





survey samples tested using the enumeration method showed that all were compliant with the 100 cfu/g microbiological criterion limit set for *L. monocytogenes* in RTE food placed on the market in Commission Regulation (EC) No 2073/2005, as amended. *L. monocytogenes* was below the limit of detection (<10 cfu/g) for the majority of samples, apart from three samples, which were non-RTE frozen petit pois, non-RTE frozen diced onion, and frozen chopped basil (RTE status not stated), all of which had 10 cfu/g *L. monocytogenes* present.

Of the 828<sup>3</sup> survey samples tested for *Listeria* spp. using the detection method, 4.5% (n=37) were positive. The enumeration method for *Listeria* spp. was used on 907 samples. The test result for the majority of these samples (n=904, 99.7%) was <10 cfu/g *Listeria* spp., while 10 cfu/g was present in two samples of non-RTE frozen sweetcorn and one sample of frozen chopped basil (RTE status not stated). The same sample of frozen chopped basil had 10 cfu/g *L. monocytogenes* present in it.

None of the survey samples tested in the national microbiological survey were found to be contaminated with *Salmonella* (n=885)<sup>4</sup>. The presence of *E. coli* as a hygiene indicator was assessed in a total of 887<sup>5</sup> frozen vegetable, fruit and herb samples. Ten of the samples tested (1.1%) were contaminated with *E. coli* at levels of between 20 and 100 cfu/g; two of these samples were RTE frozen vegetables. There were two non-RTE samples of frozen spinach with *E. coli* levels of 1100 cfu/g and 570 cfu/g present.

The isolates confirmed as *L. monocytogenes* (n=27) were sent for serotyping using molecular typing methods and genomic characterisation by whole genome sequencing (WGS) to the National Reference Laboratory (NRL) for *L. monocytogenes* based in the Department of Agriculture, Food and the Marine (DAFM). Most of the isolates were in the molecular serogroup IIa (n=23), while three of them were in the molecular serogroup IVb and one was in the molecular serogroup IIb. The results showed diversity in the strains, as 13 different clonal complex (CC) groups were identified using WGS. CC8 was the predominant type, accounting for 26% (n=7) of the *L. monocytogenes* isolates cultured in the survey.

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<sup>3</sup> Seventy-eight samples were not tested for *Listeria* spp. using the detection method because the OFML that received these samples was not accredited for the test. The detection method for *Listeria* spp. was also not used on one sample of RTE frozen sour cherries.

<sup>4</sup> Analysis of *Salmonella* spp. was carried out on the first sample unit only of five batch samples collected (each consisting of five individual sample units). The *Salmonella* spp. test was also not carried out on two single samples, but all other survey parameters were assessed in these samples.

<sup>5</sup> Analysis of *E. coli* was carried out on the first sample unit only of five batch samples collected (each consisting of five individual sample units).



The minimum spanning tree (MST)<sup>6</sup> visualised four small clusters, three of which contained isolates cultured from frozen sweetcorn samples, along with samples of frozen mixed vegetables, fruit smoothie mix and cherries (Clusters A, B and C, respectively). Cluster D comprised two isolates, both cultured from petit pois samples.

## Consumer survey

The total number of interviews achieved for the consumer survey on the island of Ireland was 815 (502 participants were based in Ireland and 313 were based in Northern Ireland). The consumer survey found that 80% (n=650) of the survey participants said they consume frozen vegetables, 40% (n=325) said they consume frozen fruits, and 13% (n=103) said they consume frozen herbs. Of the 678 adults on the island of Ireland who responded to the question on consuming uncooked frozen vegetables, fruits and/or herbs, 68% (n=460) said they do not consume any uncooked frozen foods. Some of the respondents consumed more than one type of frozen vegetables, fruits and/or herbs uncooked. The survey responses showed that frozen fruits such as strawberries (n=101), blueberries (n=79), raspberries (n=78), and mixed berries (n=68) were the most likely to be consumed uncooked. The main way in which frozen fruits were consumed uncooked was in a dessert or in a smoothie. A smaller number of survey participants said they would normally consume uncooked frozen vegetables such as sweetcorn (n=21), carrots (n=21), peas (n=14), peppers (n=13), and spinach (n=12). The main way in which consumers would use these uncooked frozen vegetables was in a salad or as a garnish.

## Risk of listeriosis

When the results of the national microbiological survey were correlated with the responses given by consumers in the survey on their consumption habits in relation to frozen vegetables, fruits and herbs, they showed that a small proportion of non-RTE frozen vegetables – which a small number of consumers say they regularly consume uncooked (i.e. sweetcorn, petit pois/garden peas, mixed vegetables, broccoli, peppers, and onion) – were contaminated with low levels of *L.*

*monocytogenes*. The levels found in the majority of these samples were detected in 25 g at <10 cfu/g, while 10 cfu/g was found in non-RTE frozen petit pois (n=1), non-RTE frozen diced onion

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<sup>6</sup> The genomic differences or similarities between all of the isolates characterised by WGS are represented by a dendrogram called the MST. A cluster is defined as isolates with  $\leq 7$  allele difference between their core genome.



(n=1), and frozen chopped basil (n=1; RTE status not designated). If these low levels were present at the point of consumption of uncooked frozen non-RTE vegetables, the risk posed to consumers who are in good health should be minimal. However, the risk could be higher for consumers who are immunocompromised, or if consumer preparation and handling practices allow any of the *L. monocytogenes* contamination present in the non-RTE frozen vegetables to increase at the point of consumption to levels high enough to potentially cause listeriosis (i.e. >100 cfu/g).

In order to avoid future food incidents similar to the European listeriosis outbreak between 2015-2018, manufacturers of frozen vegetables, fruits and herbs are advised to follow the hygiene guidelines published by PROFEL (the European Association of Fruit and Vegetable Processors) for the control of *L. monocytogenes* in the production of quick-frozen vegetables (PROFEL, 2020), and to also follow the recommendations made by the European Food Safety Authority Panel on Biological Hazards (EFSA BIOHAZ Panel) in its Scientific Opinion on the public health risk posed by *Listeria monocytogenes* in frozen fruit and vegetables, including herbs, blanched during processing (EFSA BIOHAZ Panel, 2020). Public health agencies providing food safety advice should encourage consumers to follow the manufacturer's instructions, as printed on the packaging, when preparing frozen vegetables, fruits and herbs.



## Introduction

Trends in healthy eating, especially those featured on social media, encourage consumers to increase their consumption of vegetables, fruits and herbs in their daily diets by incorporating them into smoothies and salads. The desire to eat more healthily, reduce food waste and save time when preparing food means that frozen vegetables, fruits and herbs are seen as a convenient choice of ingredient. In response, frozen food manufacturers and retailers have substantially increased the range of frozen vegetables, fruits and herbs available to consumers (Bord Bia, 2019). Some of these frozen vegetables, fruits and herbs are specifically labelled as RTE, or do not have cooking instructions on their packaging, and are therefore considered RTE by default (e.g. frozen fruits intended for use in smoothies, or frozen herbs added as a garnish). However, others, and frozen vegetables in particular, are considered by the manufacturer as non-ready-to-eat (non-RTE). According to the Food Safety Authority of Ireland (FSAI) *Guidance Note 27*, non-RTE foods have cooking instructions printed on the packaging and do not indicate anywhere on the packaging that they can be consumed without cooking (FSAI, 2014).

Two listeriosis outbreaks traced to consumption of frozen vegetables (particularly frozen sweetcorn) in Europe (ECDC-EFSA, 2018) and the United States of America (USA) (CDC, 2016) show that eating uncooked non-RTE frozen produce can represent a serious risk to human health. The 2015–2018 European outbreak resulted in 53 listeriosis cases, with 10 fatalities, and affected consumers in five European countries (ECDC-EFSA, 2018; EFSA BIOHAZ Panel, 2020). Some of the frozen vegetables implicated in this outbreak were placed on the market in Ireland. In July 2018, the FSAI issued a recall of the implicated batches (FSAI, 2018a). Some of the people who were ill with listeriosis during these outbreaks indicated that they had eaten non-RTE frozen vegetables without following the cooking instructions on the packaging (e.g. by adding them uncooked to salads and smoothies).

From the food histories collected during both outbreaks, it would appear that some consumers do not perceive eating uncooked non-RTE frozen vegetables as a potential source of foodborne illness. However, compared with the production of fresh produce, there is an increased likelihood of a microbiological contamination event happening during the frozen vegetables, fruits and herbs manufacturing process. This is due to the potential for environmental contamination with *L. monocytogenes* in the manufacturing facility (EFSA BIOHAZ Panel, 2020). WGS of the *L. monocytogenes* strain involved in the 2015–2018 European outbreak showed that the outbreak strain persisted in the environment of the implicated frozen vegetable manufacturing facility in Hungary over many years despite cleaning and disinfection procedures carried out by the food business (ECDC-EFSA, 2018; EFSA BIOHAZ Panel, 2020).



A search of the Rapid Alert System for Food and Feed (RASFF) shows that microbiological contamination of frozen vegetables, fruits and herbs with *L. monocytogenes*, *Salmonella*, hepatitis A virus and norovirus has been notified occasionally in previous years (Appendix 1). While no specific outbreak of listeriosis has been attributed to frozen fruits and frozen herbs, many of these products are processed in the same facility as frozen vegetables, meaning that they could also be a potential source of foodborne illness if *L. monocytogenes* is persistent in the processing environment. Frozen fruit was recalled as part of the US outbreak as it was processed in the same facility (CDC, 2016).

The listeriosis risk can be addressed by consumers ensuring that they cook non-RTE frozen vegetables, fruits and herbs prior to consumption, as per the cooking instructions on the packaging. However, the popularity among Irish consumers of eating uncooked non-RTE frozen vegetables, fruits and herbs in smoothies and salads is unknown. Information on consumer behaviour in relation to consumption of frozen food would be beneficial, in order to assess the risk of listeriosis from eating contaminated uncooked frozen vegetables, fruits and herbs in salads and smoothies. To better understand consumer behaviour in relation to this, a **safefood**-funded consumer research survey on frozen food consumption was conducted. The results of the **safefood** consumer survey are co-published in this report to complement the results of the microbiological data generated by the national microbiological survey. The consumer survey provides vital information on consumer attitudes and behaviours on the consumption of cooked and uncooked frozen vegetables, fruits and herbs by adults on the island of Ireland. The consumer survey was also used as an opportunity to ask participants about their general knowledge regarding the risk of listeriosis from consuming RTE food. Information from this consumer survey will be used as a future basis for delivering targeted food safety advice to limit the risks of listeriosis in those who are particularly vulnerable.

Additionally, the consumer survey provided a good opportunity to gauge public awareness of previous foodborne outbreaks of norovirus and hepatitis A virus linked to the consumption of uncooked imported frozen berries across Europe since 2013. As a result of these outbreaks, the FSAI recommends boiling imported frozen berries for 1 minute prior to consumption (FSAI, 2020b). Consumption of uncooked frozen berries and frozen vegetables thawed and eaten without thorough cooking are listed as a high-risk food choice for people who are particularly vulnerable to foodborne illness in the FSAI factsheet *Reduce the Risk of Food Poisoning: Information for People who are Particularly Vulnerable* (FSAI, 2018b).



## Aims of the microbiological and consumer surveys

Given the limited data available on the level of microbiological contamination in frozen vegetables, fruits and herbs placed on the market in Ireland and the potential unknown risk to public health, the FSAI in conjunction with the Environmental Health Service (EHS) and the Health Service Executive (HSE) Official Food Microbiological Laboratories (OFMLs), conducted a national microbiological survey in 2019 to investigate the microbiological quality of RTE and non-RTE frozen vegetables, fruit and herbs.

To generate information on consumption habits in Ireland in relation to RTE and non-RTE frozen vegetables, fruits and herbs, a consumer survey was conducted by **safefood** to complement the results of the national microbiological survey. The consumer survey gathered information on the popularity of RTE and non-RTE frozen vegetables, fruits and herbs among consumers, together with information on their consumption habits in relation to uncooked non-RTE frozen vegetables, fruits and herbs. A blank copy of the research questionnaire to assess consumer attitudes on frozen food preparation and consumption is provided in Appendix 2.

The specific aims of the national microbiological survey were to:

- Determine the microbiological safety of RTE frozen vegetables, fruits and herbs placed on the market in Ireland, and
- Generate useful prevalence data on pathogens through the monitoring and surveillance of non-RTE frozen vegetables, fruits and herbs placed on the market in Ireland.

The specific aims of the consumer survey were to:

- Generate consumer behaviour data on the consumption of uncooked non-RTE frozen vegetables, fruits and herbs on the island of Ireland
- Gauge general consumer awareness of the risk of listeriosis from consuming RTE food
- Gauge general consumer awareness of the risks of foodborne illness due to possible norovirus and hepatitis A virus contamination in imported frozen berries, and
- Generate information to determine if a consumer awareness campaign regarding the possible risk of foodborne illness from eating uncooked non-RTE frozen vegetables, fruits and herbs is necessary.



## National microbiological survey methods

### Sample collection

Between 1 August and 30 November 2019, EHOs from the HSE collected 882 single samples of RTE and non-RTE frozen vegetables, fruit and herbs from the following establishments:

- Wholesalers, distributors, and transporters
- Caterers
- Retailers such as supermarkets, corner shops, convenience stores, market stalls, health food shops, petrol station forecourts, etc.

Five batch samples, each comprising five individual sample units, were taken at the manufacturing and packing stage (n=25 samples in total).

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 manufacturing/packing stage and not during the distribution or retail stages.

### RTE status

The RTE status of the frozen vegetables, fruits and herbs sampled for the national microbiological survey was determined by evaluating the product label at the time of sampling, in order to establish whether the sample was RTE or non-RTE; this was done by following the guidance set out in the decision tree in Figure 1, *FSAI Guidance Note 27* (FSAI, 2014, p. 32). Survey samples were considered RTE if they were not labelled with cooking instructions, and/or if the packaging indicated anywhere that the frozen vegetables, fruits or herbs could be eaten without cooking (e.g. if there was a serving suggestion or directions for use printed on the packaging which indicated that the product could be added directly to smoothies or salads, or used as a garnish without cooking). This information was entered into the National Sample Submission Form at the time of sampling by the sampling officer. Sampling officers were instructed not to collect samples of frozen vegetables, fruits or herbs if it was considered that the consumer was most likely to always cook the product based on the presentation and marketing on the packaging label, e.g. the use of the words “oven”, “steam”, or “stir-fry” on the front of the pack.





## Sample analysis

Samples were analysed for:

- Detection of *Listeria* species, including *Listeria monocytogenes*, using ISO 11290-1:2017<sup>7</sup>
- Enumeration of *Listeria* species, including *Listeria monocytogenes*, using ISO 11290-2:2017
- Presence or absence of *Salmonella* species, using ISO 6579:2017
- Enumeration of *E. coli*, using ISO 16649-1:2018 or 16649-2:2001

## Interpretation of microbiological test results

### Enumeration method for *L. monocytogenes* and *Listeria* spp. in RTE frozen vegetables, fruits and herbs

*L. monocytogenes* enumeration results in samples of RTE frozen vegetables, fruits and herbs were assessed against the criterion set in Commission Regulation (EC) No 2073/2005, Food Category 1.3 (unable to support the growth of *L. monocytogenes*). *Listeria* spp. enumeration results in samples of RTE frozen vegetables, fruits and herbs were assessed against the criterion set in FSAI *Guidance Note 3* (foods that cannot support the growth of *Listeria* spp.). This is because *Listeria* spp. cannot grow at the recommended holding temperatures for frozen food (during the period it remains frozen).

### Detection method for *L. monocytogenes*, *Listeria* spp., *Salmonella* and enumeration method for *E. coli* in RTE frozen vegetables, fruits and herbs

The detection method for *L. monocytogenes* and *Listeria* spp. in RTE frozen vegetables, fruits and herbs was used for monitoring and surveillance purposes only, with a view to obtaining useful

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<sup>7</sup> The scope of ISO 11290-1/2 was revised in 2017 to include a horizontal method for *Listeria* spp. (including *L. monocytogenes*). Prior to that, ISO 11290 only documented an analytical method for *L. monocytogenes* and it did not include an analytical method for *Listeria* spp (non-*monocytogenes*). The national microbiological survey took place in 2019 and at that time the microbiological results for *Listeria* spp. were assessed and reported against the guideline microbiological criterion limits for *Listeria* spp. (non-*monocytogenes*) in Table 4 of FSAI *Guidance Note 3* Revision 3 (Jan 2019). A revision to Table 4 of *Guidance Note 3* was published in November 2020 which amended the guideline microbiological criterion for *Listeria* spp. to include *L. monocytogenes* so that it is in keeping with the scope of ISO 11290-1/2:2017.





prevalence data. The result of the detection method for these organisms from frozen food cannot be designated under Commission Regulation (EC) No 2073/2005, Food Category 1.2 (able to support the growth of *L. monocytogenes*) or under FSAI *Guidance Note 3* because *Listeria spp.* cannot grow at the recommended holding temperatures for frozen food.

As no legal criteria are set for *Salmonella* or *E. coli* in RTE frozen vegetables, fruits and herbs in Commission Regulation (EC) No 2073/2005, the guideline limits for a satisfactory result for “RTE food placed on the market” as set in FSAI *Guidance Note 3* were used to assess compliance and safety.

### **Detection and enumeration method for *L. monocytogenes* and *Listeria spp.*, detection method for *Salmonella spp.*, and enumeration method for *E. coli* in non-RTE samples of frozen vegetables, fruits and herbs**

The detection method and the enumeration method for *L. monocytogenes* and *Listeria spp.*, as well as the detection method for *Salmonella spp.* and the enumeration method for *E. coli* in non-RTE samples of frozen vegetables, fruits and herbs were used for monitoring and surveillance purposes only, with a view to obtaining useful prevalence data. The test result for these organisms from frozen non-RTE vegetable, fruit and herb samples cannot be designated under Commission Regulation (EC) No 2073/2005, Food Category 1.3, or under FSAI *Guidance Note 3*. This is because the food is not considered RTE, as the manufacturer has clearly stated on the packaging that the food must be thoroughly cooked or thoroughly reheated, and it has provided cooking or reheating instructions which will ensure that the microorganisms of concern are eliminated or reduced to an acceptable level.



## Typing and characterisation of *L. monocytogenes*

All *L. monocytogenes* strains isolated from the survey samples of frozen vegetables, fruits and herbs by the HSE OFMLs were forwarded to the Food Microbiology Division (formerly the Dairy Science Laboratory) in the Department of Agriculture, Food and Marine (DAFM), as it is the National Reference Laboratory (NRL) for *L. monocytogenes* under Regulation (EU) 2017/625 on official controls performed to ensure the verification of compliance with feed and food law, animal health and welfare rules.

*L. monocytogenes* strains were serotyped using molecular typing methods and were characterised by WGS. Both methods are accredited to ISO 17025:2017 by the Irish National Accreditation Board (INAB). All *L. monocytogenes* isolates were assigned to a molecular serogroup (IIa, IIb, IIc, IVa or IVb) using a multiplex polymerase chain reaction (PCR) to amplify target genes associated with each *L. monocytogenes* serotype (Table 1). These molecular serogroups are associated with serological serotypes, as outlined in Table 2.

**Table 1** Target genes for *L. monocytogenes* for typing and characterisation

Target gene	Serotype (with target gene)
PrfA	All <i>L. monocytogenes</i>
Prs	All <i>Listeria</i> spp.
Lmo 0737	1/2a – 3a, 1/2c – 3c
Lmo 1118	1/2c – 3c
Orf 2819	1/2b – 3b – 4b, 4ab – 4d – 4e – 7
Orf 2110	4ab – 4b – 4d – 4e

**Table 2** Correlation between serological and molecular serotyping

Serological serotypes	Molecular serogroup
1/2a – 3a	IIa
1/2b – 3b – 7	IIb
1/2c – 3c	IIc
4a – 4c	IVa
4ab, 4b, 4d, 4e	IVb
1/2a – 3a	IIa



## Whole genome sequencing

The NRL uses whole genome sequencing (WGS) to perform typing and genomic characterisation of *L. monocytogenes*. The raw sequencing reads are generated using the Illumina sequencing platform. The raw reads are trimmed and assembled using a BioNumerics Calculation Engine (CE). The resulting assembled reads are analysed by BioNumerics (7.6.3) to determine:

- Clonal complex multi-locus sequence typing (CC MLST) – the MLST plugin assigns a sequence type (ST) for seven housekeeping genes. These seven genes are used to generate a CC MLST type for each isolate.
- Core genome multi-locus sequence typing (cgMLST) – the CE assigns an ST for each loci within the core genome (1,748 loci) of each isolate.
- Serotype and virulence profile – these are assigned by the *Listeria* BioNumerics Plugin 1.0.

The degree of genetic difference (cluster analysis) between isolates tested was determined using 1,748 core loci (cgMLST). A cluster is defined as isolates with  $\leq 7$  allele difference between their core genome. The differences or similarity between all of the cgMLST alleles (variation within each gene) are represented by a dendrogram or by an MST.

## Consumer survey methods

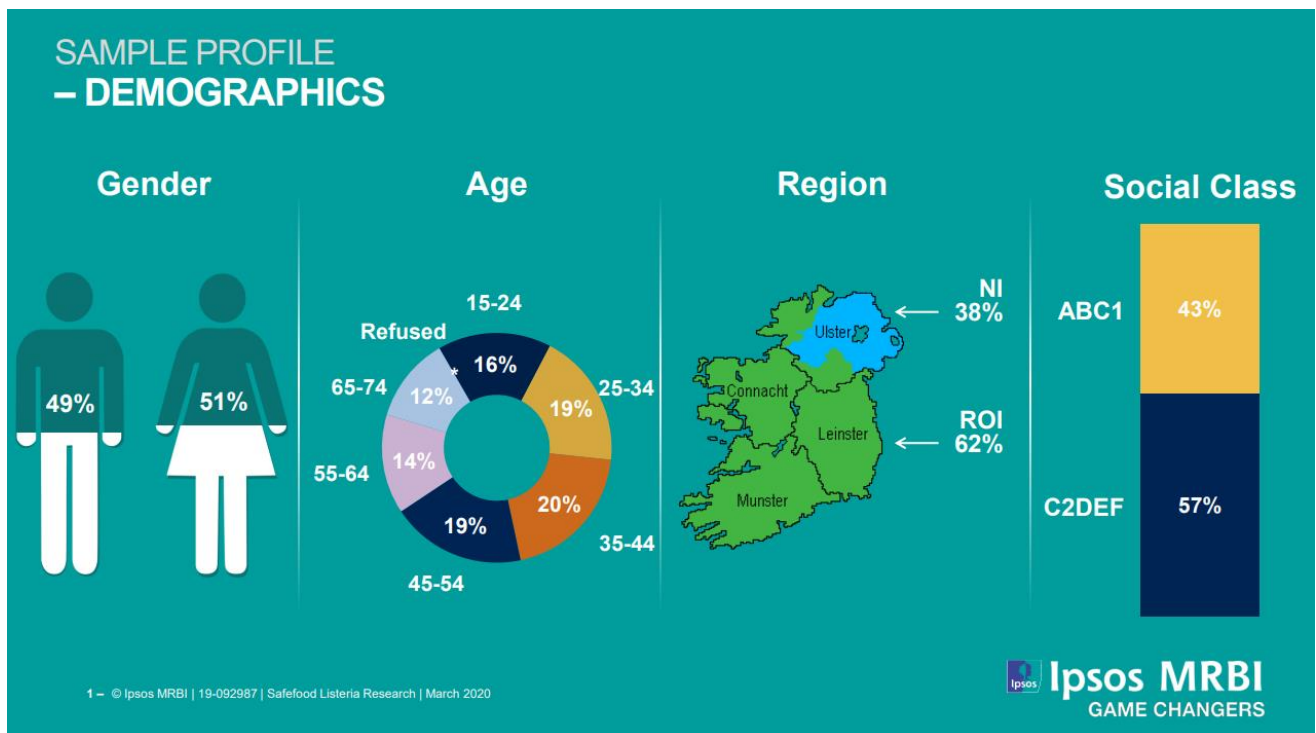
**safefood** commissioned a consumer survey by Ipsos MRBI to gain insights into how adults on the island of Ireland prepare and consume frozen vegetables, fruits and herbs. The consumer survey was conducted between late January and early March 2020. The survey participants were asked a number of questions to gauge consumer awareness and understanding of the potential risks from consuming uncooked frozen vegetables, fruits and herbs (Appendix 2). The interviews were conducted face-to-face, in-home, among a nationally representative, quota-controlled sample of adults aged 15 years and over. The total number of interviews achieved was 815 (502 in Ireland and 313 in Northern Ireland). The key demographics of consumers who took part in the survey are shown in Figure 1.

A multi-staged quota-controlled probability sampling procedure was employed, with randomly selected starting points. This sampling procedure has been employed by Ipsos MRBI in all of its quantitative studies. In order to achieve a firm, representative spread of the sample, it was first stratified by region, and the required number of points were drawn using probability sampling procedures.



The second stage of the sampling procedure involved the systematic sampling of individuals within each of the pre-selected sampling points. At each point, the interviewers adhered to a quota control matrix based on the known profile of all adults in each area in terms of age, gender and socioeconomic grouping. From each address sampled, interviewers followed the random route procedure (first left, next right, etc.) calling at every fifth residence in order to complete an interview, until their quota controls were fulfilled.

At the analysis stage, the data were weighted to census estimates for Ireland and Northern Ireland, in order to correct for any deviations from quotas. The accuracy level is estimated to be +/-3.4%. In all respects, the survey was conducted within the guidelines laid down by the Association of Irish Market Research Organisations (AIMRO), the Market Research Society (MRS), and by the European Society of Opinion and Market Research Organisations (ESOMAR).



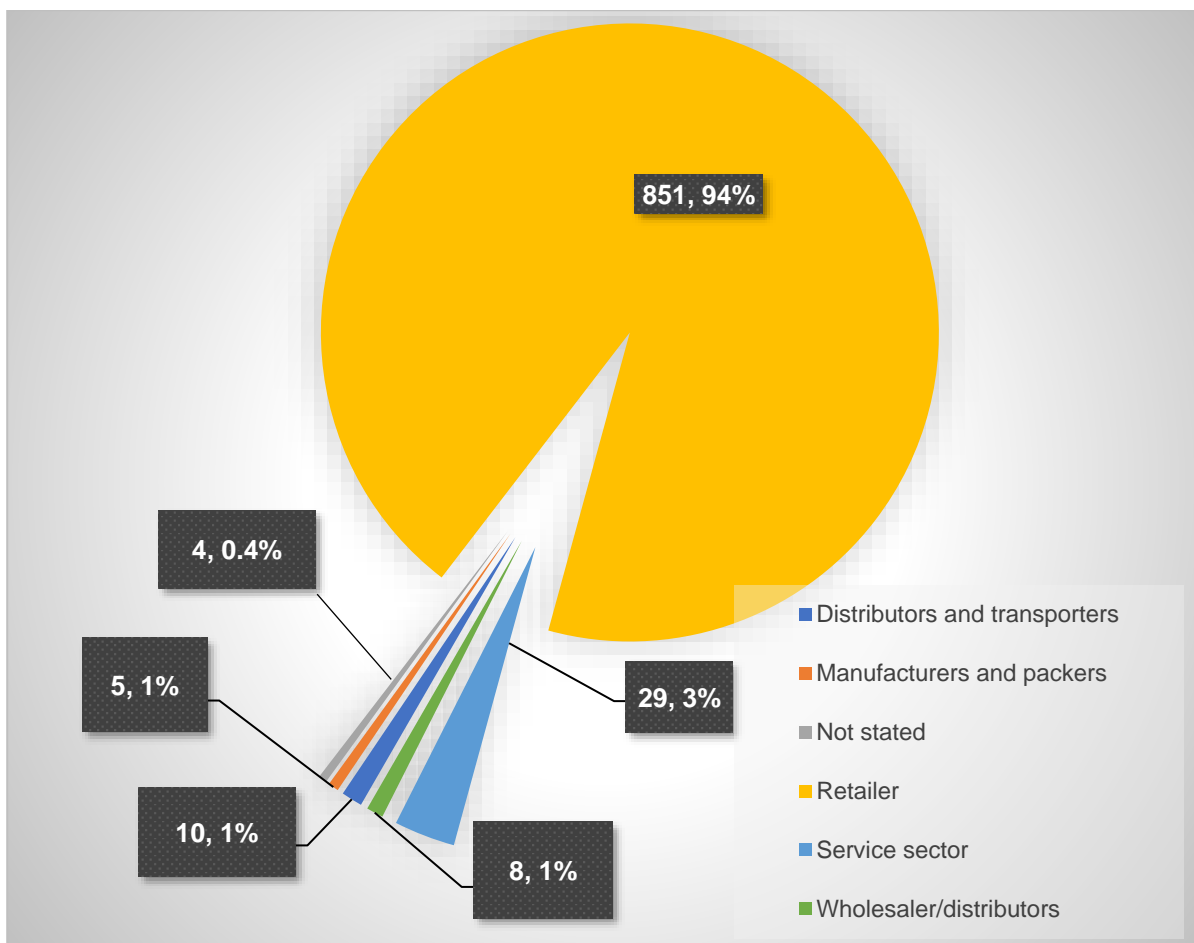
**Figure 1** The demographics of consumers interviewed for the consumer survey to determine how adults on the island of Ireland prepare and consume frozen vegetables, fruits and herbs



## National microbiological survey results and discussion

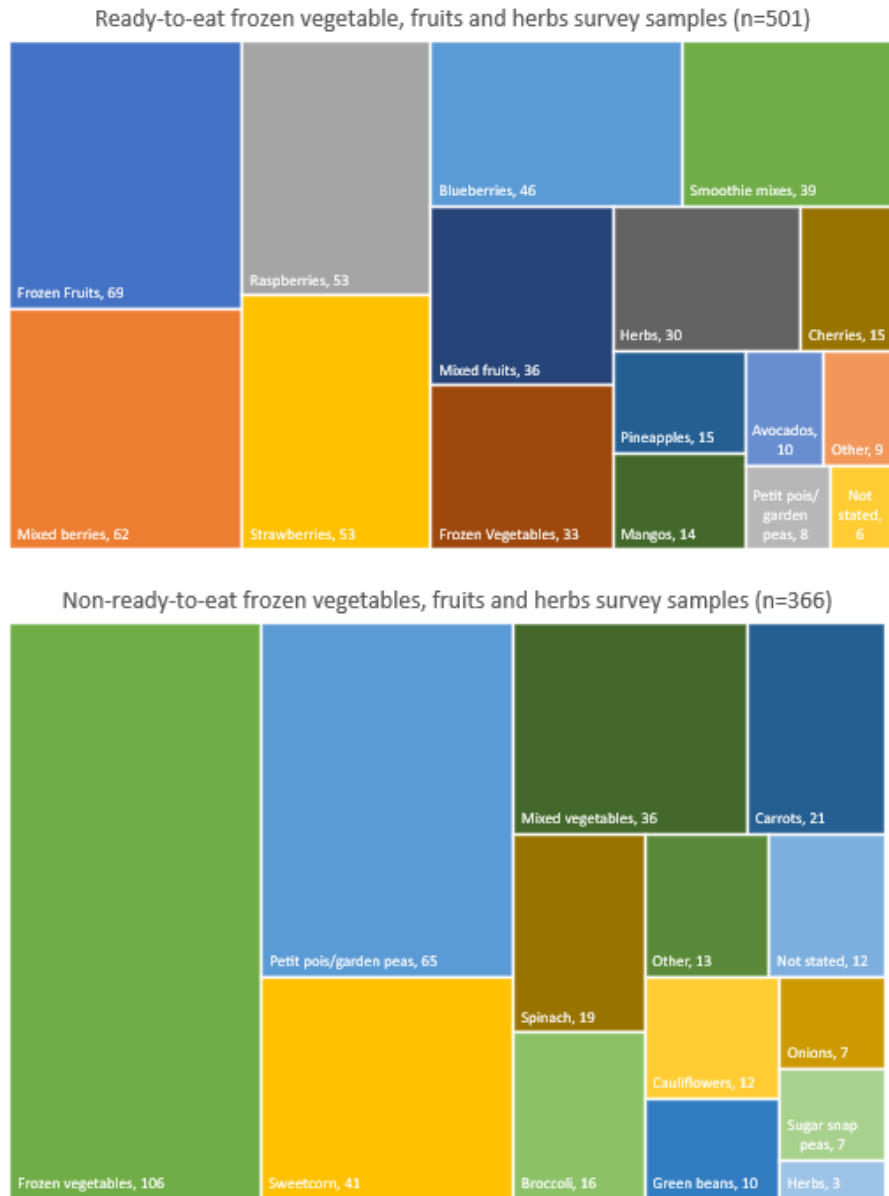
A total of 907 samples were collected for the national microbiological survey; the majority of these (94%) were taken at retail level (Figure 2). A variety of frozen vegetables, fruits and herbs types were collected throughout the survey period. Fifty-five per cent (n=501) of these were labelled RTE, or were considered RTE due to the absence of cooking instructions on the packaging, and/or a serving suggestion indicating that use as an RTE food was appropriate (Figure 3).

Most of these (n=882) were single samples. Five batch samples, each comprising five individual sample units, were taken at the manufacturing and packing stage (n=25 samples in total). All individual sample units of each batch sample were analysed for *L. monocytogenes* and *Listeria* spp. using both the detection method and enumeration method. Analysis of *Salmonella* spp. and *E. coli* was carried out on the first sample unit only (n=1). The tests were not carried out on the remaining sample units (n=4) of these five batches.





**Figure 2** Percentage breakdown of frozen vegetable, fruit and herb samples (n=907) collected, by food chain stage



**Figure 3** Product descriptions of RTE and non-RTE frozen vegetable, fruit and herb samples analysed for the survey

The RTE status was not designated for 4% (n=40) of the samples collected. Frozen fruit samples included blackberries, redcurrants, plums, pomegranates, and grapes. Frozen vegetable samples included kale, butternut squash, Brussels sprouts, broad beans, pumpkins, mushrooms, and peppers. A large number of samples collected were only described as “frozen vegetable” or “frozen



fruit”, with no other information provided. Other frozen sample types analysed included lime leaves, turmeric shots and yellow wax beans. The types of frozen herbs analysed included basil, coriander, thyme, garlic, chilli, rosemary, parsley, and ginger.

### *Listeria monocytogenes*

The *L. monocytogenes* detection method was used to test 906<sup>8</sup> samples, while the *L. monocytogenes* enumeration method was used to test 907 samples. Overall, *L. monocytogenes* was detected in 27 of 906 (3%) survey samples assessed using the detection method (Table 3). The enumeration results show that the number of *L. monocytogenes* present in the contaminated frozen vegetable, fruit or herb samples was at a low level. For the majority of the contaminated samples, it was below the limit of detection (<10 cfu/g). *L. monocytogenes* was enumerated in three samples of frozen non-RTE petit pois, frozen non-RTE diced onion, and frozen chopped basil (RTE status not stated) at 10 cfu/g.

Of the *Listeria* spp., only *L. monocytogenes* is considered to be a significant human pathogen. If *L. monocytogenes* is detected or enumerated in RTE food, the reported result is assessed for its compliance with the criteria for RTE food set out in Commission Regulation (EC) No 2073/2005. All of the RTE survey samples tested using the enumeration method (n=501) were compliant with the limit of 100 cfu/g when placed on the market. All of the non-RTE survey samples tested (n=366), or those in which the RTE status was not designated (n=40), were below the limit of 100 cfu/g.

Figure 4 shows that most of the survey samples found to be contaminated with *L. monocytogenes* were non-RTE (n=21), the largest proportion of which were petit pois (n=7), followed by sweetcorn (n=3), mixed peppers (n=3), and mixed vegetables (n=3). A smaller number of RTE survey samples were contaminated with *L. monocytogenes* (n=6). Four of these were RTE frozen fruit (raspberries, cherries and fruit smoothie mix). No enforcement action was taken on the RTE samples in which *L. monocytogenes* was detected, as the enumeration results for each sample showed that the level present was below the limit of detection (<10 cfu/g), and therefore the legal criterion limit of 100 cfu/g for Food category 1.3 was not breached.

The national microbiological survey found that 9.3% (n=37/399) of frozen vegetables sampled did not have cooking instructions printed on the packaging, or did not indicate to the consumer that the frozen vegetables must be fully cooked prior to consumption, which means that they were categorised as RTE by default in accordance with FSAI *Guidance Note 27* (2014). Seven of these

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<sup>8</sup> The *L. monocytogenes* detection method was not used to test one sample of RTE frozen sour cherries. The same sample of RTE frozen sour cherries was tested using the *L. monocytogenes* enumeration method and had a test result of <10 cfu/g.





samples were petit pois/garden peas, one of which had *L. monocytogenes* detected in 25 g at <10 cfu/g. Willis *et al.* (2020) investigated the occurrence of *Listeria* and *E. coli* in frozen fruit and vegetables collected from retail and catering premises in England between 2018 and 2019, and also found that the intended use of more than 10% of frozen vegetables was not stated on the packaging.

If the manufacturers of non-RTE frozen vegetables, fruits and herbs intend that the consumer should cook the frozen food prior to consumption in order to mitigate any potential risks from foodborne pathogens such as *L. monocytogenes*, they should ensure that there is adequate clear labelling on the packaging to indicate to the consumer that it is a non-RTE product; they should also provide cooking instructions so as to ensure thorough cooking of the product prior to consumption.

The national microbiological survey enumerated 10 cfu/g *L. monocytogenes* and 10 cfu/g *Listeria* spp. in the same sample of frozen chopped basil. However, the detection result for both *L. monocytogenes* and *Listeria* spp. in this sample was not detected in 25 g. This could be due to two different portions of the same sample being tested using Part 1 and Part 2 of the ISO 11290:2017 method for the detection and enumeration of *L. monocytogenes* and *Listeria* spp. respectively, and an uneven distribution of the microbiological contamination in the portion of frozen chopped basil sampled.

It is known that the distribution of microbiological contamination in a food can be heterogeneous (i.e. it is not uniformly contaminated). It can happen occasionally that the target microorganism is detected or enumerated in one portion of a food sample, but not detected or enumerated following a second test carried out on a different portion of the same food sample. Some of the reasons for this include how the food is contaminated (on the surface of the food or throughout the food product), a clustered distribution of microorganisms in the food, or how the intrinsic and extrinsic characteristics of different food matrices affect microbial growth and survival (ICMSF, 2017). The potential for a non-homogenous bacterial distribution to account for discordance between results if performing enumeration and detection on a different subsample of the batch, particularly for low counts, is also highlighted in the *Listeria* guidelines for manufacturers of non-RTE frozen vegetables by the European Association of Fruit and Vegetable Processors (PROFEL 2020, p. 45). *L. monocytogenes* isolated in frozen chopped basil using the enumeration method was not included in the WGS analysis.





**Table 3** The prevalence of *Listeria monocytogenes* in frozen vegetables, fruits and herbs

	Detection method <sup>a</sup>			Enumeration method <sup>b</sup>		
	Total number of samples tested	Not detected in 25 g	Detected in 25 g	Total number of samples tested	Compliant with limit of 100 cfu/g <sup>c</sup>	Exceeds limit of 100 cfu/g
<b>Overall</b>	906 <sup>d</sup>	879 (97%)	27 (3%)	907 <sup>d</sup>	907 (100%)	0 (0%)
<b>RTE samples</b>	500	494 (98.8%)	6 (1.2%)	501	501 (100%)	0 (0%)
<b>Non-RTE samples</b>	366	345 (94.3%)	21 (5.7%)	366	366 (100%)	0 (0%)
<b>RTE status not designated</b>	40	40 (100%)	0 (0%)	40	40 (100%)	0 (0%)

<sup>a</sup> The detection method for *L. monocytogenes* in RTE and non-RTE frozen vegetables, fruits and herbs was used for monitoring and surveillance purposes only, with a view to obtaining useful prevalence data. The test results cannot be designated under Commission Regulation (EC) No 2073/2005, Food category 1.2 (able to support the growth of *L. monocytogenes*) or under FSAI *Guidance Note 3* because *L. monocytogenes* cannot grow at the recommended holding temperatures for frozen food.

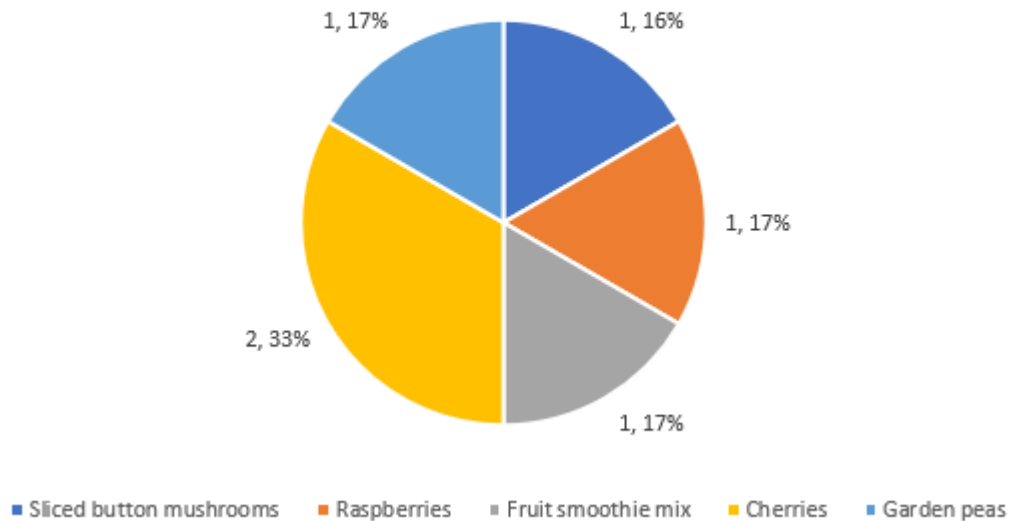
<sup>b</sup> *L. monocytogenes* enumeration results in samples of RTE frozen vegetables, fruits and herbs were assessed against the criterion set in Commission Regulation (EC) No 2073/2005, Food category 1.3 (unable to support the growth of *L. monocytogenes*) because *L. monocytogenes* cannot grow at the recommended holding temperatures for frozen food (during the period it remains frozen). *L. monocytogenes* enumeration results in samples of non-RTE frozen vegetable, fruit and herb samples cannot be designated under Commission Regulation (EC) No 2073/2005, Food category 1.3, as the test was carried out for monitoring and surveillance purposes only, with a view to obtaining useful prevalence data.

<sup>c</sup> 10 cfu/g *L. monocytogenes* were enumerated in three samples, which were frozen non-RTE petit pois, frozen non-RTE diced onion, and frozen chopped basil (RTE status not designated).

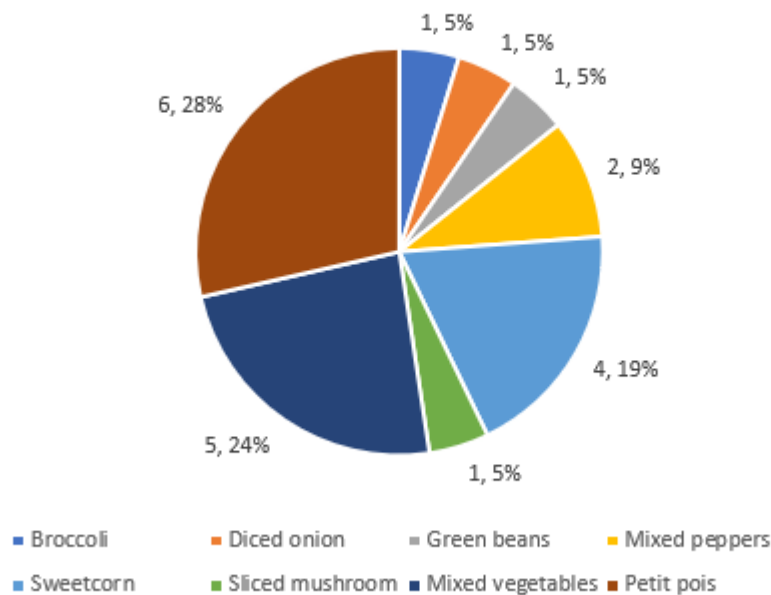
<sup>d</sup> The *L. monocytogenes* detection method was not used on one sample of RTE frozen sour cherries; the same sample was tested using the *L. monocytogenes* enumeration method and had a test result of <10 cfu/g.



RTE vegetable, fruit and herb samples in which *L. monocytogenes* was detected



Non-RTE frozen vegetables, fruit and herb sample descriptions in which *L. monocytogenes* was detected



**Figure 4** Product descriptions of RTE (n=6) and non-RTE (n=21) survey samples that were contaminated with *L. monocytogenes*



## *L. monocytogenes* typing and characterisation

Twenty-seven isolates confirmed as *L. monocytogenes* were sent to the NRL for serotyping using molecular typing methods and characterisation by WGS. Twenty-three of the isolates were in the molecular serogroup IIa, three were IVb, and one was in the molecular serogroup IIb (Table 4).

Table 4 also shows the percentage of *L. monocytogenes* contaminated samples detected for each sample type tested.

**Table 4** Sample description of frozen vegetable, fruit and herb samples with *L. monocytogenes* detected in 25 g, along with their molecular characterisation results

Sample description	Number of each sample type tested	Number and percentage (%) of each sample type with <i>L. monocytogenes</i> detected in 25 g	Molecular serogroup	Clonal complex (CC MLST)
Petits pois <sup>a</sup>	26	6 (23.1%) <sup>b</sup>	IIa	CC8 (n=4)
				CC18 (n=1)
				CC20 (n=1)
Garden peas <sup>a</sup>	47	1 (2.1%) <sup>c</sup>	IIb	CC5 (n=1)
Sweetcorn	41	4 (9.8%) <sup>b</sup>	IIa	CC321 (n=1)
				CC121 (n=2)
				CC21 (n=1)
Mixed vegetables	36	5 (13.9%) <sup>b</sup>	IIa	CC101 (n=2)
				CC37 (n=1)
				CC121 (n=2)
Mushrooms	5	2 (40%)	IIa <sup>b</sup>	CC14 (n=1)
			IVb <sup>c</sup>	CC4 (n=1)
Mixed peppers	5	2 (40%) <sup>b</sup>	IVb	CC6 (n=1)
			IIa	CC451 (n=1)
Diced onion	7	1 (14.3%) <sup>b</sup>	IVb	CC6 (n=1)
Raspberries	53	1 (1.9%) <sup>c</sup>	IIa	CC8 (n=1)
Fruit smoothie mix	39	1 (2.6%) <sup>c</sup>	IIa	CC8 (n=1)
Cherries	15	2 (13.3%) <sup>c</sup>	IIa	CC21 (n=1)
				CC8 (n=1)
Green beans	10	1 (10%) <sup>b</sup>	IIa	CC14 (n=1)
Broccoli	16	1 (6.3%) <sup>b</sup>	IIa	CC101 (n=1)

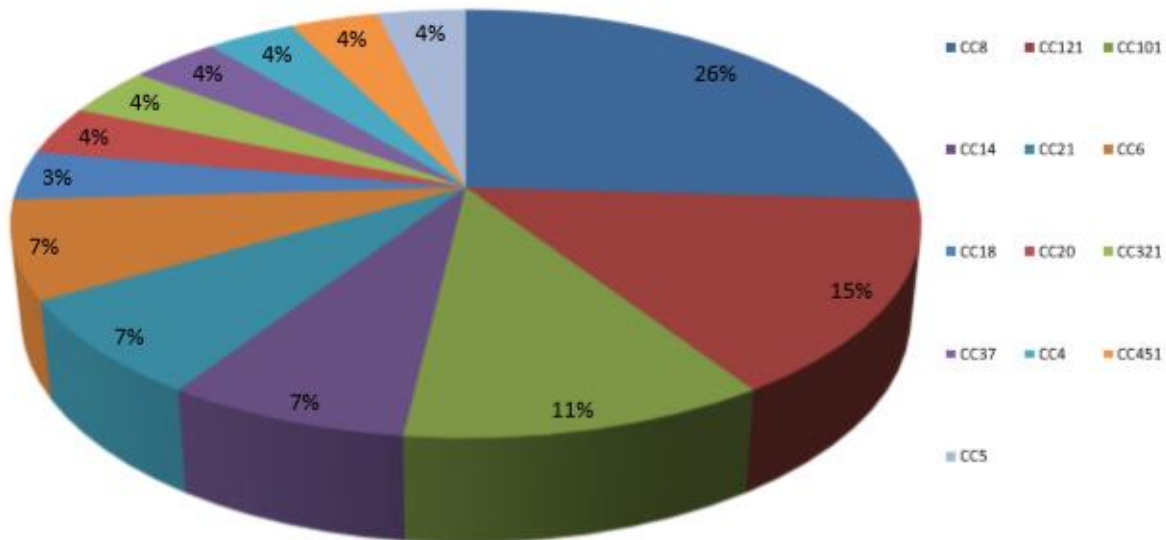
<sup>a</sup> When the results of petit pois and garden peas are combined, 9.6% were contaminated with *L. monocytogenes*.

<sup>b</sup> Positive sample(s) were categorised as non-RTE frozen food.

<sup>c</sup> Positive sample(s) were categorised as RTE frozen food.



The results showed diversity in the strains, as 13 different clonal complex (CC) groups were identified (Table 4 and Figure 5) using WGS. CC8 was the predominant CC type, accounting for 26% (n=7) of the *L. monocytogenes* isolates cultured in the survey.



**Figure 5** Distribution of clonal complexes (CC MLST)

Cluster analysis also highlighted the genetic diversity within the 27 isolates. The MST in Figure 6 shows the allele difference observed between the 27 isolates. The number between each node (isolate) indicates the allele difference. Isolates with the same node colour are within the same cluster. A cluster is defined as isolates with  $\leq 7$  allele difference between their core genome.

Four small clusters (Cluster A, B, C and D) were identified:

- Cluster A (green) contained four isolates cultured from sweetcorn and mixed vegetables samples.
- Cluster B (red) contained two isolates cultured from fruit smoothie mix and sweetcorn samples.
- Cluster C (purple) comprised two isolates cultured from sweetcorn and cherry samples.
- Cluster D (yellow) comprised two isolates cultured from petit pois samples.





## *Listeria* spp.

*Listeria* spp. was detected in 37 of 828 (4.5%) survey samples assessed using the detection method (Table 5). Seventy-eight samples were not tested for *Listeria* spp. using the detection method because the OFML that received these samples was not accredited for the test. The detection method for *Listeria* spp. was also not used on one sample of RTE frozen sour cherries.

The enumeration method for *Listeria* spp. was used on 907 samples (Table 5). The enumeration results show that the number of *Listeria* spp. present in the contaminated frozen vegetable, fruit or herb samples was at a low level. For the majority of the contaminated samples, it was below the limit of detection (<10 cfu/g). A sample of non-RTE frozen sweetcorn and frozen chopped basil (RTE status not stated) was each found to contain 10 cfu/g *Listeria* spp.

Only the *Listeria* spp. enumeration results in samples of RTE frozen vegetables, fruits and herbs were assessed against the criterion set in FSAI *Guidance Note 3*. The level of *Listeria* spp. in all of the RTE frozen vegetable, fruit and herb survey samples assessed was compliant with the limit of 100 cfu/g and therefore the test result was designated as satisfactory against the criterion in Table 4 of *Guidance Note 3*.

The detection method for *Listeria* spp. in RTE and non-RTE survey samples, and the enumeration method for *Listeria* spp. in non-RTE survey samples, were used for monitoring and surveillance purposes only. These test results cannot be designated under *Guidance Note 3* because *Listeria* spp. cannot grow at the recommended holding temperatures for frozen food. However, the survey generated useful prevalence data and showed how many different frozen vegetable, fruit and herb product types placed on the market in Ireland are contaminated with *Listeria* spp. and what level the contamination is at, if it is present. All of these survey samples were compliant when assessed against the guideline limits set out in *Guidance Note 3* for information purposes.

*Listeria* spp. contamination was found in 29 non-RTE products and 7 RTE products (Figure 7). Non-RTE frozen mixed vegetables were the most contaminated products identified (n=12), followed by peas (n=6) and sweetcorn (n=4). *Listeria* spp. was identified in RTE fruit mixes such as mixed berries (n=2), smoothie mix (n=1) and compote (n=1). Figure 8 shows that seven survey samples were contaminated with both *L. monocytogenes* and *Listeria* spp. One of these was labelled as an RTE product, (dark sweet cherries) and the other product (sliced button mushrooms) was considered RTE by default due to the absence of cooking instructions on the packaging label. *L. monocytogenes* (10 cfu/g) and *Listeria* spp. (10 cfu/g) were enumerated in the same sample of frozen chopped basil. The RTE status of this sample was not provided; however, fresh basil is a herb that is often eaten as an RTE food by consumers.



**Table 5** The prevalence of *Listeria* spp. in frozen vegetables, fruits and herbs

	Detection method <sup>a</sup>			Enumeration method <sup>b</sup>		
	Total number of samples tested	Not detected in 25 g	Detected in 25 g	Total number of samples tested	Compliant with limit of 100 cfu/g <sup>c</sup>	Exceeds limit of 100 cfu/g
<b>Overall</b>	828 <sup>d</sup>	791 (95.5%)	37 (4.5%)	907 <sup>d</sup>	907 (100%)	0 (0%)
<b>RTE samples</b>	456	449 (98.5%)	7 (1.5%)	501	501 (100%)	0 (0%)
<b>Non-RTE samples</b>	332	303 (91.3%)	29 (8.7%)	366	366 (100%)	0 (0%)
<b>RTE status not designated</b>	40	39 (97.5%)	1 (2.5%)	40	40 (100%)	0 (0%)

<sup>a</sup> The detection method for *Listeria* spp. in RTE and non-RTE frozen vegetables, fruits and herbs was used for monitoring and surveillance purposes only, with a view to obtaining useful prevalence data. The test results cannot be designated under FSAI *Guidance Note 3* because *Listeria* spp. cannot grow at the recommended holding temperatures for frozen food.

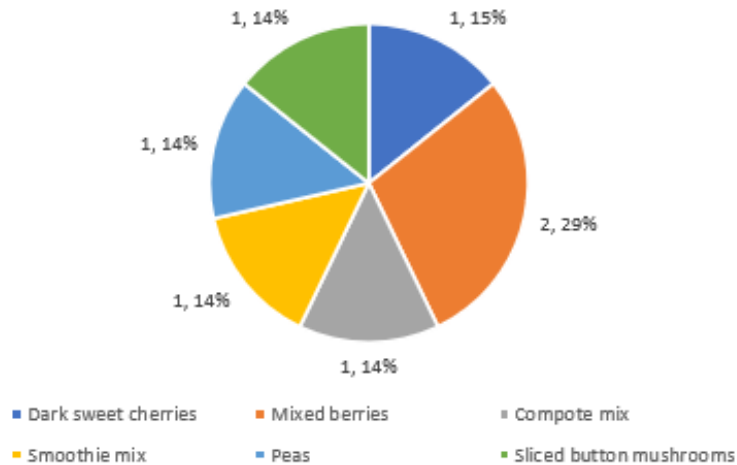
<sup>b</sup> *Listeria* spp. enumeration results in samples of RTE frozen vegetables, fruits and herbs were assessed against the criteria set out in FSAI *Guidance Note 3* (foods that cannot support the growth of *Listeria* spp.) because *Listeria* spp. cannot grow at the recommended holding temperatures for frozen food (during the period it remains frozen). *Listeria* spp. enumeration results in samples of non-RTE frozen vegetable, fruit and herb samples cannot be designated under FSAI *Guidance Note 3* as the test was carried out for monitoring and surveillance purposes only, with a view to obtaining useful prevalence data.

<sup>c</sup> 10 cfu/g *Listeria* spp. were enumerated in two samples, which were non-RTE frozen sweetcorn and frozen chopped basil (RTE status not designated).

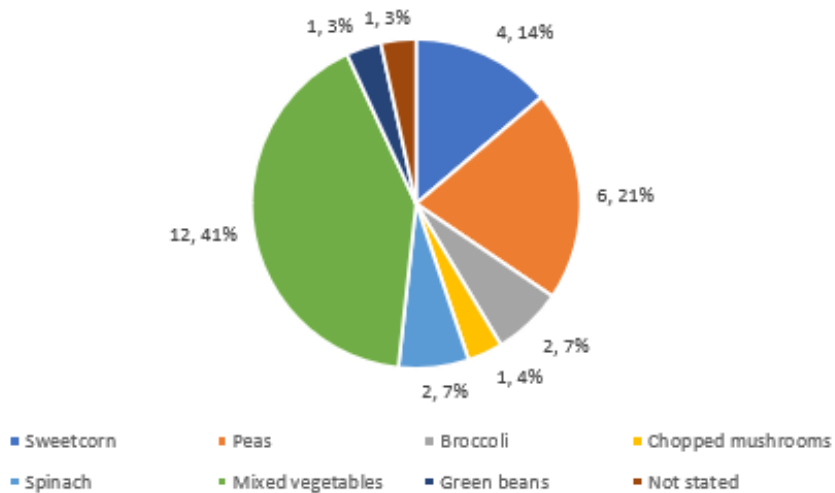
<sup>d</sup> 78 samples were not tested using the detection method for *Listeria* spp. because the OFML that received these samples was not accredited for the test. These 78 samples were assessed using the enumeration method for *Listeria* spp. The detection method for *Listeria* spp. was also not used on one sample of RTE frozen sour cherries; the same sample was tested using the enumeration method for *Listeria* spp.



RTE vegetable, fruit and herb samples in which *Listeria* spp. was detected



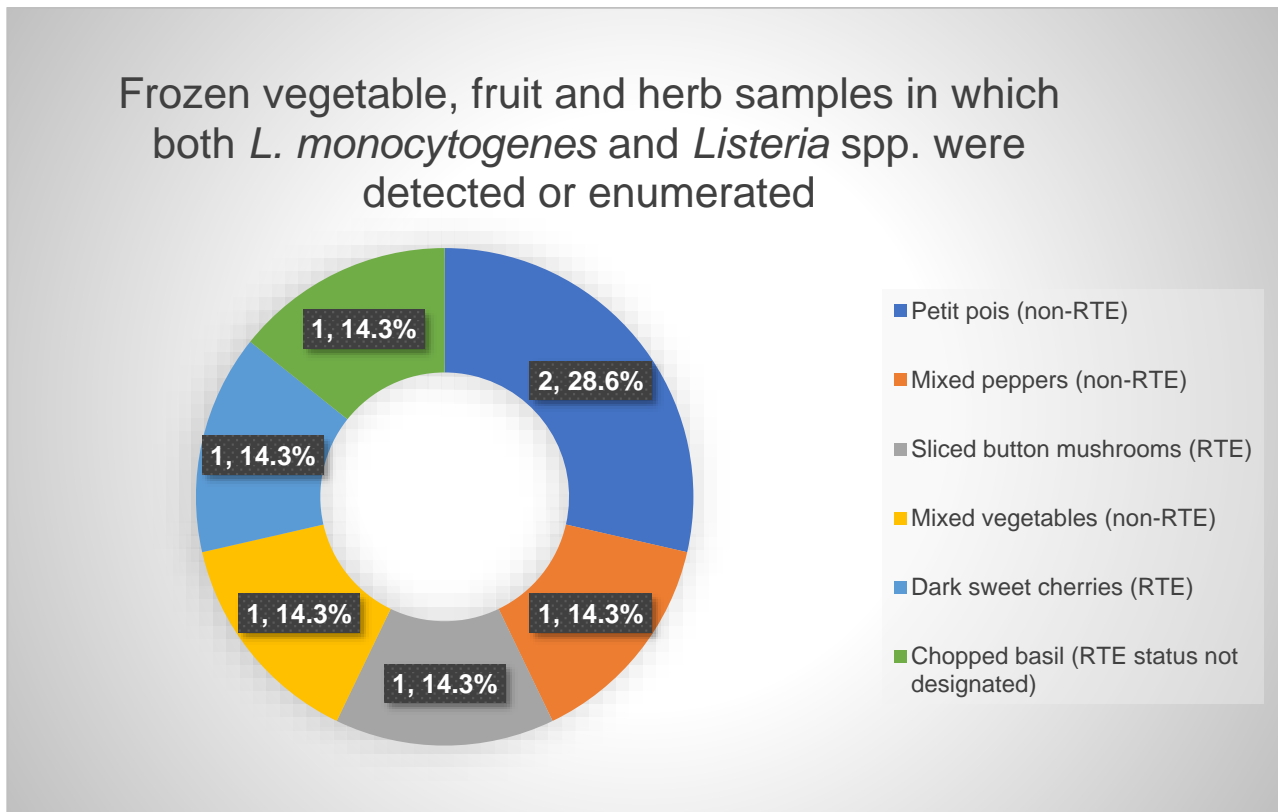
Non-RTE vegetable, fruit and herb samples in which *Listeria* spp. was detected



**Figure 7** Product descriptions of RTE (n=7) and non-RTE (n=29) survey samples that were contaminated with *Listeria* spp.<sup>9</sup>

<sup>9</sup> The RTE status of *Listeria* spp. isolated from sliced peppers was not designated and it is not included in Figure 7.





**Figure 8** Product descriptions of survey samples (n=7) that were contaminated with both *L. monocytogenes* and *Listeria* spp.



## Salmonella

*Salmonella* was included as a microbiological parameter in this survey in order to ascertain whether there were any issues regarding this pathogen in frozen produce, given that the presence of *Salmonella* in fresh produce often occurs and causes foodborne illness (FSAI, 2019). None of the 499 RTE or 346 non-RTE samples assessed for the national microbiological survey were found to be positive for *Salmonella* (Table 6). There have been 11 notifications of *Salmonella* in frozen vegetables, fruits and herbs previously reported via the RASFF, mostly in frozen fruits (n=7), but also in frozen vegetables (n=2) and frozen herbs (n=3) (Appendix 1).

**Table 6** The prevalence of *Salmonella* in frozen vegetables, fruits and herbs

	Total samples tested	Satisfactory (%)	Unsatisfactory (%)
<b>Overall</b>	885 <sup>a</sup>	885 (100%)	0 (0%)
<b>RTE samples<sup>b</sup></b>	499	499 (100%)	0 (0%)
<b>Non-RTE samples<sup>c</sup></b>	346	346 (100%)	0 (0%)
<b>RTE status not designated</b>	40	40 (100%)	0 (0%)

<sup>a</sup> Analysis of *Salmonella* spp. was carried out on the first sample unit only of five batch samples collected (each consisting of five individual sample units). The test for *Salmonella* spp. was not carried out on the remaining sample units of these five batches (n=20 in total). The *Salmonella* spp. test was not carried out on two single samples, but all other survey parameters were assessed in these samples.

<sup>b</sup> For RTE samples, the *Salmonella* test result was assessed against the guideline microbiological limits for “RTE food placed on the market” set out in FSAI *Guidance Note 3* as there are no legal microbiological criteria for *Salmonella* in frozen vegetables, fruits and herbs in Commission Regulation (EC) No 2073/2005.

<sup>c</sup> For non-RTE samples, the *Salmonella* test result was assessed against the guideline microbiological limits set out in FSAI *Guidance Note 3* for information purposes. The test result cannot be designated because the food is not considered RTE and the test was carried out for monitoring and surveillance purposes only, with a view to obtaining useful prevalence data.



## *E. coli*

A total of 887 frozen vegetable, fruit and herb samples were assessed for the presence of *E. coli* as an indicator of the hygiene status of the survey samples tested. Analysis of *E. coli* was carried out on the first sample unit only of five batch samples collected (each consisting of five individual sample units). The test for *E. coli* was not carried out on the remaining sample units of these five batches (n=20 in total).

While an unsatisfactory result for a hygiene indicator test does not mean that the batch of food is considered unsafe under Article 14, Regulation (EC) No 178/2002, as amended, the presence of unsatisfactory levels of *E. coli* can indicate that faecal pathogens could be present. *E. coli* are removed from the food processing environment by effective cleaning and sanitisation (FSAI, 2020a). Table 7 shows that 10 survey samples had borderline levels (between 20 and 100 cfu/g) and two samples had unsatisfactory levels (>100 cfu/g) of *E. coli* present when assessed against the microbiological criteria set out in FSAI *Guidance Note 3* (p. 16).

The two RTE samples designated as borderline for *E. coli* (butternut squash and sliced button mushrooms) were considered RTE by default as they did not have cooking instructions on the packaging. The same sample of sliced button mushrooms had *L. monocytogenes* IVb (<10 cfu/g) and *Listeria innocua* (<10 cfu/g) present in it, along with 80 cfu/g *E. coli*. If these low levels were present at the point of consumption, the risk posed to consumers who are in good health should be minimal. However, the risk could be higher for consumers who are immunocompromised, or if consumer preparation and handling practices allow any of the *L. monocytogenes* contamination present in the frozen sliced mushrooms to increase at the point of consumption to levels high enough to potentially cause listeriosis. Levels of *L. monocytogenes* >100 cfu/g at the point of consumption is considered to represent a risk to consumers (European Commission, 1999).



**Table 7** The prevalence of *E. coli* in frozen vegetables, fruits and herbs

	Total samples tested	Satisfactory (%) <20 cfu/g	Borderline (%) 20–100 cfu/g	Unsatisfactory (%) >100 cfu/g	
<b>Overall</b>	887 <sup>a</sup>	875 (98.6%)	10 (1.1%)	2 (0.2%) <sup>b</sup>	
<b>RTE samples</b>	501	499 (99.6%)	2 (0.4%)	0 (0%)	
			<b>Sample description and level of <i>E. coli</i> found</b>		
			Butternut squash (n=1) 25 cfu/g		
			Sliced button mushrooms (n=1) 80 cfu/g		
<b>Non-RTE samples</b>	346	336 (97.1%)	8 (2.3%)	2 (0.6%)	
			<b>Sample description and level of <i>E. coli</i> found</b>		
			Green beans (n=1) 100 cfu/g		Spinach (n=1) 1100 cfu/g <sup>c</sup>
			Petit pois/garden peas (n=3) 60, 25 and 20 cfu/g		
			Baby carrots (n=2) 20 and 25 cfu/g		Chopped spinach (n=1) 570 cfu/g <sup>c</sup>
			Diced onions (n=1) 20 cfu/g		
			Frozen vegetables (n=1) 20 cfu/g		
<b>RTE status not designated</b>	40	40 (100%)	0 (0%)	0 (0%)	

<sup>a</sup> Analysis of *E. coli* was carried out on the first sample unit only of five batch samples collected (each consisting of five individual sample units). The test for *E. coli* was not carried out on the remaining sample units of these five batches (n=20 in total).

<sup>b</sup> For RTE samples, the *E. coli* test result was assessed against the guideline microbiological limits for “RTE food placed on the market” set out in FSAI *Guidance Note 3*, as there are no legal microbiological criteria for *E. coli* in frozen vegetables, fruits and herbs in Commission Regulation (EC) No 2073/2005.

<sup>c</sup> For non-RTE samples, the *E. coli* test result was assessed against the guideline microbiological limits set out in FSAI *Guidance Note 3* for information purposes. The test result cannot be designated because the food is not considered RTE and because the test was carried out for monitoring and surveillance purposes only, with a view to obtaining useful prevalence data.



## Consumer survey results and discussion

The total number of interviews achieved for the consumer survey on the island of Ireland was 815 (502 were based in Ireland and 313 in Northern Ireland). The fieldwork was conducted between late January and early March 2020. Appendix 2 lists the detailed questions that were asked of participants in the consumer survey. Table 8 shows how many consumers responded to each survey question, depending on how relevant it was to them. For example, some survey participants said they never consumed frozen vegetables (n=165), frozen fruits (n=490) or frozen herbs (n=712). Therefore, some of the questions asking for information on the types of frozen vegetables, fruits and/or herbs normally consumed, or whether they have ever consumed them uncooked, were not relevant to them.

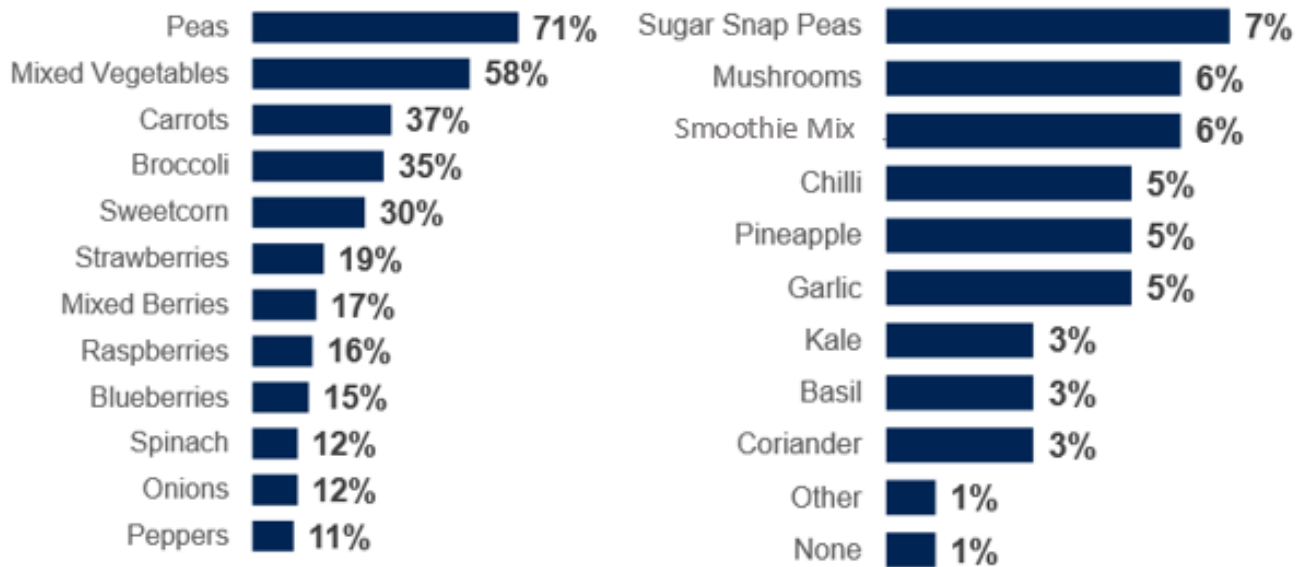
The consumer survey found that out of 815 adults surveyed on the island of Ireland, 80% (n=650) consume frozen vegetables, 40% (n=325) consume frozen fruits and 13% (n=103) consume frozen herbs. Population estimates for key survey results were calculated for some of the top-level results to give an indication of the numbers involved. In Ireland, based on a population of 3,903,000 adults,<sup>10</sup> it was calculated that this equates to approximately 3,083,370 adults who consume frozen vegetables, 1,561,200 adults who consume frozen fruits, and 429,330 adults who consume frozen herbs. In Northern Ireland, based on a population of 1,497,700 adults,<sup>11</sup> it was calculated that this equates to approximately 1,228,114 adults who consume frozen vegetables, 584,103 adults who consume frozen fruits, and 209,678 adults who consume frozen herbs.

Consumption of frozen vegetables is highest among 25–44-year-olds, at 83% (n=264/318), as is consumption of frozen herbs, at 17% (n=54/318). Consumption of frozen fruits is highest among 15–44-year-olds, at 46% (n=206/448). Of the 680 adults on the island of Ireland who said they consume frozen foods, frozen peas and frozen mixed vegetables are the most commonly consumed, at 71% (n=480) and 58% (n=391), respectively (Figure 9).

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<sup>10</sup> Ireland population figures for adults aged 15 years and over was based on data collected by the Central Statistics Office (CSO) for its Labour Force Survey (LFS) Quarter 4 2018 to Quarter 3 2019. For more information see: <https://www.cso.ie/en/statistics/labourmarket/labourforcesurvey/lfs/>

<sup>11</sup> Northern Ireland population figures for adults aged 16 years and over were based on data collected by the Northern Ireland Statistics and Research Agency (NISRA) for its 2019 Mid-Year Estimates. For more information see: <https://www.nisra.gov.uk/statistics/population/mid-year-population-estimates>



**Figure 9** The types of frozen vegetables, fruits and herbs most frequently consumed by adults surveyed on the island of Ireland (n=680)

**Table 8** The number of respondents to each question asked as part of the consumer survey

Question number	Survey questions	Number of respondents to each survey question		
		Island of Ireland	Ireland	Northern Ireland
1–3	How often, if at all, do you consume frozen fruits, vegetables and/or herbs?	815	502	313
4	Which of the following frozen foods, if any, do you usually consume?	680 <sup>a</sup>	409	271
5	Which frozen fruits, vegetables or herbs, if any, do you eat uncooked?	678 <sup>a</sup>	407	271
6	If you consume uncooked frozen vegetables, fruits and/or herbs, how do you use them?	218 <sup>b</sup>	131	87
7	For each frozen food, read out which do you feel needs to be cooked before eating, or not?	815	502	313
8	In your opinion is the risk of consuming uncooked frozen fruits, vegetables and herbs lower, higher or about the same risk as consuming uncooked fresh fruits, vegetables or herbs?	815	502	313
9	Have you ever heard of <i>Listeria</i> before now?	815	502	313
10	And can you recall where you heard about <i>Listeria</i> ?	426	237	189
11	What foods, if any, do you associate with <i>Listeria</i> ?	426	237	189
12	Which groups of people, if any, do you think are at most risk of infection with <i>Listeria</i> ?	426	237	189
13	Do you currently prepare food at home for any of the following vulnerable groups?	815	502	313
14	When preparing frozen vegetables for this person or persons, how often, if ever, do you follow the cooking instructions on the packaging?	327	192	135
15	Do you ever use uncooked frozen fruits or vegetables as a snack for your child or children?	200	123	77
16	Which of these statements have you have heard about before now, or not? 1. In 2018 there was an outbreak of listeriosis across Europe connected with the consumption of frozen vegetables. 2. There is a risk of food poisoning specifically related to consuming imported frozen berries. 3. Imported frozen berries should be boiled for at least 1 minute before eating.	815	502	313

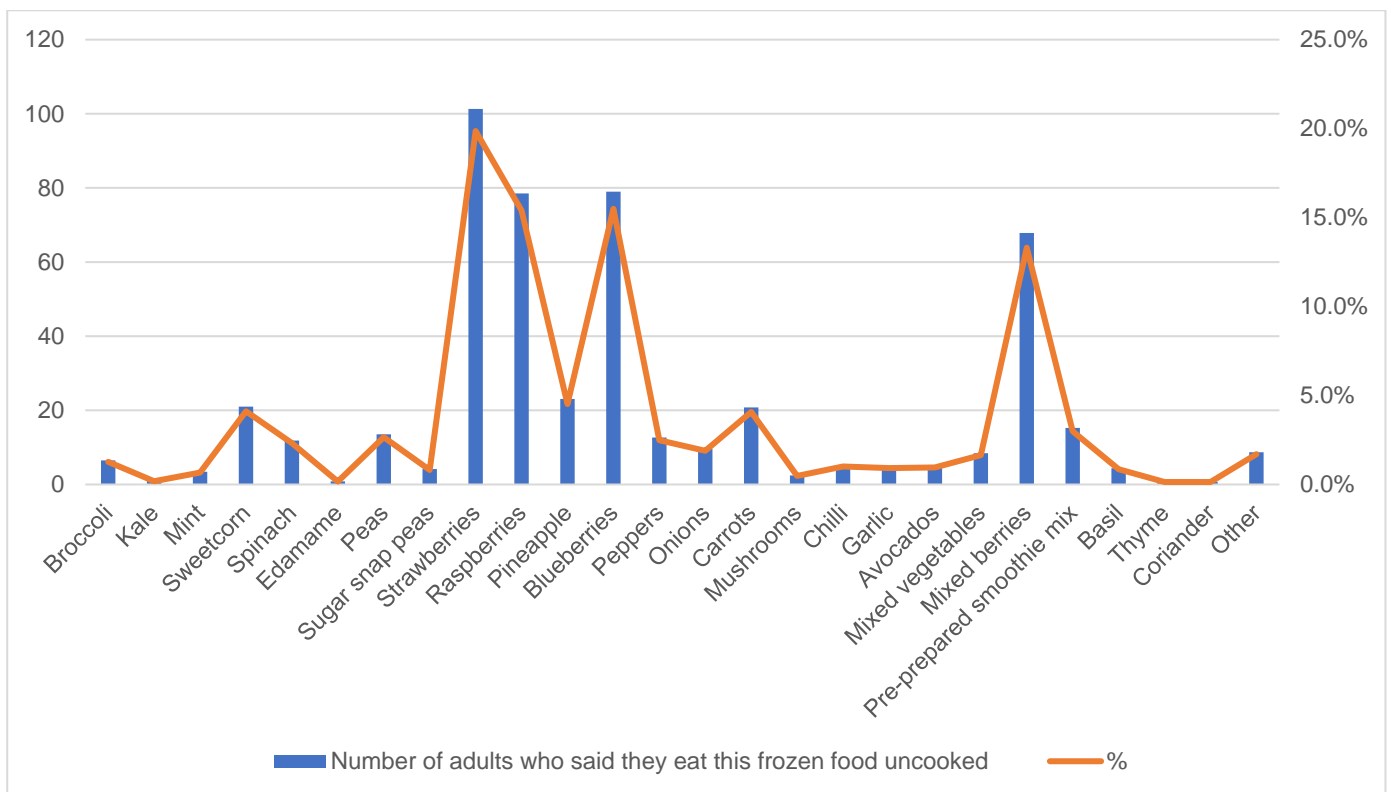
<sup>a</sup> All who consume frozen vegetables, fruits and/or herbs

<sup>b</sup> All who have consumed uncooked frozen vegetables, fruits and/or herbs



## Consumption of uncooked frozen vegetables, fruits and herbs

Of the 678 adults on the island of Ireland who responded to the question on consuming uncooked frozen vegetables, fruits and/or herbs, 68% (n=460) said they do not consume any uncooked frozen foods. Of the 218 survey participants who said they do consume uncooked frozen vegetables, fruits and/or herbs, there was a cumulative number of 510 positive responses when the survey participants were read a list of certain frozen vegetables, fruits and herbs as per question 5 in Appendix 2, and were asked to specify which frozen fruits, vegetables or herbs they eat uncooked. Figure 10 provides an overview of the proportion and types of frozen vegetables, fruits and/or herbs that the respondents said they eat uncooked. Some of the respondents ate more than one type of frozen vegetable, fruit and/or herb uncooked. The survey responses showed that frozen fruits such as strawberries, blueberries, raspberries and mixed berries were the most likely to be consumed uncooked. When the respondents to this question were asked how they use the uncooked frozen vegetables, fruits and/or herbs as per question 6 in Appendix 2, the main way in which frozen fruits were consumed uncooked is 'in a dessert' or 'in a smoothie' (Table 9).



**Figure 10** The types and percentage of frozen vegetables, fruits and/or herbs that adults on the island of Ireland said they eat uncooked





**Table 9** The ways in which the top five frozen fruits eaten uncooked are used by consumers on the island of Ireland

Uses	Strawberries	Blueberries	Raspberries	Mixed berries	Pineapple
	<b>Number of respondents who eat this frozen fruit uncooked</b>				
	<b>101</b>	<b>79</b>	<b>78</b>	<b>68</b>	<b>23</b>
<b>In a dessert</b>	55%	50%	55%	39%	48%
<b>In a smoothie</b>	44%	39%	46%	56%	50%
<b>As a snack</b>	7%	6%	8%	4%	4%
<b>As a garnish</b>	6%	5%	6%	4%	4%
<b>Breakfast (unspecified)</b>	4%	8%	5%	7%	4%
<b>With yogurt</b>	3%	4%	4%	4%	4%
<b>With cereal</b>	3%	5%	6%	6%	3%
<b>With porridge</b>	3%	5%	2%	9%	-
<b>In a salad</b>	3%	7%	2%	1%	9%
<b>In a drink</b>	2%	-	1%	-	-
<b>Other</b>	1%	4%	-	5%	-

Figure 10 shows that a small number of the consumers said they eat uncooked frozen vegetables such as sweetcorn (n=21), carrots (n=21), peas (n=14), peppers (n=13), spinach (n=12), onions (n=10), mixed vegetables (n=8), broccoli (n=6), sugar snap peas (n=4), mushrooms (n=2), and kale (n=1). A small number of consumers said they eat frozen herbs uncooked, but these could be placed on the market as either an RTE or non-RTE food with cooking instructions printed on the packaging. The frozen herbs that consumers said they eat uncooked were mint (n=3), chilli (n=5), garlic (n=5), basil (n=4), thyme (n=1) and coriander (n=1). RTE frozen avocados that can be defrosted for use in smoothies and salads is a newer trend on the retail shelves in since around 2015. Of the consumers who said they eat frozen avocados (n=11), only 45% (n=5) said they eat them uncooked.

Most frozen vegetables such as sweetcorn, peas, mixed vegetables and carrots are considered by the manufacturer as non-RTE and have cooking instructions printed on the packaging. In the 2015–2018 European listeriosis outbreak, illness was particularly associated with the consumption of uncooked non-RTE frozen sweetcorn and frozen vegetable mixes containing sweetcorn (ECDC-EFSA, 2018; EFSA BIOHAZ Panel, 2020). The current consumer survey showed that 30% (n=203/680) of adults on the island of Ireland regularly consume frozen sweetcorn, but only 10.3% (n=21/203) of those said they ever eat uncooked frozen sweetcorn. Table 10 shows an analysis of consumers who said they consume a certain frozen vegetable, fruit and/or herb, compared with those who said they would consume the same frozen vegetable, fruit and/or herb uncooked. It also



shows the proportion of these sample types that were found to be contaminated with *L. monocytogenes* when analysed as part of the national microbiological survey for the current study. The consumers surveyed were not specifically asked about their consumption of cherries or green beans; however, the national microbiological survey detected *L. monocytogenes* in 12.5% (n=2/16) samples of cherries tested and 10% (n=1/10) of green beans samples.

## Main ways uncooked frozen vegetables, fruits and herbs are consumed

Table 11 shows the ways in which the top five frozen vegetables eaten uncooked are used by consumers on the island of Ireland. The top use identified for uncooked frozen vegetables was 'in a salad' (with figures ranging from 74% to 91%), followed by use 'as a garnish' (ranging from 11% to 27%). In particular, a high percentage of the respondents said they would eat uncooked frozen sweetcorn (82%) and peppers (91%) in salads. The national microbiological survey found 9.8% of frozen sweetcorn and 40% of peppers tested to be contaminated with low levels of *L. monocytogenes* (detected in 25 g at <10 cfu/g). *Listeria* spp. was detected and enumerated at 10 cfu/g in a sample of frozen sweetcorn, but *L. monocytogenes* was not detected or enumerated in the same sample. A high number of respondents (74%) said they would eat uncooked frozen peas in a salad. When the analysis of the results for petit pois and garden peas are combined, *L. monocytogenes* was detected in 9.6% of samples tested. Of the seven samples contaminated, six were described as petit pois (23.1% detection rate) and one as garden peas (2.1% detection rate). The enumerated test result for six of these samples was <10 cfu/g, while one sample of petit pois was found to have 10 cfu/g *L. monocytogenes* present. Twenty-three per cent of consumers said they would eat frozen basil uncooked. The national microbiological survey enumerated 10 cfu/g *L. monocytogenes* and 10 cfu/g *Listeria* spp. in the same sample of frozen chopped basil. The RTE status of the frozen chopped basil sample was not provided on the National Sample Submission Form at the time of sampling.



**Table 10** The percentage of certain frozen vegetables, fruits and herbs normally consumed by adults in Ireland, compared with those who said they would consume this frozen food uncooked

Frozen food	Total number who said they consume this frozen food	Total number who said they consume this frozen food uncooked (%)	Percentage of each sample type contaminated with <i>L. monocytogenes</i> according to the national microbiological survey results
Peas	480	14 (2.9%)	9.6% (n=7/73)
Mixed vegetables	391	8 (2.0%)	13.9% (n=5/36)
Carrots	250	21 (8.4%)	0% (n=0/21)
Broccoli	235	6 (2.6%)	6.3% (n=1/16)
Sweetcorn	203	21 (10.3%)	9.8% (n=4/41)
Strawberries	130	101 (77.7%)	0% (n=0/53)
Mixed berries	113	68 (60.2%)	0% (n=0/62)
Raspberries	105	78 (74.3%)	1.9% (n=1/53)
Onions	80	10 (12.5%)	14.3% (n=1/7)
Spinach	80	12 (15.0%)	0% (n=0/19)
Peppers	75	13 (17.3%)	40% (n=2/5)
Mushrooms	42	2 (4.8%)	40% (n=2/5)
Pre-prepared smoothie mix	38	15 (39.5%)	2.6% (n=1/39)
Avocados	11	5 (45.5%)	0% (n=0/10)
Basil	19	4 (21.1%)	10% (n=1/10)

**Table 11** The top five ways frozen vegetables are eaten uncooked by consumers in Ireland

Uses	Sweetcorn	Carrots	Peas	Peppers	Spinach
	<b>Number of respondents who eat this frozen vegetable uncooked</b>				
	<b>21</b>	<b>21</b>	<b>14</b>	<b>13</b>	<b>12</b>
In a dessert	-	5%	-	-	-
In a smoothie	-	7%	-	-	7%
As a snack	6%	19%	14%	9%	
As a garnish	15%	24%	23%	11%	27%
Lunch (unspecified)	4%	-	-	-	-
In a salad	82%	79%	74%	91%	78%
Other (unspecified)	4%	5%	-	-	7%

If the test result of 10 cfu/g *L. monocytogenes* for frozen chopped basil or frozen petit pois, or the detected in 25 g at <10 cfu/g result for petit pois/garden peas, sweetcorn or peppers was assessed as an RTE food, it was compliant with the microbiological limit of 100 cfu/g *L. monocytogenes* for



Food category 1.3 in Commission Regulation (EC) No 2073/2005. However, if these foods were subjected to temperature abuse under reasonably foreseeable conditions of distribution, storage and use throughout the shelf life of the products as per Article 3.1 (b) in Commission Regulation (EC) No 2073/2005, the level of *L. monocytogenes* present in these foods could increase and breach the criterion limit of 100 cfu/g set out in the Regulation. The EFSA BIOHAZ Panel Scientific Opinion (2020) found that the occurrence of low levels of *L. monocytogenes* at the end of the production process (e.g. <10 cfu/g) would be compatible with the limit of 100 cfu/g in uncooked frozen vegetables, fruits and herbs at the moment of consumption, but only if any labelling recommendations for thawing and food storage are strictly followed (i.e. 24 hours at 5 °C). However, the Scientific Opinion cautions that under reasonably foreseeable conditions of use (i.e. 48 hours at 12 °C), *L. monocytogenes* levels present need to be considerably lower (i.e. not detected in 25 g), in order to avoid a potential breach of this criterion limit.

## Growth of *L. monocytogenes* in thawed frozen vegetables, fruits and herbs

The potential for growth of *L. monocytogenes* in frozen vegetables, fruits and herbs at the consumer stage will be determined by how the consumer stores, handles and normally consumes the product. Frozen foods do not support the growth of *L. monocytogenes* while kept at freezing temperatures. However, the pathogen can survive for extended periods when stored at  $\leq -18$  °C. For many frozen vegetables in particular, the consumer is instructed via the label on the packaging to cook the vegetables prior to consumption. The packaging of 9.3% (n=37/399) of the frozen vegetable samples tested in the national microbiological survey was determined to be RTE based on the absence of cooking instructions on the label, combined with no indication to the consumer on the label that the product was to be fully cooked prior to consumption. Similarly, Willis *et al.* (2020) reported that the packaging advice on frozen vegetables placed on the market in the UK is also variable, with 10% not stating whether the intended use of the frozen vegetable was as a non-RTE food.

According to the EFSA BIOHAZ Panel (2020), if *L. monocytogenes* is present in frozen vegetables, the levels may increase if the vegetables are thawed and kept at storage conditions that enable growth of the pathogen. The extent of the *L. monocytogenes* growth in thawed blanched vegetables will depend on several factors, including the type of product (e.g. due to its intrinsic factors such as pH,  $a_w$ , sugar/starch content, presence of antimicrobial compounds resistant to the blanching process, and occurrence of cut surfaces, or packaging conditions in cases where modified atmosphere is applied); the presence, type and level of competitive background



microbiota; as well as the time/temperature profile of the product during its storage. The Scientific Opinion also highlights that the heat treatment associated with blanching of vegetables may result in a product that facilitates *L. monocytogenes* growth during subsequent storage after thawing due to various factors. The Scientific Opinion found that sufficient data describing the growth of *L. monocytogenes* inoculated in blanched frozen vegetables during thawing and/or storage were scarce. However, predictive microbiology models do indicate that *L. monocytogenes* is well adapted to the intrinsic characteristics of vegetables and can initiate its growth almost immediately when the product temperature allows it. Despite the limited data, it seems that some vegetables favour a faster growth of *L. monocytogenes* (e.g. asparagus, green peas, sweetcorn, and carrots) than others (e.g. broccoli and beans). However, the Scientific Opinion cautions that the data can hardly be compared, as they come from different experiments, using specific strains and experimental conditions.

The results of the consumer survey showed that a small number of the participants said they would consume non-RTE frozen vegetables uncooked, mostly in salads or as a garnish (Table 11), which means that they are most likely defrosted by the consumer and stored for a period of time prior to consumption. Even if the defrosted frozen vegetables are stored under refrigeration temperatures, Kennedy *et al.* (2005) reported that, on average, 59% of fridges in Ireland are operating at temperatures of  $\geq 5$  °C. This consumer practice could permit *L. monocytogenes* to grow to a level that would cause illness if the frozen vegetables consumed uncooked by the consumer are initially contaminated with the pathogen at low levels. According to Section 3.3.2, Table 10 in the EFSA BIOHAZ Panel Scientific Opinion (2020), *L. monocytogenes* could increase in frozen-thawed sweetcorn and green peas by 0.5 log<sub>10</sub> in 13 hours or less if they are stored at  $\geq 8$  °C. The results from the current consumer survey show that 10.3% and 2.9% of consumers who regularly eat frozen sweetcorn and frozen peas, respectively, would eat them uncooked (Table 10). Table 11 shows that the main way in which they would consume sweetcorn and peas uncooked is in a salad (82% and 74%, respectively). The results from the national microbiological survey found that 9.8% and 9.6% of the frozen sweetcorn and peas analysed were contaminated with low levels of *L. monocytogenes*, respectively.

Following the 2018 European listeriosis outbreak related to frozen sweetcorn and possibly other frozen vegetables, PROFEL (the European Association of Fruit and Vegetable Processors) published hygiene guidelines for the control of *L. monocytogenes* in the production of quick-frozen vegetables (PROFEL, 2020). The guidelines were prepared by the European frozen vegetable sector with the support of Ghent University and in consultation with the European Commission and Member States. The aim of the guidelines is to deliver best practice guidance to vegetable freezing companies on how to control *L. monocytogenes* in the production of quick-frozen vegetables, and



to ensure consumer safety by providing information on how frozen vegetables should be stored, defrosted and prepared. To inform the advice given to frozen vegetable manufacturers and consumers of frozen vegetables, challenge testing was carried out on different frozen vegetables to assess the behaviour of *L. monocytogenes* during defrosting/refrigerated storage of frozen vegetables under reasonably foreseen conditions at the consumer's home. The technical report for this work is included in the PROFEL document (2020) under Annex III. The work carried out by PROFEL demonstrated that even with a well-implemented food safety management system in place, some quick-frozen products on the retail market may be occasionally contaminated with low levels of *L. monocytogenes* (detected in 25 g but usually at <10 cfu/g).

The results of the challenge testing carried out by PROFEL (2020) were comparable to the results of growth modelling performed for the EFSA BIOHAZ Panel Scientific Opinion (2020) in that they showed growth of *L. monocytogenes* in frozen vegetables during defrosting and storage in a refrigerator. Frozen sweetcorn in particular was the most susceptible and was shown to support the outgrowth of more than 1 log<sub>10</sub> *L. monocytogenes* after 24 hours defrosting in a refrigerator at 9 °C. Given these results, the PROFEL guidelines (2020) advise in Section 5 of the association's document (pp. 43-47) that frozen vegetables should always be regarded as non-RTE food and that this message should be very clearly communicated to the consumer on the product's packaging. This should be done via labelling and technical end product specifications, and using other communication channels such as websites, recipes, information brochures, and social media. The communication needs to be consistent, in order to avoid misunderstanding on how to store, defrost, and prepare or use these frozen vegetables in an appropriate manner. In particular, the PROFEL guidelines highlight the importance of communicating risk to susceptible groups who are more at risk of contracting foodborne listeriosis. If the frozen vegetables are intended for catering or servings directed towards susceptible consumers (e.g. for use in a nursing home or crèche), these frozen vegetables need to be considered as non-RTE and this must be clearly communicated to the caterer in order to ensure that an adequate heat treatment is mandatory during preparation.

## Consumers' food preparation habits

When the consumer survey participants were asked about their food preparation habits in relation to frozen vegetables, fruits and herbs, a high percentage recognised that frozen vegetables like sweetcorn, peas, mushrooms and mixed vegetables need to be cooked prior to consumption; in contrast, however, the majority of Irish adults believe that frozen fruits do not need to be cooked before eating (Table 12). Of the 815 adults surveyed, 45% (n=367) perceived the risk from consuming uncooked frozen fruits, vegetables or herbs to be the same as the risk from consuming





fresh fruits, vegetables or herbs. Forty-two per cent of adults (n=342) perceived the risk from consuming uncooked frozen fruits, vegetables or herbs as being higher than the risk from consuming uncooked fresh fruits, vegetables or herbs. This was highest among those aged 35–44 years, at 49% (n=80/163). Thirteen per cent of Irish adults surveyed (n=106) perceive the risk from consuming uncooked frozen fruits, vegetables or herbs as being lower than the risk from consuming uncooked fresh fruits, vegetables or herbs.

## Consumer awareness of foodborne listeriosis

The consumer survey asked the participants a number of questions to determine their general level of awareness with regard to the risk of illness from eating foods potentially contaminated with *L. monocytogenes*. They were also asked about their knowledge of foods most frequently associated with causing foodborne listeriosis and the groups of people most at risk of infection. Just over one-half of adults (n=426, 52%) on the island of Ireland stated that they had heard of *Listeria*, including 56% of the over 65 years age group (n=54/96). Family, friends or colleagues (n=140, 33%) are the top source for information on *Listeria*, closely followed by hearing about an outbreak in the news (n=131, 31%). Hearing about *Listeria* from friends, family or colleagues is most common among those aged 65–74 years, at 40% (n=22/54). A wide variety of foods were associated with *Listeria*, with meat (n=55, 13%) and chicken/poultry (n=51, 12%) recording the top mentions. A smaller number of consumers stated eggs (n=30, 7%) and cheese (n=26, 6%) were associated with *Listeria*. There seems to be some awareness of the listeriosis risk related to consuming frozen vegetables, fruits and herbs. Frozen fruits or frozen berries were listed as a possible source of infection by 5% (n=22) and 3% (n=12) of survey respondents, respectively, and 6% (n=26) listed frozen vegetables as a possible source.

Seventy-two per cent of those aware of *Listeria* (n=306) listed the elderly as most likely to be at risk of infection from listeriosis, followed by babies/infants (n=236, 55%), young children (n=183, 43%) and pregnant women (n=167, 39%). The survey participants were asked about who they routinely prepare food for, to see if any of these people belong to a group who are vulnerable to contracting listeriosis through consumption of food if that food was contaminated with *L. monocytogenes*. Table 13 shows that 40% of adults surveyed on the island of Ireland (n=328/815) prepare food for at least one of the vulnerable groups. Of the 328 adults who prepare food for a vulnerable group, 42% (n=138) of adults said they follow the cooking instructions on the packaging “all of the time”, 17% (n=56) said they do so “a lot of the time”, 15% (n=48) said “occasionally”, 10% (n=33) said “rarely” and 16% (n=52) said “never”. The survey participants were asked if they ever used uncooked frozen fruits or vegetables as a snack for a child or children. Of the 200 adults



on the island of Ireland who responded, the vast majority said they do not use uncooked frozen fruits/vegetables as snacks for children (n=168, 84%). However, 16% (n=33) said that they have given uncooked frozen fruits or vegetables as a snack to a child or children.

**Table 12** Consumer perception as to whether certain frozen vegetables, fruits and herbs require cooking prior to eating

Frozen food	Yes, needs to be cooked before eating	No, does not need to be cooked before eating	Not sure
<b>815 adults on the island of Ireland responded to this question</b>			
Raspberries	9%	80%	11%
Strawberries	10%	78%	12%
Blueberries	10%	77%	13%
Pineapple	9%	78%	13%
Smoothie mix	14%	64%	22%
Mixed berries	16%	67%	18%
Avocado	21%	54%	25%
Mint	30%	44%	26%
Thyme	35%	41%	25%
Basil	35%	40%	24%
Coriander	37%	37%	26%
Peppers	56%	32%	12%
Garlic	51%	31%	18%
Chilli	53%	30%	18%
Onions	65%	24%	10%
Sweetcorn	67%	24%	9%
Sugar snap peas	65%	22%	12%
Spinach	69%	19%	12%
Carrots	79%	19%	3%
Kale	67%	17%	16%
Edamame	33%	15%	52%
Mushrooms	78%	12%	10%
Broccoli	84%	11%	5%
Peas	88%	10%	2%
Mixed vegetables	89%	8%	3%





**Table 13** The percentage of adults on the island of Ireland who prepare food for at least one of the vulnerable groups shown below

Vulnerable group	Number of adults who prepare food for one or more of these vulnerable groups <sup>1</sup>	%
An infant aged 6–12 months	53	7
A child or children aged 13 months to 5 years	181	22
A woman who is pregnant	27	3
An adult or adults aged 65 years or over	139	17
A person or persons whose immune system may be compromised, such as those receiving cancer treatment or those with other medical conditions/problems	48	6
None of these	487	60

<sup>1</sup> 815 adults on the island of Ireland responded to this question

## Consumer awareness of previous foodborne outbreaks

The last questions in the consumer survey were designed to gauge awareness of consumers on the island of Ireland about previous foodborne outbreaks in relation to the consumption of frozen vegetables. The opportunity was also taken to determine the awareness of consumers regarding previous norovirus and hepatitis A virus outbreaks related to the consumption of uncooked imported frozen berries across Europe since 2013. As a result of these outbreaks, the FSAI recommends boiling imported frozen berries for 1 minute prior to consumption (FSAI, 2020b). This is particularly important when serving these foods to vulnerable people, such as nursing home residents. The final question in the consumer survey assessed whether the participants were aware of this advisory to consumers. Survey participants were read three statements and asked if they had heard about each of them before now, or not. Their responses are shown in Table 14.



**Table 14** Consumer awareness of the European 2018 listeriosis outbreak associated with frozen vegetables and the risk of foodborne illness related to consuming uncooked imported frozen berries

Statement	Participants were asked if they had heard each statement before now <sup>a</sup>		
	Yes (%)	No (%)	Not sure (%)
<b>In 2018 there was an outbreak of listeriosis across Europe connected with the consumption of frozen vegetables</b>	172 (21%)	572 (70%)	71 (9%)
<b>There is a risk of food poisoning specifically related to consuming imported frozen berries</b>	172 (21%)	563 (69%)	79 (10%)
<b>Imported frozen berries should be boiled for at least 1 minute before eating</b>	139 (17%)	592 (73%)	84 (10%)

<sup>a</sup> 815 adults on the island of Ireland responded to this question

Approximately one in five adults on the island of Ireland had previously heard of the European outbreak of listeriosis connected with the consumption of frozen vegetables. The 2015–2018 European outbreak was reported by various media outlets at the time as it was a large foodborne outbreak that resulted in 53 listeriosis cases, including 10 fatalities, affecting consumers in five European countries. The implicated food source attributed to causing the outbreak was consumption of uncooked frozen vegetables, particularly sweetcorn or mixed vegetables containing sweetcorn (ECDC-EFSA, 2018; EFSA BIOHAZ Panel, 2020). Some of the frozen vegetables implicated in this outbreak were placed on the market in Ireland and the FSAI issued a recall of the implicated batches in July 2018 (FSAI, 2018a). This outbreak was the basis for carrying out the national microbiological survey and consumer survey. It also prompted the EFSA BIOHAZ Panel (2020) to provide a Scientific Opinion on the relevant control actions that food business operators should implement in order to lower the risks of contamination in frozen vegetables. Just over one-fifth of the consumer survey participants were aware of the risks of foodborne illness related to consuming imported frozen berries, and a smaller proportion were aware of the FSAI advice to boil imported frozen berries for 1 minute before eating (Table 14).



## Conclusions

### National microbiological survey

The results of the national microbiological survey show that the majority of RTE and non-RTE frozen vegetable, fruit and herb samples tested were of good microbiological quality.

*L. monocytogenes* was detected in a small proportion (3%, n=27/906) of frozen vegetables, fruits and herbs at low levels. The majority of these were non-RTE frozen vegetables (n=21). *L. monocytogenes* was below the limit of detection (<10 cfu/g) for most of the samples, apart from three samples, which were non-RTE frozen petit pois, non-RTE frozen diced onion, and frozen chopped basil (RTE status not designated), all of which had 10 cfu/g present.

Of the 828 survey samples tested for *Listeria* spp. using the detection method, 4.5% (n=37) were positive. The enumeration method for *Listeria* spp. was used on 907 samples. The test result for the majority of these samples (n=904, 99.7%) was <10 cfu/g *Listeria* spp., while 10 cfu/g was present in two samples of non-RTE frozen sweetcorn and one sample of frozen chopped basil (RTE status not designated). The same sample of frozen chopped basil had 10 cfu/g *L. monocytogenes* present in it.

None of the survey samples tested in the national microbiological survey were found to be contaminated with *Salmonella* (n=885). The presence of *E. coli* as a hygiene indicator was assessed in a total of 887 frozen vegetable, fruit and herb samples. Ten of the samples tested (1.1%) were contaminated with *E. coli* at levels of between 20 and 100 cfu/g, two of which were RTE frozen vegetables. There were two non-RTE samples of frozen spinach with *E. coli* levels of 1100 cfu/g and 570 cfu/g present.

WGS analysis of the 27 *L. monocytogenes* isolates detected in the frozen vegetable, fruit and herb survey samples showed diversity in the strains isolated, as 13 different CC groups were identified. CC8 was the predominant type, accounting for 26% (n=7) of the *L. monocytogenes* isolates cultured in the survey. Cluster analysis highlighted the genetic diversity within the 27 isolates in general. Four small clusters were visualised by the MST, three of which contained isolates cultured from frozen sweetcorn samples, along with samples of frozen mixed vegetables, fruit smoothie mix and cherries (Clusters A, B and C, respectively). Cluster D comprised two isolates, both cultured from petit pois samples.



## Consumer survey

The results from the consumer survey provided some interesting insights into the consumption patterns of adults on the island of Ireland in relation to frozen vegetables, fruits and herbs, and their behaviour regarding the handling and normal use of these frozen foods. The total number of interviews achieved for the consumer survey on the island of Ireland was 815 (502 participants were based in Ireland and 313 were based in Northern Ireland). Eighty per cent of adults surveyed on the island of Ireland said they consume frozen vegetables, 40% said they consume frozen fruits, and 13% said they consume frozen herbs. Of the 678 survey participants who regularly consume frozen vegetables, fruits and/or herbs, 68% (n=460) said they do not consume any uncooked frozen foods. A small number of survey participants said they would normally consume uncooked frozen vegetables such as sweetcorn (n=21), carrots (n=21), peas (n=14), peppers (n=13) and spinach (n=12). The main way in which consumers would use these uncooked frozen vegetables was in a salad or as a garnish, with a smaller proportion saying they would use them in a smoothie, or as a snack for themselves or their children (Table 11). A larger number of survey participants said they would normally consume uncooked frozen fruits such as strawberries (n=101), blueberries (n=79), raspberries (n=78) and mixed berries (n=68) uncooked. This is not surprising as most frozen fruit and herb products on the retail shelves are intended by the manufacturer to be eaten as RTE food and do not have cooking instructions printed on the packaging. The main way in which frozen fruits were consumed uncooked was in a dessert or in a smoothie.

## Risk of illness due to consumption of uncooked non-RTE frozen vegetables such as sweetcorn

The cause of the 2015–2018 European listeriosis outbreak was linked to the consumption of uncooked frozen sweetcorn and other frozen vegetable mixes, including corn, possibly in salads or smoothies (ECDC-EFSA, 2018; EFSA BIOHAZ Panel, 2020). The results of the consumer survey showed that while 30% (n=203) of adults on the island of Ireland said they regularly consume frozen sweetcorn, only 10.3% (n=21) of those said they would eat it uncooked. The national microbiological survey found that 9.8% of the frozen sweetcorn samples tested were contaminated with low levels of *L. monocytogenes* (detected in 25 g at <10 cfu/g). In terms of consumer perceptions regarding the consumption of uncooked frozen vegetables, a high number of the 815 consumer survey respondents said that frozen vegetables such as peas (88%), mixed vegetables (89%), broccoli (84%), mushrooms (78%), carrots (79%), spinach (69%) and kale (67%) do need



to be fully cooked before eating. For frozen sweetcorn, 24% said that sweetcorn does not need to be cooked before eating and 9% said they were unsure whether it needs to be cooked before eating (Table 12). Taking the results of the national microbiological survey and consumer survey together, it is clear that a proportion of consumers normally eat uncooked non-RTE frozen vegetables, such as sweetcorn, some of which could be contaminated with low levels of *L. monocytogenes*. Under Article 14.3 of Regulation (EC) No 178/2002 (European Commission, 2002), food business operators must give regard to the normal conditions of use of the food by the consumer, and to the information provided to the consumer, including information on the label, in determining whether any food is unsafe.

When the results of the national microbiological survey are correlated with the responses given by consumers in the survey on their consumption habits in relation to frozen vegetables, fruits and herbs, it shows that there were a small proportion of non-RTE frozen vegetables – which a small number of consumers say they regularly consume uncooked (i.e. sweetcorn, petit pois/garden peas, mixed vegetables, broccoli, peppers, and onion) – that were contaminated with low levels of *L. monocytogenes* (Table 10). The levels found in the majority of these samples were detected in 25 g at <10 cfu/g, while 10 cfu/g was found in non-RTE frozen petit pois (n=1), non-RTE frozen diced onion (n=1) and frozen chopped basil (n=1; RTE status not designated). If these low levels were present at the point of consumption of uncooked frozen non-RTE vegetables, the risk posed to consumers who are in good health should be minimal. However, the risk could be higher for consumers who are immunocompromised, or if consumer preparation and handling practices allow *L. monocytogenes* detected in non-RTE frozen vegetables to increase at the point of consumption to levels high enough to potentially cause listeriosis (i.e. >100 cfu/g). For example, this could happen if consumers thaw frozen non-RTE vegetables which are contaminated with *L. monocytogenes* detected in 25 g at <10 cfu/g and that, prior to consumption, they keep them at storage conditions that enable growth of the pathogen. The responses from the consumer survey show that there is potential for this to happen; this is because among those who regularly eat uncooked non-RTE frozen vegetables the top use identified by those who said they regularly eat uncooked non-RTE frozen vegetables was ‘in salads’ (ranging from 74% to 91%), followed by ‘use as a garnish’ (ranging from 11% to 27%) (Table 11).

The results of the national microbiological survey were comparable to other recent studies published by the EFSA BIOHAZ Panel (2020), PROFEL (2020) and Willis *et al.* (2020) in that they all show that a small proportion of frozen vegetables, fruit and herbs retail samples were contaminated with low levels of *L. monocytogenes* (detected in 25 g at <10 cfu/g). The PROFEL hygiene guidelines (2020) note that although a frozen food manufacturer may have a well-implemented food safety management system in place, it is possible that some quick-frozen non-



RTE frozen vegetable products on some occasions can be contaminated with low levels of *L. monocytogenes* (detected per 25 g, but usually <10 cfu/g). In light of this, they advise that the manufacturer should implement a year-round end product sampling plan in the frame of verification of the food safety management system. They recommend an end-product limit of *L. monocytogenes* not detected in 25 g at <10 cfu/g after production, and a limit of <100 cfu/g throughout the shelf life of the non-RTE frozen vegetable product during both frozen storage and defrosting/refrigerator storage when placed on the market.

## Importance of labelling clear cooking instructions on non-RTE frozen vegetables, fruits and herbs

Of the 328 survey respondents who prepare food for a vulnerable group, 194 (59%) said they either always follow the cooking instructions as printed on the packaging, or do so a lot of the time. However, it is a concern that 85 (26%) survey respondents said they either rarely or never follow the cooking instructions as printed on the packaging of frozen vegetables, fruits and herbs when preparing frozen food for vulnerable groups more at risk of contracting foodborne listeriosis. For food safety purposes, consumers (particularly those in vulnerable groups) would be best advised to thoroughly cook frozen vegetables prior to consumption, unless the packaging explicitly states that the frozen vegetables can be consumed as RTE food.

If the manufacturers intend for these products to be thoroughly cooked prior to consumption, they should ensure that this is clearly indicated on the packaging, and they should provide cooking instructions which ensure that the product will reach a core temperature of 75 °C in order to ensure that any pathogens that might be present are destroyed. Both the EFSA BIOHAZ Panel Scientific Opinion (2020) and the PROFEL hygiene guidelines (2020) highlight the importance of a good risk communication strategy to inform the public of the possible risk of listeriosis from consuming non-RTE frozen vegetables uncooked, particularly for anyone in a vulnerable group more susceptible to contracting listeriosis; they also highlight the importance of manufacturers clearly communicating to consumers the instructions for proper use of the non-RTE frozen vegetables via the product label, technical specifications, website information, and social media.





## Guidelines on minimising the risks of *L. monocytogenes* contamination in frozen vegetables, fruits and herbs

Both the EFSA BIOHAZ Panel Scientific Opinion (2020) and the guidelines published by PROFEL (2020) give advice on relevant control actions that food business operators can implement in order to lower the risks of contamination in frozen vegetables. The PROFEL guidelines give advice specific to the manufacturing sector producing non-RTE quick frozen vegetables, while the advice given by the EFSA BIOHAZ Panel covers frozen vegetables, fruits and herbs, blanched during processing. The best practice guidance in these publications gives information on cleaning and disinfection of the food-producing environment, raw material control and supplier selection, the importance of time and temperature control at different processing steps, and the need to ensure accurate labelling of non-RTE frozen vegetables in particular in order to avoid potential misuse by the consumer. Both the EFSA BIOHAZ Panel Scientific Opinion and PROFEL guidelines stress the importance of monitoring the food-producing environment for *L. monocytogenes* because this pathogen can persist in the food processing environment, from which it can contaminate food.

The EFSA BIOHAZ Panel Scientific Opinion (2020) makes recommendations to consumers on how to reduce risks at home. The key is to maintain good hygiene practices, such as storing frozen or thawed vegetables in a clean freezer or refrigerator at the appropriate temperature, and following the instructions on the frozen foods labelling for safe preparation. The PROFEL guidelines (2020) also highlight the importance of further communicating risk and information to consumers of non-RTE frozen vegetables. PROFEL recommends that manufacturers provide appropriate cooking instructions and specific indications on the product label that the non-RTE frozen vegetables should be fully cooked prior to consumption. PROFEL also encourages manufacturers to include these specific instructions on technical specifications, website information, and social media. In particular, PROFEL recommends that manufacturers use a more stringent risk communication strategy for frozen sweetcorn and frozen sweet potatoes than for other frozen vegetables because the associated risk is higher for these two types of frozen vegetables based on the microbiological challenge testing performed (PROFEL 2020, p. 46).

## Activities to promote consumer awareness of listeriosis

When the FSAI was alerted to the European frozen vegetable listeriosis outbreak in 2018, it updated its factsheet *Reduce the Risk of Food Poisoning: Information for People who are Particularly Vulnerable* (FSAI, 2018b). The updated advice recommended thoroughly cooked frozen vegetables as a safer food choice due to the potential of these foods to be contaminated



with *L. monocytogenes*. Public health nurses in Ireland and the Irish Nutrition and Dietetic Institute (INDI) were asked to circulate the updated advice on how to minimise risk of listeriosis from frozen vegetables to their members when it was published in 2018. Dietitians play a vital role in disseminating new information to groups of people who are particularly vulnerable to food poisoning, as well as to the catering and food sector in general. This is in line with the recommendations by PROFEL to target risk communication to medical staff, healthcare professionals, caregivers, or those who provide dietary guidance to groups susceptible to the risk of contracting foodborne listeriosis (PROFEL 2020, p. 47).

**safefood** has been actively promoting awareness of the risks of foodborne listeriosis by running many different public health information campaigns on television, radio, and social media, as well as updating information on the **safefood** website. For example, the “*Listen to the voice of food safety*” campaign was aimed at adults aged 65 years and over on the island of Ireland. The aim of the integrated TV, radio and outdoor poster campaign was to communicate the well-known principles of food safety at home – cooking, cleaning, chilling and avoiding cross-contamination (the 4Cs) – in an engaging way to support proactive behavioural change among the target audience and reinforce why these should matter to them. Information on the **safefood** website was also updated in relation to *Listeria* and pregnancy, and specific information was given on cooking frozen vegetables prior to consuming them.

The results of the consumer survey show that there may be more scope to promote public awareness of the risks of foodborne listeriosis. Only 52% (n=426) of adults on the island of Ireland stated in response to the consumer survey that they had previously heard of *Listeria*. Hearing about *Listeria* from family, friends or colleagues was indicated to be the main source of information for 33% (n=140/426) of those aware of *Listeria*, closely followed by 31% (n=131/426) who responded that they remembered hearing about an outbreak in the news. It is encouraging to see that 72% (n=306/426) of those aware of *Listeria* recognised that the elderly are most likely to be at risk of infection from listeriosis, followed by 55% (n=236/426) who said “babies/infants”, 43% (n=183/426) who said “young children”, and 39% (n=197/426) who said “pregnant women”.

Only 21% (n=172/815) of survey participants said they were aware of previous norovirus and hepatitis A virus outbreaks related to the consumption of uncooked imported frozen berries across Europe since 2013, with just 17% (n=139/815) stating that they were aware of the FSAI advice to boil imported frozen berries for at least 1 minute prior to consumption (FSAI, 2020b). This shows that only a relatively small number of consumers are aware of the advice, even though the FSAI regularly publishes reminders of this advice to consumers through its social media channels and on the FSAI website.





## Recommendations

- While only 3% (n=27/906) of the frozen vegetables, fruits and herbs tested were found to be contaminated with low levels of *L. monocytogenes*, contracting listeriosis is a potential risk to the small number of consumers who said they regularly eat uncooked frozen non-RTE vegetables, fruits and/or herbs. Manufacturers of frozen vegetables, fruits and herbs are advised to follow the best practice guidelines published by PROFEL (2020) and the EFSA BIOHAZ Panel in its Scientific Opinion (2020) to minimise the risk of future listeriosis outbreaks linked to the consumption of uncooked frozen vegetables, fruits and herbs.
- The national microbiological survey found that clear instructions to consumers to fully cook frozen vegetables intended by the manufacturer to be non-RTE was lacking on the packaging of 9.3% (n=37/399) of samples tested. Manufacturers of frozen non-RTE vegetables, fruits and/or herbs are advised to follow the packaging advice and risk communication strategies stated in the PROFEL guidelines (2020) and the EFSA BIOHAZ Panel Scientific Opinion (2020).
- The consumer survey found that 52% of 815 adults on the island of Ireland were aware of the risks associated with foodborne listeriosis. This indicates that while the FSAI and **safefood** have made some good progress in raising public awareness of this issue, there is scope for improvement. It is recommended that the FSAI and **safefood** explore further collaboration opportunities in this regard. The results of the national microbiological survey and the consumer survey could be disseminated as appropriate to advise consumers of the need to fully cook non-RTE frozen vegetables, fruits and herbs prior to consumption. Any planned risk communication strategies should take into consideration the recommendations made by PROFEL (2020) and the EFSA BIOHAZ Panel (2020) to raise public awareness of the health risks associated with the consumption of uncooked non-RTE frozen vegetables, fruits and herbs, and in particular to target the advice to those who prepare food for susceptible groups, e.g. nursing home residents.
- Although the FSAI already promotes awareness of the risk of norovirus and hepatitis A virus outbreaks related to the consumption of uncooked imported frozen berries in various ways, only 21% of the 815 adults surveyed on the island of Ireland were aware of the advice to boil imported frozen berries for 1 minute prior to consumption. It is recommended that the FSAI and **safefood** work together to explore further opportunities to communicate this public health message to consumers.



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<sup>12</sup> All European food legislation and FSAI publications are available to download at [www.fsai.ie](http://www.fsai.ie)



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## Appendix 1

### Selected RASFF notifications for microbiological contamination of frozen vegetables, fruits and herbs (2006–2021)

No.	Date	Reference	Classification	Notified By	Subject
1	20/05/2021	2021.2555	Border rejection notification	Finland	<i>Salmonella</i> Bareilly in frozen green beans from India
2	16/04/2021	2021.1903	Alert	France	Norovirus in raspberries
3	22/03/2021	2021.1448	Alert	Germany	<i>Salmonella</i> spp. in frozen herbal mixture from Germany
4	14/01/2021	2021.0205	Alert	Belgium	<i>Salmonella</i> in frozen parsley
5	02/10/2020	2020.4062	Information for attention	United Kingdom	<i>Salmonella</i> and high count of <i>Escherichia coli</i> in frozen grated coconut from India
6	24/05/2019	2019.1927	Information for attention	Italy	Hepatitis A virus (presence/25 g) in mixed frozen berries from Italy, with raw material from Ukraine, Lithuania and Romania
7	07/12/2018	2018.3574	Information for attention	Poland	<i>Salmonella</i> (present/25 g) in frozen blueberries from Ukraine, packaged in Poland
8	16/07/2018	2018.1999	Alert	Netherlands	Consumer recall of frozen corn from Hungary in relation to a multi-country foodborne outbreak
9	11/07/2018	2018.1958	Alert	United Kingdom	Consumer recall of frozen corn from United Kingdom in relation to a multi-country foodborne outbreak
10	11/07/2018	2018.1955	Alert	Croatia	Consumer recall of frozen corn from Hungary in relation to a multi-country foodborne outbreak
11	10/07/2018	2018.1933	Alert	Germany	Consumer recall of frozen corn from Belgium in relation to a multi-country foodborne outbreak
12	28/06/2018	2018.1813	Alert	Sweden	Foodborne outbreak suspected to be caused by and hepatitis A virus (present) in frozen strawberries from Poland
13	09/05/2018	2018.1272	Alert	Finland	<i>Listeria monocytogenes</i> (<100 CFU/g) and <i>Salmonella enterica</i> ser. Orion (presence/25 g) in frozen fruits mix from Belgium
14	10/05/2016	2016.0598	Alert	United Kingdom	Foodborne outbreak suspected ( <i>Listeria monocytogenes</i> ) to be caused by frozen organic vegetable mix from the United States
15	06/08/2015	2015.1016	Alert	France	<i>Salmonella</i> (present/25 g) in frozen cherries from Poland, packaged in Serbia



No.	Date	Reference	Classification	Notified By	Subject
16	07/10/2013	2013.1334	Alert	Italy	Hepatitis A virus in frozen berries mix processed in Italy, with raw material from Poland, Serbia, Chile, Bosnia and Herzegovina, Belarus, Romania and Estonia
17	12/12/2012	2012.1713	Information for attention	Sweden	<i>Salmonella</i> (presence/25 g) in chopped frozen pineapple from Vietnam
18	25/11/2011	2011.1713	Information for follow-up	Finland	<i>Salmonella</i> Aberdeen (presence/25 g) in frozen vegetable mix from Sweden
19	29/04/2010	2010.0528	Alert	France	<i>Escherichia coli</i> (between 4200 and 61000 CFU/g), <i>Salmonella</i> and sulphite reducing anaerobes (2000 CFU/g) in frozen parsley from China, via the United Kingdom
20	29/04/2010	2010.0526	Alert	Finland	<i>Salmonella</i> Arizonae in frozen fruit mix in passion fruit juice from France, via Belgium
21	08/05/2006	2006.BCP	Information	United Kingdom	<i>Salmonella</i> Bareilly (presence/25 g) in frozen grated coconut from Indonesia

**Search criteria 1:** Subject: "Frozen"; Product category: Fruits and vegetables; Hazard category: Pathogenic microorganisms.

**Search criteria 2:** Subject: "Frozen"; Product category: Herbs and spices; Hazard category: Pathogenic microorganisms.

[RASFF portal](#) searched using these criteria on 15 June 2021.



## Appendix 2

### Consumer survey questionnaire on frozen vegetable, fruit and herb preparation and consumption



The survey should take no longer than 10 minutes and is about food preparation and consumption.

#### FOOD PURCHASING AND CONSUMPTION

1. How often, if at all, do you consume frozen fruit?
2. And what about frozen vegetables?
3. And what about frozen herbs?

	Frozen fruit	Frozen vegetables	Frozen herbs
Every day .....			
Every other day.....			
Twice a week .....			
Once a week .....			
Never .....			

4. Which of the following frozen foods, if any, do you usually consume?

Broccoli .....	
Kale .....	
Mint .....	
Sweetcorn .....	
Spinach .....	
Edamame .....	
Peas .....	
Sugar snap peas .....	
Strawberries .....	
Raspberries .....	
Pineapple .....	
Blueberries .....	
Peppers.....	
Onions .....	
Carrots .....	
Mushrooms .....	
Chilli .....	
Garlic .....	
Avocado .....	
Mixed vegetables.....	
Mixed berries.....	
Pre-prepared smoothie mix.....	
Basil .....	
Thyme .....	
Coriander .....	
Other (specify _____) .....	

# National Microbiological Survey and Consumer Habits in relation to Frozen Vegetables, Fruits and Herbs



MONITORING & SURVEILLANCE SERIES | MICROBIOLOGY

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5. And can you tell me which frozen fruits, vegetables or herbs, if any, you eat uncooked<sup>13</sup>?

Broccoli .....	
Kale .....	
Mint .....	
Sweetcorn .....	
Spinach .....	
Edamame .....	
Peas .....	
Sugar snap peas .....	
Strawberries .....	
Raspberries.....	
Pineapple.....	
Blueberries .....	
Peppers.....	
Onions .....	
Carrots .....	
Mushrooms .....	
Chilli .....	
Garlic .....	
Avocado .....	
Mixed vegetables.....	
Mixed berries.....	
Pre-prepared smoothie mix.....	
Basil .....	
Thyme .....	
Coriander .....	
Other (specify _____) .....	
None .....	

6. And can you tell me how you normally use uncooked?

- i. In salad
- ii. As a garnish
- iii. In a smoothie
- iv. In a dessert
- v. Other (specify \_\_\_\_\_)

7. For each frozen food that I read out I'd like you to tell me if you feel it needs to be cooked before eating, or not

	Yes, needs to be cooked before eating	No, does not need to be cooked before eating	Not sure
Broccoli .....			
Kale .....			

<sup>13</sup> Interviewer instruction: by uncooked we mean that they are eaten either frozen or thawed. Do not prompt.

# National Microbiological Survey and Consumer Habits in relation to Frozen Vegetables, Fruits and Herbs



MONITORING & SURVEILLANCE SERIES | MICROBIOLOGY

Mint .....			
Sweetcorn .....			
Spinach .....			
Edamame .....			
Peas .....			
Sugar snap peas .....			
Strawberries .....			
Raspberries.....			
Pineapple.....			
Blueberries .....			
Peppers.....			
Onions .....			
Carrots .....			
Mushrooms .....			
Chilli .....			
Garlic .....			
Avocado .....			
Mixed vegetables.....			
Mixed berries.....			
Pre-prepared smoothie mix.....			

8. In your opinion is the risk of consuming uncooked frozen fruit, vegetables and herbs...?
  - i. Lower than the risk of consuming uncooked fresh fruit, vegetables or herbs
  - ii. About the same as the risk of consuming uncooked fresh fruit, vegetables or herbs
  - iii. Higher than the risk of consuming uncooked fresh fruit, vegetables or herbs
  
9. Have you ever heard of *Listeria* before now?
  - i. Yes
  - ii. No
  - iii. Don't know

**IF ANSWER IS YES, ASK:**

10. And can you recall where you heard about *Listeria*? Anywhere else?
  - i. From friends/family/colleagues
  - ii. Heard about a product recall in the news
  - iii. Heard about an outbreak in the news
  - iv. Heard about it from my doctor
  - v. Other (specify \_\_\_\_\_)
  - vi. Can't recall

**IF ANSWER IS YES, ASK:<sup>14</sup>**

11. What foods, if any, do you associate with *Listeria*? Anything else?

12. Which groups of people, if any, do you think are at most risk of infection with *Listeria*? Any others?

\_\_\_\_\_

<sup>14</sup> Interviewer instruction: do not prompt. Record all foods mentioned.



# National Microbiological Survey and Consumer Habits in relation to Frozen Vegetables, Fruits and Herbs



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- i. Babies/Infants
- ii. Young children
- iii. The elderly
- iv. Pregnant women
- v. A person or persons whose immune system may be compromised such as those receiving cancer treatment or those with other medical conditions problems
- vi. Other (specify \_\_\_\_\_)
- vii. Don't know

13. Do you currently prepare food at home for any of the following?
- i. An infant aged 6–12 months
  - ii. A child or children aged 13 months to 5 years
  - iii. A woman who is pregnant
  - iv. An adult or adults aged 65 years or over
  - v. A person or persons whose immune system may be compromised such as those receiving cancer treatment or those with other medical conditions
  - vi. None of these

## ASK ALL WHO CURRENTLY PREPARE FOOD AT HOME FOR ANY OF THE ABOVE

14. When preparing frozen vegetables for this person or persons, how often, if ever, do you follow the cooking instructions on the packaging? Would that be....?
- i. All of the time
  - ii. A lot of the time
  - iii. Occasionally
  - iv. Rarely
  - v. Never
15. Do you ever use uncooked frozen fruit or vegetables as a snack for your child or children?
- i. Yes
  - ii. No
16. I am now going to read out a list of statements. For each one I'd like you to tell me if you have heard about this before now, or not.

	Yes, have heard	No, have not heard	Not sure
In 2018 there was an outbreak of listeriosis across Europe connected with the consumption of frozen vegetables.			
There is a risk of food poisoning specifically related to consuming imported frozen berries.			
Imported frozen berries should be boiled for at least 1 minute before eating.			



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