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Microbiological survey of chilled and frozen coated poultry (22NS6)

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

Abbreviations

Abbreviation	Term
AD	Allelic difference
AMP	Ampicillin
AMR	Antimicrobial resistance
BLAST	Base local alignment search tool
CE	Calculation engine
cgMLST	Core genome multi-locus sequence typing
CHL	Chloramphenicol
CIP	Ciprofloxacin
DAFM	Department of Agriculture, Food and the Marine
DoH	Department of Health
ECDC	European Centre for Disease Prevention and Control
EHO	Environmental Health Officer
EFSA	European Food Safety Authority
EN ISO	European Standard International Organisation for Standardisation
EU/EEA	European Union/European Economic Area
FAO of the UN	Food and Agriculture Organisation of the United Nations
FSA UK	Food Standards Agency United Kingdom
FSAI	Food Safety Authority of Ireland
FSS	Food Standards Scotland
HPSC	Health Protection Surveillance Centre
HSE	Health Service Executive
INAB	Irish National Accreditation Board
MST	Minimum Spanning Tree
NAL	Nalidixic acid
NEHS	National Environmental Health Service
NRL	National Reference Laboratory
NSSF	National Sample Submission Form
OFML	Official Food Microbiology Laboratory
OIE	World Organisation for Animal Health (formerly Office International des Epizooties)
pESI	Plasmid of emerging *S.* Infantis
RASFF	Rapid Alert System for Food and Feed

S.I.	Statutory Instrument
SMX	Sulfamethoxazole
Spp.	Species
ST	Sequence type
TET	Tetracycline
UK	United Kingdom
UKHSA	United Kingdom Health Security Agency
WGS	Whole Genome Sequencing
WHO	World Health Organisation

Summary

Salmonella is a leading global cause of foodborne illness, significantly contributing to the health burden of foodborne diseases (WHO, 2015). From 2018 to 2020, a multi-country outbreak of *Salmonella* Enteritidis infections was caused by the consumption of frozen breaded poultry products in the European Union/European Economic Area (EU/EEA) and the United Kingdom (UK) (ECDC-EFSA, 2021). On the basis of this outbreak, a national microbiological survey was undertaken by the Food Safety Authority of Ireland (FSAI) in conjunction with the National Environmental Health Service (NEHS) and the Health Service Executive Official Food Microbiology Laboratories (HSE OFMLs), to gain a better understanding of the microbiological quality of chilled and frozen coated poultry meat preparations and poultry meat products intended to be eaten cooked. Samples were taken from wholesale, retail and catering establishments in Ireland.

Between 5 September and 28 November 2022, 382 samples were collected by Environmental Health Officers (EHOs) for this national microbiological survey. The survey found that 1.3% (n=5/382) of non-ready-to-eat chilled and frozen coated poultry placed on the market in Ireland were contaminated with *Salmonella* Infantis; the isolates of which exhibited various patterns of antimicrobial resistance (AMR). These results were a legal breach under Regulation (EC) No 2073/2005, as amended, and risk management actions were carried out accordingly to reduce risk to consumers' health.

In general, if *Salmonella* contamination is present in these non-ready-to-eat poultry products, the risk posed to consumers who handle the products hygienically and thoroughly cook them as per the cooking instructions labelled on the packaging, should be minimal. However, this risk could be higher for consumers who do not strictly follow the preparation and cooking instructions labelled on the packaging and/or do not handle or store these products by following good hygiene practices. To avoid future foodborne outbreaks of salmonellosis resulting from the undercooking and/or unhygienic handling of these food products by consumers, manufacturers of chilled and frozen coated poultry must have a robust food safety management system in place based on principles of Hazard Analysis and Critical Control Points (HACCP). They need to carefully follow Regulation (EC) No 853/2004 laying down the specific hygiene requirements that must be implemented when handling food of animal origin at all stages of the food chain. In addition, it is imperative to ensure these products are clearly labelled as non-ready-to-eat products. They must have valid cooking instructions labelled on the packaging (FSAI, 2014). Consumer advice is required to raise public awareness on microbiological risks regarding undercooking and unhygienic handling of chilled and frozen coated poultry. Consumers need to follow the cooking instructions exactly as labelled on the product packaging and adhere to good hygienic practice during preparation to minimise the risk of salmonellosis.

Introduction

Salmonellosis

Salmonellosis refers to infections caused by *Salmonella* spp. These bacteria are commonly found in a variety of livestock, primarily poultry, pigs, and cattle. Among various sources of exposure, humans often become infected with *Salmonella* by consuming undercooked contaminated meat, or by eating food that has been cross contaminated by raw meat or food contact surfaces harbouring *Salmonella*. The European Food Safety Authority's (EFSA) 2022 zoonoses report noted that the highest levels of *Salmonella* were found in 'meat and meat products from broilers' across Member States (EFSA, 2023). This evidence indicates that poultry meat potentially plays an important role in the transmission of *Salmonella* spp.

Upon infection, the symptoms and severity of illness an individual will experience can vary depending on the number of bacteria present, their own immune status, and virulence of the strain of *Salmonella* present. Older adults, infants, and those with impaired immune systems are more likely to have more severe illness. Symptoms such as nausea, stomach pain, diarrhoea, fever, and vomiting generally appear from 12-36 hours after eating the contaminated food (i.e., the incubation period). They will usually subside after a few days. On a rare occasion, severe dehydration may occur and require hospitalisation (ECDC, 2024).

Incidence of salmonellosis in Ireland and Europe

In the European Union (EU), salmonellosis was the second most commonly reported foodborne gastrointestinal human infection in 2022 (cases n=65,208) (EFSA, 2023). It was the most frequent cause of foodborne outbreaks, accounting for 17.6% of all foodborne outbreaks in 2022 (EFSA, 2023). The most common serovars attributed to human infection in Europe in 2022 were *S.* Enteritidis (67.3%), *S*. Typhimurium (13.1%), monophasic *S.* Typhimurium (1,4,[5],12:i:-) (4.3%), *S.* Infantis (2.3%) and *S.* Derby (0.89%) (EFSA, 2023). In Ireland, salmonellosis places a challenging burden on public health. In 2022, the notification rate for human salmonellosis in Ireland was 6.6 per 100K population, with *S*. Enteritidis and *S*. Typhimurium being the most commonly reported serotypes among human infections (HPSC, 2024).

Antimicrobial resistance (AMR)

Antimicrobial medicines are essential to protect both human and animal health in the treatment of diseases. AMR occurs when bacteria, viruses, fungi and parasites change over time and no longer

respond to antimicrobials making infections harder to treat. This can increase the risk of disease spread, severe illness and death. As a result, the antimicrobials become ineffective and infections persist in the body, increasing the risk of spread to others (WHO, 2024). This development is globally recognised as a serious threat to public health (WHO, 2023). As such, Ireland's National Action Plans on AMR seek to tackle the threat of AMR nationally (DoH and DAFM, 2021).

Priority lists of antimicrobials used in human medicine and veterinary medicine have been developed by the WHO (2018) and OIE (2007), respectively. In both publications, each antimicrobial is classified, in ascending order of priority, as being important, highly important, or critically important; determined on the basis of criteria agreed by the expert panels in respect to their own fields. This ranking aims to ensure that antimicrobials, particularly those deemed critically important, are used prudently in both human and veterinary medicine.

It is suggested the misuse of antimicrobials in the livestock sector, crop production and aquaculture may lead to the emergence and spread of antimicrobial resistant microorganisms throughout the food chain (FAO, 2021). Subsequently, consumers may be exposed to AMR in pathogens via food (e.g. AMR in *Salmonella* spp.), although at present this is not well understood. Transmission of antimicrobial resistant bacteria from food to humans is of key concern due to its potential to either make systemic illness more difficult to treat or to share antimicrobial traits with other bacteria within the gut microbiota (i.e., via horizontal gene transfer). In particular, foods of animal origin may play an important role for antimicrobial resistant bacteria entering the food chain (EFSA, 2008).

Further information on the topic of AMR in foodborne pathogens is provided in The Scientific Committee of the FSAI report titled '*Potential for Transmission of Antimicrobial Resistance in the food chain*' (2015).

Salmonellosis cases associated with the consumption of coated poultry

Since 2020, there have been several recalls of frozen partially cooked and raw coated poultry in the Ireland and the UK due to contamination with *Salmonella* spp. Some of these recalls were related to the multi-country outbreak of *S.* Enteritidis infections between May 2018 and December 2020 linked to the consumption of frozen breaded poultry in the EU/EEA and the UK (ECDC-EFSA, 2021). During that outbreak, 193 human cases of *S. Enteritidis* sequence type (ST) 11 were reported in Denmark (2), Finland (4), France (33), Germany (6), Ireland (12), the Netherlands (3), Poland (5), Sweden (6), and the UK (122). One in five cases were hospitalised, while one death

was reported. Fifty percent of the cases were observed in individuals less than 18 years old. Epidemiological studies carried out at the time, identified an increased risk of *S. Enteritidis* infection associated with the consumption of frozen breaded chicken. The outbreak was traced back to different meat suppliers, slaughterhouses, and/or farms in Poland (ECDC-EFSA, 2021).

However, since this initial *S.* Enteritidis outbreak (2018-2020), high levels of salmonellosis cases associated with the consumption of frozen coated poultry continue to be reported (FSA UK, 2022; 2023). This is despite the control measures taken to date. There is concern that this may be due to a combination of a small percentage of frozen coated poultry being placed on the market which are contaminated with *Salmonella* spp., and consumers not following the cooking instructions exactly as labelled. In addition, there is a risk of cross-contamination to hands and kitchen surfaces due to consumers mishandling the contaminated frozen coated poultry.

UK survey on consumer practices regarding coated poultry

Following the 2018-2020 *S. Enteritidis* outbreak (ECDC-EFSA, 2021), a survey on consumer practices regarding non-ready-to-eat frozen coated poultry that are to be cooked and eaten in the home was commissioned by the Food Standards Agency UK (FSA UK) and Food Standards Scotland (FSS) (Ipsos MORI, 2021). In this survey, participants (n=5,599) were asked about their handling and cooking practices of “coated frozen chicken products that you cook or eat at home”. Results from this survey highlighted that some consumers do not prepare these products as per the manufacturer’s cooking instructions and/or do not follow good domestic hygiene practices during/after preparation (Ipsos MORI, 2021). The FSA UK are now utilising this information as a foundation for its ongoing risk communication activities, advising consumers on best practices for the storage, handling, and preparation of chilled and frozen coated chicken products to minimise the risk of food poisoning (FSA UK, 2021).

UK microbiological retail surveys

The 2018-2020 *S.* Enteritidis outbreak (ECDC-EFSA, 2021) was the basis for two microbiological retail surveys undertaken by the UK Health Security Agency (UKHSA) in conjunction with the FSA UK to establish the prevalence and levels of *Salmonella* spp. and *Escherichia coli* in frozen, part-cooked breaded and battered poultry on sale at retail within the UK (Jørgensen *et al.,* 2022; Willis *et al.,* 2022).

In the 2020 retail level study carried out by UKHSA/FSA UK, 483 samples of frozen coated poultry sampled between October and December were tested. *Salmonella* spp. was detected in 42 of the

483 (8.8%) retail samples (Jørgensen *et al.,* 2022). Among the survey samples from which *Salmonella* was isolated - *S.* Infantis was detected in 25 samples, *S.* Enteritidis was detected in 17, *S.* Newport was detected in four, and *S.* Java, *S.* Livingstone, and *S.* Senftenberg were detected in one sample each (Figure 1). Seven samples were found to be co-contaminated with two different *Salmonella* serovars. The contaminated retail samples surveyed originated from six out of 53 production plants. One of these plants was located in Ireland. Out of 30 samples tested originating from the Irish manufacturer, eight were positive for *Salmonella* spp. (Jørgensen *et al.,* 2022).

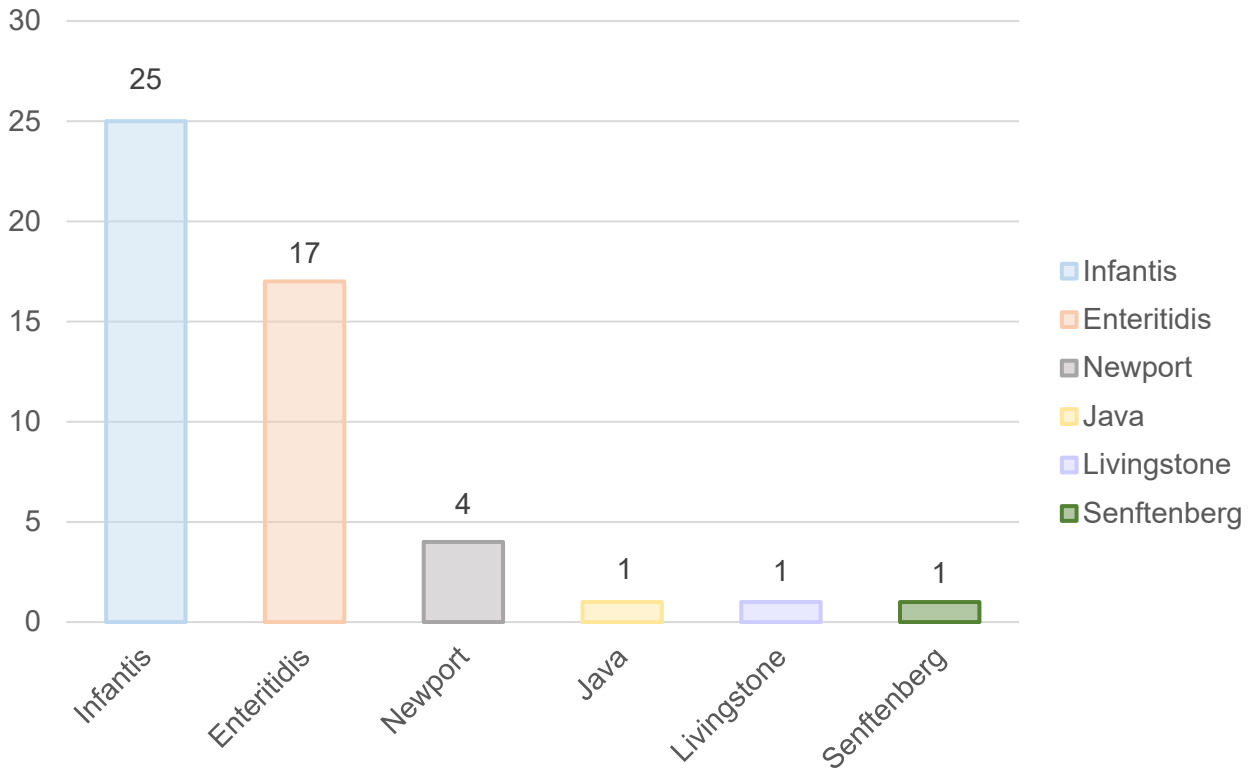

Figure 1 Summary of *Salmonella* serovars (n=49) isolated from 42 chicken samples (Jørgensen *et al*., 2022).

In the 2021 retail level study carried out by UKHSA/FSA UK and published by Willis *et al*. (2022), 310 samples of frozen coated chicken products containing either raw or partly cooked chicken were collected and tested for *E. coli* and *Salmonella* spp. *Salmonella* spp. was detected in five (1.6%) of the 310 samples tested (Willis *et al.,* 2022). These were identified as *S.* Infantis (n=3) and S. Java (n=2). Whole Genome Sequencing (WGS) analysis showed that one of the *S.* Infantis

isolates fell into the same genetic cluster as *S.* Infantis isolates from three recent human cases of infection; the second fell into another cluster containing two recent cases of infection (Willis *et al.,* 2022). Countries of origin recorded on the packaging of the five *Salmonella* contaminated samples were Hungary (n=1), Ireland (n=2) and the UK (n=2). The prevalence rate (1.6%) reported for *Salmonella* spp. in frozen coated chicken in the retail level study by Willis *et al.* (2022) showed that while the contamination of frozen coated poultry with *Salmonella* spp. is still an issue in the UK food chain, the detection level found was considerably lower than the 8.8% prevalence rate reported for the previous year (Jørgensen *et al.,* 2022).

The UKHSA/FSA UK retail survey samples that were contaminated with *Salmonella* spp. constituted a legal breach under Regulation (EC) No 2073/2005, as amended (Jørgensen *et al.,* 2022, Willis *et al.,* 2022). The FSA UK issued food alerts requiring the recall of these products through the EU Rapid Alert System for Food and Feed (RASFF). In Ireland, the FSAI also issued food alerts for the implicated batches of frozen coated poultry which were linked to the 2018-2020 *S.* Enteritidis outbreak, and the microbiological surveys carried out by UKHSA/FSA UK.

Considering the insights gained from the UK consumer behaviour survey along with the results from the two UK microbiological retail surveys, the FSA UK and FSS issued precautionary advice on cooking frozen raw or part-cooked coated chicken such as nuggets, goujons, dippers, poppers, and kievs (FSA UK, 2022).

Twelve Irish cases of salmonellosis were identified as part of the 2018-2020 *S.* Enteritidis multi-country outbreak (ECDC-EFSA, 2021). Additionally, ten of the retail samples positive for *Salmonella* spp. reported by Jørgensen *et al.* (2022; n=8) and Willis *et al.* (2022; n=2) were manufactured in Irish production plants. Therefore, the present microbiological survey was carried out to determine the prevalence of *Salmonella* spp. in non-ready-to-eat frozen and chilled coated poultry placed on the market in Ireland, and to raise consumer awareness regarding the risks of such products, if they are not cooked or handled appropriately.

Irish survey on consumer practices with regard to coated poultry

In 2022, the all-island Food Safety Promotion Board in Ireland, Safefood, commissioned market research company, Ipsos, to investigate consumer perceptions and preparation methods across the Island of Ireland in regard to breaded frozen chicken (McCann and Gordon, 2024). Their survey collected data from 2,073 residents across the Island of Ireland using a telephone omnibus approach in Ireland (n=1,032), and an online omnibus approach in Northern Ireland (n=1,041).

These data were weighted to reflect the population profiles for both Northern Ireland and Ireland using recent figures from the Central Statistics Offices, and the cumulative findings for the Island of Ireland were derived.

This FSAI national microbiological survey report will only focus on the results reported for consumer behaviour regarding cooking and handling of frozen breaded chicken in Ireland. The findings were analysed in conjunction with the results of the FSAI national microbiological survey on *Salmonella* contamination in non-ready-to-eat chilled and frozen coated poultry to assess the potential public health risks concerning these products in Ireland.

An overview of the responses deemed relevant to the scope of the FSAI national microbiological survey gained from the Safefood consumer behaviour survey are presented as follows:

Perception of food poisoning risk:

Of respondents who prepare food or cook at home (n=878):

- 11% (n=100) believe that there is no risk associated with frozen breaded chicken,
- 37% (n=329) perceive a low risk,
- 31% (n=274) perceive a medium risk, and
- 20% (n=175) perceive a high risk.

When comparing the preparation of frozen breaded chicken versus raw poultry, more respondents felt there is a higher risk of food poisoning associated with raw poultry (medium/high at 72% [n=638]), compared to frozen breaded chicken (medium/high at 51% [n=449]).

Following cooking Instructions:

Of respondents who prepare food or cook at home (n=878):

- 42% (n=365) always follow instructions,
- 25% (n=217) follow instructions most of the time,
- 21% (n=181) rarely follow instructions, and
- 13% (n=115) never follow instructions.

Hygiene practices:

Of respondents who cook frozen breaded chicken at home:

- 82% (n=610/748) wash their hands before handling and preparing these products,
- 92% (n=684/744) remove the product from its packaging and place it directly onto the cutting board or baking tray,
- 88% (n=653/745) wash their hands after handling and preparing these products, and
- 82% (n=613/749) wash surfaces and utensils after preparation.

Aim of the microbiological survey

The aim of this survey is to determine the prevalence and characteristics of *Salmonella* spp. in non-ready-to-eat chilled and frozen coated (e.g. battered or breaded) meat preparations[2] and meat products[3] made from poultry meat intended to be eaten cooked that are placed on the market in Ireland.

Methods

Food category status under Regulation (EC) No 2073/2005

Commission Regulation (EC) No 2073/2005, as amended, sets legal microbiological criteria for *Salmonella* spp. in certain foods when placed on the market during their shelf-life, including for meat preparations and meat products. The categorisation of the non-ready-to-eat chilled and frozen poultry survey samples as a meat preparation (food category 1.5) or a meat product (food category 1.9) under Regulation (EC) No 2073/2005 was determined by evaluating the product label at the time of sampling against the definitions in 852/2004[2,3].

Survey samples were considered to be a meat preparation (food category 1.5) if they were labelled as containing raw meat or raw poultry, with consumer advice to wash hands and surfaces after handling. The label also stated the product must be fully cooked before consumption, listing cooking instructions that require more time for cooking (e.g. 180-200ºC (fan oven) for 20-30 minutes) than required for a fully cooked poultry meat product that just required reheating. Survey samples were considered to be a meat product (food category 1.9) if on the label there was no mention that the product contains raw meat or poultry, if no advice was provided to consumers in regard to the risk of handling or undercooking, and if the cooking instructions outline a shorter time

[2] Regulation (EC) 853/2004 defines '*Meat preparations'* as '*fresh meat, including meat that has been reduced to fragments, which has had foodstuffs, seasonings or additives added to it or which has undergone processes insufficient to modify the internal muscle fibre structure of the meat and thus to eliminate the characteristics of fresh meat. Meat preparations must not be re-frozen after thawing'*.

[3] Regulation (EC) 853/2004 defines *'Meat products'* as *'processed products resulting from the processing of meat or from the further processing of such processed products, so that the cut surface shows that the product no longer has the characteristics of fresh meat'*.

for cooking (e.g. 180-200ºC (fan oven) for 12-15 minutes) than that required for a raw or partially cooked poultry meat preparation.

Sample collection

Between 5 September and 28 November 2022, EHOs from the HSE collected 382 samples of non-ready-to-eat chilled and frozen coated poultry meat preparations and poultry meat products intended to be eaten cooked from the following establishments:

- Wholesalers and distributors
- Retailers such as supermarkets, corner shops, convenience stores, farm shops, butcher shops, market stalls, health food shops, petrol station forecourts, etc.
- Caterers from the food service sector such as restaurants, cafés and take-away services.

At retail and catering levels, a single sample of at least 100 grams was taken. For distribution and wholesale establishments, batch samples comprising five individual sample units (n=5) were taken.

Sample analysis

Samples were analysed for the presence of *Salmonella* spp., using either reference method ISO 6579:2017/AMD 1:2020, or using an alternative method validated against the reference method in accordance with Article 5.5 of Commission Regulation (EC) No 2073/2005.

Interpretation of microbiological test results

The test results for *Salmonella* spp. in non-ready-to-eat chilled or frozen coated poultry were assessed for compliance against the microbiological food safety criteria outlined by Regulation (EC) No 2073/2005 for food categories 1.5 and 1.9. The criteria for *Salmonella* spp. in meat preparations (food category 1.5) and meat products (food category 1.9) is “not detected in 25g” in five sample units, meaning that none of the five samples taken from the market during their shelf-life should contain *Salmonella* spp. when 25 grams of each sample are tested (Table 1).

Table 1 Interpretation of *Salmonella* spp. test results under Regulation (EC) No 2073/2005.

***Salmonella* spp. result**	**Test/Sample/Batch result designation [4]**	**Test/Sample/Batch result designation basis**
Not detected in 25 g	Satisfactory	**Food category 1.5** *Minced meat and meat preparations made from poultry meat intended to be eaten cooked* or **Food category 1.9** *Meat products made from poultry meat intended to be eaten cooked* in Regulation (EC) No 2073/2005.
Detected in 25 g	Unsatisfactory	

Typing, characterisation and antimicrobial susceptibility testing of *Salmonella* spp. isolates

All of the *Salmonella* spp. strains isolated from the survey samples by the HSE OFMLs were forwarded to the (i) Food Microbiology and (ii) Bacteriology Divisions in DAFM. These divisions host the National Reference Laboratories (NRLs) for (i) *Salmonella* spp. (for food, feed and animal health) and (ii) Antimicrobial Resistance 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.

The NRL for *Salmonella* performed serotyping and WGS characterisation of *Salmonella* isolates received from the OFMLs. Both methods are accredited to ISO 17025:2017 by the Irish National Accreditation Board (INAB). The NRL for Antimicrobial Resistance performed antimicrobial susceptibility testing of *Salmonella* isolates received from the OFMLs.

[4] Both single samples and batch samples were designated for the retail level survey as sampling was undertaken for monitoring and surveillance purposes (European Commission, 2006, p. 9)

Serotyping

The NRL for *Salmonella* examined pure colonies of *Salmonella* spp. isolates for the presence of their respective specific somatic and flagellar antigens. The serotype was identified by comparing this data against the WHO manual for determining the assigned name of each isolate in respect to each combination of specific somatic and flagellar antigens.

WGS based core genome MLST cluster analysis

The NRL for *Salmonella* used WGS to perform typing and genomic characterisation of the *Salmonella* spp. isolates. 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 to determine the 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.

In order to perform cluster analysis, the degree of genetic difference between isolates tested was determined using 1,748 core loci (cgMLST). A cluster is defined as isolates with ≤7 allelic difference (AD) between their core genomes. The differences or similarity between all of the cgMLST alleles (variation within each gene) are represented by a dendrogram or by a Minimum Spanning Tree (MST).

Antimicrobial susceptibility testing

The NRL for Antimicrobial Resistance performed antimicrobial susceptibility testing on the *Salmonella* isolates using a broth microdilution according to guidelines set out by the Clinical and Laboratory Standards Institute. Isolates are classified as non-wild type by employing epidemiological cut-offs recommended by EUCAST and listed in European Commission Implementing Decision 2020/1729.

For azithromycin, colistin, sulfamethoxazole and tricycline, cut-offs of >16, >2, >256, and >0.5 µg/ml, respectively, were used. AMR genes, plasmid replicons, and nucleotide polymorphisms isolates conferring fluoroquinolone resistance were detected by uploading data to Resinder 4.1 (ResFinder 4.1 [dtu.dk] and Plasmidfinder 2.1 [dtu.dk]). In addition, in-silico analysis of mobile genetic elements was carried out using the base local alignment tool (BLAST).

Results and discussion

Establishment type

Samples were taken from retail (n=247/382), wholesale and distribution (n=20/382), and food service (n=32/382) establishments. Most of the survey samples (65%) were taken at the retail level. This is likely due to the large availability of these products at these establishments. The type of establishment sampled was not recorded for 83 of the results obtained for single samples from this survey (Figure 2).

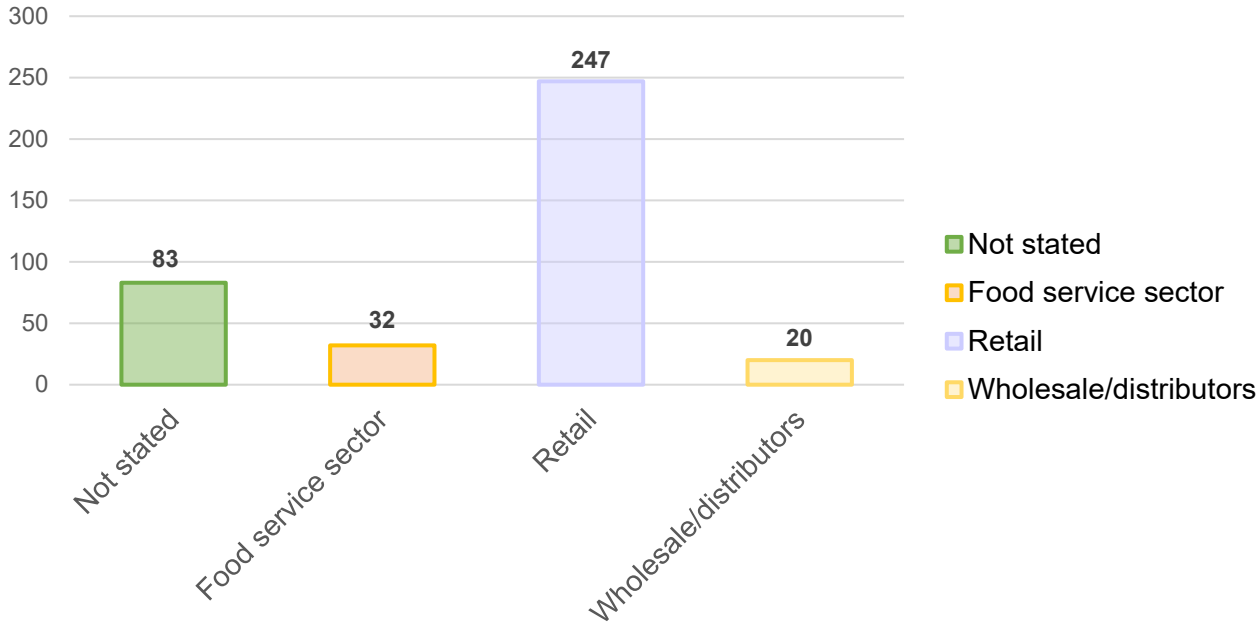

Figure 2 The type of retail establishments sampled as part of the microbiological survey (total n=382).

Product categorisation under Regulation (EC) No 2073/2005

The survey products were categorised under food categories 1.5 for meat preparations, or 1.9 for meat products in Commission Regulation (EC) No 2073/2005.

Of survey samples tested (n=382), 205 (53.66%) were classified as food category 1.5 for meat preparations, while 164 (42.93%) were classified as food category 1.9 for meat products. Some of the samples (n=13/382) were not categorised at the time of sampling (i.e., not stated) and were without sufficient information to allocate their categorisation thereafter.

Prevalence of *Salmonella* spp.

Five (1.30%) of the 382 samples assessed for the national microbiological survey were contaminated with *S.* Infantis (Table 2). The type of survey samples found to be contaminated were chilled chicken balls (n=1 product), frozen chicken fillets (n=2 products) and frozen chicken goujons (n=2 products).

Of the samples found positive for *S.* Infantis, four of the products (n=4/5) were classified as food category 1.5 for meat preparations, while one product (n=1/5) was classified as food category 1.9 for meat products.

Table 2 The prevalence of *Salmonella* in non-ready-to-eat chilled and frozen coated poultry meat preparations (food category 1.5) and meat products (food category 1.9).

Food category under Regulation (EC) No 2073/2005	Total number of samples tested	Number (%) satisfactory	Number (%) unsatisfactory
1.5 Meat preparations made from poultry meat intended to be eaten cooked	205	201 (98.05%)	4 (1.95%)
1.9 Meat products made from poultry meat intended to be eaten cooked	164	163 (99.4%)	1 (0.6%)
Food category not stated	13	13 (100%)	0 (0%)
Overall	382	377 (98.7%)	5 (1.3%)

From a historical perspective, it is interesting to note that there have been eight notifications of *Salmonella* spp. contamination in breaded poultry reported in the past decade via RASFF. Seven of these eight notifications detailed detections of serotypes *S.* Infantis (n=4/8), *S.* Enteritidis (n=2/8), and *S.* Agona (n=1/8). Notifications were observed in the following types of products: chilled/frozen coated poultry: chicken goujons (n=3/8), chicken nuggets (n=2/8), chicken burgers (n=1/8), chicken fillet chunks (n=1/8), marinated chicken breast strips (n=1/8), and marinated turkey steaks (n=1/8) (see Appendix 1).

Thermal processing status of contaminated products

The *S.* Infantis contaminated products were described as being raw (n=1/5), partially cooked (n=3/5), or fully pre-cooked (n=1/5). The raw survey sample (n=1) did not undergo any thermal treatment during its production process. It is possible that contamination with *S.* Infantis, may have been in the raw materials prior to intake by the manufacturer, or through cross-contamination during production. In 2022, the prevalence of *S.* Infantis in broiler flocks and fresh poultry meat was observed in Europe at 1.3% (n=178/13,505) and 2.3% (n=452/19,876) of total samples respectively (EFSA, 2022). In view of this, it is possible that the poultry meat used to produce the surveyed coated poultry in which *S.* Infantis was detected may have been the source of contamination.

Three contaminated products were described as being partially cooked (60%, n=3/5). The processing for partially cooked products would have involved a mild heating step (e.g. flash frying). This is usually applied to maintain the shape of the product and to 'set' the crumb coating providing it with a golden-brown colour prior to packaging. This step, however, is not intended to fully cook the product and therefore does not provide complete lethality of harmful microorganisms throughout the product. Similar to the raw product, contamination may have been present in the raw materials prior to intake by the manufacturer or occurred through cross-contamination during processing. As partially cooked products may appear visually as fully cooked to the consumer but the core remains raw, there is a risk that consumers perceive these products as already being cooked and therefore do not think they need to fully cook them again, even though they are instructed to do so on the label.

To mitigate the risk of salmonellosis in consumers, partially cooked coated poultry manufacturers could consider transitioning to producing fully pre-cooked coated poultry. This should in turn reduce the risk of *Salmonella* contamination remaining in these products when they are placed on the market. This would reduce the risk to certain consumers who regularly undercook or unhygienically handle coated poultry prior to eating.

One product (20%, n=1/5) was described as being fully pre-cooked at retail. This product would have undergone thermal treatment at the manufacturer level intended to eliminate *Salmonella*. The most likely cause of cross-contamination after the thermal treatment would be cross-contamination with *Salmonella* after thermal treatment during the production process. However, it is also possible that the critical control point related to the time-temperature requirement for the thermal treatment of this poultry meat product may not have been successfully met.

This in turn could mean that contamination may have occurred at any stage of the production process; before the intake of raw materials, or at some stage along the manufacturing process to the point of placing the poultry meat product on the market.

Consumer cooking and handling practices of coated poultry

In the Irish consumer behaviour study, a greater proportion of respondents identified a higher risk associated with raw poultry meat (medium/high risk at 72%, n=638 out of 878) compared to frozen breaded chicken (medium/high risk at 51%, n=449 out of 878) (McCann and Gordon, 2024). This demonstrates that in general consumers tend to view coated poultry as being of lower risk compared to uncoated raw fresh poultry meat

Low awareness among consumers on the salmonellosis risks associated with coated poultry may in turn lead to a lack of adherence when following cooking instructions and/or following hygienic practices in the kitchen. The survey of consumer behaviour in Ireland highlighted that only 41% of respondents state to consistently follow the cooking guidelines for frozen breaded chicken products (n=365/878), while 33% (n=296/878) state to rarely or never abide to the cooking instructions for these products (McCann and Gordon, 2024).

In regard to the consumer's hygienic practices, 12% of consumers (n=92/745) stated to not wash their hands after handling and preparing these products, and 18% (n=136/749) stated to not clean all surfaces with hot soapy water following preparation (McCann and Gordon, 2024). The insights gained on consumer practices in regard to preparing and cooking breaded chicken underscore a gap that exists on consumer awareness concerning the risks associated with these products. This could lead to consumers undercooking coated poultry products and subsequently being exposed to *Salmonella*, if present.

Typing and characterisation of *Salmonella* spp. isolates

All five *Salmonella* isolates from the survey were serotyped as *S.* Infantis by the NRL (Table 3) and identified as belonging to Actmann MLST sequence type ST32.

For context, the genetic distance threshold for determining the relatedness of isolates is ≤7 allelic differences (AD). The NRL described three of these isolates as being closely related to each other with a maximum of 4 AD between their genome sequences (cgMLST cluster A). Two of these isolates were indistinguishable by cgMLST. The three clustered isolates (≤4 AD) were found in products containing poultry meat sourced from the same country, specifically Ukraine. Thus, it is possible that contamination for these isolates may have resulted from a common source, or from closely related events.

The remaining two *S.* Infantis isolates were not related to each other (60 AD), or to any of the other isolates cultured in the survey (71-72 AD). Considering this genetic diversity, it is likely that their contamination resulted from multiple sources, or from distinct contamination events.

None of the five isolates were found to be closely related to any of the previously detected *S.* Infantis sequences archived in the NRL database. However, previously sequenced isolates in the NRL database with the fewest AD (13 or greater) were that from processed chicken meat products imported into Ireland. This alignment suggests a possible link towards imported chicken meat as a source of contamination. To note, the country of origin for the poultry meat used in the manufacture of the samples found to be positive in the present survey were Poland (n=1/5) and Ukraine (n=3/5). The country of origin could not be definitively established for one isolate (n=1/5).

Table 3 Summary of typing, characterisation and product traceability of *Salmonella* spp. isolates.

Isolate reference	*Salmonella* Serotype	MLST Sequence Type	cgMLST Cluster	Country of origin for poultry meat	Food category
S22-003926	Infantis	ST32	A	Ukraine	1.5 Meat preparation
S22-004009	Infantis	ST32	none	Not Established	1.5 Meat preparation
S22-004085	Infantis	ST32	none	Poland	1.5 Meat preparation
S22-004398	Infantis	ST32	A	Ukraine	1.5 Meat preparation
S22-004399	Infantis	ST32	A	Ukraine	1.9 Meat product

Antimicrobial resistant phenotypes and genotypes of *S.* Infantis isolates

As shown in Table 4, all five *S.* Infantis isolates were resistant to nalidixic acid (NAL) and ciprofloxacin (CIP). These are critically important antibiotics used to treat infections in humans and animals (WHO, 2018; OIE, 2007). These isolates harboured the novel mutations of T57S in their *parC* gene and S83Y in their *gyrA* gene, which alter the target enzymes of NAL and CIP, respectively. These mutations therefore reduce the effectiveness of these antibiotics.

Four isolates had *sul1* and *tet*A resistance genes, decreasing their susceptibility to sulfamethoxazole (SMX) and tetracycline (TET) antimicrobials. Both of these antibiotics are deemed critically important for veterinary medicine (OIE, 2007), and highly important for human medicine (WHO, 2018).

One isolate (S22-003926) was also resistant to ampicillin (AMP) and chloramphenicol (CHL), harbouring associated resistance genes *bla*TEM-(1B) and *CmlA1*-like, respectively. Ampicillin is regarded as a critically important antimicrobial towards the treatment of human and animal infections (WHO, 2018; OIE, 2007), while chloramphenicol is regarded as highly important in human medicine (OIE, 2007).

The plasmid incompatibility group replicon, IncFIB, was detected in all isolates, including S22-004009 which did not harbour any transmissible resistance genes. The presence of plasmid type IncFIB in all isolates, including the one without transmissible resistance genes, indicates the involvement of mobile genetic elements for spreading resistance. This resistance, carried by plasmids, allows bacteria to share these AMR traits with other bacteria, which may increase the spread and threat of AMR to human and animal health.

Considering the insights gained from the consumer behaviour survey previously described in this report (McCann and Gordon, 2024), the results acquired from the antimicrobial susceptibility testing indicate that some consumers may become exposed to isolates of *S.* infantis demonstrating various attributes of AMR through the consumption of undercooked coated poultry, or via cross-contamination during the unhygienic preparation and handling of these products. Exposure to these isolates in turn may lead to consumers developing more serious and/or difficult to treat salmonellosis infections.

Table 4 Resistant phenotypes and genotypes of *S.* Infantis isolates reported by the NRL.

NRL isolate reference	Resistance Pattern	Resistance genes	*gyrA* mutation	*parC* mutation	Plasmid type
S22-003926	AMP CHL CIP NAL SMX TET	*bla*TEM-1B *aadA1*-like *aadA2b*-like *cmlA1*-like *sul1* *tet*A	S83Y	T57S	IncFIB, IncX1-like
S22-004009	CIP NAL	Not detected	S83Y	T57S	IncFIB
S22-004085	CIP NAL SMX TET	*aadA1*-like *sul1* *tet*A	S83Y	T57S	IncFIB
S22-004398	CIP NAL SMX TET	*aadA1*-like *sul1* *tet*A	S83Y	T57S	IncFIB
S22-004399	CIP NAL SMX TET	*aadA1*-like *sul1* *tet*A	S83Y	T57S	IncFIB

Conclusions

S. Infantis was detected in a small proportion (1.3%, n=5/382) of survey samples. These results were a legal breach under Commission Regulation (EC) No 2073/2005, as amended. Detections were observed in chicken goujons (n=2/382), chicken fillets (n=2/382), and chicken balls (n=1/382). One of the products was described as being fully pre-cooked. This suggests that cross-contamination post-processing may have occurred, or that the critical control point of a time-temperature treatment for this meat product during manufacturing may have failed.

As presented in Table 3, the poultry meat used in the production of four of the contaminated products were sourced from Poland (n=1/5) and Ukraine (n=3/5). However, the country of origin could not be conclusively determined for one isolate (n=1/5). *S.* Infantis isolates were characterised by WGS. WGS analysis showed that all survey isolates belonged to sequence Actmann MLST type ST32 of *S.* Infantis. A close relationship was observed between three clustered isolates originating from products which all contained poultry meat imported from Ukraine. This suggests that contamination may have resulted from the same source, or from closely related events. In addition, when compared to archived sequences in the NRL database, the survey isolates were most similar to *S.* Infantis previously isolated from imported poultry meat. These findings signal a link towards imported poultry meat as a possible source of contamination.

Antimicrobial susceptibility testing showed that all five *S.* Infantis isolates demonstrated resistance to ciprofloxacin and nalidixic acid, four isolates exhibited resistance to sulfamethoxazole and tetracycline, while one isolate demonstrated further resistance to chloramphenicol and ampicillin. The presence of these AMR traits in *S.* Infantis isolated from the survey samples suggests that coated poultry may serve as a possible source of AMR transmission to consumers, increasing the spread and threat of AMR to public health.

While a low prevalence of *Salmonella* was detected in the survey samples, there is a potential risk of salmonellosis to consumers who do not maintain stringent hygienic practices when handling these products, and/or do not exactly follow the cooking instructions as labelled prior to consumption. The consumer behaviour surveys conducted by Safefood and FSA UK suggest that a number of consumers do not fully cook coated poultry, and/or handle them unhygienically, because they perceive the risk to be lower compared to uncoated raw poultry (McCann and Gordon,2024; Ipsos MORI, 2021). The various AMR traits observed in all five of the survey isolates also indicate that consumers who become infected with salmonellosis via coated poultry may be at risk of developing more serious and/or difficult to treat infections.

If *Salmonella* is present in chilled and frozen coated poultry meat preparations and poultry meat products, and consumers do not strictly follow the cooking instructions labelled, undercooking the

product may allow for it to survive and infect the person who consumes the food. Additionally, poor hygienic handling practices in the kitchen may result in cross-contamination of the food handler and others in the home (e.g. by poor hand hygiene) and/or the kitchen environment (e.g. by not thoroughly washing contact surfaces or utensils after cooking). Therefore, consumers should be aware of the potential microbiological risks associated with chilled and frozen coated poultry.

Food business operators have a legal responsibility to ensure their products comply with the microbiological criteria laid down in Commission Regulation (EC) No 2073/2005. They are required to put in place, implement and maintain a permanent procedure or procedures based on the HACCP principles (Regulation (EC) No 852/2004). The findings gained from this survey may assist food business operators to identify areas of improvement in the manufacturing process(es) of these products and thus, implement more stringent controls within their food safety management system. In turn, this may help protect consumer health.

Recommendations

The results of the national microbiological survey showed that 1.3% of non-ready-to-eat chilled and frozen coated poultry (n=5/382) were contaminated with *S.* Infantis. This finding suggests there is a small but appreciable risk of salmonellosis in consumers who do not thoroughly cook these products by following the exact cooking instructions labelled on the packaging. Consumers are also at risk if they do not maintain good hygiene practices when handling coated poultry meat preparations and meat products. This includes washing hands thoroughly after handling and ensuring all utensils and preparation surfaces that have been in contact with coated poultry meat preparations and meat products are washed thoroughly before and after being re-used.

Advice to food business operators:

To minimise the risk of future salmonellosis outbreaks linked to the consumption of non-ready-to-eat chilled and frozen coated poultry, the following recommendations are made to food business operators who manufacture these products:

- Carefully follow Regulation (EC) No 853/2004 laying down the specific hygiene requirements that must be implemented when handling food of animal origin at all stages of the food chain.
- Have a robust food safety management system in place, based on the principles of HACCP, to prevent the risk of cross-contamination from raw materials and the environment (Regulation (EC) No 852/2004).
- As imported poultry meat has been strongly linked as a potential source of contamination in the survey findings both here and in the UK, it is imperative that manufacturers have stringent control of their supply chain. Food business operators should ensure that the raw poultry used to manufacture their products comply with legal microbiological requirements, and ensure they have full traceability of all raw materials utilised.
- Food business operators may set more stringent limits for *Salmonella* spp. in fresh poultry meat than that defined in the applicable legislation under food category 1.28 in Commission Regulation (EC) No. 2073/2005 as part of their specification agreement with their suppliers if they deem it necessary. If food business operators choose to do this, the corrective actions required for test results in breach of the more stringent limits should be documented and agreed with their suppliers first.
- Ensure coated poultry labels clearly indicate to the consumer that the product is non-ready-to-eat and needs to be thoroughly cooked and handled hygienically.
- Ensure coated poultry is labelled with valid and clear cooking instructions.

- Manufacturers of coated poultry meat preparations could consider transitioning to producing a fully pre-cooked coated poultry meat product, which should in turn reduce the risk of *Salmonella* contamination in these products.

Advice to consumer protection agencies:

In view of the important insights gained from both the present FSAI national microbiological survey and the Safefood consumer behaviour survey (McCann and Gordon, 2024), it is recommended that the agencies work together to explore opportunities to provide risk communication information to consumers. It is important to raise awareness on the microbiological risks associated with these products.

Advice to consumers:

Consumers are advised to take measures to effectively minimise the risk of salmonellosis from preparing and consuming coated poultry by:

- **Storage:** Keeping food at safe temperatures.
- **Preparation:** Maintaining good hand hygiene, handling and preparing food correctly, and separating raw ingredients from cooked foods.
- **Cooking:** Cooking food thoroughly by following the manufacturer's instructions as labelled on the product packaging.

The FSAI website provides more information to consumers on how to safely store, prepare, and cook food at home[5].

[5] https://www.fsai.ie/consumer-advice/food-safety-and-hygiene

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Appendix 1

Table 5 RASFF notifications for microbiological contamination of breaded poultry meat and poultry meat products (2014 to 01 October 2024).

No	Date	Reference	Classification	Notified By	Subject
1	15/11/2023	2023.7899	Alert	France	Detection of *listeria monocytogenes* in breaded poultry cutlets
2	04/11/2022	2022.6477	Information for attention	Ireland	*Salmonella* detected in breaded chicken goujons
3	20/10/2022	2022.6138	Alert	EU Commission	*Salmonella* in frozen breaded chicken goujons from Northern Ireland
4	13/10/2022	2022.5976	Alert	EU Commission	*Salmonella* Infantis in chilled chicken meat from Poland used in breaded chicken nuggets and breaded chicken burgers from Northern Ireland
5	27/05/2022	2022.3122	Information for attention	Germany	*Salmonella* Infantis in marinated breaded chicken breast strips, with raw material from the Netherlands
6	04/02/2022	2022 0706	Information for follow-up	Ireland	*Salmonella* Infantis in breaded chicken goujons from Ireland
7	24/03/2021	2021.1493	Information for attention	Ireland	*Salmonella* Infantis Detected in Battered Chicken Fillet Chunks

8	14/03/2024	2024.1912	Alert	Romania	*Salmonella* in chicken nuggets from Germany
9	06/02/2023	2023.0864	Alert	France	*Listeria monocytogenes* (present /25g) in chilled sliced roast chicken thighs and Mexican chicken nuggets from France
10	10/09/2021	2021.4852	Information for follow-up	Spain	*E. coli* O157 in frozen chicken nuggets from Germany
11	28/09/2020	2020.3959	Information for follow-up	Estonia	*Listeria monocytogenes* in chilled chicken nuggets from Lithuania
12	07/12/2021	2021.6695	Information for attention	Austria	*Salmonella* agona in marinated turkey steak from Italy
13	22/05/2024	2024.3960	Information for follow-up	EU Commission	*Listeria monocytogenes* in frozen breaded chicken goujons from Northern Ireland

Search criteria 1: Subject: “Breaded”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 2: Subject: “Battered”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 3: Subject: “Nuggets”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 4: Subject: “Goujons”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 5: Subject: “Dippers”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 6: Subject: “Steak”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 7: Subject: “Popcorn”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 8: Subject: “Poppers”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 9: Subject: “Kiev”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 10: Subject: “Chicken-burgers”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

Search criteria 11: Subject: “Chicken-balls”; **Product category:** Poultry meat and poultry meat products; **Hazard category:** Pathogenic microorganisms.

RASFF portal searched using these criteria on 1 October 2024.

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