Food Safety
AUTHORITY OF IRELAND

MICROBIOLOGY

MONITORING & SURVEILLANCE SERIES

Establishing Baseline Data on the Presence of *Listeria monocytogenes* on Cooked Meat Slicers in Retail and Catering Premises

FEBRUARY 2011

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EXECUTIVE SUMMARY

The purpose of this survey was to establish baseline information on the presence of *Listeria monocytogenes* and other *Listeria* species on cooked meat slicers in retail and catering premises. A secondary purpose was to establish the level of understanding and knowledge in relation to the cleaning and sanitation of this type of equipment in these premises.

The survey investigated 2664 samples taken from 665 meat slicing machines in the Republic of Ireland. The survey revealed that 99.29% (2645/2664) of all test results were categorised as 'Not Detected' for *Listeria* species. Approximately 0.71% (19/2,664) of all test results were categorised as 'Detected' for *Listeria* species. Of these, 0.26% (7/2,664) were categorised as 'Detected' for *L. monocytogenes,* 0.23% (6/2,664) were categorised as 'Detected' for *Listeria innocua* and 0.23% (6/2,664) were categorised as 'Detected' for *Listeria welshimeri*.

Of the seven test results, from six food businesses, where *L. monocytogenes* was 'Detected' two of the samples were from swabs taken on the back plate, one from the product collecting table, two from the meat holder, and two from the rotary blade of the cooked meat slicer. Of the 12 other test results, where *L. innocua* and *L. welshimeri* where 'Detected', five of these were from the back plate, one each from the product collecting table and the meat holder and five from the rotary blade of the cooked meat slicer. Detection of *Listeria* species in the food processing environment, particularly on food contact surfaces, such as cooked meat slicers should be viewed as an indicator of an increased risk of *L. monocytogenes* contamination.

There was no significant ($p>0.05$) correlation between the location of the swab and the presence of *Listeria* species. However, *L. monocytogenes* was the most prevalent species, isolated on the four surfaces examined.

Data from the questionnaires indicated that 74.7% of samples were from retailers 15.9% from the service sector and 7.8% from butcher shops. Approximately 1.5% of questionnaires did not state an establishment type. Over 81% of food businesses indicated in returned questionnaires that they had a cleaning/sanitation schedule for their cooked meat slicer. 15.5% had no cleaning/sanitation schedule in place and 3.2% of food businesses were unstated. However, only 52.5% of these food businesses had a documented cleaning/sanitation schedule with only 27.2% including information on how the meat slicer should be disassembled. No food business included information on how the meat slicer should be cleaned & sanitised and only 0.6% included information on how often the meat slicer should be cleaned & sanitised.

Of the six food businesses with meat slicers positive for *L. monocytogenes*, one had no cleaning/sanitation schedule and one was unstated. One other food business with no cleaning/sanitation schedule for their cooked meat slicer was positive for *L. innocua*. Based on the questionnaires, 13 food businesses were given follow-up instructions by the investigating Environmental Health Officer (EHO).

Over 55 different makes and/or models of meat slicer were recorded in the questionnaires. The most popular make was used by 28% of premises surveyed. No correlation ($p > 0.05$) between make of meat slicer and presence of *Listeria* species could be identified.

The results of this survey indicate that the presence of *L. monocytogenes* and other *Listeria* species on cooked meat slicers is low. However, given the bacterium's ability to establish itself, and persist, in the food processing environment and the severity of illness it causes, it is recommended that food businesses consider the food safety hazards and risks associated with the use of cooked meat slicing machines. In so doing, procedures outlining the precautions and actions to be implemented should be documented in food safety management systems. A prerequisite system which includes a cleaning and sanitation procedure for equipment of this nature, as per manufacturer's instructions, should be developed by the food business. Training for all staff in dissembling, cleaning and sanitising this type of equipment should be a priority for the food business in preventing contamination. The frequency of cleaning should be documented and regularly verified by the manager/supervisor.

ACKNOWLEDGEMENTS

The Food Safety Authority of Ireland wishes to thank the Environmental Health Officers and the laboratory staff of the Official Food Microbiology Laboratories and other food microbiology laboratories of the Health Service Executive who participated in this survey.

ABBREVIATIONS

Aerobic Colony Count **(ACC)**

The Food Safety Authority of Ireland **(FSAI)**

Environmental Health Officers **(EHOs)**

Health Service Executive **(HSE)**

Food Business Operators **(FBOs)**

International Standards Organisation **(ISO)**

Official Food Microbiology Laboratories **(OFMLs)**

Hazard Analysis and Critical Control Point **(HACCP)**

European Commission **(EC)**

Colony Forming Units **(CFU)**

Ready-to-Eat **(RTE)**

INTRODUCTION

Listeria monocytogenes infection or listeriosis in humans is typically foodborne, resulting in febrile gastroenteritis or invasive systemic infection (Drevets & Bronze, 2008). Febrile gastroenteritis occurs when otherwise healthy individuals consume high numbers (>8 log CFU) of *L. monocytogenes*. This form of listeriosis is usually self-limiting, although infection with highly virulent strains of serotype 4b can be fatal (Warriner & Namvar, 2009). The invasive form of the disease occurs mostly in people whose immune system is compromised (e.g. pregnant women and neonates, the young, older people, or those with chronic illness) and has a high fatality rate of up to 44% (ACMSF, 2009).

Outbreaks of listeriosis have been linked to a wide variety of foods including soft ripened cheese, salads, unpasteurised milk, ready-to-eat (RTE) foods such as sliced cooked meat/poultry products, smoked salmon, coleslaw, and sandwiches (Henning & Cutter, 2001; ACMSF, 2009). *L. monocytogenes* is of particular significance to food business operators (FBOs) producing ready-to-eat foods because of the bacterium's ability to establish itself and persist in the food processing environment. Also, because of its persistent nature, *L. monocytogenes* can survive and grow between -1.5^{o}C and 45^{o}C, pH 4.2 to 9.5, water activity (a_w) 0.90 to > 0.99 and salt concentrations up to 20% water phase (FSAI, 2005a).

Efforts to prevent contamination of RTE foods with *L. monocytogenes* must be conducted at all stages of the food chain. This is a difficult task given the fact that *L. monocytogenes* is so widespread in the environment (Henning & Cutter, 2001; FSAI, 2005a). While significant advances have been made by the industry and equipment suppliers to minimise environmental contamination of RTE foods, the prevalence of pathogens such as *L. monocytogenes* in these foods remains a concern.

Due to their construction, meat slicers are often difficult to clean and maintain adequately and therefore constitute probable contamination sources for food products (Blatter *et al,,* 2010). Contamination may be exacerbated as slicing machines are often held at room temperature and cleaned infrequently (Humphrey & Worthington, 1990). As such, meat slicing machines may act as harbourage sites for *L. monocytogenes* (Humphrey & Worthington, 1990) and other *Listeria* species. *L. monocytogenes* can also rapidly adhere to surfaces such as stainless steel, commonly used in the construction of this equipment, which may then also act as a reservoir for further contamination (Beresford *et al.,* 2001; Frye *et al.,* 2002; Gombas *et al.,* 2003 & Gormley *et al.,* 2010).

A survey from the United Kingdom in 1990 revealed that 13% of examined retail meat slicers were contaminated with *L. monocytogenes* (Humphrey & Worthington, 1990). In 2008, a Canadian meat processing company (Maple Leaf Foods) was linked to an outbreak of listeriosis caused by the consumption of RTE meat products contaminated with *L. monocytogenes*. About 57 people were ill and 22 died in the outbreak (Government of Canada, 2009). The report of the independent inquiry into the outbreak revealed that *L. monocytogenes* may have accumulated in slicing equipment at one of the companies processing plants and caused the contamination (Government of Canada, 2009). The report also commented on the time it took to clean the meat slicing machines that were implicated in the outbreak *"to take the meat slicing machines completely apart, thoroughly sanitize and then reassemble would have required shutting down the plant for three days."*

Most recently, in 2010, a study of a Swiss sandwich plant has indicated that slicers, bread feeding machines, conveyor belts and water hoses are the areas most at risk for contamination by *L. monocytogenes* and continuous monitoring of plant equipment and the environment can provide an early warning system for processors (Blatter *et al.,* 2010).

In 2003, a microbiological examination of 619 pre-packed, cooked, sliced ham samples from retail premises throughout the Republic of Ireland qualitatively detected *L. monocytogenes* in 0.2% (1/618) of samples. However, following quantification, all samples (n=615) were categorised as satisfactory (i.e. <20 CFU/g) for the pathogen (FSAI, 2003). A 2004 study by the FSAI, reported a *L. monocytogenes* prevalence of 2.6% (20/757) in whole or sliced (loose sold) fermented meats on retail sale in Ireland (FSAI, 2004). Quantitative analysis was carried out on 762 samples (this included the 20 samples in which *L. monocytogenes* was detected qualitatively). All results were classified as satisfactory (i.e. <20 CFU /g).

Furthermore, a study in 2005 investigating the microbiological quality/safety of loose cooked sliced ham from retail premises indicated that all samples tested quantitatively (n= 919) were satisfactory (< 20 CFU/g) for *L. monocytogenes* (FSAI, 2005b). No qualitative testing was conducted in this survey. Interestingly, in this 2005 study the microbiological quality (Aerobic Colony Count) of the cooked sliced ham was affected by the time of slicing. The quality of ham sliced in the retail premises at the time of sampling was significantly better ($p<0.05$) than the quality of ham sliced in the retail premises prior to sampling (FSAI, 2005b).The Aerobic Colony Count (ACC) results from this 2005 survey (FSAI, 2005b) differed significantly to the results of a previous 2003 FSAI survey on the microbiological quality/safety of ham sliced and pre-packed in processing plants (FSAI, 2003). Significantly, more samples sliced in retail businesses were unsatisfactory for ACC.

Two American studies have investigated the cross contamination dynamics of *L. monocytogenes* (Lin *et al.*, 2006; Vorst *et al.*, 2006). In one study, examining cross contamination of *L. monocytogenes* between slicing equipment and deli meats, the degree of transfer correlated with the numbers of *Listeria* inoculated onto the slicer blade, where the inoculum levels were from 1 to 3 log CFU/g (Lin *et al.*, 2006). It has also been shown that the cutting force, fat and moisture contents are significant factors affecting cross contamination of *L. monocytogenes* between equipment and sliced meats (Vorst *et al.*, 2006).

OBJECTIVES

To establish baseline data on the presence of *Listeria monocytogenes* and other *Listeria* species on cooked meat slicers in retail and catering premises. Detection of other *Listeria* species is viewed as an indicator of an increased risk of *L. monocytogenes* contamination.

METHODOLOGY

Sample source

Samples were collected from food business operators (FBOs) across the Republic of Ireland who used a cooked meat slicer e.g. delicatessens, hotels, supermarkets, butchers, hospitals etc. All other food businesses manufacturing cooked meats for further sale were excluded.

Sample period

Sampling took place between September and December 2009 inclusive.

Description of Cooked Meat Slicer

Cooked meat slicers have a number of components including a rotary blade, meat holder (or chute), back plate and product collection table *i.e. behind and under the rotary blade*. A pushing/guarding device with a handle or plunger may be used to apply pressure to the meat against the slicer blade, or pressure may be applied by gravity and/or by an attachment connected to the meat holder.

Sample description

Each sample consisted of four swabs. One swab was taken from each location on the meat slicer:

A Back-Plate

B Product Collecting Table

C Meat Holder

D Rotary Blade

Sample collection

Sampling was undertaken by Environmental Health Officers (EHOs) from the Health Service Executive (HSE). Where possible, swabs were taken during the operation of the cooked meat slicer or before equipment clean-up. Swabs were not taken immediately after equipment clean-up as residues of detergents can reduce the viability of *Listeria* species that may have been detected. Where samples were taken following equipment clean-up, a minimum period of two hours after cleaning and sanitising was allowed before swabbing the four locations.

Swabs were taken using a sterile Viscose Tip Swab in a Peel Pouch available with 5ml or 10ml of neutralising buffer, using a technique based on ISO 18593 *(ISO, 2004)*[1]. The swab was removed from its peel pouch and inserted into the tube containing the neutralising buffer. The tip of the swab was then pressed against the wall of the tube to remove excess liquid[2]. The surface of each swab location was swabbed whilst rotating the swab between the thumb and forefinger in two directions at right angles to each other, e.g. horizontally and vertically. Each of the four locations was swabbed for at least 20 seconds. However, due to the design of cooked meat slicers it was not always possible to swab an appropriate area of 100cm^2 to 1000cm^2 as specified in ISO 18593 *(ISO, 2004)*.

When each swab was taken, it was inserted half-way into the tube containing the neutralising buffer and cut aseptically so that the swab remained in the fluid. The swab container was then labelled, placed in a cool box maintained between 1°C and 4°C and transported to the Health Service Executive (HSE) Official Food Microbiology Laboratories (OFMLs) within four hours where possible. EHOs were asked to complete one sample submission form and one questionnaire (Annex 1) for each sample (i.e. four swabs). Information on questionnaires is provided on the next page.

Sample Analysis

Analysis of samples was carried out not later than 24 hours after receipt of the sample in the laboratory. Analysis was carried out to confirm the presence or not of *L. monocytogenes* using ISO method 11290-1 *(ISO, 1996)*. No quantitative analysis was conducted. Detection of other *Listeria* species, e.g. *L. ivanovii, L. innocua, L. welshimeri, L. seeligeri* and *L. grayi* from the swabs was viewed as an indicator of an increased risk of *L. monocytogenes* contamination. As such, if the presence of other *Listeria* species was detected this was reported by the OFMLs (FSAI, 2005a).

Reporting of results

Results were reported as Listeria species 'Detected' or 'Not Detected' per swab. Laboratory reports were forwarded to EHOs and the FSAI using the normal reporting channels. Laboratories were requested to forward reports to the FSAI within one month of the survey completion date. A positive result for *L. monocytogenes* implied that cooked meats may have touched that area of the cooked meat slicer and may be potentially contaminated with *L. monocytogenes*. A positive result for other *Listeria* species implied that *L. monocytogenes* may also be present and cooked meats may be potentially contaminated with *L. monocytogenes*. The assumption being, that if a particular surface on the cooked meat slicer is supporting a species of *Listeria*, it could potentially serve as a reservoir for *L. monocytogenes* (FSAI, 2005a).

[1] Alternatively swabs which are normally used by a laboratory and/or have been previously validated for use were also used. However, if swabs other than a Viscose Tip Swab were used the type of swab was indicated on Section 1 of the questionnaire.

[2] As neutralising buffer can leave residues, it was recommended that EHOs rinse swabbed surfaces with clean water or wipe with a suitable bactericidal wipe after swabbing was complete.

Follow-up action

Microbiological criteria for *L. monocytogenes* in ready-to-eat foods are specified in Commission Regulation (EC) No 2073/2005 (as amended) (EC, 2005)[3]. The Regulation does not specify criteria for surfaces in food businesses such as cooked meat slicers. However, it does indicate that FBOs manufacturing RTE foods which may pose a risk of *L. monocytogenes* must sample the processing areas and equipment for this pathogen as part of their sampling scheme (EC, 2005).

Where positive results were reported, EHOs advised FBOs to remove the implicated equipment from use, disassemble (as per manufacturer's instructions), clean, sanitise and re-test for the presence of *Listeria species*. The FBO was advised to appropriately dispose of any cooked meat product still within its control, which was sliced using the contaminated equipment and not offer this product for sale. Furthermore, the FBO was advised to review their hygiene procedures and food safety management plan e.g. HACCP to ensure the elimination of the source of contamination. Following cleaning and sanitisation, additional ongoing testing of the equipment was advised until it could be clearly shown that the contamination had been eliminated.

Questionnaire Data

A questionnaire (Appendix 1) was completed for every sample set (i.e. four swabs from each cooked meat slicer) to obtain information on details such as the premises sampled, equipment make and model, cleaning practices and follow-up actions. Upon receipt of the laboratory results, EHOs were requested to complete the questionnaire and return it to the FSAI within six weeks of the survey completion date. Questionnaires received after these dates were excluded from the analysis in this report.

Statistical Analysis

Chi square (X2) and Fisher's Exact Test analysis was performed using SPSS version 18.0, with significance defined at the $p<0.05$ level.

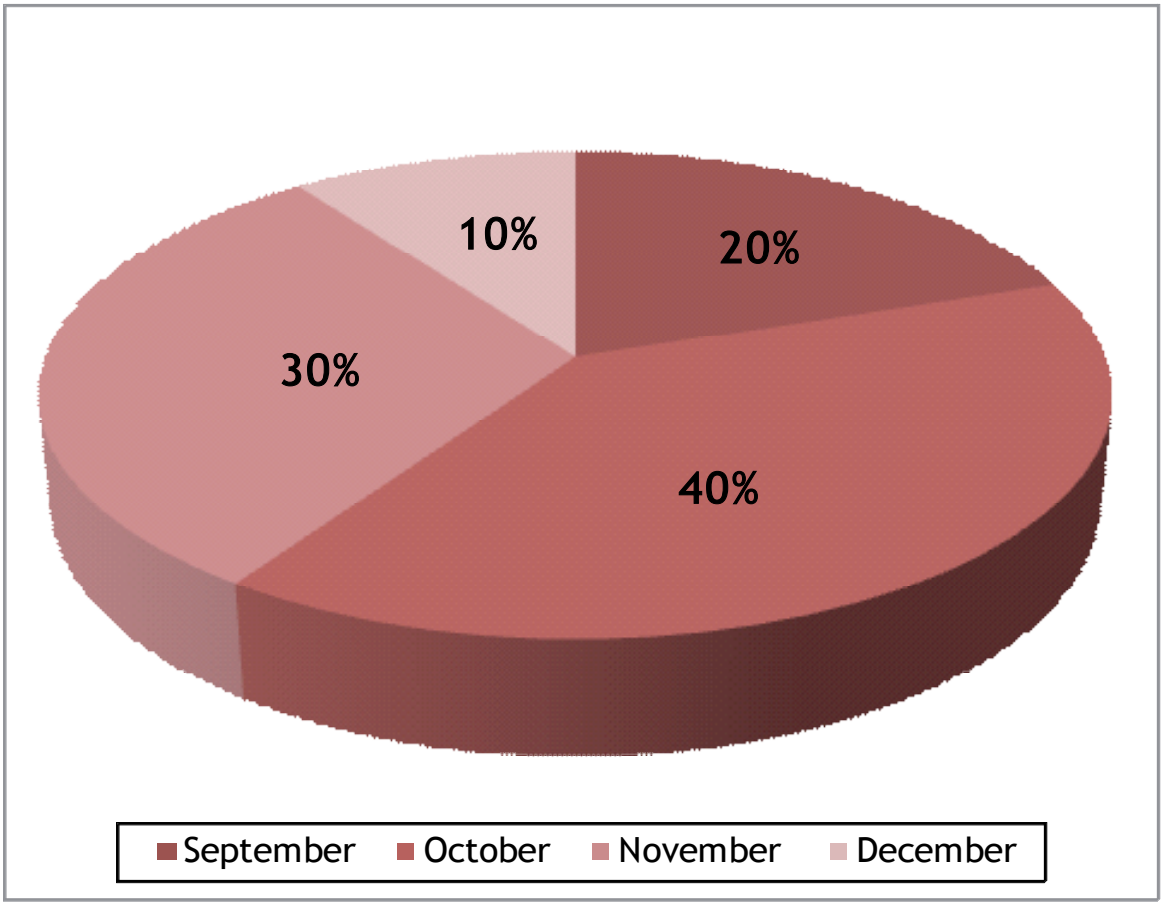
[3] All FBOs have a legal responsibility to produce safe food and all FBOs (with the exception of primary producers) are legally obliged to put in place, implement and maintain permanent procedures based on Hazard Analysis and Critical Control Point (HACCP) principles. Commission Regulation (EC) No 2073/2005 contains microbiological criteria for specific food/microorganism combinations and the implementing rules to be complied with by FBOs at all stages of the food chain. These criteria should be used by FBOs when validating and verifying the correct functioning of their HACCP based procedures and other hygiene control measures. In relation to *L. monocytogenes*, FBOs manufacturing RTE foods must ensure that their products comply with the criteria for this pathogen throughout their shelf-life.

RESULTS AND DISCUSSION

Sample Collection

In total, 2664 of 2698 samples collected by EHOs were considered for this report. Two samples which were not analysed by the laboratories due to labelling issues, 28 samples which were collected outside the specified time-frame (September to December 2009 inclusive) and four samples from a manufacturer/packer were excluded. Of the 32 samples analysed but excluded, all were *Listeria* negative. The number of samples submitted from each HSE region and area is presented in Appendix 2. Of the 2664 samples included, 70% (1869/2664) were collected in October and November 2009 (Figure 1).

Figure 1: Percentage of Samples Collected per Month during the Survey *(n=2664)*

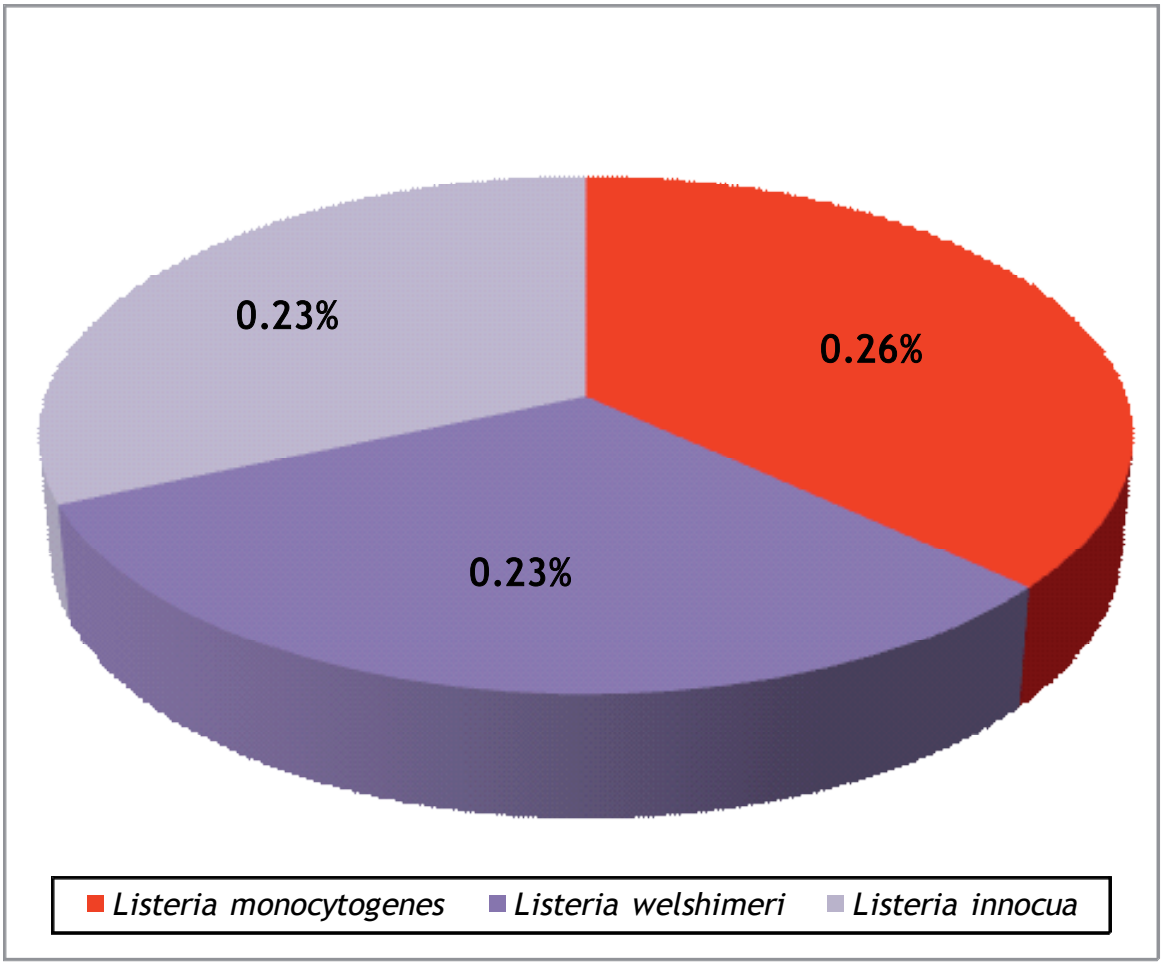


The number of samples analysed per month by the seven OFMLs is given in Appendix 3.

Presence of *Listeria* Species on Cooked Meat Slicers

The genus *Listeria* has six identified species: *L. monocytogenes, L. ivanovii, L. innocua, L. welshimeri, L. seeligeri* and *L. grayi* (FSAI, 2005a). The results of this survey revealed that 99.29% (2645/2664) of all test results were categorised as 'Not Detected' for *Listeria* species. 0.71% (19/2,664) of all test results were categorised as 'Detected' for *Listeria* species. Of these, 0.26% (7/2,664) were categorised as 'Detected' for *Listeria monocytogenes,* 0.23% (6/2,664) were categorised as 'Detected' for *Listeria innocua* and 0.23% (6/2,664) were categorised as 'Detected' for *Listeria welshimeri* (Figure 2).

Figure 2: Positive *Listeria* species as Percentage of Samples Tested *(n=2664)*



Of the seven test results, from six FBOs, where *L. monocytogenes* was found to be 'Detected' two of the samples were from swabs taken on the back plate (Swab A), one from the product collecting table (Swab B), two from the meat holder (Swab C), and two from the rotary blade (Swab D) of the cooked meat slicer (Table 1).

Table 1: Details of Samples Positive for *Listeria monocytogenes (n=7)*

Analysis Laboratory	Swab Description	Month of Sampling	FBO &Location
Cherry Orchard	B - Product Collecting Table	September	Supermarket: Dublin
	C - Meat Holder	October	Retail Multiple: Dublin
	D - Rotary Blade	November	Butcher: Dublin
Galway	C - Meat Holder	September	Butcher: Roscommon
Limerick	A - Back Plate	September	Convenience Store: Clare
	D - Rotary Blade		
Sir Patrick's Dunnes	A - Back Plate	September	Butcher: Dublin

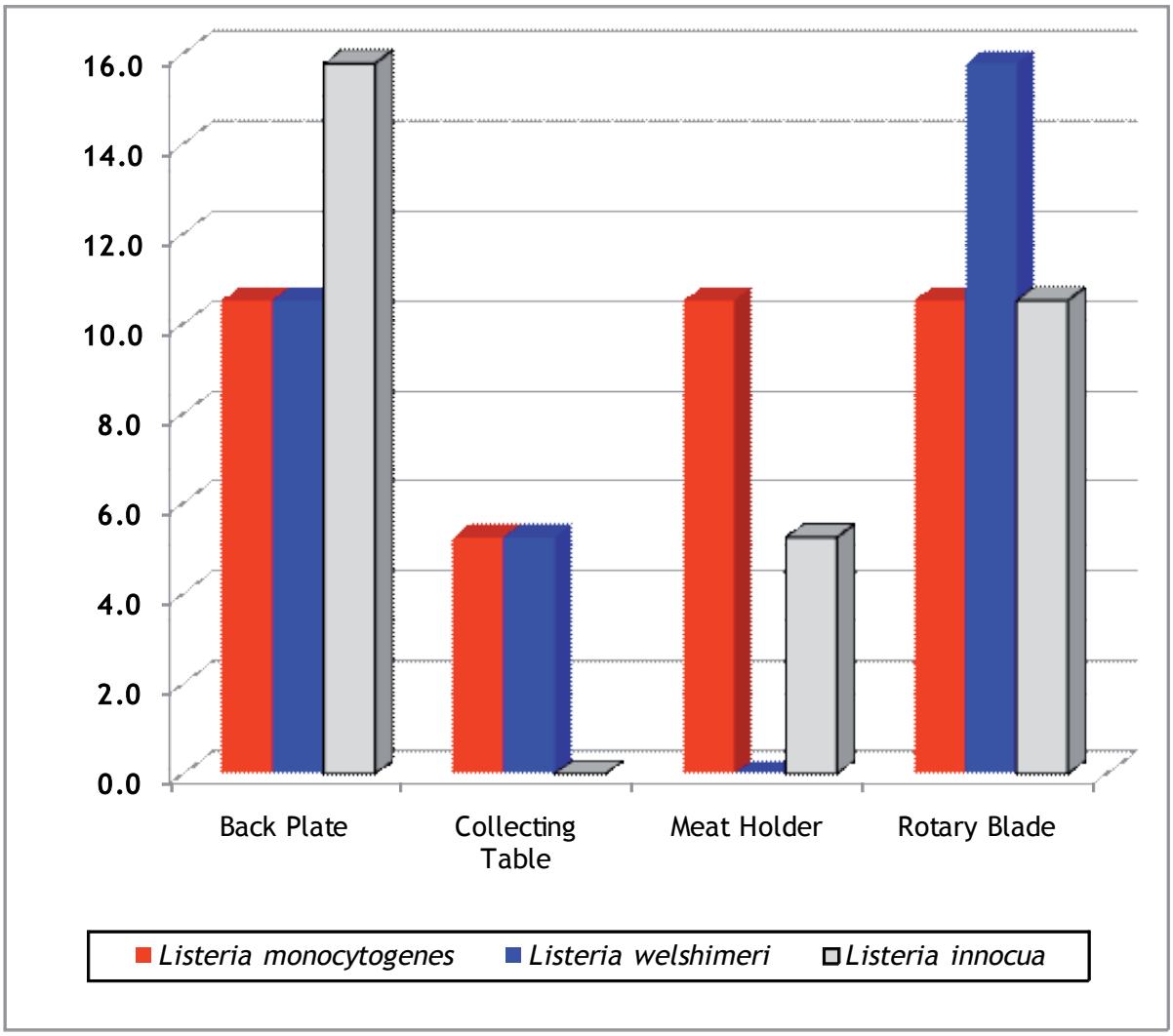
Of the 12 other test results where *L. innocua* and *L. welshimeri* were found to be 'Detected' five of these were from the back plate, one each from the product collecting table and the meat holder and five from the rotary blade of the cooked meat slicer (Table 2).

Table 2: Details of Samples Positive for other *Listeria* species *(n=12)*

Analysis Laboratory	Swab Description	Month of Sampling	FBO & Location	*Listeria* Species
Cherry Orchard	A - Back Plate	November	Butcher: Dublin	*L. innocua*
	A - Back Plate	December	Supermarket: Dublin	*L. innocua*
	D - Rotary Blade			*L. innocua*
Limerick	C - Meat Holder	September	Convenience Store: Clare	*L. innocua*
Sir Patrick Dunnes	B - Product Collecting Table	September	Hospital: Westmeath	*L. welshimeri*
	D - Rotary Blade			*L. welshimeri*
	A - Back Plate	September	Chinese Supermarket: Dublin	*L. welshimeri*
	D - Rotary Blade	November	Retail Multiple: Longford	*L. welshimeri*
	A - Back Plate	November	Butcher: Dublin	*L. innocua*
	D - Rotary Blade			*L. innocua*
	A - Back Plate	December	Convenience Store: Wicklow	*L. welshimeri*
	D - Rotary Blade			*L. welshimeri*

In the case of one cooked meat slicer, two locations on the equipment were positive for *L. monocytogenes* (Table 1) and one for *L. innocua* (Table 2). Another cooked meat slicer was positive for *L. monocytogenes* (Table 1) and also *L. innocua* (Table 2) at two separate swab locations.

Figure 3: Percentage Positive *Listeria* species by Location on Slicer *(n=19)*



There was no significant ($p>0.05$) correlation between the location of the swab i.e. back plate, collection table, meat holder or rotary blade and the presence of *Listeria* species. However, *L. monocytogenes* was the most prevalent species, isolated on the four surfaces examined i.e. back plate, product collecting table, meat holder and the rotary blade (Figure 3). The number of *L. monocytogenes* cells at these swab locations was not determined in the current survey.

Analysis of Questionnaires

Environmental Health Officers were requested to complete a questionnaire at the time of sampling which provided additional information on the four swab samples taken from each meat slicer. 77.5% (2088/2696) of expected questionnaires were returned within the specified timeframe i.e. on or before 15/02/2010, and included in the final 09NS2 dataset[4]. This represents a decrease of 7.5% on the 85% of questionnaires which were returned within the specified timeframe for the previous national survey i.e. 09NS1 on the microbiological safety of pre-packaged sandwiches (FSAI, 2010).
Approximately 8.6% of questionnaires were not returned within the specified timeframe and 13.9% of expected questionnaires were not received and are excluded from the final 09NS2 dataset. The microbiological results of these 2088 samples are similar ($p>0.05$) to the microbiological results of the 2696 samples therefore, in terms of microbiology these 2088 samples are representative of the total sample population.

Of the questionnaires included in the final 09NS2 dataset, 99.6% were matched into a complete batch of four sample swabs as per the 09NS2 protocol (FSAI, 2009). 0.4% of the included questionnaires contained information on three or less sample swabs.

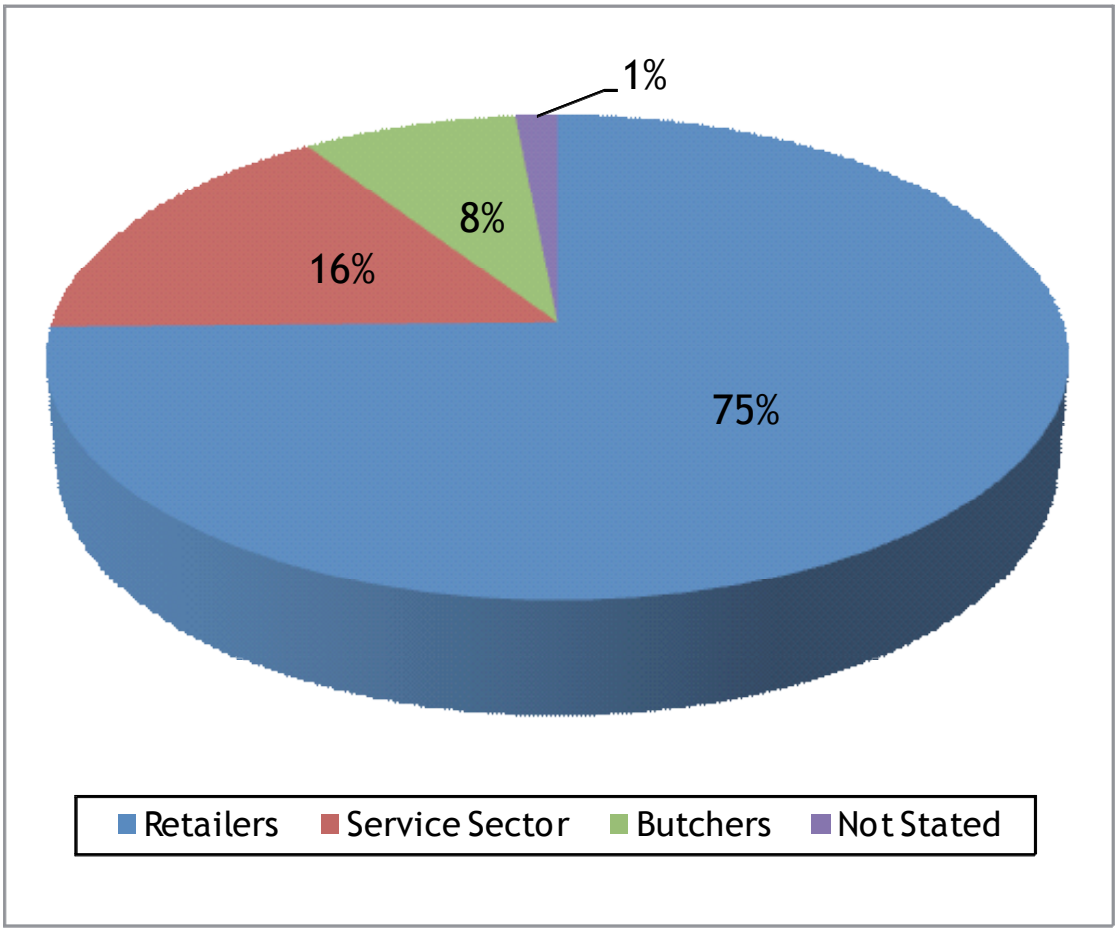
Data from the questionnaires indicated that 75.1% of samples were taken using a viscose tipped swab as recommended in the survey protocol. 9.9%, 8.4% and 0.6% of the samples were taken using cotton, nylon and polyester swabs, respectively. 5.9% of the samples were taken using 'another' type of swab.

Questionnaires were returned for 95% (18/19) of samples that had a positive detection of *Listeria* species. Only one questionnaire was not returned where *Listeria spp.* was detected. This was in relation to a swab taken on a meat holder (Swab C) that tested positive for *L. monocytogenes*.

Data from the returned questionnaires indicates that 74.7% of the samples were taken from retailers i.e. supermarkets, delicatessens, grocery stores etc., 15.9% from the service sector i.e. restaurants, hotels, hospitals, coffee shops, etc., and 7.8% from butcher shops. 1.5% of returned questionnaires did not state an establishment type (Figure 4).

[4] Please note that each questionnaire contains information on four swab samples (i.e. 4 lab reports). For the purposes of working out percentages, the questionnaire figures above are based on swab samples (i.e. each questionnaire equals 4 swab samples). This calculation is required because a laboratory report was received for each swab sample. In order to determine questionnaires received as a percentage of laboratory reports received, each questionnaire was counted 4 times.

Figure 4: Details of Food Businesses Sampled During 09NS2 Survey *(n=2088)*



Data from the returned questionnaires indicates that over 81% of FBOs had a cleaning/sanitation schedule for their cooked meat slicer. 15.5% had no cleaning/sanitation schedule in place and this information was not provided for 3.2%. However, only 52.5% of those FBOs with a cleaning/sanitation schedule documented it, with only 27.2% including information on how the meat slicer should be disassembled. No FBO included information on how the meat slicer should be cleaned & sanitised and only 0.6% included information on how often the meat slicer should be cleaned & sanitised.

Over 55 different make/models of meat slicer were recorded in the questionnaires. The most popular make was used by 28% of FBOs. No correlation ($p > 0.05$) between make of meat slicer and presence of *Listeria* species could be identified.

Of the six FBOs with positive *L. monocytogenes* (Table 1), one had no cleaning/sanitation schedule and one was unstated. One other FBO (FSAI 0106) with no cleaning/sanitation schedule for their cooked meat slicer was positive for *L. innocua* (Table 2).

Based on submitted questionnaire information, 13 FBOs were given follow-up instructions by the investigating EHO as outlined in Section 7 of the survey protocol (FSAI, 2009). However, two of these FBOs had no *Listeria* species isolated from sampled equipment. The remaining 11 FBOs, previously outlined in Tables 1 and 2, did have *Listeria* species isolated from sampled equipment and follow-up action was warranted in these cases. It is unclear in the case of one FBO with equipment positive for *L. monocytogenes* (Table 1), if follow-up action was advised as this section of the questionnaire was left blank for this sample.

Approximately 47% of FBOs indicated that cleaning and sanitation of the equipment had taken place within the previous 12 hours before sampling. This however, was unverifiable, as written records were only maintained by 6.3% of FBOs and verified by 5.6% of FBO manager/supervisors. Over 33%of FBOs did not know when the equipment was last cleaned and sanitised.

Only 6% of FBOs maintained cleaning and sanitation records for the cooked meat slicer and <6% of these could be verified by the manager or supervisor in the FBO. The period of time elapsing since the last cleaning and sanitation of the equipment was also examined by the questionnaire. Just 47% indicated that equipment was cleaned and sanitised within the previous 12 hours. However, 40.2% didn't know how long it was since the equipment was last cleaned and sanitised.

CONCLUSIONS

The isolation of *Listeria* species from surveyed cooked meat slicers was low. Only 0.71% of samples were positive for *Listeria* species, with only 0.23% positive for *L. monocytogenes*. However, while the isolation of *Listeria* species from this type of equipment was low, the fact that *L. monocytogenes* in particular, was detected demonstrates the importance of its control in FBOs using this type of equipment. While not mandatory in the FBOs surveyed (i.e. retail and food service outlets), plants manufacturing RTE foods are required to carry out environmental sampling for *L. monocytogenes* under Commission Regulation (EC) No 2073/2005. This sampling can identify potential sources of *Listeria* contamination, such as slicing equipment, within the premises to which additional cleaning and disinfection procedures can be targeted.

There was no significant ($p>0.05$) correlation between the location of the swab taken from the slicing equipment and the presence of *Listeria* species. However, *L. monocytogenes* was the most prevalent species, isolated on the four surfaces examined. No significant ($p>0.05$) correlation between the make of meat slicer and the presence of *Listeria* species was identified.

The survey highlighted a poor understanding and knowledge of the importance of cleaning and sanitation of this type of equipment by FBOs. While over 63% of FBOs had a cleaning/sanitation schedule for their cooked meat slicer, only 52% documented the schedule and only 27% provided specific information on how the meat slicer should be disassembled. No FBO with a documented schedule had precise information on how the meat slicer should be cleaned & sanitised. While some FBOs verbally indicated to EHOs how often the meat slicer should be cleaned & sanitised, <1% documented this information.

In many of the FBOs sampled in the current survey, the slicing of RTE cooked meats was the final processing step, prior to packaging and sale/service to the consumer. This process poses a microbiological risk because of 1) the potential for spread of microbial contamination via the slicing blade onto the cooked product and 2) the increase in the surface area (and thus the exposed area) of the sliced product (FSAI, 2003). Sliced meats are as such a potential source of *L. monocytogenes* as cross contamination during handling or slicing on the premises can occur if proper controls are not in place (Swaminathan & Gerner-Smidt, 2007).

RECOMMENDATIONS

From the findings of this study, the following is recommended:

- The food safety hazards associated with the use of meat slicing machines should be considered by FBOs. Procedures outlining the precautions and actions to be implemented should be documented in the FBOs food safety management system
- Meat slicers have numerous surfaces that contact food. FBOs should document a cleaning and sanitation procedure for equipment of this nature, as per manufacturer's instructions, if available. The slicer should at a minimum be thoroughly cleaned and sanitised each day prior to and after use. The frequency of cleaning should be documented
- Throughout continuous use at room temperatures, the contact surfaces of the equipment should be cleaned and sanitised at least every 2-4 hours. This time interval may be longer if the equipment is used at refrigerated temperatures
- The efficacy of cleaning and sanitation of meat slicing machines should be verified
- Training for all staff in dissembling, cleaning and sanitising this equipment should be provided
- As the risk of contamination of this equipment and cross-contamination of products is high, separate slicing machines for raw and cooked meats should be considered
- All meat slicing equipment should be maintained with regular maintenance checks
- Records of all routine and maintenance checks or repairs, cleaning and sanitation, staff training etc. should be kept
- When purchasing a meat slicer, ensure the equipment is hygienically designed to facilitate easy disassembly, cleaning and sanitation[5]. Ensure the equipment design and materials used in its construction are safe and durable[6].

[5] Directive 98/37/EC states the following "....machinery must be designed and constructed in such a way that it is possible to clean internal parts which have contained dangerous substances or preparations without entering them; any necessary unblocking must also be possible from the outside. If it is absolutely impossible to avoid entering the machinery, the manufacturer must take steps during its construction to allow cleaning to take place with the minimum of danger."

[6] Specifically in relation to agri-foodstuffs machinery the Directive 98/37/EC states the following: "Where machinery is intended to prepare and process foodstuffs (e.g. cooking, refrigeration, thawing, washing, handling, packaging, storage, transport or distribution), it must be so designed and constructed as to avoid any risk of infection, sickness or contagion. All surfaces in contact with the foodstuffs must be easily cleaned and disinfected, where possible after removing easily dismantled parts. The inside surfaces must have curves of a radius sufficient to allow thorough cleaning."

FOLLOW-UP ACTIONS IN THE EVENT OF DETECTION OF *LISTERIA* SPECIES

If *L. monocytogenes* or other *Listeria* species are detected on a food contact surface, such as a cooked meat slicer, follow-up action should include the following (FSAI, 2005a):

- Production batches which may have come into contact with a contaminated surface should be put on hold, sampled and tested for *L. monocytogenes*
- Suspect equipment should be disassembled, cleaned and sanitised before being reassembled. In some cases the equipment should be dismantled, all sensitive (e.g. electronic parts) and hazardous components (e.g. lubricating oil) removed, and heat applied (i.e. water/steam > 70^{o}C) to the remaining parts. Heat can be applied in the form of steam or using an oven for smaller parts. Sensitive components should be cleaned and sanitised in accordance with the manufacturer's instructions
- Lubricating oils and grease should be replaced with oils containing a listericidal component
- Worn or damaged parts in equipment should be replaced
- Further environmental samples including samples from all previous sample sites should be tested
- Sanitation procedures and records should be reviewed
- Any changes or inconsistencies in sanitation procedures, equipment, personnel and records should be identified
- The causes of the contamination and steps taken to prevent future incidents should be recorded
- The control and HACCP systems should be reviewed and revised as necessary
- It should be verified by microbiological testing that environmental and production control has been re-established.

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APPENDIX 1 QUESTIONNAIRE - 09NS2

Please return before 15th Feb 2010

1. General Information

EHO Name: _____

Name of Establishment: _____

Type of Establishment: _____

Type of Swab Used if not Viscose Tip Swab: Cotton ☐ Nylon ☐ Polyester ☐ Foam ☐ Other ☐

Make/Model of Cooked Meat Slicer: _____

2. Swab A *(Back Plate)*

EHO Sample Reference Number: e.g. 1234-A _____

Corresponding OFML Lab Number: _____

3. Swab B *(Product Collecting Table)*

EHO Sample Reference Number: e.g. 1234-B _____

Corresponding OFML Lab Number: _____

4. Swab C *(Meat Holder)*

EHO Sample Reference Number: e.g. 1234-C _____

Corresponding OFML Lab Number: _____

5. Swab D *(Rotary Blade)*

EHO Sample Reference Number: e.g. 1234-D _____

Corresponding OFML Lab Number: _____

6. Cleaning Practices

Does the FBO have a cleaning/sanitation schedule for the cooked meat slicer? Yes ☐ No ☐

If so is it documented? Yes ☐ No ☐ N/A ☐

If so does it contain the following?

How the meat slicer should be disassembled? Yes ☐ No ☐ N/A ☐

How the meat slicer should be cleaned and sanitised? Yes ☐ No ☐ N/A ☐

How often the meat slicer should be cleaned and sanitised? Yes ☐ No ☐ N/A ☐

Are cleaning/sanitation records maintained for the cooked meat slicer? Yes ☐ No ☐

Are these records verified by the manager/supervisor? Yes ☐ No ☐ N/A ☐

What period (Days) since last cleaning/ sanitation of cooked meat slicer? _____

What period (Days) till next cleaning/sanitation of cooked meat slicer? _____

7. Follow-Up Action

Was follow-up action as outlined in Section 7 of the protocol required? Yes ☐ No ☐

APPENDIX 2 SAMPLES PER MONTH BY HSE REGION AND AREA *(N = 2664)*

HSE Region	Dublin Mid Leinster			Dublin North East		Western			Southern	
HSE **Area**	*East Coast*	*Mid-Lands*	*South-Western*	*North Eastern*	*Northern*	*Mid Western*	*North Western*	*Western*	*South Eastern*	*Southern*
August ***(Excluded)***	0	0	0	0	0	28	0	0	0	0
September	28	80	52	32	56	80	84	88	0	28
October	48	108	100	56	60	100	80	100	383	20
November	56	76	136	84	64	136	110	104	0	48
December	12	0	80	16	0	24	75	24	0	36
Total Sample Area	**144**	**264**	**368**	**188**	**180**	**340**	**349**	**316**	**383**	**132**
Total Sample Region	**776**			**368**		**1005**			**515**	
Total Samples										**2664**

APPENDIX 3 NUMBER OF SAMPLES ANALYSED PER MONTH BY OFMLS

Month / OFML	September	October	November	December	*Total*
Cherry Orchard	60	136	196	44	*436*
Cork	28	20	48	36	*132*
Galway	88	100	104	24	*316*
Limerick	80	100	136	24	*368*
Sligo	84	80	110	75	*352*
Sir Patrick's Dunnes	188	236	220	64	*712*
Waterford	0	383	0	0	*384*
Total	*528*	*1055*	*814*	*267*	**2664**
Percentage of Total	19.82	39.60	30.56	10.02	100

(n = 2664)

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