1st Quarter National Microbiological Survey 2003 (NS1):

Microbiological quality/safety of pre-packed cooked sliced ham

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Report of 1st Quarter National Survey 2003 (NS1):

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Executive Summary

The microbiological quality/safety of 619 pre-packed cooked sliced ham samples was examined. The samples were sourced from retail premises throughout the Republic of Ireland in the first quarter of 2003. The microbiological quality of the samples was assessed by analysing for Aerobic Colony Count (ACC) and *Enterobacteriaceae*, while the microbiological safety was assessed by analysing for *Listeria monocytogenes*. The following are the main findings:

- 13% (79/618) of samples were unsatisfactory for ACC and 4% (24/615) were unsatisfactory for *Enterobacteriaceae*. These findings highlight the need for more emphasis to be placed on control strategies which will improve the overall microbiological quality of cooked sliced ham.
- *L. monocytogenes* was detected qualitatively in 0.2% (1/618) of samples, however following quantification all samples (n=615) were categorised as satisfactory (i.e. <20cfu/g) for this pathogen.
- Slice width (traditional slice/wafer type) had no effect (p<0.05) on microbiological quality/safety.
- There was no relationship between the temperature displayed on the digital display unit of the storage cabinet and the core sample temperature. The core temperature had a significant effect (p<0.05) on microbiological quality/safety.

Finally, an assessment of different techniques for the non-invasive temperature measurement of pre-packed foods has led to the conclusion that between pack measurements are more accurate than infra red measurements.

1.   Introduction

Cooked sliced ham is a popular convenient ready-to-eat food which is widely but not exclusively used as a sandwich filler. This product may be sliced at the point of sale or sliced and pre-packed in a processing plant. This survey investigated the microbiological quality/safety of cooked sliced ham from retail premises which was sliced and pre-packed in a processing plant.

L. monocytogenes is a pathogen which has been detected in many commercially processed ready-to-eat foods (RTE) including ham [1,2]. Its presence in these foods raises concern as 1) these foods receive no further listericidal step$^{\partial}$ prior to consumption and 2) this pathogen is capable of proliferating under refrigerated conditions (i.e. the typical storage conditions for high risk RTE foods such as cooked ham). Levels of *L. monocytogenes* >100cfu/g at the point of consumption is considered to represent a risk to consumers [3]; however this limit is the subject of much debate. Consumption of food contaminated with high levels of *L.*

$^{\partial}$ A listericidal step is any step which will reduce the level of *L. monocytogenes*, e.g. cooking.

monocytogenes can cause listeriosis[¥] in susceptible members of the population. Symptoms range from a mild flu-like condition to severe life-threatening infections characterised by septicaemia and meningoencephalitis. Pregnant women, neonates, the elderly and immunocompromised are particularly vulnerable. Infection during pregnancy can result in abortion or stillbirth.

Although raw materials, equipment and personnel have been identified as potential sources of contamination [4-8]; the environment has been identified as the primary source of post process contamination in commercially prepared processed foods [9, 10]. To address this issue it is imperative that food processors implement a *L. monocytogenes* monitoring and control programme. The objective of such a programme is to highlight areas and processes which support the survival and proliferation of *L. monocytogenes* in the processing plant and to implement procedures to control the risks. Strategies include the elimination of niche environments, the implementation of environmental sampling programmes and where appropriate end product testing.

Currently there are no microbiological criteria for *L. monocytogenes* in RTE foods; however the European Commission is in the process of revising the existing criteria. In Ireland, microbiological guidelines for ready-to-eat foods exist at national level [11]. These guidelines indicate that the presence of *L. monocytogenes* at a level >100cfu/g is unacceptable/potentially hazardous.

Samples were also assessed for aerobic colony count (ACC) and *Enterobacteriaceae*. The ACC is an indicator of hygiene and freshness and its value gives an overall indication of the microbiological quality of the foodstuff. *Enterobacteriaceae* are indicators of hygiene and post process contamination of heat processed foods. These give an indication of the likelihood of the presence of pathogens as well as providing accurate information on the handling and storage of the foodstuff.

Temperature measurement
It has been recognised that wide variation exists between Irish health boards in their sampling practices and in particular in their temperature monitoring practices. To address this issue, a group comprising of Environmental Health Officers and laboratory microbiologists (EHO/OFML sampling group) was set up by the Food Safety Authority of Ireland in August 2002 to identify and agree areas where standardisation of sampling practices would be beneficial. Non-invasive temperature monitoring of pre-packed foods (at the point of sampling) was identified as an area requiring standardisation and this was examined during this survey.

[¥] Listeriosis is the disease caused by *L. monocytogenes*.

2.   Specific Objectives

The specific objective of this survey was to assess the microbiological quality/safety of pre-packed cooked sliced ham with respect to Aerobic Colony Counts (ACC), *Enterobacteriaceae* and *Listeria monocytogenes*. A secondary objective was to determine the most accurate non-invasive technique to measure the temperature of pre-packed foods at the time of sampling.

3.   Method

3.1 Microbiological Analysis

Sample source:
Samples were obtained from retail premises selling pre-packed cooked sliced meats.

Sample description:
Samples surveyed were pre-packed cooked sliced ham that had been pre-packed at processing level. Packs closest to their use-by date were selected. Luncheon meats, salami and smoked ham were excluded from the survey, as were raw hams such as Parma, Serrano and Bayonne.

Sample collection and analysis:
Environmental Health Officers from the 10 health boards (Appendix 1) collected samples (75 g or more) during January, February and March of 2003. Generally from each retail premises, one sample was submitted from each manufacturer. If a repeat sample was deemed necessary, it was not included in the survey.

The samples were analysed in one of the 7 Official Food Microbiology Laboratories (OFML's – Appendix 2) using approved/standard methods (methods accredited by the National Accreditation Board). The samples were analysed for the following parameters:
   1. Aerobic colony count (ACC) at $30^{o}C$
   2. *Enterobacteriaceae*
   3. *Listeria monocytogenes* (detection and enumeration)

The results were classified according to the 2001 Irish microbiological guidelines [11]. The relevant classification for pre-packed cooked sliced ham is given below in Table 1.

Table1: Guidelines for the assessment of the microbiological quality/safety of cooked sliced ham

Parameter	Microbiological quality/safety (cfu/g)			
	Satisfactory	Acceptable	Unsatisfactory	Unacceptable/ Potentially hazardous
Aerobic Colony Count [¥]	$<10^6$	$10^6\text{-}<10^7$	$\geq 10^7$	Not applicable
Enterobacteriaceae	<100	$100\text{-}<10^4$	$\geq 10^4$	Not applicable
L. monocytogenes - Quantitative	<20	$20\text{-}<100$	N/A	≥ 100
L. monocytogenes -Qualitative	Not detected in 25 g Or detected in 25g and <20 cfu/g			

3.2 Determination of the most accurate method for the non-invasive temperature measurement of pre-packed foods

Taking and recording the sample temperature is an important part of sampling. Ideally the core temperature of the sample should be measured as this is the most representative. However, this is an invasive technique and while it is feasible for bulk food it is not always feasible for pre-packed food (pre-packs must be opened to permit measurement of the core temperature and these packs are subsequently discarded).

Techniques used to measure the temperature of pre-packed foods in a non-invasive manner include i) between pack measurements and ii) infra red measurements. These methods do not involve wastage of the pre-packed sample and are thus beneficial in this regard. However, very little is known about the relationship between these temperatures and the core temperature of the pre-packed food. These relationships were investigated in this study.

Two packs of pre-packed cooked sliced ham from the same batch and which were stored under identical conditions were selected; one was referred to as the control sample and one as the test sample.
Non-invasive measurements
1) *Between pack temperature measurements:* This temperature was measured by surface probing between the two packs while they were pressed together.
2) *Infra-red temperature measurement:* If the equipment was available, an infra-red surface probe measurement of the test pack was also made.
Invasive measurement
1) *Core temperature:* The control sample was opened and the core temperature of the ham was measured using an immersion probe.

[¥] Cooked sliced ham is classified as food category D for ACC in the Irish microbiological guidelines [(11)].

Correlation analysis was used to determine the strength of the relationship between each of the non-invasive techniques and the invasive technique. In other words, correlations were made between:
1)   the temperature recorded between packs (non-invasive) and the corresponding core temperature (invasive)
2)   the temperature recorded by infra red (non-invasive) and the corresponding core temperature (invasive).

All probes used in this study were calibrated. The temperature displayed on the refrigerated display unit was also recorded.

All temperatures were recorded on the questionnaire provided. Additional information on product description (e.g slice width) was also recorded.

4. Results and Discussion

4.1 Microbiological Results

A total of 619 samples of pre-packed cooked sliced ham were submitted from the 10 health boards for microbiological analysis. Details of the number of samples analysed from each health board are presented in Appendix 1.

4.1.1 Aerobic Colony Count (ACC)

618 samples were tested for ACC (Table 1). 79% (n=490) of samples were satisfactory, 8% (n=49) acceptable and 13% (n=79) unsatisfactory for ACC. A breakdown of results by health board is given in Appendix 3.

Table 1. Microbiological quality based on Aerobic Colony Counts

No. of samples (%)	Microbiological quality		
	Satisfactory $<10^6$ cfu/g (%)	**Acceptable** 10^6-$<10^7$ cfu/g (%)	**Unsatisfactory** $\geq 10^7$ cfu/g (%)
618 (100)	490 (79)	49 (8)	79 (13)

ACC was measured to assess the overall microbiological quality of the samples. In a processed RTE food such as cooked sliced ham, high ACC levels are indicative of poor process control (including poor temperature control in the cook chill process) and/or post process contamination. The finding that 13% of samples were unsatisfactory for ACC suggests that more emphasis must be placed on control measures.

Similar studies have been carried out in other countries (Table 2). In two studies carried out in the UK, ACC levels $>10^6$ cfu/g were detected in 25% [12] and 38.4% [13] of samples. The results of this Irish study (21% of samples $>10^6$ cfu/g) differ significantly (p<0.05) from the results of the latter study. It is worth noting that in a Greek study [14] ACC levels $>10^6$ cfu/g were recorded in 96.6% of samples.

Table 2: ACC results - a comparison with other surveys

Origin of study	Year of study	Sample description	No. of samples	Results		
				Range (cfu/g)	No. samples	% of samples
UK [12]	1993	Pork/Ham Cooked meats	451	$>10^6$	113	25
UK [13]	2002	RTE sliced meats	2890	$<10^6$	2069	71.6
				$10^6 - <10^7$	357	12.4
				$\geq 10^7$	464	16
Greece [14]	2000	Pre-packed slices of cooked ham	30	$>10^6$	29	96.6
Ireland (this study)	2003	Pre-packed cooked sliced ham	618	$<10^6$	490	79
				$10^6 - <10^7$	49	8
				$\geq 10^7$	79	13

4.1.2 *Enterobacteriaceae*

Enterobacteriaceae are indicators of hygiene and post process contamination of heat processed foods and give an indication of the likelihood of the presence of pathogens. In this study, 615 samples were tested for *Enterobacteriaceae* (Table 3). 89% (n=548) of samples were satisfactory, 7% (n=43) acceptable and 4% (n=24) unsatisfactory. A breakdown of results by health board is given in Appendix 4.

Table 3. Microbiological quality based on *Enterobacteriaceae*

No. of samples (%)	Microbiological quality		
	Satisfactory <100 cfu/g (%)	Acceptable 100-$<10^4$ cfu/g (%)	Unsatisfactory $\geq 10^4$ cfu/g (%)
615 (100)	548 (89)	43 (7)	24 (4)

The detection of *Enterobacteriaceae* in samples at unsatisfactory levels ($\geq 10^4$ cfu/g) is of concern, however the incidence is lower than that recorded in a UK (7.6%) [13] and in a Greek (10%) [14] study. The findings of this Irish study are significantly different (p<0.05) to the findings of the UK study [13] (Table 4).

Table 4: *Enterobacteriaceae* results - a comparison with other surveys

Origin of study	Year of study	Sample description	No. of samples	Results		
				Range (cfu/g)	No. samples	% of samples
UK [13]	2002	RTE sliced meats	2890	<100	2154	74.5
				10^2-$<10^4$	517	17.9
				$\geq 10^4$	219	7.6
Greece [14]	2000	Pre-packed slices of cooked ham	30	$>10^4$	3	10
Ireland (this study)	2003	Pre-packed cooked sliced ham	615	<100	548	89
				10^2-$<10^4$	43	7
				$\geq 10^4$	24	4

It is worth noting that in this study, 86 samples were unsatisfactory for 1 or more microbiological parameter. 62 samples were unsatisfactory for ACC alone, 7 samples were unsatisfactory for *Enterobacteriaceae* alone and 17 samples were unsatisfactory for both ACC and *Enterobacteriaceae* (Table 5). These findings highlight the necessity to test for both parameters as indicators of quality.

Table 5. Samples unsatisfactory for ACC and *Enterobacteriaceae*

	Unsatisfactory samples	Samples unsatisfactory for <u>ACC only</u>	Samples unsatisfactory for *Enterobacteriaceae* <u>only</u>	Samples unsatisfactory for *Enterobacteriaceae* <u>and ACC</u>
Number of samples (%)	86 (100)	62 (72)	7 (8)	17 (20)

4.1.3 Listeria monocytogenes

Qualitative analysis was carried out on 618 samples and *L. monocytogenes* was detected in only 1 sample (0.2%). Quantitative analysis was carried out on 615 samples. All samples were satisfactory (<20 cfu/g) for *L. monocytogenes* (Table 6). This finding is very encouraging and suggests that adequate steps are taken throughout the food chain to control this pathogen.

Table 6: *L. monocytogenes* results

Qualitative Analysis		Quantitative Analysis			
No. of samples	*L. monocytogenes* detected (%)	No. of samples	Satisfactory <20 cfu/g (%)	Acceptable 20-<100 cfu/g (%)	Unacceptable/ Potentially Hazardous ≥100 cfu/g (%)
618	1* (0.2%)	615¥	615 (100%)	0 (0%)	0 (0%)

* This sample was tested quantitatively and was categorised as satisfactory for *L. monocytogenes*
¥ 3 samples tested qualitatively were not tested quantitatively: WHB (n=1), SWAHB (n=1); MHB (n=1)

The findings of this study are better than the findings of a survey carried out by the FSAI on the microbiological status of smoked salmon (n=321) [15]. In that survey 98.08% of samples were satisfactory, 1.28% acceptable and 0.64% unacceptable/potentially hazardous.

The majority of studies which have been undertaken to assess *L. monocytogenes* in cooked ham are qualitative rather than quantitative. A number of these surveys are reported in Table 7 (in some surveys details about the nature of the product were not provided therefore it is difficult to compare results). These data show the variability in the prevalence of *L. monocytogenes* between studies. This may be explained by a number of factors including the ubiquitous nature of this pathogen and the nature of the product. It is worth noting that the Australian survey [17] targeted premises which also handled raw meat, suggesting that cross-contamination maybe partly responsible for the high incidence of *L. monocytogenes*.

Table 7: *L. monocytogenes* qualitative results – a comparison with other surveys

Origin	Year	Sample description	No. of samples analysed	No. of positive samples	Prevalence (%)
UK [12]	1993	Pork/Ham Cooked meats	451	13	3
UK [13]	2002	RTE sliced meats	2874	61	2.12
Greece [14]	2000	Pre-packed slices of cooked ham	30	5	16.7
Ireland [16]	1994	- Cooked ham (MAP)	20	0	0
		- Cooked ham (unpacked)	20	2	10
Australia [17]	2000/2001	RTE ham	27	11	41
Ireland (this study)	2003	Pre-packed cooked sliced ham	618	1	0.2

4.1.4 Effect of slice width and temperature on microbiological quality/safety

Information on slice width (traditional slice or wafer) and temperature (of both the storage cabinet and of the sample) were captured by means of a questionnaire. Questionnaires were returned with 203 samples, i.e. there was a 32.8% (203/619) response rate. Details of the number of questionnaires returned from each health board are listed in Appendix 5.

a) Slice width

Slicing is a process which is carried out post-cooking. 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. In recent years, wafer style sliced ham has been introduced onto the market. This product is sliced thinner than traditional sliced ham. This study was carried out to investigate if there is a difference in the microbiological quality/safety between both products.

Information on slice width was available for 199 of the 203 samples returned with a questionnaire. 71.8% (143/199) of samples were traditional sliced ham while 28% (56/199) of samples were wafer type ham. The microbiological quality of the samples based on slice width is presented in Table 8. Statistically, slice width had no effect ($p < 0.05$) on microbiological quality.

Table 8. Microbiological quality of samples by slice width

Slice width	Number of samples	Number of satisfactory[ß] samples		Number of acceptable[γ] samples		Number of unsatisfactory[δ] samples	
Traditional slices	143	105	73.4%	16	11.2%	22	15.4%
Wafer type	56	45	80.4%	5	8.9%	6	10.7%
Total	**199**	**150**	**75.4%**	**21**	**10.6%**	**28**	**14%**

[ß] A sample was classified as Satisfactory if it was satisfactory for ACC, *Enterobacteriaceae* & *L. monocytogenes*

[γ] A sample was classified as Acceptable if it had an acceptable result for either ACC or *Enterobacteriaceae* but had no unsatisfactory result.

[δ] A sample was classified as Unsatisfactory if it had an unsatisfactory result for either ACC or *Enterobacteriaceae* .

b) Temperatures

Unit temperature

The temperature displayed on the digital display of the storage unit was recorded (Table 9).

80.7% (134/166) of samples were stored in units where the temperature displayed was in the range 0-5°C. 13.8% (23/166) of samples were stored in units where the temperature displayed was >5°C. The recommended storage temperature is <5°C [18].

Table 9: Temperature recorded from the digital display unit of the storage cabinet

Temperature displayed (^{o}C)	No. of samples stored at this temperature (% of samples)
<0	9 (5.5)
0-5	134 (80.7)
>5-10	20 (12)
>10-15	3 (1.8)
Total	**166**

It is worth noting that it was not a requirement of this survey to confirm the accuracy of the temperature on the digital display.

Core sample temperature

The core temperature of 55.4% of these samples (92/166) was measured and the temperature was recorded. The relationship between the temperature on the digital display of the storage unit and the core temperature is outlined in Table 10:

Table 10: Relationship between storage unit temperature and core temperature

Storage unit temperature		Core temperature			
Temperature on the digital display of storage unit (^{o}C)	No. of samples stored at this temperature	No. of samples for which a core temperature was taken	Average	Min	Max
<0	9	7	4.2	2.2	5.4
0-5	134	73	5.6	1.5	12.7
>5-10	20	9	6.2	3.7	9.2
>10-15	3	3	10.6	9.5	11.3
Total	**166**	**92**	**5.7**	**1.5**	**12.7**

The data presented in Table 10 clearly show that the temperature on the digital display of the storage unit is not indicative of the core temperature of the food. For example, an average core temperature of 4.2^{o}C was recorded for samples stored in a unit where the temperature displayed was <0°C (information on core temperature was available for 7 of the 9 samples). Reasons for this difference may include inaccuracies in the temperature display, inadequate equilibration of the food to the storage unit temperature and temperature fluctuations within the storage unit.

The relationship between sample temperature and microbiological quality/safety is presented in Table 11. The sample temperature had a significant effect ($p < 0.05$) on microbiological quality/safety.

Table 11: Relationship between core sample temperature (n=92) and microbiological quality/safety

Average Core sample temperature (^{o}C)	No. of samples	Satisfactory (%) [ß]	Acceptable (%) [ɣ]	Unsatisfactory (%) [δ]
< 5°C	37	34 (91.9)	3 (8.1)	0 (0)
>5°C	55	34 (61.8)	7 (12.7)	14 (25.5)

[ß] A sample was classified as Satisfactory if it was satisfactory for ACC, *Enterobacteriaceae* & *L. monocytogenes*
[ɣ] A sample was classified as Acceptable if it had an acceptable result for either ACC or *Enterobacteriaceae* but had no unsatisfactory result.
[δ] A sample was classified as Unsatisfactory if it had an unsatisfactory result for either ACC or *Enterobacteriaceae* .

4.2 Determination of the most accurate method for the non-invasive temperature measurement of pre-packed foods

As outlined in section 3.2, the temperature of the cooked sliced ham was measured using both invasive and non-invasive techniques and the results are presented in Table 12.

Table 12. Sample temperatures recorded using each technique

Type of technique	Method of measurement	No. of samples	Temperature recorded (^{o}C)		
			Average	Minimum	Maximum
Invasive	Core temperature	103	5.6	1.5	12
Non-invasive	Infra-red probe	109	6.3	1.0	13.8
Non-invasive	Between pack measurement				
	-with surface probe	138	5.5	-1.5	11.9
	-with immersion probe	32	6.0	2.4	13.3

Correlation analysis was used to determine the strength of the relationship between the temperature recorded using each of the non-invasive techniques and the temperature recorded using the invasive technique.

1) **Correlation between the temperature recorded using the infra red probe (non-invasive) and the core temperature (invasive):**
The temperatures of 78 samples were measured using both techniques (infra red and core temperature). The relationship between the temperatures measured is illustrated in Figure 1. The correlation coefficient was calculated as 0.76.

2) **Correlation between the temperature recorded using the between pack measurement (non-invasive) and the core temperature (invasive):**
The temperatures of 103 samples were measured using both techniques (between pack measurements and core temperature). The relationship between the temperatures measured is illustrated in Figure 2. The correlation coefficient was calculated as 0.84.

Analysis of the correlation coefficients shows that the temperature measured between packs was the closest to the core temperature of the food (i.e. its correlation coefficient was the nearest to 1). Therefore, this is the most accurate technique for the non-invasive temperature measurement of pre-packed food.
Therefore when it is not feasible/practical to take the core temperature (invasive technique) of pre-packed foods, the between pack temperature measurement should be taken.

Figure 1: Scatter-plot of the temperature of samples using Immersion probing and infra red (IR) temperature probing (n=78)
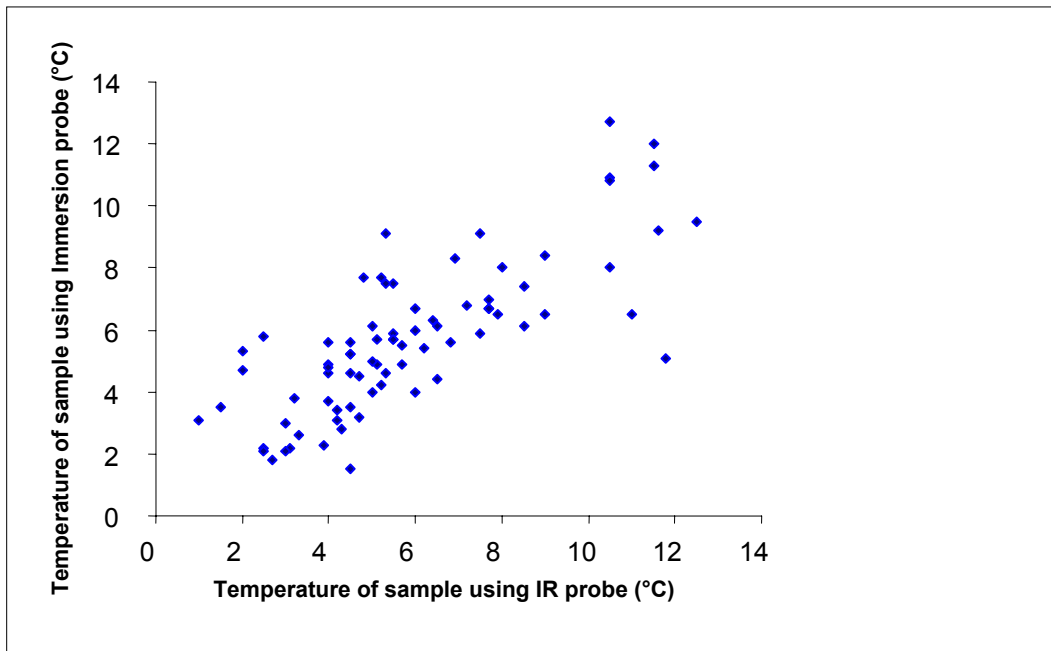
Correlation coefficient(r) = 0.76

Figure 2: Scatter-plot of the temperature of samples using Immersion probing and between pack probing (n=103)*
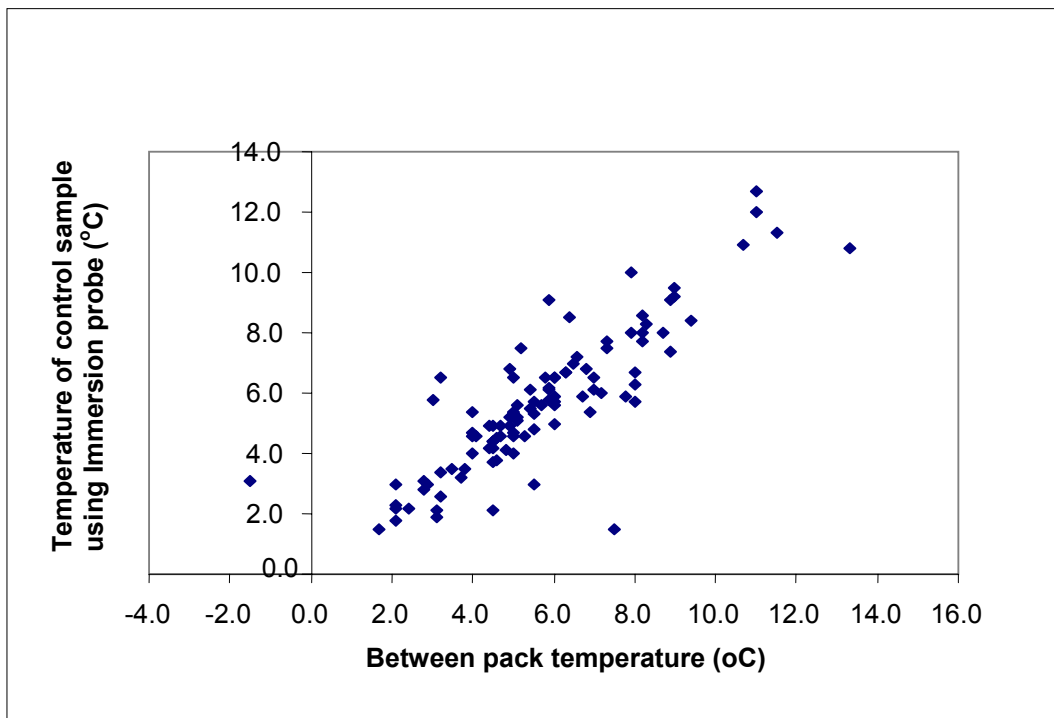
Correlation coefficient r = 0.84
* includes between pack temperatures which were measured using either a surface probe or an immersion probe

5. Conclusions

The finding that 13% (79/618) and 4% (24/615) of samples were unsatisfactory for ACC and *Enterobacteriaceae* suggests that more emphasis must be placed on hygiene and handling practices. Good practices are required at all stages in the food chain (e.g. manufacturing, distribution, retail) to ensure that the microbiological quality (and safety) of the foodstuff is not compromised. Although this study was not designed to determine the stage in the food chain where the microbiological quality deteriorated; it is important that each sector of the food chain is aware of the significance of its role and strives to achieve and maintain high standards.

All sectors of the food chain have a role to play in the control of *L. monocytogenes*. In this study, the finding that all samples were satisfactory for this pathogen is very encouraging and suggests that adequate controls are in place. However processors should not become complacent as this pathogen is ubiquitous in nature and is capable of re-establishing itself in processing environments, thus increasing the potential for post process contamination of the processed foodstuff. Likewise, distributors and retailers must not become complacent. Temperature control during distribution and storage is essential to ensure that this pathogen (if present) does not exceed 100cfu/g at the point of consumption. Finally, a food safety management system based on the principles of HACCP should be implemented by all food businesses. This has been a legal requirement in Ireland since 1998 [19].

Finally, assessment of different techniques for the non-invasive measurement of the temperature of pre-packed foods has led to the conclusion that between pack measurements are more accurate than infra red measurements.

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Appendix

Appendix 1: List of Health Boards

Health board	Abbreviation	Number of samples analysed
East-Coast Area Health Board	ECAHB	44
Midland Health Board	MHB	26
Mid-Western Health Board	MWHB	56
Northern Area Health Board	NAHB	59
North-Eastern Health Board	NEHB	31
North-Western Health Board	NWHB	74
South-Eastern Health Board	SEHB	84
Southern Health Board	SHB	102
South-Western Area Health Board	SWAHB	84
Western Health Board	WHB	59
		619

Appendix 2: List of the Official Food Microbiology Laboratories (OFMLs)

Laboratory
Cherry Orchard Hospital
Mid-Western Regional Hospital
Public Analysts Laboratory, Dublin
Sligo General Hospital
St Finbarr's Hospital, Cork
University College Hospital, Galway
Waterford Regional Hospital

Appendix 3: Classification of samples from each health board according to Aerobic Colony Counts (ACC)

Health Board	Number of Samples tested	Satisfactory		Acceptable		Unsatisfactory	
		No.	%	No.	%	No.	%
ECAHB	44	32	72.8%	6	13.6%	6	13.6%
MHB	26	18	69%	5	19%	3	12%
MWHB	56	41	73%	4	7%	11	20%
NAHB	59	51	86%	0	0%	8	14%
NEHB	31	25	80.7%	1	3.2%	5	16.1%
NWHB	74	52	70%	7	9%	15	20%
SEHB	84	70	83%	3	4%	11	13%
SHB	102	89	87%	13	13%	0	0%
SWAHB	83	67	80.7%	6	7.3%	10	12%
WHB	59	45	76%	4	7%	10	17%
Total	618	490	79%	49	8%	79	13%

Appendix 4: Classification of samples from each health board according to *Enterobacteriaceae* counts

Health Board	Number of Samples tested	Satisfactory		Acceptable		Unsatisfactory	
		No.	%	No.	%	No.	%
ECAHB	44	40	91%	3	7%	1	2%
MHB	25	22	88%	3	12%	0	0%
MWHB	56	48	86%	6	11%	2	4%
NAHB	58	55	95%	1	2%	2	3%
NEHB	31	25	81%	3	10%	3	10%
NWHB	74	72	97%	2	3%	0	0%
SEHB	84	68	81%	10	12%	6	7%
SHB	102	89	87%	8	8%	5	5%
SWAHB	82	75	91%	5	6%	2	2%
WHB	59	54	92%	2	3%	3	5%
Total	615	548	89%	43	7%	24	4%

Appendix 5: Number of samples from each health board accompanied by sample details and temperature recordings questionnaire

Health Board	Number of questionnaires submitted
ECAHB	12
MHB	6
MWHB	5
NAHB	11
NEHB	10
NWHB	41[¥]
SEHB	45
SHB	19
SWAHB	54
WHB	0
Total	**203**

[¥] A total of 42 questionnaires were returned from the NWHB, however, 1 questionnaire was returned with a sample which was unsuitable for analysis and therefore was not included in the analyses.