2nd Trimester National Microbiological Survey 2004 (04NS2):

EU Coordinated programme 2004

Bacteriological Safety of Cheeses made from Raw or Thermised Milk

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Executive Summary

This study investigated the bacteriological safety of cheeses made from raw or thermised milk for the following 5 microbiological parameters: *Salmonella* spp., *Staphylococcus aureus*, *Listeria monocytogenes*, *Campylobacter* spp. and *Escherichia coli*. Sampling took place from May to August 2004 inclusive. Cheese samples were obtained at production level (by Dairy Produce Inspectors) and at retail level (by Environmental Health Officers). The following are the main findings:

Products at production level:
Batch samples (comprising of 5 individual samples) were obtained at production level.

- Applying the criteria proposed by the European Commission (EC) for this survey; all batch samples (n=28) were classified as satisfactory for *Salmonella* spp., *L. monocytogenes*, *Campylobacter* spp. and *E. coli*. In relation to *S. aureus*, 71.4% (20/28), 14.3% (4/20) and 14.3% (4/20) of batches were classified as satisfactory, acceptable and unsatisfactory respectively. Follow-up action was taken by the Dairy Produce Inspectors on unsatisfactory samples. No enforcement action was deemed necessary.

Products at retail level:
Single samples were obtained at retail level.

- Applying the criteria proposed for this survey; all samples were classified as satisfactory for *Salmonella* spp. (n=506) and *Campylobacter* spp. (n=509); while 94.5% (483/511), 97.0% (492/507) and 99.4% (506/509) of samples were classified as satisfactory for *S. aureus*, *L. moncytogenes* and *E. coli* respectively.

Sampling at retail level highlighted a problem with *L. monocytogenes* in cheese from one particular manufacturer (*L. monocytogenes* was detected in 15 samples and 8 of these samples were obtained from the one manufacturer). This problem was addressed by the Authorities and the manufacturer.

1. Introduction

Cheese production evolved centuries ago as a means of preserving raw milk. Over the years this process has been refined and cheese has now developed into a food of *haute cuisine* with epicurean qualities [(1)]. It is estimated that over 1400 varieties of cheese are produced worldwide [(2)]. Many attempts have been made to classify these varieties and today one of the most common classification schemes is based on moisture content (Table 1).

Table 1: A scheme for the classification of cheese [(3)]

Category	Moisture content	Examples
Hard	26-50%	• *Internally ripened, no added ripening microorganisms* e.g. Parmesan, Cheddar, Double Gloucester • *Internally ripened, added ripening bacteria* e.g. Emmental • *Internally ripened, secondary surface ripened by mould* e.g. Blue Cheshire
Semi-hard	42-52%	• *Internally ripened, no added ripening microorganisms* e.g. Lancashire, Edam • *Internally ripened, ripening mould added* e.g. Stilton, Roquefort
Semi-soft	45-55%	• *Surface ripened, ripening bacteria added* e.g. Limburger, Port du Salut
Soft	48-80%	• *Surface ripened, ripening mould added* e.g. Brie, Camembert • *Unripened* e.g. Cottage, Coulommier
Others		e.g Brined varieties, Whey cheese

The basic process for the production of cheese involves two distinct phases: 1) manufacturing and 2) ripening. The manufacturing phase is based on the lactic acid fermentation of milk. Traditionally this was achieved through the action of the indigenous microflora, nowadays it is most often achieved through the addition of specific starter cultures (e.g. *Lactococcus lactis*). When sufficient acid is produced the casein within the milk is coagulated (aided by rennet). The curd is then cut leaving a mixture of curds (solid constituents) and whey (the liquid). After heating, the liquid whey is drained off and the curds are subjected to different processes, such as shaping and salting, resulting in the production of cheese. The ripening phase determines the characteristic flavour and texture of the cheese. The period of ripening can vary from about 2 weeks (e.g. Mozzarella) to 2 years (e.g. parmigiano-reggiano or extra-mature cheddar); however, it is worth noting that some cheeses are consumed fresh. During ripening, a complex set of biochemical changes occur through the catalytic action of the coagulant, indigenous milk enzymes, starter bacteria and secondary microflora [(4,5)].

Pasteurisation of milk is one of the main critical control points (CCPs) in the cheese production process, i.e. it ensures the destruction of vegetative pathogens which maybe present in the raw milk (e.g. *Salmonella s*pp., Verocytotoxigenic *Escherichia coli* (VTEC), *Listeria monocytogenes*, *Escherichia coli*). Nevertheless, in the European Community a tradition exists for the production and consumption of cheeses made from raw/thermised[ϒ] milk [(6)] (these cheeses are favoured for their organoleptic properties). Low pH (high acidity) and competition from starter cultures are the main control steps during the production of these cheeses.

In general cheeses have a good record in terms of microbiological safety; however, there have been incidences where they have been implicated as vehicles in the transmission of foodborne outbreaks [(7, 8)]. The majority of outbreaks reported are associated with the consumption of cheese made from unpasteurised (i.e. raw/thermised) or improperly-pasteurised milk. In addition, it has been recognised that post process contamination can also occur [(8)]. It should be noted that ability of pathogens to survive and grow in cheese is dictated by both intrinsic and extrinsic parameters. Intrinsic parameters of cheese include water content, pH, acidity, nutrient content, presence of antimicrobial compounds and the presence of competitive microflora. These parameters vary between cheese varieties. For example, soft cheese is a more suitable environment for the survival and growth of pathogens than hard cheese. In the latter a combination of factors including low pH, high salt content and low water activity (A_w) render the cheese microbiologically safer. Extrinsic parameters include factors such as processing steps, type of packaging and storage conditions.

Within the European Union, microbiological standards[♦] for milk and milk based products are laid down in Council Directive 92/46/EEC [(9)] (this Directive is implemented in Ireland by Statutory Instrument No. 9/1996 [(10)]). These standards are applicable at the end of production (standards for fresh and soft cheeses made from raw/thermised milk are summarised in Appendix 1). In addition, microbiological guidelines[▲] exist in Ireland for ready-to-eat (RTE) foods sampled at the point of sale [(11)]. In relation to cheese, these guidelines (see Appendix 2) do not differentiate between cheese categories (e.g. soft, fresh, hard etc) or the type of milk (raw, thermised or pasteurised) used in its manufacture. This is necessary considering that the risk of pathogen survival and growth varies between cheese varieties. These guidelines are due to be reviewed by the FSAI and these issues will be taken into consideration.

This study was carried out as part of the EU Coordinated Programme for the Official Control of Foodstuffs 2004 (outlined in Commission Recommendation 2004/24/EC [(6)]). The aim of this study was to collate information from all member states on the prevalence of pathogenic and indicator organisms in cheeses made from raw or thermised milk. This

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[ϒ] Thermised milk is milk that has been subject to a heat-treatment that is less severe than the full pasteurisation process of 71.7°C for 15 seconds or equivalent.

[♦] A microbiological standard is a microbiological criterion contained in law where compliance is mandatory.

[▲] A microbiological guideline provides a benchmark against which unacceptable microbial contamination of food can be identified. It is not legally enforceable.

study will be followed in 2005 by a programme on the bacteriological safety of cheeses made from pasteurised milk. The data obtained from the 2005 study will establish the baseline contamination in other categories of cheese in order to be able to draw meaningful conclusions on the specific risk of cheeses made from raw/thermised milk.

2. Specific Objective

To investigate the bacteriological safety (*Salmonella* spp., *Campylobacter* spp., *Staphylococcus aureus*, *E. coli* and *L. moncytogenes*) of cheeses made from raw or thermised milk.

3. Methods

3.1 Sample Source

Samples were obtained from both processing establishments and retail premises.

3.2 Sampling Period

Sampling took place from May to August 2004 inclusive.

3.3 Sample Description

Three categories of cheese manufactured from raw or thermised milk were sampled (Table 2). Both loose and pre-packed samples were obtained.

Table 2: Categories of cheese made from raw/thermised milk sampled

Category	Examples
Unripened soft cheese (fresh)	Cottage (UK), Cream cheese (UK), Ricotta (Italy), Petit Suisse (France)
Ripened soft cheese	Brie (France), Camembert (France), Bel Paes (Italy), Neufchatel (France)
Semi-hard cheese	Gorgonzola (Italy), Stilton (UK), Port Salut (France), Munster (France)

The following cheeses were specifically excluded from the survey:

- Hard cheese, e.g. Edam, Cheddar, Emmental, Gouda, Fontina
- Processed cheese
- Cheese manufactured from pasteurised milk

3.4 Sample Collection and Analysis

Sample Collection

Batch samples from processing establishments: Sampling in processing establishments was undertaken by Dairy Produce Inspectors (DPIs) from the Department of Agriculture and Food (DAF). Sampling was carried out in accordance with the DAF standard

operating procedure (SOP OPS/001). Each batch sample comprised of 5 individual samples. Each sample was a minimum of 150g in weight, thus the batch sample consisted of 5 x 150g samples. The 5 samples were obtained on the same date from the same batch of finished product.

Retail samples: Sampling at retail level was undertaken by Environmental Health Officers (EHOs) from the 10 Health Boards. Although the EU programme recommended testing samples in batches of five, it was recognised that this was not practical for products on the market. Therefore at retail level single samples were taken. Each sample was a minimum of 150g in weight. In any given retail premises only one sample was taken from products of the same brand name.

Sample Analysis
All samples (irrespective of source) were analysed in one of the seven Official Food Microbiology Laboratories (OFMLs) using an approved/standard method.

3.5 Reporting of results, Interpretation of results and Follow-up/enforcement action

Reporting of laboratory results:
The OFMLs reported the microbiological results to i) the FSAI and ii) the relevant sampling officer, i.e. the DPI or the EHO.

Interpretation of results
Upon receipt of the laboratory results, DPIs determined the microbiological safety of the batch samples from processing establishments using the criteria outlined in Table 3 and EHOs determined the microbiological safety of the single samples from retail premises using the criteria outlined in Table 4.

Follow-up/enforcement action:
When a sample (i.e. a batch or a single sample) was classified as unsatisfactory, follow-up (and where necessary enforcement action) was required. The type of follow up action was taken at the discretion of the sampling officer with advice as necessary from the FSAI or the OFML.

3.6 Questionnaire data
Questionnaires were distributed to all sampling officers prior to the commencement of this survey (Appendix 3A & 3B). These questionnaires were completed and returned to the FSAI within one month of the survey completion date. Questionnaires were returned for 71% (20/28) of batch samples and for 56% (287/512) of retail samples.

Table 3: Microbiological criteria* for batch samples⊗ from processing establishments

Microorganism	Microbiological safety		
	Satisfactory	Acceptable	Unsatisfactory
Salmonella spp.	Not detected in 25g in any of the 5 samples	N/A	Detected in 25g in any of the 5 samples
S. aureus	All 5 samples $<10^3$ cfu/g	No sample $>10^4$ cfu/g and no more than 2 samples in the range $10^3 – 10^4$ cfu/g	Any sample $>10^4$ cfu/g or more than 2 samples in the range $10^3 – 10^4$ cfu/g
L. monocytogenes	Not detected in 25g	Detected in 25g and $\leq 10^2$ cfu/g	Detected in 25g and $>10^2$ cfu/g
Campylobacter spp.	Not detected in 25g in any of the 5 samples	N/A	Detected in 25g in any of the 5 samples
E. coli	All 5 samples $<10^4$ cfu/g	No sample $>10^5$ cfu/g and no more than 2 samples in the range $10^4 – 10^5$ cfu/g	Any sample $>10^5$ cfu/g or more than 2 samples in the range $10^4 – 10^5$ cfu/g

* These criteria were proposed by the European Commission (EC) for the purpose of this survey (Commission Recommendation 2004/24/EC [6]).

⊗A batch sample consisted of 5 individual samples (each sample was a minimum of 150 g)

N/A: Not Applicable

The microbiological standards specified in legislation (summarised in Appendix 1) differ to the criteria outlined in table 3 as follows:

Campylobacter spp.: There is no standard specified in legislation for *Campylobacter* spp.

S. aureus: The standard for *S. aureus* in fresh cheeses (m=10, $M=10^2$, n=5, c=2) is different to the proposed criterion. However, the standard specified in legislation for *S. aureus* in soft cheese is the same as the criterion proposed for this survey

Table 4: Microbiological criteria for products available on the market – Single samples♦

Parameter	Bacteriological safety		
	Satisfactory	**Acceptable**	**Unsatisfactory**
Salmonella spp.	Not detected in 25g	N/A	Detected in 25g
S. aureus	$<10^3$ cfu/g	$10^3 – 10^4$ cfu/g	$>10^4$ cfu/g
L. monocytogenes	Not detected in 25g	Detected in 25g and $\leq 10^2$ cfu/g	Detected in 25g and $> 10^2$ cfu/g
Campylobacter spp.	Not detected in 25g	N/A	Detected in 25g
E. coli	$<10^4$ cfu/g	$10^4 – 10^5$ cfu/g	$>10^5$ cfu/g

♦The European Commission (EC) proposed that batch samples (each batch comprising of 5 samples) should be taken from products available on the market. This was deemed inappropriate in the Irish context. Therefore single samples were taken and the criteria proposed in Commission Recommendation 2004/24/EC[(6)] were amended accordingly.

N/A -not applicable

4. Results and Discussion

4.1 Overall Results

4.1.1 Production samples (Batch samples)

Microbiological data

In this study, 28 batches of cheeses (each batch comprised of 5 samples) were submitted for analysis to the OFMLs (Appendix 4). The microbiological status of the batch samples were determined using the criteria proposed by the EC for this survey (criteria outlined in Table 3). Applying these criteria it was established that:

- All batches (n=28) were satisfactory for *Salmonella* spp., *L. monocytogenes, Campylobacter* spp. and *E. coli.*
- 71.4% (20/28), 14.3% (4/28) and 14.3% (4/28) of batches were classified as satisfactory, acceptable and unsatisfactory respectively for *S. aureus* (Table 5).

Table 5: Microbiological status of production samples (batch samples) based on the criteria proposed by the EC✦ for this EU coordinated survey

		Microbiological status		
Microorganism	**No. of batches analysed**	**Satisfactory (%)**	**Acceptable (%)**	**Unsatisfactory (%)**
***Salmonella* spp.**	28	28 (100)	N/A	0 (0)
S. aureus	28	20 (71.4)	4 (14.3)	4 (14.3)⊗
L. monocytogenes	28	28 (100)	0 (0)	0 (0)
***Campylobacter* spp.**	28	28 (100)	N/A	0 (0)
E. coli	28	28 (100)	0 (0)	0 (0)

✦ Criteria as specified in Commission Decision 2004/24/EC [6] and as outlined in table 3.
⊗ Three of these batches were obtained from the one manufacturer.

The microbiological standards specified in legislation for cheeses made from raw/thermised milk are summarised in Appendix 1 (i.e. standards for *Salmonella* spp., *L. monocytogenes, E.coli and S. aureus)*. Applying these standards it was established that:

- All batches (n=28) complied with the microbiological standards for *Salmonella* spp., *L. monocytogenes* and *E.coli.*
- 70% (14/20) of batches of soft cheese complied with the relevant standard for *S. aureus*.

  Please note: There are 2 standards for *S. aureus* in cheese made from raw/thermised milk. One standard is for fresh cheese while the other standard is for soft cheese. In this survey, information on the nature (i.e. fresh/soft) of the cheese was only available for 20 batches as

questionnaires were not returned for the remaining 8 batches. Therefore the relevant *S. aureus* standard could only be applied to 20 batches.

Questionnaire data

Questionnaires were returned with 20 of the 28 processing batches (i.e. 71.4% response rate). Data was captured on 1) the type of sample and 2) the follow up/enforcement action.

1) Type of sample:

The 20 batch samples were ripened soft cheese made from raw milk.

2) Follow up action:

Follow up action was taken on the 4 batches which were classified as unsatisfactory for *S. aureus* (the follow-up action is summarised in Table 6).

Table 6: Details of follow up action taken on the 4 batches which were classified as unsatisfactory for *S. aureus*.

		Type of follow-up action	
Unsatisfactory Batch No.	**Manufacturer**	**Hygiene inspections**	**Testing for the staphylococcal enterotoxin (SE)**
1	A	Yes	Yes*
2	B	Yes	No
3	B	Yes	No
4	B	Yes	No

* Levels of *S.aureus* exceeded 10^5cfu/g in all 5 samples of this batch. The batch was negative for the SE (testing was carried out in the Dairy Science Laboratory, Cork).

Hygiene inspections were carried out in all premises where unsatisfactory batches were obtained. In addition, testing for the staphylococcal enterotoxin (SE) was undertaken when staphylococcal levels exceeded 10^5cfu/g (when staphylococcal levels exceed this level the heat-stable staphylococcal enterotoxin may be produced). In this study testing for the SE was carried out on one unsatisfactory batch. That batch of cheese was detained until the SE results were available. The batch was negative for the SE.

Based on the findings of the follow-up action, no enforcement action was deemed necessary.

4.1.2 Retail samples (Single samples)

Microbiological Data
A total of 512 samples submitted from the 10 Health Boards were analysed for 1 or more microbiological parameter (Appendix 5).

The microbiological status of the samples was determined using the criteria outlined in Table 4. All samples were classified as satisfactory for *Salmonella* spp. (n=506) and *Campylobacter* spp. (n=509); while 94.5% (483/511), 97.0% (492/507) and 99.4% (506/509) of samples were classified as satisfactory for *S. aureus*, *L. moncytogenes* and *E. coli* respectively (Table 7). Details regarding the microbiological status of samples from each Health Board are outlined in Appendices 6 to 10.

Table 7: Microbiological status of samples available on the market (single samples) using the criteria proposed for this survey[⊗] (n=512)

		Microbiological status		
Microbiological parameter	**Total no. of samples tested**	**Satisfactory (%)**	**Acceptable (%)**	**Unsatisfactory[♦] (%)**
***Salmonella* spp.**	506	506 (100)	N/A	0 (0)
S. aureus	511	483 (94.5)	12 (2.4)	16* (3.1)
L. monocytogenes	507	492 (97.0)	14 (2.8)	1** (0.2)
***Campylobacter* spp.**	509	509 (100)	N/A	0 (0)
E. coli	509	506 (99.4)	3 (0.6)	0

[⊗] Criteria outlined in Table 4
[♦] No sample was unsatisfactory for more than 1 microbiological parameter
* *S. aureus* counts: $>10^4$-10^5 (n=8); $>10^5$-10^6 (n=7); $3.3x10^6$ (n=1)
** *L. monocytogenes* count: $5.7x10^3$ cfu/g

Questionnaire data
Questionnaires were returned with 287 single samples, this represents a response rate of 56% (287/512). The following information was captured on the questionnaire:

- follow up/enforcement action taken on unsatisfactory samples
- sample source
- sample type
- type of packaging
- storage conditions and
- origin of sample

Follow-up/enforcement action taken on unsatisfactory samples

Of the 16 samples classified as unsatisfactory for *S. aureus* questionnaires were returned for only 4 samples. The results of these 4 samples were reported to the Department of Agriculture and Food.

A questionnaire was returned with the sample classified as unsatisfactory for *L. monocytogenes*. Of particular significance was the finding that *L. monocytogenes* was detected in 7 other samples from this manufacturer (these 7 samples were classified as acceptable for *L. monocytogenes*). The prevalence of *L. monocytogenes* in this manufacturer's cheese was investigated further by DAF, the Health Boards, FSAI and the manufacturer. Details of the actions taken are outlined in detail in section 4.2.3 of this report. These included:

i) laboratory analysis of the *L. monocytogenes* isolates,
ii) inspection of the manufacturing premise,
iii) a review of hygiene procedures and
iv) environmental monitoring.

Sample source, sample type, type of packaging, storage conditions and origin of sample

Data on sample source, sample type, type of packaging, storage conditions and origin of sample are presented in Figures 1 to 5 respectively.

The overall microbiological status (i.e. satisfactory, acceptable or unsatisfactory) of each sample was determined and its relationship with 1) sample source, 2) sample type, 3) type of packaging, 4) storage conditions and 5) origin of sample was determined (Table 8). Both 'sample type' and 'origin of sample' had a significant effect (95% confidence limit) on the overall microbiological status. However, it should be pointed out that these results are 'skewed' by the fact that 80% (i.e. 4/5) of the unsatisfactory samples were from the same manufacturer.

Figure 1: Sample source (n=287)

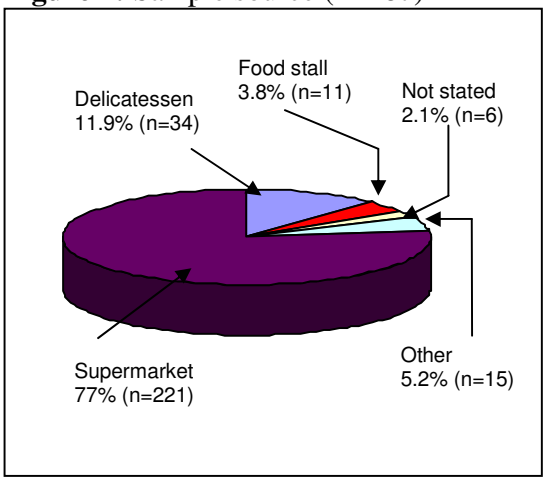

Figure 2: Sample type (n=287)

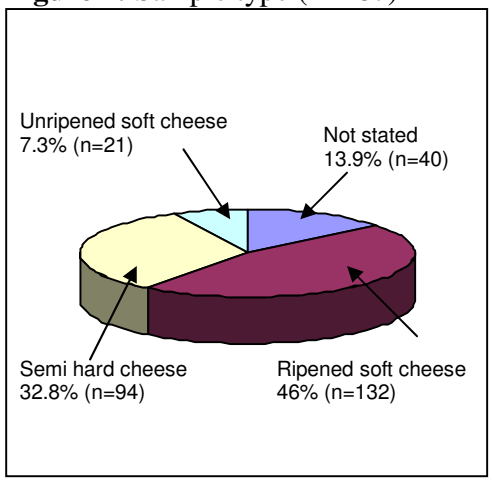

Figure 3: Type of packaging (n=287)

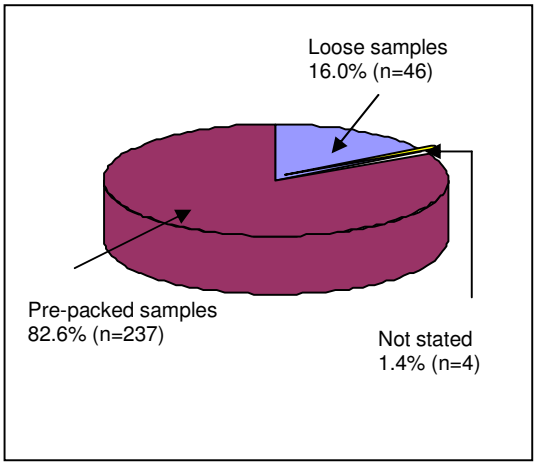

Figure 4: Storage conditions (n=287)

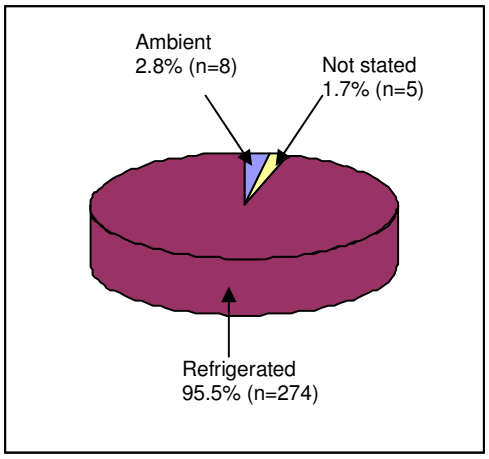

Figure 5: Origin of sample (n=287)

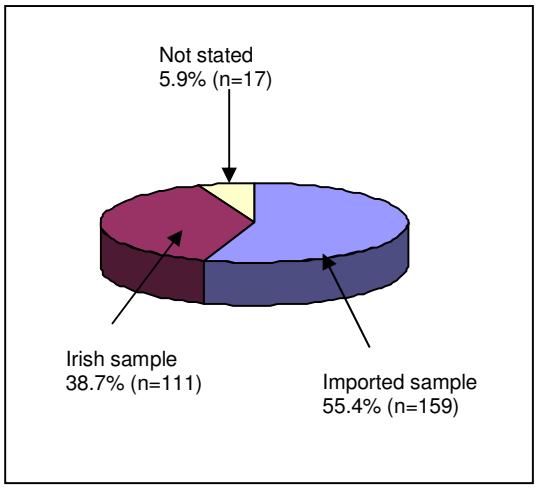

Table 8: Effect of various parameters on microbiological status

Parameter	Parameter details	Overall microbiological status[ר]			Total
		S (%)	A (%)	U (%)	
Sample source	**Supermarket**	203 (94.4)	8 (3.7)	4 (1.9)	**215**[*]
	Delicatessen	29 (85.3)	4 (11.8)	1 (2.9)	**34**
	Food stall	10 (90.9)	1 (9.1)	0 (0)	**11**
	Other	14 (100)	0 (0)	0 (0)	**14**[▪]
	Not stated	5 (83.3)	1 (16.7)	0 (0)	**6**
Sample Type	**Ripened soft cheese**	118 (92.2)	10 (7.8)	0 (0)	**128**[▲]
	Semi-hard cheese	85 (91.40)	3 (3.2)	5 (5.4)	**93**[♦]
	Unripened soft cheese (fresh)	20 (95.2)	1 (4.8)	0 (0)	**21**
	Not stated	38 (100)	0 (0)	0 (0)	**38**[♥]
Type of packaging	**Pre-packed**	216 (93.5)	10 (4.3)	5 (2.2)	**231**[•]
	Loose	42 (91.3)	4 (8.7)	0 (0)	**46**
	Not Stated	3 (100)	0 (0)	0 (0)	**3**[⊗]
Storage conditions	**Refrigerated**	249 (93.2)	13 (4.9)	5 (1.9)	**274**
	Ambient	8 (100)	0 (0)	0 (0)	**8**
	Not Stated	4 (80)	1 (20)	0 (0)	**5**
Origin of sample	**Imported sample**	153 (98.1)	3 (1.9)	0 (0)	**156**[Ø]
	Irish sample	93 (86.9)	9 (8.4)	5 (4.7)	**107**[♣]
	Not stated	15 (88.2)	2 (11.8)	0 (0)	**17**

[ר] Microbiological status determined using the criteria proposed for this survey.

S=Satisfactory: Sample satisfactory for all 5 microbiological parameters

A=Acceptable: Sample acceptable for 1 or more microbiological parameter and satisfactory for the remaining parameters

U=Unsatisfactory: Sample unsatisfactory for 1 or more microbiological parameter and either acceptable or satisfactory for the remaining parameters

[*] 221 samples submitted but 6 samples were not tested for all 5 microbiological parameters
[▪] 15 samples submitted but 1 sample was not tested for all 5 microbiological parameters
[▲] 132 samples submitted but 4 samples were not tested for all 5 microbiological parameters
[♦] 94 samples submitted but 1 sample was not tested for all 5 microbiological parameters
[♥] 40 samples submitted but 2 samples were not tested for all 5 microbiological parameters
[•] 237 samples submitted but 6 samples were not tested for all 5 microbiological parameters
[⊗] 4 samples submitted but 1 sample was not tested for all 5 microbiological parameters
[×] 274 samples submitted but 7 samples were not tested for all 5 microbiological parameters
[Ø] 159 samples submitted but 3 samples were not tested for all 5 microbiological parameters
[♣] 111 samples submitted but 4 samples were not tested for all 5 microbiological parameters

4.2 Results by microbiological parameter

4.2.1 *Salmonella* spp.

Salmonellae are bacterial pathogens. They reside in the intestinal tract of infected animals and humans and are shed in the faeces. They are one of the most common cause of foodborne illness (salmonellosis is the disease caused by *Salmonella* spp.). Foods including those of animal origin (e.g. dairy products, meat and eggs) and those subject to faecal contamination (e.g. fruit and vegetables) have been implicated as vehicles in the transmission of this pathogen to humans [(12)]. In Ireland, 486 clinical isolates of *Salmonella enterica* were referred to the National Salmonella Reference Laboratory in 2003 (crude incidence rate of 11.5 cases per 100,000) [(35)].

Raw milk is the principal reservoir of *Salmonella* spp. in the dairy industry. The microflora of raw milk is derived from several sources including the interior of the udder, the exterior surfaces of the animal (materials such as soil, bedding, feed residues, manure etc. are present on the udder, teats and coat of the cow), milking equipment and the environment. The reported prevalence (1985-1996) of salmonellae in raw milk is 0%-8.9% (data from 7 countries: Canada, England, Wales, France, India, Ireland & United States) [(13)]. In a more recent European report (2002 Report on Trends and Sources of Zoonotic Agents in the European Union and Norway [(14)]) incidence has been reported at 0%-0.25% (salmonella detected in raw milk from Germany, Italy and France).

In principle, products derived from raw milk may also be contaminated with salmonellae [(15)]. However, it should be noted that during the cheese manufacturing process, salmonellae (if present) should decrease during cheese ripening [(7)].

In this study:

- *Salmonella* spp. was not detected in any batch sample obtained at processing level. Therefore, using the criteria proposed by the EC for this survey (Table 3) all batch samples were classified as satisfactory.
- *Salmonella* spp. was not detected in any sample obtained at retail level. Therefore, using the criteria proposed for this survey (Table 4) all samples were classified as satisfactory.

Similar findings have been reported in other studies (Table 9):

Table 9: Prevalence of *Salmonella* spp. in cheeses made from raw/thermised milk as reported in other surveys

Location	Year	No. of samples	Sample source	Type of sample	Results
Belgium [16]	2002*	71	Retail premises and the direct marketing sector	Cheese made from raw milk	*Salmonella* spp. not detected in 25g of any sample
Belgium [17]	2002	16	On-farm	Cheese made from raw cows milk	*Salmonella* spp. not detected in 25g of sample
Spain [18]	1992*	24	On-farm	Goats milk cheese (made from raw milk)	*Salmonella* spp. not detected in 25g of sample
This study	2004	506	Retail premises	Cheese made from raw/thermised milk	*Salmonella* spp. not detected in 25g of any sample
This study	2004	28 batch samples⊗	Processing premises	Cheese made from raw/thermised milk	*Salmonella* spp. not detected in 25g of any batch sample

* Survey date not given. This is the date of the publication.
⊗ A batch sample consisted of 5 individual samples

Although the findings of this study are encouraging, it is important that processors do not become complacent because:

- *Salmonella* spp. can survive in various cheeses for more than 60 days [19]
- Epidemiological studies have linked this pathogen to several outbreaks
- Some species of salmonella are heat resistant and antimicrobial resistant.

4.2.2 *Staphylococcus aureus*

S. aureus is a pathogenic bacterium which is a common cause of food poisoning. Staphylococcal food poisoning is caused by ingestion of a heat stable toxin formed by *S. aureus* in the food (the bacterium must grow to levels $>10^5$ cells/g before producing sufficient quantities of the heat-stable staphylococcal toxin to cause illness [20]). Both the onset and the severity of the symptoms depend on the susceptibility of the person and the amount of toxin consumed. The main symptoms include abdominal cramps, vomiting and diarrhoea [21].

S. aureus competes poorly with other bacteria and seldom causes food poisoning in raw products; however, raw milk from a mastitic cow is an exception. Research has shown that *S. aureus* may be present in up to 70% of raw milk samples in numbers up to 10^2-10^5 cfu/ml [7]. In addition, the enterotoxin can be pre-synthesised in the udder and secreted in the milk [22].

S. aureus is an ubiquitous pathogen. It occurs in the skin and mucous membranes of most warm blooded animals including humans. It is estimated that up to 50% of humans are carriers of this bacterium on their skin, nose and throat [21]. Food handlers are commonly implicated in the transmission of this pathogen to food. *S. aureus* is also capable of surviving in the environment and is commonly found in food factories where it may become part of the flora of processing equipment [21, 23]. Survival in the environment can lead to contamination or recontamination of foodstuffs.

During cheese manufacture growth of *S. aureus* is inhibited. This is due to a number of factors including acid production by the starter culture and low pH. However, if the starter culture fails, conditions may become favourable for the growth of *S. aureus* and enterotoxin maybe produced [20]. Of further concern is the ability of the enterotoxin to survive for months in cheese even if the viable counts decrease [7].

In this study:

- *Processing batch samples:* 14.3% (4/28) of batch samples were classified as unsatisfactory for *S. aureus* using the criteria proposed for this survey (Table 3). The four batches were obtained from two processing premises. Follow-up action included hygiene inspections in both premises and laboratory analysis for the presence of the staphylococcal enterotoxin (This was carried out on one batch where the staphylococcal levels exceed 10^5cfu/g. The batch was negative for the staphylococcal enterotoxin). Enforcement action was not deemed necessary.
- *Retail single samples:* Applying the criteria proposed for this survey (Table 4); 94.5% (483/511), 2.4% (12/511) and 3.1% (16/511) of samples were classified as satisfactory, acceptable and unsatisfactory respectively for *S. aureus*.

In other studies the prevalence of *S. aureus* at levels $>10^4$ cfu/g has been reported to range from 0-17% (Table 10):

Table 10: Prevalence of *S. aureus* in cheeses made from raw milk as reported in other surveys

Location	Year	No. of samples	Sample source	Type of sample	Results			Enterotoxin
					$<10^3$ cfu/g	10^3-10^4 cfu/g	$>10^4$ cfu/g	
Belgium [16]	2002*	24	Retail premises and the direct marketing sector	Soft cheese made from raw milk			17% (4/24)¥	All samples with *S. aureus* counts $>10^3$ were tested for enterotoxins. In one sample two staphylococcal enterotoxins were detected.
Belgium [17]	2002	16	On-farm	Cheese made from raw cows milk	81.2% (13/16)	18.8% (3/16)		All samples $>10^3$ tested negatively for the presence of staphylococcal enterotoxins
Spain [18]	1992*	24	On-farm	Goats milk cheese (made from raw milk)	Mean count = 1.54 log cfu/g (i.e. 34.657 cfu/g)			
This study	2004	511	Retail premises	Cheese made from raw/thermised milk	94.5% (483/511)	2.4% (12/511)	3.1% (16/511)	
This study	2004	28 batch samples⊗	Processing premises	Cheese made from raw/thermised milk	71.4% (20/28)	14.3% (4/28)	14.3% (4/28)	

* Survey date not given. This is the date of the publication.

¥ All cheeses were sampled twice with approximately 5 weeks between the two sampling dates. On the second sampling date only 4% of samples exceeded *S. aureus* levels of 10^4 cfu/g compared with 17% of samples on the first sampling date.

⊗ A batch sample consisted of 5 individual samples.

4.2.3 *Listeria monocytogenes*

Listeria monocytogenes is a bacterium which can cause a serious food borne illness called listeriosis. Although healthy people rarely contract this illness, it can be severe for certain groups of the population (e.g. newborn babies, the elderly, pregnant women and those with a weakened immune system). Symptoms include meningitis, septacemia and abortion in pregnant women.

L. monocytogenes is ubiquitous in the environment. It is present in many raw foods of animal origin including raw milk (It has been estimated that low levels of *L. monoctogenes* exist in commercial bulk-tank raw milk [24, 25]). This pathogen is also a frequent contaminant of processing environments. Numerous surveys have documented the presence of listeria within the dairy plant environment including floors, freezers, processing rooms, floor mats etc. [26, 27]. In relation to cheeses made from raw/thermised milk both the raw milk and the processing environment are potential sources of contamination from *L. monocytogenes*.

Studies on the behaviour of *L. monocytogenes* during cheese manufacture and cheese ripening show that its fate varies considerably with the type of cheese. In mould surface ripened cheese *L. monocytogenes* has been shown to multiply to large numbers during the latter stages of ripening. This has been attributed to high moisture levels, high pH (due to lactate metabolism by moulds) and susceptibility to surface contamination during the ripening process [4]. In general, *L. monocytogenes* does not grow (and in most cases it decreases) during the ripening period in semi-hard and semi-soft cheese without surface ripening [7].

In this survey

- *Processing batch samples: L. monocytogenes* was not detected in any batch sample. Using the criteria proposed by the EC for this survey (Table 3) all batch samples were classified as satisfactory (Table 3).
- *Retail single samples:* Applying the criteria proposed for this survey (Table 4), one sample (1/507, 0.20%) was classified as unsatisfactory. However, it should be noted that *L. monocytogenes* was detected in 15 samples (i.e. 3.0%) and that 8 of these samples were from the same manufacturer (Table 12). These 8 samples were from 7 different batches of cheese and were sampled in 6 different Health Board areas over the survey period. Further analyses (serotyping, Pulse Field Gel Electrophoresis (PFGE) and ribotyping) on a number of *L. monocytogenes* isolates from this manufacturer's cheese were carried out in two laboratories (University College Hospital, Galway and Waterford Regional Hospital). The results presented in Table 13 show that the isolates were identical.

Table 12: Manufacturers of cheese from which *L. monocytogenes* was isolated (n=15)

Manufacturer	Number of positive samples
A	8
B	1
C	1
D	1
Not stated	4
Total	**15**

Table 13: Analysis of *L. monocytogenes* isolates

Analysis	Laboratory	No. of isolates	Results
Serotyping	University College Hospital, Galway	5	The 5 isolates were identified as serotype 1/2*
PFGE	University College Hospital, Galway	5	The 5 isolates had the same PFGE pattern
Ribotyping	Waterford Regional Hospital	6	The six isolates were assigned to the same ribogroup (Ribo 251-71-S-1) based on similarity coefficient values ≥0.97 and into DuPont ID (Dup-1053) based on similarity coefficient values ≥0.85.

* This serotype has been associated with listeriosis in humans

The prevalence of *L. monocytogenes* in this manufacturer's cheese was investigated further by DAF, the Health Boards, FSAI and the manufacturer. This involved:

- Examination of the survey data
- Inspections of the manufacturing premises
- Swabbing of the environment by the manufacturer and environmental testing by Teagasc, Moorepark
- A review of hygiene procedures by i) the authorities and ii) an advisor appointed by the manufacturer

In other studies, the prevalence of *L. monocytogenes* has been reported in the range of 0-42% (Table 11). The prevalence of *L. monocytogenes* in the samples investigated in this study is at the lower end of that range.

Although the findings of this study are encouraging, it is important to note that *L. monocytogenes* is recognised as a high-risk pathogen in cheese [7] on account of its:

- Low infective dose (levels of *L. monocytogenes* exceeding 100cfu/g in ready-to-eat food represent a risk to consumer health [31])
- Ability to grow at refrigeration temperatures (<5^{o}C)
- Ability to survive and proliferate in some cheeses

In addition, many outbreaks of listeriosis have been associated with the consumption of cheese made from raw/thermised milk [32,33]. The individual annual cumulative risk of listeriosis associated with the consumption of raw cheese has been calculated in a Canadian quantitative risk assessment [34]. The risk ranges from 1 in 507 million to 1 in 16 million in a low risk population and from 1 in 961, 000 to 1 in 14,000 in a high risk population.

Table 11: Prevalence of *L. monocytogenes* in cheeses made from raw milk as reported in other surveys

location	Year	No. of samples	Sample Source	Type of sample	Results	
					Qualitative (i.e. presence/absence)	Quantitative (cfu/g)
Belgium [16]	2002[⊗]	71	Retail premises and the direct marketing sector	Cheese made from raw milk	*L. monocytogenes* detected in 2 samples (2.8%)	
Belgium [17]	2002	16	On-farm	Cheese made from raw cows milk	*L. monocytogenes* not detected in any sample (0%)	
United States [28]	2000 & 2001	2931	Retail premises	Fresh soft cheese (doesn't state if they are from unpasteurised milk)	*L. monocytogenes* detected in 5 samples (0.2%)	Levels: all 5 samples ≤100 cfu/g
Germany [29]	May – December 1999	166	Local stores, wholesalers, ex-farm producers, dairies	Cheese made from raw milk	*L. monocytogenes* detected in 8 samples (4.8%)*	
Sweden [30]	1989-1993[¥]	31	Retail premises	Cheese made from raw milk	*L. monocytogenes* detected in 13 samples (42%)**	
This study	2004	507	Retail premises	Cheese made from raw/thermised milk	*L. monocytogenes* detected in 15 samples (3.0%)	14 samples (2.8%) ≤100 cfu/g 1 sample (0.20%) >100cfu/g
This study	2004	28 batch samples[⊗]	Processing premises	Cheese made from raw/thermised milk	*L. monocytogenes* not detected in any batch (0%)	

[⊗] Survey date not given. This is the date of the publication.
* This survey also looked at the incidence of *L. monocytogenes* in pasteurised cheese (n=163). Interestingly the incidence of *L. monocytogenes* was higher in pasteurised (n=13, 8%) rather than raw cheese.
** This survey also looked at the incidence of *L. monocytogenes* in cheese made from heat treated milk (n=302). *L. monocytogenes* was detected in 7 samples (2%)
[¥] Samples were obtained 3 times in this sampling period
[⊗] A batch sample consisted of 5 individual samples

4.2.4 *Campylobacter* spp.

Campylobacter spp. are the leading cause of bacterial gastroenteritis in humans (*C. jejuni* and *C. coli* are the species most often encountered). There were 1568 cases of confirmed campylobacteriosis[ɣ] reported in Ireland in 2003 (crude incidence rate of 39.9 cases per 100,000). This was an increase on the previous two years (1336 cases in 2002 and 1286 in 2001) [(35)]. Symptoms include diarrhoea, abdominal pain, malaise, fever and headaches. Complications, although rare, include Guillian-Barre Syndrome and reactive arthritis [(36)].

Campylobacteriosis is principally a foodborne disease. *Campylobacter* spp. are commonly found in the alimentary tract of animals used for food production. They are frequently found in dairy cows and maybe present in raw milk as a result of faecal contamination or mastitic infection [(36)]. In the 2002 Report on '***Trends and Sources of Zoonotic Agents in the European Union and Norway***' the prevalence of *Campylobacter* spp. in raw milk has been reported to range from 0 to 1.45% (data from 6 countries) [(14)]. In Ireland, a survey on the prevalence of Campylobacter in retail foods (March 2001 to October 2002) found that 1.6% (1/62) of raw milk samples contained this pathogen [(37)].

Although very little information is available on the impact of the cheese production process on the survival and growth of *Campylobacter* spp., its prevalence in raw milk raises concern. In addition, the EU Scientific Committee on Veterinary Measures Relating to Public Health (SCVMPH) has identified the consumption of unpasteurised milk and dairy products made from non-heat treated milk as one of the risk factors associated with sporadic illness due to *Campylobacter* spp. [(38)].

In this study:

- *Campylobacter* spp. was not detected in any batch sample obtained at production level. Therefore applying the criteria proposed by the Commission for this survey (Table 3) all batch samples were classified as satisfactory.
- *Campylobacter* spp. was not detected in any sample obtained at retail level. Therefore applying the criteria proposed for this survey (Table 4) all samples were classified as satisfactory. Similar findings were reported in an Irish survey carried out between March 2001 and October 2002 on the prevalence of *Campylobacter* spp. in retail foods. In that study *Campylobacter* spp. were not detected in any sample (66 samples tested) of unpasteurised cheese [(37)].

[ɣ] Disease caused by *Campylobacter* spp.

4.2.5 *Escherichia coli*

E. coli is an enteric organism. Most strains of *E. coli* are harmless; however, several are known to be pathogenic. The pathogenic strains may be categorised based on the mechanism underlying the illness. Currently four categories of pathogenic *E. coli* have been associated with foodborne illness: Enteropathogenic (EPEC), Enterotoxigenic (ETEC), Enteroinvasive (EIEC) and Enterohaemorrhagic (EHEC) *E. coli* [(39)].

E. coli is often used as an indicator of faecal contamination in food. Its presence in cheese suggests that other food-borne pathogens of faecal origin may also be present (e.g. *Listeria* spp., *Salmonella* spp., *Campylobacter* spp. and pathogenic *E. coli*).

In this study:

- All batch samples from processing premises were classified as satisfactory using the criteria proposed for this survey (Table 3).
- 99.4% (506/509) of retail single samples were classified as satisfactory and 0.6% (3/309) samples were classified as acceptable using the criteria proposed for this survey (Table 4).

Irrespective of sample source, levels of *E. coli* did not exceed 10^5 cfu/g in any sample tested. In other studies the prevalence of *E. coli* at levels >10^5 cfu/g has been reported to range from 0% to 17% (Table 14):

Table 14: Prevalence of *E. coli* in cheeses made from raw milk as reported in other surveys

Location	Year	No. of samples	Sample source	Type of sample	Results (>10^5 cfu/g)
Belgium [(16)]	2002*	24	Retail premises and the direct marketing sector	Soft cheese made from raw milk	17% (n=4) ▲
Belgium [(17)]	2002	16	On-farm	Cheese made from raw cows milk	0% (n=0)
England and Wales [(40)]	January & February 1997	801	Retail premises	Cheese made from raw or thermised milk	1.4% (n=11)
Ireland (this study)	January – April 2004	28 batch samples⊗	Processing establishments	Cheese made from raw or thermised milk	0% (n=0)
Ireland (this study)	January – April 2004	509	Retail premises	Cheese made from raw or thermised milk	0% (n=0)

* Survey date not given. This is the date of the publication.

▲ All cheeses were sampled twice with approximately 5 weeks between the two sampling dates. On the second sampling date only 13% (3/23) of samples exceeded *E. coli* levels of 10^5 cfu/g compared with 17% of samples on the first sampling date.

⊗ A batch sample consisted of 5 individual samples

5. Conclusions

While the findings of this study are encouraging in terms of the microbiological quality and safety of cheeses made from raw/thermised milk, there is room for improvement and it is imperative that industry does not become complacent. This is essential considering:

- epidemiological studies have shown that cheeses made from raw/thermised milk have been implicated in outbreaks of food poisoning.
- the infective dose of many pathogens are quite low (e.g. *L. monocytogenes*)
- many pathogens are capable of surviving and proliferating through the manufacture and ripening stages
- *L. monocytogenes* is capable of growing during the storage of smear and mould ripened soft and semi-hard cheese (Although this pathogen is rarely found in the body of the cheese, pH conditions under the rind create an ideal growth environment for *L. monocytogenes*. It should be noted that removal of the rind and the surface of the cheese prior to consumption will reduce but not necessarily eliminate the risk of listeriosis).

Strategies to control the microbiological safety and quality of cheeses made from raw/thermised milk must be implemented at all stages throughout the food chain. Strategies include:

- The use of high quality milk.
- The use of active starter cultures (inactive starter cultures can lead to delayed acid formation thereby allowing acid sensitive pathogens time to grow).
- Strict plant sanitation.
- Good handling practices, Good hygiene practices (GHP) and good manufacturing practices (GMP).
- Good process control.

All food businesses should implement a food safety management system based on the principles of HACCP. These strategies should be incorporated into this plan.

In addition, susceptible individuals (e.g. the elderly, pregnant women and those with a weakened immune system) are advised not to consume cheeses made from raw/thermised milk.

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7. Appendices

Appendix 1

Microbiological standards (S.I. No. 9/1996) for cheese made from raw/thermised milk

Microorganism	Fresh cheese	Soft cheese
L. monocytogenes	Absent in 25g n=5, c=0	
***Salmonella* spp.**	Absent in 25g n=5, c=0	
E. coli	$m=10^4$, $M=10^5$ n=5, c=2	
S. aureus	m=10, $M=10^2$ n=5, c=2	$m=10^3$, $M=10^4$ n=5, c=2

Appendix 2

Irish National microbiological guidelines for cheese[ϒ] sampled at the point of sale

	Satisfactory	Acceptable	Unsatisfactory	Unacceptable/potentially hazardous
***Salmonella* spp.**	Not detected in 25g	N/A	N/A	Detected in 25g
***Campylobacter* spp.**	Not detected in 25g	N/A	N/A	Detected in 25g
S. aureus	<20	20-<100	100-$<10^4$	$\geq 10^4$
E. coli	<20	20-<100	≥100	N/A
L. monocytogenes	<20	20-<100	N/A	≥100

ϒ No differentiation is made between cheese varieties (e.g. fresh, soft, hard etc) or between the type of milk (raw, thermised or pasteurised) used in its manufacture

Appendix 3A
Questionnaire completed by the DPIs for samples taken from processing premises

General Information:

* Sampling officer:_____

* Premises Approval No.: _____

* Laboratory Reference Numbers (upon receipt of lab report):

1)_____

2)_____

3)_____

4)_____

5)_____

Sample Information:

* Brand name (if available): _____

* Batch No.: _____

* Type of sample

	Type of milk used during production		
	Raw	Thermised	Unknown
Unripened soft cheese (fresh)	☐	☐	☐
Ripened soft cheese	☐	☐	☐
Semi-hard cheese	☐	☐	☐

* Use-By Date:_____ Not Available ☐

Bacteriological Safety *(please complete for each bacteria)*:

	Satisfactory	Acceptable	Unsatisfactory
Salmonella spp.	☐	N/A	☐
Campylobacter spp.	☐	N/A	☐
S. aureus	☐	☐	☐
E. coli	☐	☐	☐
L. monocytogenes	☐	☐	☐

Enforcement Action *(please tick as many boxes as necessary):*

None	☐
Verbal warning	☐
Written warning	☐
Improved in house control required	☐
Product recall	☐
Other (Please specify)	_____

Completed by:

Area / Regional Inspector_____

Appendix 3B
Questionnaire completed by the EHOs for samples taken at retail level

General Information:

* EHO Name: _____
* EHO Sample Reference Number (i.e. EHO's own personal reference number for the sample): _____
* Laboratory Reference Number (upon receipt of lab report): _____

Premises Information (business type):

Supermarket (*incl. corner shops*) □; Food stall (*e.g. country market*) □; Delicatessen shop □; Other (*Please specify*)_____

Sample Information:

* Brand name (if available): _____

* Type of sample (*See p.2 of protocol*)
  - Unripened soft cheese (fresh) □
  - Ripened soft cheese □
  - Semi-hard cheese □

* Type of packaging: Loose □ Pre-packed □

* Batch Number:_____

* Use-By Date: _____ Not Available □

* Storage condition of sample in premises:
  Ambient □ Refrigerated □

* Sample temperature *(Complete as appropriate, see p.3 of protocol)*
  Core temperature (loose samples): _____^{o}C
  Between pack temperature (pre-packed samples): _____^{o}C

* Plant Number (*as recorded on label*):_____

* Import sample □ Irish sample □

Bacteriological Safety *(See p.3 of protocol)*:

	Satisfactory	Acceptable	Unsatisfactory
Salmonella spp.	□	N/A	□
Campylobacter spp.	□	N/A	□
S. aureus	□	□	□
E. coli	□	□	□
L. monocytogenes	□	□	□

Enforcement Action *(please tick as many boxes as necessary):*

None	□
Verbal warning	□
Written warning	□
Improved in house control required	□
Product recall	□
Other (Please specify)	_____

Appendix 4

Number of batch samples analysed in each OFML

Offical Food Microbiology Laboratory	Number of batch samples
Cherry Orchard Hospital	0
St Finbarr's Hospital, Cork	8
University College Hospital, Galway	0
Mid-Western Regional Hospital	12
Sligo General Hospital	4
Public Analysts Laboratory, Dublin	0
Waterford Regional Hospital	4
Total	**28**

Appendix 5

Numbers of single samples submitted from each health board and analysed in each OFML

	Official Food Microbiology Laboratory (OFML)							
Health Board	Cherry Orchard Hospital	St Finbarr's Hospital, Cork	University College Hospital, Galway	Mid-Western Regional Hospital	Sligo General Hospital	Public Analysts Laboratory, Dublin	Waterford Regional Hospital	**Total**
ECAHB	6	0	0	0	0	25	0	**31**
MHB	0	0	0	0	0	27	0	**27**
MWHB	0	0	0	48	0	0	0	**48**
NAHB	36	0	0	0	0	13	0	**49**
NEHB	28	0	0	0	0	0	0	**28**
NWHB	0	0	0	0	49	0	0	**49**
SEHB	0	0	0	0	0	0	69	**69**
SHB	0	104	0	0	0	0	0	**104**
SWAHB	52	0	0	0	0	3	0	**55**
WHB	0	0	52	0	0	0	0	**52**
Total	**122**	**104**	**52**	**48**	**49**	**68**	**69**	**512**

Appendix 6

Salmonellae results (single samples) per health board

		Microbiological status *	
Health_Board	**Total number of samples tested**	**Satisfactory (%)**	**Unsatisfactory (%)**
ECAHB	31	31 (100)	0 (0)
MHB	27	27 (100)	0 (0)
MWHB	48	48 (100)	0 (0)
NAHB	49	49 (100)	0 (0)
NEHB	28	28 (100)	0 (0)
NWHB	49	49 (100)	0 (0)
SEHB	69	69 (100)	0 (0)
SHB	98[∅]	98 (100)	0 (0)
SWAHB	55	55 (100)	0 (0)
WHB	52	52 (100)	0 (0)
Grand Total	**506**	**506 (100)**	**0 (0)**

* Microbiological status based on criteria proposed for this survey (outlined in Table 4)
Satisfactory: *Salmonella* spp. not detected in 25g of sample
Unsatisfactory: *Salmonella* spp. detected in 25g of sample
∅ 104 samples submitted from SHB, but only 98 samples tested for *Salmonella* spp.

Appendix 7

Staphylococcus aureus results (single samples) per health board

		Microbiological status *		
Health_Board	**Total no. of samples tested**	**Satisfactory (%)**	**Acceptable (%)**	**Unsatisfactory (%)**
ECAHB	31	30 (96.8)	0 (0)	1 (3.2)
MHB	27	27 (100)	0 (0)	0 (0)
MWHB	48	44 (91.7)	3 (6.2)	1 (2.1)
NAHB	49	47 (95.9)	2 (4.1)	0 (0)
NEHB	28	28 (100)	0 (0)	0 (0)
NWHB	49	46 (93.9)	0 (0)	3 (6.1)
SEHB	69	67 (97.1)	2 (2.9)	0 (0)
SHB	103[∅]	99 (96.1)	3 (2.9)	1 (1.0)
SWAHB	55	53 (96.4)	2 (3.6)	0 (0)
WHB	52	42 (80.8)	0 (0)	10 (19.2)
Grand Total	**511**	**483 (94.5)**	**12 (2.4)**	**16 (3.1)**

* Microbiological status based on criteria proposed for this survey (outlined in Table 4)
Satisfactory: $<10^3$cfu/g
Acceptable: 10^3-10^4cfu/g
Unsatisfactory: $>10^4$cfu/g
∅ 104 samples submitted from SHB but 1 sample not tested for *S. aureus*

Appendix 8
L. monocytogenes results (single samples) per Health Board

		Microbiological status*		
Health_Board	**No. of samples tested**	**Satisfactory (%)**	**Acceptable (%)**	**Unsatisfactory (%)**
ECAHB	31	29 (93.5)	2 (6.5)	0 (0)
MHB	27	27 (100)	0 (0)	0 (0)
MWHB	44∅	42 (95.4)	1 (2.3)	1 (2.3)
NAHB	49	48 (98.0)	1 (2.0)	0 (0)
NEHB	28	27 (96.4)	1 (3.6)	0 (0)
NWHB	48*	46 (95.8)	2 (4.2)	0 (0)
SEHB	69	69 (100)	0 (0)	0 (0)
SHB	104	97 (93.3)	7 (6.7)	0 (0)
SWAHB	55	55 (100)	0 (0)	0 (0)
WHB	52	52 (100)	0 (0)	0 (0)
Grand Total	**507**	**492 (97.0)**	**14 (2.8)**	**1 (0.2)**

* Microbiological status based on criteria proposed for this survey (outlined in Table 4)
Satisfactory: Not detected in 25 g
Acceptable: Detected in 25g and $\leq 10^2$ cfu/g
Unsatisfactory: Detected in 25g and $>10^2$ cfu/g
∅ 48 samples submitted from MWHB but only 44 tested for *L. monocytogenes*
* 49 samples submitted from NWHB but only 48 tested for *L. monocytogenes*

Appendix 9
Campylobacter results (single samples) per health board

		Microbiological status *	
Health Board	**Total no. of samples tested**	**Satisfactory (%)**	**Unsatisfactory (%)**
ECAHB	31	31 (100)	0 (0)
MHB	27	27 (100)	0 (0)
MWHB	48	48 (100)	0 (0)
NAHB	49	49 (100)	0 (0)
NEHB	27[∅]	27 (100)	0 (0)
NWHB	49	49 (100)	0 (0)
SEHB	69	69 (100)	0 (0)
SHB	102[⊗]	102 (100)	0 (0)
SWAHB	55	55 (100)	0 (0)
WHB	52	52 (100)	0 (0)
Grand Total	**509**	**509 (100)**	**0 (0)**

* Microbiological status based on criteria proposed for this survey (outlined in Table 4)
Satisfactory: *Campylobacter* spp. not detected in 25g of sample
Unsatisfactory: *Campylobacter* spp. detected in 25g of sample
∅ 28 samples were submitted from the NEHB, however 1 was not tested for *Campylobacter* spp.
⊗ 104 samples were submitted from the SHB, however 2 were not tested for *Campylobacter* spp.

Appendix 10
E. coli results (single samples) per Health Board

Health Board	Total no. of samples tested	Microbiological status*		
		Satisfactory (%)	Acceptable (%)	Unsatisfactory (%)
ECAHB	31	30 (96.8)	1 (3.2)	0 (0)
MHB	27	26 (96.3)	1 (3.7)	0 (0)
MWHB	48	47 (97.9)	1 (2.1)	0 (0)
NAHB	47[∅]	47 (100)	0 (0)	0 (0)
NEHB	28	28 (100)	0 (0)	0 (0)
NWHB	49	49 (100)	0 (0)	0 (0)
SEHB	69	69 (100)	0 (0)	0 (0)
SHB	103[⊗]	103 (100)	0 (0)	0 (0)
SWAHB	55	55 (100)	0 (0)	0 (0)
WHB	52	52 (100)	0 (0)	0 (0)
Grand Total	**509**	**506 (99.40)**	**3 (0.60)**	**0 (0)**

* Microbiological status based on criteria proposed for this survey (outlined in Table 4)
Satisfactory: $<10^4$ cfu/g
Acceptable: 10^4-10^5 cfu/g
Unsatisfactory: $>10^5$ cfu/g
[∅] 49 samples were tested , however 2 samples with unreliable results, therefore they could not be categorised
[⊗] 104 samples submitted but 1 sample not tested