

**European Commission Co-ordinated Programme for the Official Control of  
Foodstuffs for 2005:**

**Microbiological Examination of Cheeses made from Pasteurised Milk from  
Production Establishments and Retail Premises in the United Kingdom**

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**On behalf of the Food Standards Agency, Local Authorities Co-ordinators of  
Regulatory Services and the Health Protection Agency**

**Summary**

As part of the European Commission co-ordinated programme for the official control of foodstuffs for 2005, a study of fresh, ripened and semi-hard cheeses made from pasteurised milk from retail and production premises was undertaken in the UK to determine the microbiological quality of these products. According to microbiological criteria in EC Recommendation 2005/175/EC, 98% of the 2636 samples from retail and batches from production were of satisfactory/acceptable microbiological quality. Only 2% were of unsatisfactory quality due to high levels of *Staphylococcus aureus* ( $\geq 10^3$  cfu/g) and/or *Escherichia coli* ( $\geq 10^3$  cfu/g). Overall contamination of *Listeria* spp. in cheeses was 2.5%. *L. monocytogenes* was detected in 0.2% (5) of samples, four at <20 cfu/g and one at 20 cfu/g. *Salmonella* spp. was not detected in any samples. Pasteurised milk cheeses were more likely to be of unsatisfactory microbiological quality when they were: semi-hard cheese varieties; sampled from retail premises rated as having little or no confidence in management and control systems; from specialist cheese shops or delicatessens; cut to order; stored or displayed above 8°C. This emphasizes the need for applying and maintaining good hygiene practices throughout the food chain to prevent contamination and/or bacterial growth.

## Introduction

Cheese making is a major industry worldwide, and much is still practised on a relatively small scale which accounts for the rich diversity of cheeses available<sup>1</sup>. Classification of cheeses is made difficult by this diversity but the most widely accepted approach is one based on moisture content, with further subdivision depending on milk type and the role of microorganisms in cheese ripening. The attribute of 'softness' or 'hardness' is therefore directly related to the moisture content of the cheese, higher moisture cheeses being softer than low moisture cheeses. Cheese consists primarily of milk fat and coagulated proteins and preservation is primarily achieved by controlling two physico-chemical parameters: pH and water activity. Reduction in pH is achieved by fermentation of lactose by starter culture organisms (lactic acid bacteria) and/or addition of acid. Water activity is reduced by pressing of the whey from the curd, and by salting and drying<sup>1</sup>. Other intrinsic parameters that may affect the growth and survival of microorganisms in cheeses are redox potential<sup>2</sup> and the presence of anti-microbial compounds produced by starter and non-starter organisms<sup>3,4,5</sup>. These properties of cheese, together with the length of maturation of the finished product and the fact that they are normally stored at a controlled temperature, constitute a 'hurdle' system of preservation that act as control steps to inhibit the growth of pathogenic bacteria.

The efficient pasteurisation of milk should eliminate the risk from viable vegetative pathogenic organisms. Pasteurisation of milk can be carried out using high temperature for a short time (72°C for at least 15 seconds) or low temperature for a long time (63°C for at least 30 minutes)<sup>6</sup>. The manufacture of cheese is well regulated in the UK, production at the time of this study was controlled by the Dairy Products (Hygiene) Regulations 1995<sup>7</sup>. From 1 January 2006 these Regulations were superseded by the new EU food hygiene regulations that apply directly to Member States<sup>8,9</sup>. The microbiological quality of cheese is also influenced by equipment and environment hygiene during manufacture, packaging and handling<sup>10</sup>. The Specialist Cheesemakers

Association has produced a Code of Best Practice in the manufacture of cheese for UK producers to help minimize microbial food safety hazards<sup>11</sup>, and the Food Standards Agency (FSA) and ADAS also set up the Specialist Cheesemakers Initiative to assist cheesemakers in implementing HACCP principles<sup>12</sup>.

Although cheeses are currently considered to be some of the safest foods consumed, pathogenic bacteria that can be transmitted by dairy products, including cheese, are important to the dairy industry. Historically there have been outbreaks of infection associated with the consumption of cheese, and the predominant organisms responsible have included *Salmonella* spp., *Listeria monocytogenes*, verocytotoxin producing *Escherichia coli* (VTEC), and *Staphylococcus aureus*<sup>13-15</sup>. Detailed investigations have demonstrated that the source of contamination was raw milk, inadequately pasteurised milk, or post-pasteurisation contamination with organisms originally derived from raw milk or from manufacturing environments. People at high risk from listeriosis, including pregnant women, are advised in the UK not to consume soft mould-ripened cheeses or blue cheeses<sup>16</sup>.

All member states are required by the EC to carry out a co-ordinated sampling programme for the official control of foodstuffs. The Local Authorities Co-ordinators of Regulatory Services (LACORS) and the Health Protection Agency (HPA) Co-ordinated Food Liaison Group programme undertook two such studies in 2004 and 2005 on the microbiological quality of cheeses from retail and production premises in the UK<sup>17,18</sup>, the first of which has been published and focused on cheeses made from raw or thermised milk<sup>19</sup>. Reported here are the results of the second of these studies on cheeses made from pasteurised milk from retail and production premises.

## **Materials and Methods**

### **Sample collection**

Unripened (fresh) or ripened soft and semi-hard cheeses made from pasteurised milk were collected from retail and production premises and examined by 30 laboratories (Health Protection Agency (HPA), HPA Collaborating Laboratories, National Public Health Service (NPHS)-Wales and Public Analysts) in the UK between 1 September and 31 October 2005 according to a standardised protocol. Cheeses made from cows', ewes', goats', and buffalo milk were included. Five sample units were collected from each batch at production premises according to class attribute sampling plans as provided in Commission Recommendation 2005/175/EC, whereas single samples were collected from retail premises<sup>18</sup>. Samples (5 x 100g from production, 100g from retail) were collected and transported to laboratories by staff from 315 local Environmental Health Departments, involving 52 Local Authority Food Liaison Groups (Annex 1), in accordance with the Food Law Code of Practice<sup>20</sup> and LACORS guidance on microbiological food sampling<sup>21</sup>.

Information on samples and premises was obtained by observation and enquiry and recorded on a standard proforma. Additional information collected included the type of cheese, country of origin, packing details, display/storage temperature, existence of a hazard analysis system and the level of food hygiene training received by the manager. Food hygiene inspections are carried out in a way that focuses enforcement authority resources on premises presenting most risk to consumers. To do this, food hygiene inspections are carried out in accordance with Food Law Code of Practice<sup>20</sup> which specifies that, amongst other factors, the number of consumers at risk and confidence in management control systems (including the application of HACCP based systems) should be assessed to produce a risk rating of the premises. The risk rating determines the frequency of inspection and at the time of this study ranged from Category A

(highest risk, inspected every 6 months) to F (lowest risk, inspected every 5 years).

### Sample examination

Salmonella spp., *L. monocytogenes* and other *Listeria* spp., *S. aureus* and *E. coli* were enumerated or presence sought in accordance with HPA Standard Microbiological Methods<sup>22-25</sup>. All isolates of *L. monocytogenes*, and other species of *Listeria* at high levels ( $\geq 100$  cfu/g) were sent to the Food Safety Microbiology Laboratory (FSML), HPA CfI for further characterisation. For *L. monocytogenes* this included sero-typing and Amplified Fragment Length Polymorphism (AFLP) as described previously<sup>26,27</sup>. Isolates of *S. aureus* obtained from samples containing  $\geq 10^4$  cfu/g were sent to FSML to determine the enterotoxin gene fragments by polymerase chain reaction (PCR)<sup>28</sup>.

The microbiological status of production batches of cheese were assessed using the class attributes plans stipulated in Recommendation 2005/175/EC<sup>18</sup> (Table 1). The microbiological status of single retail samples of cheese were also assessed using the criteria in Recommendation 2005/175/EC<sup>18</sup> (Table 2).

**Table 1. Microbiological criteria for batch samples from production premises (Recommendation 2005/175/EC<sup>18</sup>)**

Microorganism	Microbiological criteria
<i>Escherichia coli</i>	n= 5 c=2 m= 10 <sup>2</sup> cfu/g M=10 <sup>3</sup> cfu/g
<i>Staphylococcus aureus</i>	n= 5 c=2 m= 10 <sup>2</sup> cfu/g M=10 <sup>3</sup> cfu/g
<i>Listeria monocytogenes</i>	n=5 c=0 Absent in 25g
<i>Salmonella</i> spp.	n=5 c=0 Absent in 25g

Where parameters n, m, M and c are defined as follows:

n = number of units comprising the sample

m = limit below which all results are considered satisfactory

M = acceptability limit beyond which the results are considered unsatisfactory

c = number of sampling units giving bacterial counts of between m and M

For *E. coli* and *S. aureus* (guideline criterion) the status of a batch is:

- Satisfactory where all the values are less than m
- Borderline acceptability where the maximum of c values are between m and M
- Unsatisfactory if one or more values is/are above M or more than c values between m and M

For *L. monocytogenes* the status of a batch is:

- Satisfactory if not detected in 25g
- Borderline acceptability if detected and <100 cfu/g
- Unsatisfactory if detected and ≥100 cfu/g

For *Salmonella* spp. the status of a batch is:

- Satisfactory where all the values are not detected in 25g
- Unsatisfactory where one or more values are detected in 25g

**Table 2: Microbiological criteria for single samples from retail premises (Recommendation 2005/175/EC<sup>18</sup>)**

Microorganism	Satisfactory	Borderline	Unsatisfactory
<i>Escherichia coli</i>	<10 <sup>2</sup>	10 <sup>2</sup> - <10 <sup>3</sup>	≥10 <sup>3</sup>
<i>Staphylococcus aureus</i>	<10 <sup>2</sup>	10 <sup>2</sup> - <10 <sup>3</sup>	≥10 <sup>3</sup>
<i>Listeria monocytogenes</i>	ND	Detected - <10 <sup>2</sup>	≥10 <sup>2</sup>
<i>Salmonella</i> spp.	ND	-	Detected

### Statistical Analysis

Descriptive and statistical analysis of the data was undertaken using Microsoft Excel and Epi Info version 6.04d. Relative proportions were compared using chi-squared ( $\chi^2$ ) and Fisher's exact test. A probability value of less than 5% was deemed to be significant.

### Microbiological status of cheeses made from pasteurised milk

#### *Production Establishments*

Sixteen production establishments were visited. Seven unripened (fresh) soft cheese, eight ripened soft cheese, and three semi-hard cheese batches were tested; five sample units were collected per batch; therefore in total 90 sample units were examined.

Applying the criteria in Recommendation 2005/175/EC<sup>18</sup>, 88.9% of the 18 batches were of satisfactory microbiological quality and 11.1% were of borderline quality. None of the batches were of unsatisfactory quality (Table 3).

**Table 3. Microbiological quality of cheeses made from pasteurised milk according to Recommendation 2005/175/EC<sup>18</sup> from production premises in the UK**

Microorganism	Product Identification	Number of samples	Analysis results		
			Satisfactory	Borderline	Unsatisfactory
<i>Salmonella</i> spp. n=5 c=0 absent in 25g	Unripened soft (Fresh)	7	7	0	0
	Ripened Soft	8	8	0	0
	Semi-Hard	3	3	0	0
<i>Staphylococcus aureus</i> n=5 c=2 m=100 cfu/g M=1000 cfu/g	Unripened soft (Fresh)	7	7	0	0
	Ripened Soft	8	8	0	0
	Semi-Hard	3	2	1	0
<i>Escherichia coli</i> n=5 c=1 m=100 cfu/g M=1000 cfu/g	Unripened soft (Fresh)	7	7	0	0
	Ripened Soft	8	7	1	0
	Semi-Hard	3	2	1 <sup>†</sup>	0
			*ND	<100cfu/g	≥100cfu/g
<i>Listeria monocytogenes</i> n=5 c=0 absent in 25g	Unripened soft (Fresh)	7	7	0	0
	Ripened Soft	8	8	0	0
	Semi-Hard	3	2	1 <sup>†</sup>	0

\*ND, Not detected in 25g

† 1 Sample had borderline levels of both *E. coli* and *L. monocytogenes*

As there were only 18 batches of cheese sampled from production sites, statistical analysis of the results and a comprehensive investigation of the influence of different parameters on cheese quality were not possible. Production premises and product information collected for these 18 batches of cheese are presented in Tables 4 and 5.

**Table 4. Microbiological quality of pasteurised milk cheeses according to Recommendation 2005/175/EC<sup>18</sup> in relation to production product details**

Product details	Number of batches		Microbiological quality of batches	
	n=18	%	No. Satisfactory	No. Borderline
<b>Cheese type</b>				
Unripened soft	7	38.9	7	0
Ripened soft	8	44.4	8	0
Semi-hard	3	16.7	1	2
<b>Milk type</b>				
Cows' milk	13	72.2	11	2
Goats' milk	3	16.7	3	0
Ewes' milk	1	5.6	1	0
Not recorded	1	5.6	1	0
<b>FSA/ADAS Specialist Cheesemakers' Initiative</b>				
Participated	11	61.1	11	0
Not participated	2	11.1	1	1
Not recorded	5	27.8	4	1
<b>Labelled as organic</b>				
Yes	1	5.6	1	0
No	17	94.4	15	2
<b>Display/Storage temperature</b>				
≤8°C	13	72.2	13	0
>8°C	4	22.2	3	1
Not recorded	1	5.6	1	1

**Table 5. Microbiological quality of pasteurised cheeses according to Recommendation 2005/175/EC<sup>18</sup> in relation to production premises details**

Premises details		Number of batches		Microbiological quality of batches	
		n=18	%	No. Satisfactory	No. Borderline
<b>Premises type</b>					
On-farm dairy producer		13	72.2	12	1
Dairy producer (non-farm)		5	27.8	4	1
<b>Inspection rating category</b>					
Category	Minimum frequency of inspection				
A	At least every 6 months	3	16.7	2	1
B	At least every year	12	66.7	12	0
C	At least every 18 months	1	5.5	1	0
Not recorded		2	11.1	1	1
<b>Consumer at risk score</b>					
0 (Very few)		0	-	-	-
5 (Few)		5	27.8	5	-
10 (Intermediate)		7	38.9	7	-
15 (Substantial)		3	16.7	2	1
Not recorded		3	16.7	2	1
<b>Confidence in management</b>					
0 (High)		0	-	-	-
5 (Moderate)		12	66.7	12	0
10 (Some)		0	-	-	-
20 (Little)		2	11.1	1	1
30 (None)		0	-	0	0
Not recorded		4	22.2	3	1
<b>Hazard analysis system</b>					
In place and documented		18	100	16	2
<b>Management food hygiene training</b>					
Received training & attended:					
Basic 6 hour course		7	38.9	7	0
Intermediate course		5	27.8	3	2
Advanced course		2	11.1	2	0
Other recognised course		1	5.5	1	0
Not known		2	11.1	2	0
No training		0	-	-	-
Not recorded		1	5.5	1	0

### Retail premises

A total of 2618 samples of cheeses were tested, of which 412 (15.7%) were unripened (fresh) soft cheese, 1622 (62.0%) were ripened soft cheese, and 584 (22.3%) were semi-hard cheese samples.



### **Microbiological quality in relation to Recommendation 2005/175/EC**

Applying the criteria in Recommendation 2005/175/EC<sup>18</sup>, 95.8% (2510/2618) of samples were of satisfactory microbiological quality, 2.2% (57) were of borderline quality, and a further 2.0% (51) were of unsatisfactory quality due to high levels of *S. aureus* (2 samples;  $1.9 \times 10^4$ ,  $4.0 \times 10^4$  cfu/g) and/or *E. coli* (50 samples ranging from  $1.1 \times 10^3$  to  $\geq 10^7$  cfu/g) (Table 6, Fig. 1). Overall contamination of *Listeria* spp. and *L. monocytogenes* in cheeses was 2.5% (66) and 0.2% (4), respectively with counts ranging from <20 to 20 cfu/g. *Salmonella* spp. was not detected in any samples examined

**Table 6. Microbiological quality of cheeses made from pasteurised milk according to Recommendation 2005/175/EC<sup>18</sup> from retail premises in the UK**

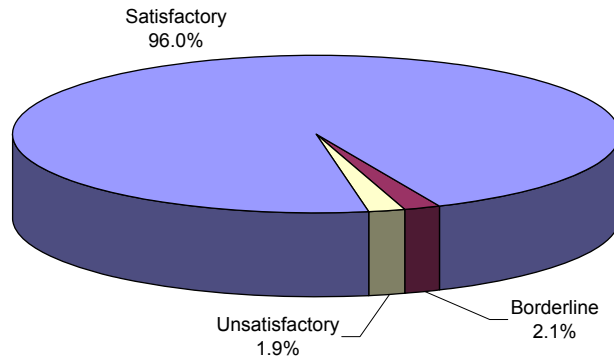
Microorganism	Product Identification	Number of samples	Analysis results		
			Satisfactory	Borderline	Unsatisfactory
<i>Salmonella</i> spp. n=5 c=0 absent in 25g	Unripened soft (Fresh)	412	412	0	0
	Ripened Soft	1622	1622	0	0
	Semi-Hard	584	584	0	0
<i>Staphylococcus aureus</i> n=5 c=2 m=100 cfu/g M=1000 cfu/g	Unripened soft (Fresh)	412	412	0	0
	Ripened Soft	1622	1622	1	1
	Semi-Hard	584	583	0	1 <sup>†</sup>
<i>Escherichia coli</i> n=5 c=1 m=100 cfu/g M=1000 cfu/g	Unripened soft (Fresh)	412	403	6	3
	Ripened Soft	1622	1568	28	26
	Semi-Hard	584	544	19 <sup>†</sup>	21 <sup>†</sup>
			<b>*ND</b>	<100cfu/g	$\geq 100$ cfu/g
<i>Listeria monocytogenes</i> n=5 c=0 absent in 25g	Unripened soft (Fresh)	412	411	1	0
	Ripened Soft	1622	1621	1	0
	Semi-Hard	584	582	2 <sup>†</sup>	0

\*ND, Not detected in 25g

† 1 Sample had borderline levels of both *E. coli* and *L. monocytogenes*

‡ 1 Sample had unsatisfactory levels of both *E. coli* and *S. aureus*

**Figure 1. Microbiological quality of retail soft and semi-hard cheeses made from pasteurised milk from retail premises using criteria in Recommendation 2005/175/EC<sup>18</sup> (n=2618)**



**Table 7. *S. aureus* isolates containing genes for staphylococcal enterotoxin recovered from retail pasteurised milk cheeses**

Milk type	Cheese type	No. samples	Staphylococcal enterotoxin gene fragments detected
Cows'	Semi-hard	1	C, G, I
Ewes'	Ripened soft	1	A, D, J

### ***L. monocytogenes* isolates present in pasteurised milk cheeses**

*L. monocytogenes* was detected in 0.2% (4) of the 2618 samples. Three of the four referred isolates were serotype 1/2a (Table 8). Four different *L. monocytogenes* subtypes were obtained from isolates recovered from the nine samples (Table 8).

**Table 8. Subtypes of *L. monocytogenes* isolated from retail pasteurised milk cheeses**

Milk type	Cheese type	No. samples	<i>L. monocytogenes</i> subtype (Serotype/AFLP*)
Goats'	Ripened soft	1	1/2a / IX
Cows'	Unripened sift	1	4b / I
Cows'	Semi hard	1	1/2a / VII
Cows'	Semi hard	1	1/2a / VI

\* , Amplified fragment length polymorphism;

## **Product information in relation to microbiological quality**

Analysis of data on retail cheese samples and product information was carried out using the criteria within Recommendation 2005/175/EC<sup>18</sup> (Table 2).

### ***Product details***

Amongst the 2618 cheeses sampled, 62.0% were ripened soft cheeses (e.g. Brie, Camembert), 22.3% were semi-hard cheeses (e.g. Emmental, Roquefort, Port Salut), and 15.7% were unripened soft cheeses (e.g. cream cheese, Ricotta) (Table 9). Significantly more samples of semi-hard cheese (3.6%) were of unsatisfactory quality compared with ripened soft (1.7%) and unripened soft cheeses (0.7%) (Table 9) ( $p=0.0021$ ).

Most (84%) samples collected were made using cows' milk (67.3%) or goats' milk (16.7%) (Table 9). Less than one percent of goats' milk cheese samples were of unsatisfactory microbiological quality which was a lower proportion compared to cheeses made from milk from other animals (e.g. cows' (2.3%), ewes' (1.2%)) (Table 9). This finding was only significant when comparing goats' milk cheese with cows' milk cheese ( $p=0.0105$ ).

Eighty-eight percent of the 2618 cheese samples were not labelled as organic products (Table 9). The proportion of cheeses labelled or not labelled as organic products of unsatisfactory quality was similar, 1.3% and 1.9% respectively. Fifty-four percent of the cheeses collected were pre-packed. Of the samples that were pre-packed, over half (51.8%) had a pack size of between 100 to 200g (Table 9). Significantly more samples that were cut to order (3.3%) were of unsatisfactory quality compared to those that were prepacked (1.1%) (Table 9) ( $p=0.0002$ ).

The majority (89.7%) of cheese samples were stored or displayed at or below 8°C (Table 9). A higher proportion of cheese samples (6.3%) that were stored above 8°C were of unsatisfactory microbiological quality compared to those stored below 8°C (1.6%) ( $p=0.0006$ ).

**Table 9. Microbiological quality of retail pasteurised milk cheeses in relation to product details**

<b>Product details</b>	<b>Number of samples n=2618 (%)</b>		<b>No. Samples of Unsatisfactory Quality (%)</b>	
<b>Cheese type</b>				
Unripened	412	15.7	3	0.7
Ripened	1622	62.0	27	1.7
Semi-hard	584	22.3	21	3.6
<b>Milk type</b>				
Cows'	1762	67.3	41	2.3
Goats'	437	16.7	2	0.5
Ewes'	81	3.1	1	1.2
Other (e.g. blends, buffalo)	144	5.5	3	2.1
Not known	194	7.4	4	2.1
<b>Labelled as organic</b>				
Yes	156	6.0	2	1.3
No	2297	87.7	43	1.9
Not known	165	6.3	6	3.6
<b>Packaging</b>				
Pre-packed	1410	53.9	15	1.1
Cut to order	878	33.5	29	3.3
Not recorded	330	12.6	7	2.1
<b>Pack size (n=1410)</b>				
< 50 g	8	0.6	1	12.5
50 – 99 g	193	13.7	3	1.6
100 – 199 g	731	51.8	5	0.7
200 – 299 g	364	25.8	5	1.4
300 – 399 g	36	2.6	0	-
≥ 400g	18	1.3	0	-
Not known	60	4.2	1	1.7
<b>Display/storage temperature</b>				
≤ 8° C	2349	89.7	38	1.6
> 8° C	159	6.1	10	6.3
Not known	110	4.2	3	2.7

### **Country of origin**

Cheeses collected from retail premises were produced in 19 countries, most of which were produced in France (33.9%) and the UK (29.9%) (Table 10). For those production countries where more than 30 samples were examined, a higher proportion of cheeses produced in Italy (5.5%) and the Republic of Ireland (3.1%) were of unsatisfactory quality compared to those produced in the UK (2.0%), France (1.4%), Germany (0.9%) and elsewhere ( $p=0.0012$ ).

**Table 10. Microbiological quality of retail pasteurised milk cheeses in relation to country of origin**

Country of origin	Number of samples		No. Samples of Unsatisfactory Quality	
	n=2618	(%)		(%)
<b>UK</b>	<b>785</b>	<b>29.9</b>	<b>16</b>	<b>2.0</b>
<b>Other EU</b>	<b>1445</b>	<b>55.2</b>	<b>26</b>	<b>1.8</b>
Belgium	4	0.2	0	
Bulgaria	6	0.3	0	
Cyprus	37	1.4	0	
Denmark	69	2.6	0	
France	888	33.9	12	1.4
Germany	109	4.2	1	0.9
Greece	4	0.2	0	
Italy	201	7.7	11	5.5
Lithuania	4	0.2	0	
Netherlands	63	2.4	0	
Poland	8	0.3	1	12.5
Portugal	8	0.3	0	
Republic of Ireland	32	1.2	1	3.1
Spain	12	0.5	0	
<b>Non – EU</b>	<b>11</b>	<b>0.4</b>	<b>0</b>	<b>-</b>
Iceland	1	0.03	0	
Norway	8	0.3	0	
Switzerland	1	0.03	0	
Turkey	1	0.03	0	
Not known	<b>378</b>	<b>14.5</b>	<b>9</b>	<b>2.4</b>

### **Premises details in relation to microbiological quality**

#### ***Type of Premises***

Fifty-two percent of the 2618 cheeses sampled were collected from supermarkets and supermarket delicatessens. The remaining 48% were collected from delicatessens (23.9%), farm shops (8.0%), specialist cheese shops (4.7%), markets (4.4%; including farmers' markets), other premises (6.6%) and for 0.6% of samples, this information was not recorded (Table 11). The proportion of cheese samples from specialist cheese shops (4.1%) and delicatessens (3.9%) of unsatisfactory microbiological quality was significantly higher when compared to those collected from other premises (0.7% - 2.3%) (Table 11) ( $p < 0.0001$ ).

### ***Food Hygiene Inspections***

Fifty five percent of samples were collected from premises categorised as inspection rating Category C (inspected at least every 18 months) (Table 11). The proportion of samples of unsatisfactory quality was similar from premises with inspection rating categories A to E (ranging from 1.2% to 2.2%).

Most samples (80.5%) were obtained from premises with a consumer at risk score 5 (few numbers of customers, 58.1%) and 10 (intermediate number of customers, 22.4%) (Table 11). The proportion of cheeses of unsatisfactory quality collected from premises with a very small number of customers was higher (2.0%) when compared to other premises with larger numbers of customers (1.0%), although this finding was not significant ( $p=0.1012$ ).

Most samples (69.2%) were collected from premises where there was a confidence in management score of 5 (moderate confidence in management/control systems, 35.4%) and 10 (some confidence in management/control systems, 33.8%) (Table 11). Significantly a greater proportion of cheeses of unsatisfactory quality were from premises with high scores (5.2%) (i.e. little or no confidence in the management) compared those with a low score (1.6%) (i.e. some to high confidence in management) ( $p= 0.0135$ ) (Table 11).

### ***Hazard analysis systems***

Seventy seven percent of samples were collected from premises that had a hazard analysis in place (59.8% documented, 14.8% undocumented; 3.9% documentation status not recorded) (Table 11). Samples collected from premises without hazard analysis systems in place were more likely to be of unsatisfactory microbiological quality (2.2%) compared to those collected from premises with hazard analysis in place (1.7%) (Table 11), although this finding was not statistically significant ( $p=0.5180$ ).

**Table 11. Microbiological quality of retail raw or thermised milk cheeses in relation to retail premises details**

Retail premises details		Number of samples n=2618 (%)		No. Samples of Unsatisfactory Quality (%)	
<b>Premises type</b>					
	Supermarket (pre-packed)	1050	40.1	7	0.7
	Supermarket (deli.)	305	11.7	6	2.3
	Delicatessen	627	23.9	25	3.9
	Specialist cheese shop	122	4.7	5	4.1
	Farm shop	209	8.0	3	1.5
	Farmers' market	14	0.5	0	-
	Other market	103	3.9	3	1.1
	Other (e.g. butchers, health food shop, grocers)	176	6.6	2	2.0
	Not known	15	0.6	0	-
<b>Inspection Rating Category</b>					
Category	Minimum frequency of inspection				
A	At least every 6 months	46	1.8	1	2.2
B	At least every year	312	11.9	6	1.9
C	At least every 18 months	1439	55.0	23	1.6
D	At least every 2 years	243	9.3	5	2.1
E	At least every 3 years	169	6.5	2	1.2
F	At least every 5 years	16	0.6	0	-
	Not recorded	393	15.0	14	3.6
<b>Consumer at risk score</b>					
	0 (Very few)	17	0.6	0	-
	5 (Few)	1522	58.1	31	2.0
	10 (Intermediate)	587	22.4	6	1.0
	15 (Substantial)	27	1.0	0	-
	Not recorded	465	17.8	14	3.0
<b>Confidence in management score</b>					
	0 (High)	195	7.4	3	1.5
	5 (Moderate)	928	35.4	15	1.6
	10 (Some)	884	33.8	13	1.5
	20 (Little)	112	4.3	6	5.4
	30 (None)	4	0.2	0	-
	Not recorded	495	18.9	14	2.8
<b>Hazard analysis system</b>					
	In place & documented	1567	59.8	22	1.4
	In place & undocumented	388	14.8	9	2.3
	In place; document status not recorded	103	3.9	4	3.9
	Not in place	366	14.0	8	2.2
	Not recorded	194	7.4	8	4.1
<b>Management Food Hygiene Training</b>					
	Received training and attended:	2171/2618	82.9	40	1.8
	Basic 6 hour course	1238/2171	57.0	27	2.2
	Intermediate course	514/2171	23.7	11	2.1
	Advanced course	121/2171	5.6	1	0.8
	Other recognised	173/2171	8.0	1	0.6
	Not specified	125/2171	5.4	0	-
	No training	117/2618	4.5	5	4.3
	Not recorded	330/2618	12.6	6	1.8

### ***Food Hygiene Training***

The majority of samples (82.9%) were collected from premises whose managers had received some form of food hygiene training (Table 11). A higher proportion of samples of unsatisfactory quality were from premises where the manager had not received food hygiene training (4.3%) compared to those that had (1.8%), although this finding was not statistically significant ( $p=0.0766$ ).

### **Discussion**

This study has shown that the vast majority (98%) of 2618 retail cheeses made from pasteurised milk in the UK were of satisfactory or borderline microbiological quality according to criteria in EC Recommendation 2005/175/EC<sup>18</sup>. Likewise, in the previous study in 2004 of raw and thermised milk cheeses, 98% were found also to be of satisfactory or borderline microbiological quality according to Recommendation 2004/24/EC<sup>17,19</sup>. In the present study, only 2% were unsatisfactory due to high levels ( $\geq 10^3$  cfu/g of *S. aureus* (2 samples) and/or *E. coli* (50 samples); full investigations were undertaken by the appropriate food authority, manufacturers and the UK Food Standards Agency. Cheeses were also sampled from production premises although in much lower numbers; of 18 batches examined none were of unsatisfactory quality. The *Salmonella* and *L. monocytogenes* criteria used in Recommendation 2005/175/EC<sup>18</sup> are the same as the food safety criteria in Regulation (EC) No. 2073/2005<sup>29</sup> on the microbiological criteria for foodstuffs that came into force in January 2006. Regulation (EC) No. 2073/2005<sup>29</sup> also contains process hygiene criteria for *E. coli* in cheeses made from pasteurised milk which again are the same as that used in Recommendation 2005/175/EC, but are applicable only during the manufacturing process when the number of *E. coli* is expected to be highest. Likewise, the Regulation contains identical criteria for *S. aureus* in ripened pasteurised cheeses ( $\geq 10^3$  cfu/g) but not for unripened soft pasteurised milk cheeses ( $\geq 10^2$  cfu/g). Again these are applicable only during the manufacturing process when the number of staphylococci is expected to be highest. Additionally where *S. aureus* levels exceed  $10^5$  cfu/g the cheese batch has to be



tested for staphylococcal enterotoxins as required by food safety criteria and withdrawn or recalled from the market if present<sup>27</sup>. In most cheeses *S. aureus* levels are highest 2-3 days after production and may reduce significantly during storage. If levels exceed  $10^5$  cfu/g at any point there is a significant risk that *S. aureus* may produce enterotoxins that will remain in the cheese regardless of the remaining recoverable level of this organism.

The prevalence of *L. monocytogenes* observed in retail pasteurised milk cheese in the UK in 2005 (0.2%) was similar to that found in Ireland in 2005 (0.11%)<sup>30</sup> and lower than that previously found in Spain (1.0%; 1997-99)<sup>31</sup>, in Sweden (2.0%; 1994)<sup>32</sup>, the UK (1.3%; 1995)<sup>33</sup>, and in Belgium (54.5%; 2001-2)<sup>34</sup>. The serogroups most often causing infection in the UK are serogroups 4b, 1/2a, and 1/2b<sup>35</sup>, with the subtype 4b AFLP I being most common, whereas the predominant serogroup recovered from food isolates in the United Kingdom during 2002 to 2005 was serogroup 1/2a, of which half were AFLP VII (J McLauchlin and K Grant, HPA pers comm). The predominant serogroup of *L. monocytogenes* recovered from the referred cheese isolates was serotype 1/2a, with subtypes 1/2a AFLP VI, VII and IX identified. The low prevalence of serogroup 4b in food isolates compared with clinical isolates has also been observed in other countries<sup>31,36,37</sup>.

This study has also highlighted contributory factors likely to cause problems with the microbiological quality of cheeses made from pasteurised milk. According to microbiological criteria within Recommendation 2005/175/EC<sup>18</sup> cheeses were of unsatisfactory quality more frequently if they were: semi-hard cheese varieties; produced in Italy; from specialist cheese shops or delicatessens; from premises rated as having little or no confidence in management and control systems; were cut or order; stored or displayed above 8°C. Appropriate hygienic measures to avoid contamination from the production environment and appropriate temperature control of cheeses are critical for minimising contamination with and growth of pathogens, such as *L. monocytogenes* and *S. aureus*, in cheese.

Storage of foods must comply with Regulation (EC) No. 852/2004 on the hygiene of foodstuffs<sup>8</sup>, i.e. should not be kept at temperatures that might result in a risk to health. In addition to the EU hygiene regulations that came into force in January 2006<sup>8-9</sup>, the Specialist Cheesemakers' Association Code of Best Practice is a comprehensive and valuable guide for both cheesemakers and retailers to help minimize microbial food safety hazards<sup>11</sup>.

## Acknowledgements

The authors would like to thank all the staff in the Environmental Health Departments throughout the UK who collected samples for this study, and all the staff in both HPA, HPA collaborating and non-HPA laboratories who performed the microbiological examinations. Thanks are extended to Obioma Mpamugo FSML, HPA Centre for Infections for assistance in typing isolates, to David Lock at LACORS for co-coordinating the participation of Environmental Health Practitioners, to the Regional Food, Water and Environmental Co-coordinators Forum for advice on the sampling protocols, and to Lilian Hucklesby for co-ordinating data entry.

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## Annex 1: Participating Laboratories and Local Authority Food Liaison Groups

**Table I: Participating HPA and HPA Collaborating Laboratories and number of samples**

HPA Region	Laboratory Name	Number of Samples
East	Chelmsford	152
	Norwich	139
London	London FWEM <sup>1</sup>	322
South East	Ashford	86
	Brighton	198
	WEMS <sup>2</sup>	146
West Midlands	Birmingham	40
	Coventry	128
	Hereford	29
	Shrewsbury & Telford	94
North West	Stoke	47
	Chester	92
	Preston	147
	Carlisle	34
North East, Yorkshire & the Humber	Hull	116
	Leeds	70
	Newcastle	124
	Sheffield	102
South West	Bristol	79
	Exeter	69
	Gloucester	37
	Truro	57
East Midlands	Leicester	63
	Lincoln	131
<b>Total</b>		<b>2502</b>

1, London Food, Water & Environmental Microbiology Services Laboratory

2, Wessex Environmental Microbiology Services

**Table II: Participating Other Laboratories and number of samples**

Nation	Laboratory	Number of Samples
England	Kings Lynn & West Norfolk	11
Northern Ireland	Belfast City Hospital	70
Scotland	Aberdeen City Council Public Analysts	2
	Edinburgh A & S Services	14
	Glasgow Scientific Services	22
Wales	Bangor	15
<b>Total</b>		<b>134</b>

**Table III: Participating Food Safety Liaison Groups and number of samples**

<b>Local Authority Food Liaison Group</b>	<b>Number of Samples</b>
Berkshire	24
Buckinghamshire	29
Cambridgeshire	77
Cheshire	68
Cornwall	57
Cumbria	49
Derbyshire	71
Devon	51
Dorset	24
Durham	26
East Sussex	79
Essex	76
Gloucestershire	37
LFCG <sup>1</sup> Greater London NE Sector	45
LFCG Greater London NW Sector	41
LFCG Greater London SE Sector	38
LFCG Greater London SW Sector	68
Greater Manchester	69
Hampshire & Isle Of Wight	64
Hereford & Worcester	47
Hertfordshire & Bedfordshire	95
Humberside	97
Kent	86
Lancashire	63
Leicestershire	63
Lincolnshire	39
Merseyside	18
North Yorkshire	59
Northamptonshire	39
Northern Ireland Food Group <sup>2</sup>	70
Norfolk	107
Northumberland	20
Nottinghamshire	74
Oxfordshire	30
Scottish Food Enforcement Liaison Committee <sup>3</sup>	38
Shropshire	38
Somerset	18
South West Yorkshire	49
Staffordshire	56
Suffolk	43
Surrey	73
Tees Valley	38
Tyne & Wear	27
Wales North Group	20
Wales South West Group	12
Warwickshire	79
West Midlands	67
West of England	45
West Sussex	46

West Yorkshire	42
Wiltshire	36
Not Recorded	9
<b>Total</b>	<b>2636</b>

1, London Food Co-ordinating Group

2, Northern Ireland Food Group comprises of the Eastern, Northern, Southern and Western Groups

3, SFELG comprises of Central Scotland, Fife & Tayside, Lothian & Scottish Borders, North Scotland, and West of Scotland