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To: submissions
Subject: Fwd: Fwd: FSANZ P1007 raw milk proposals P1007 / Outstanding Applications A530/531
Attachments: image003.jpg; FSANZ P1007 proposal 1st assessment 2010 - critique - final.doc; FSANZ P1007 proposal supporting docouments 2010 - critique - final.doc; UK Final Report on EU Unpasteurised Milk cheeses 2004.doc; WL October 2002 - with PN comments.doc

Please find attached a formal submission to FSANZ proposal P1007 Primary Production and Processing Requirements for Raw Milk Products (Australia only) First Assessment report

1) REPLY TO FSANZ OVERARCHING QUESTIONS

The overarching scope of the Proposal is assessing the safety of raw milk products using the Category Framework. FSANZ has undertaken a Technical Assessment based on three Risk Assessments (Raw Cow Milk, Raw Goat Milk and Raw Milk Cheese), a Consumer Study and Nutrition Assessment – Can you identify any aspects we have not covered at this point?

The Proposals exaggerate the risks of raw milk products .

They state that "Because of the potential for raw milk to be contaminated with pathogens, raw milk and *products made from raw milk* present a high level of risk to public health and safety if there are no control measures to manage the microbiological hazards that may be present."

It is a false assumption that the risks are "high level" for raw milk products . A more realistic description for raw milk products is " they present an additional risk to public health and safety compared with products made from correctly pasteurised milk.

We have summarised the impacts by option in Table 1 in the Report. Do you have any comments on the overall assessment? Can you identify other benefits and costs to the affected parties?

For raw milk cheese, the overall assessment seems to be far more alarmist than the technical assessment suggests. The technical assessment indicates that all soft cheese should be placed in Category 2, reserving Category 3 for raw drinking milk alone.

FSANZ should provide information or data on current production and processing practices that can help further detail Category parameters and inform how identified control measures could work in practice. For fermented products such as cheese, the effect of a competing microflora (The Jameson Effect) needs to be considered.

In regard to the Technical Assessment, FSANZ should provide further information or data that can be taken into account when determining the risks associated with each of the three Categories The following two publications provide good evidence for the safety of raw milk cheeses.
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* CL Little[1*], J Harris[1], SK Sagoo[1], M Greenwood[2] V Mithani[1], K Grant[1], J McLauchlin[1] and the Food, Water and Environmental Surveillance Network[†].
and,European Commission Co-ordinated Programme for the Official Control of Foodstuffs for 2004: *Microbiological Examination of Cheeses made from Raw or Thermised Milk from Production Establishments and Retail Premises in the United Kingdom* CL Little[1*], JR Rhoades[1], SK Sagoo[1], M Greenwood[2] V Mithani[1], K Grant[1], J McLauchlin[1] and the Food, Water and Environmental Surveillance Network[†].

FSANZ need to recommend what support materials or systems be in place to help producers and processors make safe products. These should recognise
A: (a) The commercial relationship between the milk producer and the cheesemaker is a vital link in assuring raw milk safety. (b) Farmer quality payment systems should include pathogen surveillance. Both aspects would benefit from a government training initiative.

Australian artisanal cheese makers should not be restricted to the production of Category 1 and 2 cheeses. Over the past two decades, international artisan and farmhouse cheese production has enjoyed a significant growth in demand due to a revolution in consumer interest. Many of these are category 3 cheeses made from raw milk, and are recognised as having an infinitely superior flavour and authentic regional character when compared to similar cheeses made from pasteurised milk.

Australian Consumers deserve a choice similar to their counterparts overseas.

The purpose of the Australian Food Standards is to guarantee safe cheese – however the assumptions made in these proposals exaggerate the risks. There is no reason why ANY cheese made from raw milk should represent a greater degree of risk than those produced from pasteurised milk provided recognised international HACCP guidelines are adopted in Australia.

The proposals do not encourage world best practice in cheese or milk production and fail to take into account the difference between the quality of 'open ' market milk and the controls on milk quality on the farm for raw milk cheese .

The proposals do not address changes to Australian microbiological food Standards which are currently out of step with scientific studies and standards applied overseas .

The proposals are anticompetitive and represent a breach of Australia's commitment to WTO:

- WTO Article 5.1 requires members to 'ensure that their sanitary or phytosanitary measures are based on an assessment, as appropriate to the circumstance, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organizations'.

- Article 5.2 states in the assessment of risks 'Members shall take into account available scientific evidence'.

- Article 5.4 states 'Members should, when determining the appropriate level of sanitary or phytosanitary protection, take into account the objective of minimizing trade effects'.

The proposals are overly prescriptive and do not meet the Council of Australian Government (COAG) guidelines on primary production and processing standards that stipulate an objective of minimal effective regulation

2) Attached Technical reports on Proposals in P1007 developed with assistance from Dr Paul Neaves .

Please acknowledge receipt of this submission in full

Thank you

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Review of supporting documents for FSANZ 1st assessment 2010

1) A risk profile of dairy products in Australia

p(vi) and p67 The diagram is a graphical plot of overall concern for different commodities and clearly shows that raw milk carries a substantially higher risk than other dairy products. This is good evidence to argue that raw milk alone should be placed in Category 3.

p(x) "Raw milk has a mixed microflora, which is derived from including the interior of the udder,..." In healthy cows, the interior of the udder is sterile; only in cases of mastitis is the interior infected.

p19 Table 2: Existing risk assessments of dairy products states: "A concise risk assessment on *B. cereus* in the Netherlands predicted that 7% pasteurised milk might have levels of *B. cereus* contamination above 10^5 per ml. (Notermans *et al.*, 1997)." What is not mentioned is that Notermans *et al* also stated that this milk was being consumed without apparent ill-effects.

p21 "Surveys conducted overseas showed that pathogens are frequently isolated from raw milk ... Pathogens were detected in raw milk in 85% of 126 surveys identified in the literature." The fact that 85% of surveys reported pathogens is no indication of the frequency, i.e. the percentage of positive samples within each survey. Pathogens may be widespread but that does not imply that they are common.

p21 "While pathogens are rarely isolated from pasteurised milk they are more frequently found in pasteurised milk products, ..." So it is acknowledged that most contamination is post-pasteurisation!

p21 "In these few surveys where raw milk cheeses were specifically identified, pathogens were however rarely detected." So, it is acknowledged that raw milk products are infrequently contaminated.

p24 "Unpasteurised dairy products are the most common cause of dairy associated outbreaks of illness." ... "The total number of dairy outbreaks associated with unpasteurised products is 61/163 (37.4%)." These two statements are contradictory; if 37.4% relates to unpasteurised products, then 62.6% must relate to products made from pasteurised milk. (See also pp226-227.)

p24 "Raw milk is as frequently involved as pasteurised milk in outbreaks, yet only a small proportion of milk and milk products are unpasteurised." A good argument for having raw milk stand alone in Category 3.

p26 "Directive 92/46" This EC legislation ceased to be in force at the end of 2005. The criterion of 400,000 somatic cells/ml only applies to milk from cows and buffaloes.

pp189-192 This section discusses the effect of processing on pathogens but fails to include the inhibitory effect of a competitive microflora.

pp226-227 Tables 5 and 6 indicate that cheese made from pasteurised milk poses a substantially greater risk of causing food-poisoning than raw milk cheeses (>37,215 cases and 987 cases respectively)!

p238 "The occurrence of microbiological hazards in Australian finished dairy products is extremely low, due largely to all products originating from pasteurised milk." The statement makes a false assumption especially as the paragraph subsequently discusses the presence of *Salmonella* in 1156 samples of dairy products tested over a 20-year period, suggesting either that pasteurisation is not working or post-pasteurisation contamination.

2) Microbiological risk assessment of raw milk cheese

p1 "The modelled raw milk Cheddar cheese was assessed as posing a high risk to all population groups due to the survival and growth of pathogenic *E. coli* during cheesemaking." As stated elsewhere, predictive models are excessively pessimistic. *E. coli* does not grow during Cheddar curd production and dies during the protracted maturation period.

p1 "The modelled raw milk Feta cheese was assessed as having a high risk to public health and safety to all population groups due to the survival of pathogenic *E. coli* during cheesemaking." Untrue. *E. coli* grows slightly during Feta curd production then dies during storage at the rate of 1 log cycle per 10 days. See: Govaris, A.; Papageorgiou, D. K; Papatheodorou, K. *Behavior of* Escherichia coli *O157:H7 during the manufacture and ripening of Feta and Telemes cheeses,* Journal of Food Protection **65** (4) 609-615 (2002).

p2 "Foodborne illness has been linked to the consumption of cheese; however 70% of all cheese implicated in foodborne illness outbreaks are raw milk cheeses." We challenge the validity of this value; it refers to the number of outbreaks, not the number of cases.

p2 "The primary source of contamination in raw milk cheese is from the raw milk itself, ..." Not so, if milk production is well controlled.

p2 "The ability of pathogens to survive and/or grow in cheese is largely dependent on: ..." The list of parameters does not include a competing microflora.

p3 Table 1 states the risk for *L. monocytogenes* in Feta as high for susceptible populations. As Feta has a pH of around 4.6, this seems an unlikely possibility.

p16 "Lag phase models were not included as an explicit step in the modelling process due to a lack of available data. Addition of a lag phase would reduce the predicted growth of pathogens during the initial phase of cheese manufacture." and "Consideration of the inhibition of growth due to rapid pH decline during acidification was not included in the model due to the complexity of describing the temporal changes in physicochemical characteristics of the cheese and a lack of quality data. Inclusion of these factors in model would reduce the total predicted concentration of pathogens at the end of production." We agree, but have lag phases and rapid acidification been taken into account in the overall assessment? If not, the assessments are unrealistically pessimistic.

p50, 9.1.7.3, para 2 With the exception of Parmesan production, where specific controls are in place (50°C, pH 3.5, overnight storage), we know of no cheesemakers who practice backslopping (i.e. using whey as the starter for the next batch of production).

p50, 9.1.7.3, para 5 fails to mention that brines are maintained at around pH 5 and often at around 10°C.

p61 Table 28 2.8% salt in moisture seems uncharacteristically low. We would expect farmhouse Cheddar to have >4.0% salt in moisture. (2% salt in, say, 40% moisture = 5%, not 2.8%)

p65 Table 35 "The process of manufacturing this raw milk Feta cheese results in no reduction of *E. coli* (EHEC) and therefore represents a **high** risk to consumers of both the general and susceptible population." Not so. See Govartis *et al.* above.

p66 10.6 "Camembert cheese is a soft cheese characterised by surface ripening using moulds such as *Penicillium Camemberti and Penicillium candidum*." *P. candidum* IS *P. camemberti. P. candidum* was the old name for *P. camemberti* and became disused around 1920!

p67 Key Findings "For raw milk Camembert cheese, the quantitative modelling predicted that there are no steps during production that result in an inactivation of the microorganisms investigated, leading to a substantial increase in microorganisms during cheesemaking." Two aspects that have not been considered are the provision of an incentive for hygienic milk production (e.g. through a vertically-integrated co-operative or a farmer quality payment scheme that includes pathogen testing) and the effect of a competing microflora during curd production.

p83 "Using the qualitative framework the principal risks to public health and safety from the consumption of raw milk Cheddar, blue, Feta and Camembert cheeses are:
- *E. coli* (EHEC) was rated **high** risk in raw milk Cheddar, Feta and Camembert cheeses
- *L. monocytogenes* was rated **high** risk for susceptible populations in blue, Feta and Camembert cheese." For reasons outlined above, we dispute a high risk categorisation for EHEC in Cheddar and Feta, and for *L. monocytogenes* in Feta.

p110 Table 12 It is arguable that high levels of coliforms in a raw milk cheese might be a good thing as they can out-compete EHEC (The Jameson Effect).

p169 3.3.1 and Table 2 In order to estimate the level of *E. coli* in Cheddar cheese, the titratable acidity must be specified as this has a major effect on its survival. A maturation period of 26 weeks is very short for farmhouse Cheddar; 9-18 months is more usual which gives more opportunity for the death of Gram-negative pathogens.

p203 The Table for Feta cheese states "**High** risk as *E. coli* survives during cheesemaking." Govartis *et al.* (2002) showed that it does not; therefore, I dispute this conclusion.

p204 Risk assessment – Camembert "The manufacturing parameters and physicochemical properties for the modelled raw milk Camembert cheese are based on experimental data and do not necessarily reflect commercial manufacturing practices." How applicable are the results then?

3) Application A 530 – Keens /Montgomery English farmhouse Cheddar

(a) The FSANZ risk assessment is based largely upon predictive (mathematical) modelling which does not account for the effect of microbiological monitoring in fermented products. Below is an extract from a report prepared for a UK farmhouse cheesemaker, which may be of interest.

Mathematical modelling studies have suggested that *Listeria* is capable of slow growth in (pasteurised) Caerphilly cheese which, if the predictions are accurate, could limit the shelf life considerably. The results conflict with the commercial track record for this type of product which suggests that growth does not occur.

On 30 July 2007, the UK Food Standards Agency published the results of a risk assessment of *Listeria monocytogenes* in UK retailed cheese (Banks, 2007). The report concluded that "the majority of semi-hard and hard cheeses (e.g. Cheddar, Cheshire, Caerphilly and Red Leicester) appear to present little risk" and that "predictive modelling based on controlling factors such as pH, water activity and salt content was found to over-estimate the growth or survival of *L. monocytogenes*. This may be because the lactic starter cultures are able to influence the growth and survival of *L. monocytogenes* in cheese." The report describes a qualitative comparison of risk for different types of cheese, some details of which are given below; the higher the Overall Risk Rating, the higher the perceived risk:

Cheese Type	**Overall Risk Rating**	Frequency of contam-ination	Contam-ination level	Effect of process step	Recontam-ination	Recontam-ination level	Growth during storage
"Territorial" Industrially made; pasteurised	**9**	3	1	1	1	1	2
Cheddar Industrially made; pasteurised	**9**	3	1	1	1	1	2
Mozzarella Lactic fermented	**11**	3	1	1	2	1	3
Feta Industrially made; pasteurised	**13**	3	1	1	3	2	3
Stilton Industrially made; pasteurised	**13**	3	1	1	2	2	4
Camembert Industrially made; pasteurised	**15**	3	1	1	3	2	5
Vacherin Artisan made; raw milk	21	3	3	3	4	3	5

Abridged from Banks, 2007

Of the cheese types listed in the Table above, Territorial cheeses, such as Caerphilly cheese, were considered to have the lowest overall risk for contamination and growth of *Listeria monocytogenes* and a contributor to this is the low risk of growth during storage. The report states that "predictive mathematical models … do not take into account the impact of the fermentative or ripening microflora on the fate of *L. monocytogenes* at any point along the manufacturing and supply chain. This is significant … as the available models for the behaviour of the pathogen tend to over-estimate risk of growth or survival to ensure that the precautionary principle is applied." It concludes "Unfortunately, as the role of the fermentative or ripening microflora is not modelled, the tool is of limited value. The use of the available predictive models should therefore be used with extreme caution."

A study that attempted to quantify the inhibition of *Listeria monocytogenes* by two bacteriocin-producing strains of *Lactococcus lactis* was reported by Rodriguez *et al.* (2005). Cheeses were manufactured from milk inoculated with *Listeria* at around 6 log cfu/ml and the lactococci were added as adjuncts to the starter culture. After 30 days, counts of *Listeria monocytogenes* were 5.30 log cfu/g in control cheese whilst, in the presence of *Lactococcus*, counts of *Listeria monocytogenes* were reduced to 2.33 and 3.66 log cfu/g. for the two adjunct cultures used. The report therefore suggests that the growth rate of *Listeria* was roughly halved in the presence of the adjunct culture.

These two publications provide strong evidence that the shelf life allocated to Caerphilly cheese is realistic and, in the unlikely event that the cheese should become contaminated with *Listeria* from nettle leaves, the product would be expected to conform to EU Regulation EC/2073/2005 at least up to its commercial expiry date.

Banks, JG. 2007. Risk assessment of *l. monocytogenes* in UK retailed cheese - Final report, FSA Project: B12006, *FSA Website* 30 July 2007, http://www.food.gov.uk/science/research/researchinfo/foodborneillness/microriskresearch/b12programme/B12projlist/b12006/b12006r.

Rodríguez, E., Calzada, J. Arqués, JL, Rodríguez, JM, Nuñez, M and Medina, M. 2005. Antimicrobial activity of pediocin-producing *Lactococcus lactis* on *Listeria monocytogenes*, *Staphylococcus aureus* and *Escherichia coli* O157:H7 in cheese, *International Dairy Journal*. **15** (1), 51-57.

(b) The FSANZ assertion that *E. coli* can grow in Cheddar.
I recall from my discussions with FSANZ in August 2006 that their main concern was *E. coli* O157 and we discussed a publication from the US suggesting its survival. I would not expect survival in UK farmhouse Cheddar and comparing the two revealed that:
- the US experiments used an exceptionally acid tolerant strain of *E. coli* O157 which may not be expected in dairy farming
- the curd was milled at a titratable acidity of 0.35, compared with >0.40 (more likely 0.50) in UK Cheddar. The lower TA would lead to moisture retention and increased survival of *E. coli.*
So, the US experimental parameters did not reflect the commercial reality of farmhouse Cheddar production.

Paul Neaves
February 2010

Wester Lawrenceton Farm

October 2002

Introduction

Following the detection of high levels of *Staphylococcus aureus* in Califer the semi-soft goats cheese produced by Wester Lawrenceton Farm, a visit was made on 3rd/4th October 2002 to review the cheesemaking procedures, and give recommendations.

Wester Lawrenceton Farm, run by Nick and Pam Rodway, produces raw milk cheeses from their own herds of cows and goats.
The cheeses made are:

Califer/Crottin semi-soft goats cheeses
Carola a semi-soft cows cheese, which may be rind washed
Sweetmilk a pressed Dunlop style made with cows milk
Caerphilly made with cows milk
Brierley a soft mould rinded cows cheese

Califer, Carola and Sweetmilk cheeses were made during the visit, Brierley had been made the day before.

The milk is cooled if it is not being used immediately. Chr Hansens starter CHN-19 (a heterofermentative mesophilic culture) is used for all cheese recipes, with surface ripening cultures added to the milk as required by each recipe. There are 2 cheese vats, a jacketed tank used with a removable stainless steel tub of approximately 60 litres capacity (referred to as Vat 1) and a water jacketed rectangular stainless steel vat of approximately 250 litres capacity (Vat 2). Since the problem was first encountered, a pH meter has been purchased, and was used for the first time during the visit. Acidimeter readings were taken using an AB Cheesemaking acidimeter. An acidmeter for Wester Lawrenceton is on order.

Staphylococcus aureus is a common skin contaminant, found on both animals and humans, and may contaminate raw milk or curds at any stage of production. Its growth in raw milk cheeses can be limited by ensuring that sufficient acidity is developed at the desired rate, that temperatures are closely controlled, and that salting and humidity are adequate. Each of these parameters should be considered as a Critical Control Point in the HACCP plans.

Recommendations

- **Milk**
  - Individual goats may shed large numbers of *Staphylococcus aureus* as a result of mastitis, and screening of the goats should continue. Mastitis monitoring and control measures should also be reviewed.
  - Milk is transferred from the bulk milk tanks to the vats by buckets. The buckets are placed on the wet floor of the tank room to be filled. Care must be taken to ensure that no contamination from the base of the bucket gets into the milk. Ideally, these should never be placed on the floor.

- **Starter**
  - CHN 19 comes in 50 unit sachets, sufficient for up to 1000 litres, and is subdivided according to the amount of milk in the vats. The method of subdividing may result in variability of the starter concentration for different batches; dividing the sachet into smaller quantities must be accurate to ensure repeatable acidification. Using too much starter is preferable to too little.

  - The starter is added into cold milk, and the milk warmed up to renneting temperature. The ripening period is timed from the milk temperature reaching making temperature. Starter will begin to grow at temperatures below the make temperature, and so smaller volumes of milk may have a shorter total ripening time than larger volumes. Standardising the ripening time for each variety will improve consistency.

- **Cheesemaking procedures**
  - The use of acidity measurements, both by pH and % lactic acid, will show how well the starter is growing during the make. Experience must be gained in the use of these techniques to be able to establish normal values.

- The method for making Califer and Carola includes an addition of salt at mould filling, when the curd is at a high pH. This step may be reducing the starter activity, and has been removed.
- Water from the jacket of Vat 2 appears to be leaking into the vat in the tap area. This is a possible source of contamination and should be repaired.

- **Room temperatures**
  - The soft and semi soft cheese varieties are filled into moulds and drained overnight in the cheeseroom. The room is not temperature controlled, and in cool conditions starter growth may be inhibited. The draining temperature should be over 18 °C throughout the night to ensure a consistent rate of acidification for different batches. A maximum/minimum thermometer should be used alongside the cheese and records kept to ensure that the required temperature is maintained.
  - All cheeses are placed in a drying room, to be air dried over several days. The temperature of this room should be maintained below 16 °C, with the use of cooling during warm weather. The maximum/minimum temperatures of this room should be recorded.
  - The temperatures of the ripening rooms should be monitored by maximum/minimum thermometers, and recorded.

- **Brining**
  - Inadequate salt content, a high (near neutral) pH and a high temperature will encourage the growth of *Staphylococcus aureus* in the brine. A brine refractometer or hydrometer should be obtained so that brine concentration is maintained above 14% salt. The pH of the brine should be maintained at 5.2 or below. Brining temperature should be below 16 °C. The brine should be kept clean.

- **Documentation**
  - In order to be able to demonstrate that cheesemaking is consistent from one batch to the next a minimum level of documentation should be kept. In addition to the usual cheesemaking log that records the cardinal times and temperature for curd production, the following records should be considered:

    1) The pH value or titratable acidity of the milk / whey should be measured at appropriate intervals between adding the starter to the milk and removing the curd from the moulds.

2) The salt concentration and pH of the brine should be monitored daily, or between batches.

3) The room temperature whilst draining the curd and throughout maturation.

4) The humidity of the maturation rooms should be measured at regular intervals.

Response to FSANZ Proposal P1007 Primary Production & Processing Requirements for Raw Milk Products (Australia only) 1st Assessment Report

p(i) **Introduction (Executive summary)**
"Because of the potential for raw milk to be contaminated with pathogens, raw milk and products made from raw milk present a high level of risk to public health and safety if there are no control measures to manage the microbiological hazards that may be present." In our opinion, it is a false assumption that for raw milk products the risks are "high level". A more realistic description would be "present an additional risk to public health and safety compared with products made from correctly pasteurised milk"

p(iii) "*Category 3* products are defined as those products for which the intrinsic characteristics and/or processing factors are likely to allow the survival of pathogens that may have been present in the raw milk and *may support the growth* of these pathogens." Most pathogens are mesophilic so, with the exception of *Listeria*, Category 3 products will only support growth if chill temperatures (<3°C) have not been maintained.

p(iv) "For Category 3 products, which include raw drinking milk, the level of public health risk cannot be reduced sufficiently and such products present a medium - high level of public health and safety risk." In our opinion, this is a n exaggeration of the facts; Category 3 products, by definition, present a higher risk than Category 1 and 2 products but we do not consider that this should be described as "high level".

p(v) first bullet. "• those that are thermised and stored for at least 90 days (cheese only)" The statement is incorrect science. A minimum maturation period was originally intended to allow the death of *Salmonella*. In the case of products produced from thermised milk, *Salmonella* will have been destroyed by the heat process; therefore there is no need to store thermised products for 90 days.

p6, para 2 "... more frequently ..." is misleading. In context, it is referring to "the most likely pathogens to be encountered", but the phrase could easily be misinterpreted to mean that raw milk products have a higher incidence that those made from pasteurised milk. In 2 UK studies (2004 and 2004), 51/2618 (1.94%) samples of cheese made from pasteurised milk were microbiologically satisfactory whereas 32/1819 (1.76%) samples of cheese made from raw or thermised milk were unsatisfactory.

p11, We agree that Roquefort should be placed in Category 2.

p15, 7.1.2 "• *Survival* means no net increase of pathogens from receipt of milk to the end of the processing stage." Given that the curd of many soft cheeses develops pH 4.6-4.8, this statement might be applicable to Camembert and Stichelton.

p16, 7.1.1.3 "and fresh cheeses, which have a higher moisture and pH profile and can support the growth of pathogens." Fresh cheeses have a low pH and may not support the growth of pathogens; therefore they should be listed in Category 2.

p16, 7.1.3.2 and p58 5.3 (Technical assessment) "... pathogens will grow and cases of illness from *Campylobacter* spp., EHEC, *Salmonella* spp. and *L. monocytogenes* can be expected"
Campylobacter does not grow in food and is not associated with cheese.

p16, Clause 7.1.3.2 implies the requirement to provide "pathogen free" raw milk and indicates that no control measures have been identified that can achieve this. The policy guidelines (p9 5.2.2) include the requirement to be consistent with Codex standards. Clause 7.1.3.2 therefore conflicts with the policy guidelines since the Codex HACCP simply requires a control measure to "reduce a hazard to an acceptable level" which, in our opinion, is perfectly achievable.

p26, Option 4, Table, 4th column, Overall Impact. We disagree with the statement that "Public health safety would be compromised." In our opinion, there is no evidence that Category 3 cheeses cause significantly more food-borne disease than products in categories 1 and 2.

pp36-40, (Technical assessment) Primary production factors f or contamination of raw milk. The technical assessment appears to have omitted what, in our opinion, are arguably the two most important factors, a famer quality payment scheme and the contractual arrangement between milk producer and cheesemaker, for which 'own milk' provides the greatest level of control and purchasing from the 'open market' the least. Roquefort cheese, for example, is produced by vertically-integrated co-operatives in which the farmers own the dairy which provides an incentive to produce 'pathogen-free' milk and forms an essential part of the overall safety programme. The technical assessment fails to acknowledge this control measure.

pp40-41, (Technical assessment) Processing The technical assessment appears to have omitted one essential parameter, microbial competition. In our opinion, organisms such as *Staph . aureus* and *Listeria monocytogenes*, are poor competitors so that an important part of their control involves exclusion by an active starter culture. This is unique to fermented foods and should be included.

pp41-42. How can pasteurisation be "most relevant" to raw milk products?

p42, 2.2.1 Cooking of the curd for Parmesan is roughly equivalent to pasteurisation. In our opinion, this is not adequately reflected in this clause.

pp56-57, Category 3 The text fails to acknowledge the importance of a competitive microflora in controlling pathogens in mould- and smear-ripened soft cheeses. In addition, for pathogens other than *Listeria*, growth is not supported at temperatures below 3°C, which could be exploited during distribution, while, for *Listeria*, growth is controlled by limiting shelf life. Also, in our opinion, the premise that "The primary source of contamination in raw milk products is from the raw milk itself." (p56, 3.4) is incorrect for *Listeria* as most contamination occurs during cheesemaking and maturation which would equally apply to cheeses made from pasteurised milk; indeed it could be argued that the latter are more susceptible to growth of *Listeria* due to the absence of a competitive microflora, having been destroyed by pasteurisation. Thus, we see no reason why all soft, mould- and smear-ripened cheeses should not be placed in Category 2. We consider that Category 3 should be reserved for raw drinking milk.

p57, Clause 3. "A wide range of microbiological hazards may be associated with raw milk. If these hazards are unmanaged, raw milk poses a high level of risk to public health and safety." In our opinion, this overstates the risk. Whilst a variety of pathogens may occur in raw milk from time to time, the incidence of these organisms in well-managed milk production is low.

pp57-58, 5.2 This clause fails to acknowledge the contribution of a competing microflora. We support the intention to make further investigations.

Paul Neaves 26/1/10

European Commission Co-ordinated Programme for the Official Control of Foodstuffs for 2004:

Microbiological Examination of Cheeses made from Raw or Thermised Milk from Production Establishments and Retail Premises in the United Kingdom

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*, Corresponding author, †, FWES Network comprises Laboratories listed in Annex 1

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 2004, a study of fresh, ripened and semi-hard cheeses made from raw or thermised 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 2004/24/EC, 98% of the 1842 samples from retail and batches from production were of satisfactory/borderline microbiological quality. Likewise, in the following study in 2005 of pasteurised milk cheeses, 98% were also found also to be of satisfactory/borderline microbiological quality according to Recommendation 2005/175/EC. Two percent of samples in the present study were of unsatisfactory quality due to high levels of *Staphylococcus aureus* ($\geq 10^4$ cfu/g), *Escherichia coli* ($\geq 10^5$ cfu/g), *Listeria monocytogenes* ($\geq 10^2$ cfu/g) or presence of *Campylobacter* spp (1 sample). *Salmonella* spp. was not detected in any samples. Raw or thermised milk cheeses were more likely to be of unsatisfactory microbiological quality when they were: unripened cheese varieties; sampled from retail premises without a hazard analysis system in place, and rated as having little or no confidence in management and control systems; stored or displayed above 8°C. Evidence from this study also indicates that labelling of cheeses with clear information on whether the cheese was prepared from raw milk requires improvement.

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[1]. 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[1]. Other intrinsic parameters that may affect the growth and survival of microorganisms in cheeses are redox potential[2] and the presence of anti-microbial compounds produced by starter and non-starter organisms[3,4,5]. 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.

Whilst the efficient pasteurisation of milk should eliminate the risk from viable pathogenic organisms, cheese can be made safely with raw milk. Many cheesemakers use raw milk or add raw milk to the cheese milk, considering it essential for good flavour, primarily due to greater proteolysis and lipolysis by the raw milk microflora in the cheese. Some cheeses are also made with thermised milk that has been given a sub-pasteurisation temperature (57°C to 68°C for at least 15 seconds) designed to eliminate spoilage bacteria. 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[6]. From 1 January 2006 these Regulations were superseded by the new EU food hygiene regulations that apply directly to Member States[7,8]. For unpasteurised milk cheese, milk production is the first critical control point

(CCP) in the cheesemaker's Hazard Analysis and Critical Control Point (HACCP) plan. *Staphylococcus aureus* is the commonest cause of mastitis in diary cows, and faecal contamination of milk during milking also poses a risk of introducing pathogens. The microbiological quality of cheese is also influenced by equipment and environment hygiene during manufacture, packaging and handling[9]. 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[10], and the Food Standards Agency (FSA) and ADAS also set up the Specialist Cheesemakers Initiative to assist cheesemakers in implementing HACCP principles[11].

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*[12-14]. 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[15]. Mandatory labelling of cheeses made from raw milk also has been introduced in Europe so that the consumer can make an informed choice of purchase[8].

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[16,17], one on cheeses made using raw or thermised milk and the other on those made using pasteurised milk.

Reported here are the results of the first of these studies on cheeses made from raw or thermised milk from retail and production premises.

Materials and Methods

Sample collection

Unripened (fresh) or ripened soft and semi-hard cheeses made from raw or thermised milk were collected from retail and production premises and examined by 33 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 2004 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 2004/24/EEC, whereas single samples were collected from retail premises[16]. Samples (5 x 100g from production, 100g from retail) were collected and transported to laboratories by staff from 264 local Environmental Health Departments, involving 271 Local Authority Food Liaison Groups (Annex 1), in accordance with the FSA Food Law Code of Practice[18] and LACORS guidance on microbiological food sampling[19].

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 FSA Food Law Code of Practice[18] 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 their presence sought in accordance with HPA Standard Microbiological Methods[20-23]. *Campylobacter* spp. were detected by enrichment in Bolton Selective Enrichment Broth with incubation at 37°C for 4 hours, followed by further incubation at 41.5°C and subculture to *Campylobacter* selective agar (CCDA) after 44±2 h. Inoculated plates were incubated at 41.5°C for 48 h, and colonies identified as described in HPA Standard Microbiological Method F21[24]. Isolates of *Campylobacter* spp. were sent to the Laboratory of Enteric Pathogens (LEP), Health Protection Agency Centre for Infections (HPA CfI), for typing and further characterisation. All isolates of *L. monocytogenes,* and other species of *Listeria* at high levels (≥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[25,26]. Isolates of *S. aureus* at $\geq 10^4$ cfu/g were also sent to FSML to determine the enterotoxin gene fragments by polymerase chain reaction (PCR)[27].

The microbiological status of production batches of cheese were assessed using the class attributes plans stipulated in Recommendation 2004/24/EC[16] (Table 1). The microbiological status of single retail samples of cheese were also assessed using the criteria in Recommendation 2004/24/EC[16] (Table 2)

Table 1. Microbiological criteria for batch samples from production premises (Recommendation 2004/24/EC[16])

Microorganism	Microbiological criteria
Escherichia coli	n= 5 c=2 m= 10^4 cfu/g M=10^5cfu/g
Staphylococcus aureus	n= 5 c=2 m= 10^3 cfu/g M=10^4 cfu/g
Listeria monocytogenes	n=5 c=0 Absent in 25g
Campylobacter spp.	n=5 c=0 Absent in 25g
Salmonella 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. and *Campylobacter* 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 2004/24/EC[16])

Microorganism	Satisfactory	Borderline	Unsatisfactory
Escherichia coli	$<10^{4*}$	10^4 - $<10^5$	$\geq10^5$
Staphylococcus aureus	$<10^3$	10^3 - $<10^4$	$\geq10^4$
Listeria monocytogenes	ND	Detected - $<10^2$	$\geq10^2$
Campylobacter spp.	ND	-	Detected
Salmonella spp.	ND	-	Detected

*, cfu/g

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 (χ^2) and fisher's exact test. A probability value of less than 5% was deemed to be significant.

Results

Microbiological status of cheeses made from raw or thermised milk

Production Establishments

Twenty-one production establishments were visited. Eight unripened (fresh) soft cheese, eight ripened soft cheese, and seven semi-hard cheese batches were tested; five sample units were collected per batch; therefore in total 115 sample units were examined.

Applying the criteria in Recommendation 2004/24/EC[16], 78% (18/23) of batches were of satisfactory microbiological quality, 18% (4) were of unsatisfactory quality due to high levels of *S. aureus* (3) or *E. coli* (1), and one (4%) batch was of unsatisfactory quality due to the presence of *L. monocytogenes* in excess of 100 cfu/g (210 cfu/g) (Table 3).

Table 3. Microbiological quality of cheeses made from raw or thermised milk according to Recommendation 2004/24/EC[16] from production premises in the UK

Microorganism	Product Identification	Number of samples	Analysis results		
			Satisfactory	Borderline	Unsatisfactory
Salmonella spp. n=5 c=0 absent in 25g	Unripened soft (Fresh) Ripened Soft Semi-Hard	8 8 7	8 8 7	0 0 0	0 0 0
Campylobacter spp. n=5 c=0 absent in 25g	Unripened soft (Fresh) Ripened Soft Semi-Hard	8 8 7	8 8 7	0 0 0	0 0 0
Staphylococcus aureus n=5 c=2 m=1000 cfu/g M=10,000 cfu/g	Unripened soft (Fresh) Ripened Soft Semi-Hard	8 8 7	6 7 7	0 0 0	2 1 0
Escherichia coli n=5 c=1 m=10,000 cfu/g M=100,000 cfu/g	Unripened soft (Fresh) Ripened Soft Semi-Hard	8 8 7	8 7 7	0 0 0	0 1 0
			***ND**	<100cfu/g	≥100cfu/g
Listeria monocytogenes n=5 c=0 absent in 25g	Unripened soft (Fresh) Ripened Soft Semi-Hard	8 8 7	8 8 6	0 0 0	0 0 1

*ND, Not detected in 25g

Two of the three batches that had high *S. aureus* counts were unripened soft raw goats' milk cheese products from different batches produced by the same on farm dairy products producer. One batch contained *S. aureus* ranging from 1.9×10^4 to 3.6×10^4 cfu/g from the five sample units; another batch contained S. *aureus* at 1.3×10^4 cfu/g in one sample unit, 3.5×10^3 to 5.8×10^3 cfu/g from a further three sample units, while the remaining sample unit contained <20 cfu/g. *S. aureus* isolates from all these sample units contained the staphylococcal enterotoxin (SE) C gene fragment. The other batch was a ripened soft blue raw cows' milk cheese containing *S. aureus* in two of the sample units at levels of 5.2×10^4 and 5.5×10^5 cfu/g (SE gene fragments were not detected), while the other three sample units had *S. aureus* present at levels < 20 cfu/g. One batch of soft ripened cheese made from raw ewes' milk had high *E. coli* levels ranging from 2.0×10^4 to 2.4×10^5 cfu/g in four sample units, and 75 cfu/g in the remaining sample unit. A batch of semi-hard raw cows' milk cheese had *L. monocytogenes* (serotype/AFLP: 1/2a/VII) present in excess of 10^2 cfu/g in one of the five samples units (210 cfu/g), while the organism was not detected in the remaining four sample units.

As there were only 23 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 23 batches of cheese are presented in Tables 4 and 5.

Table 4. Microbiological quality of raw or thermised milk cheeses according to Recommendation 2004/24/EC[16] in relation to production product details

Product Details	No. Batches (n=23)	No. Batches %	No. Batches of Unsatisfactory Quality (n=5)
Cheese type			
Unripened soft	8	35	2
Ripened soft	8	35	2
Semi-hard	7	30	1
Milk species			
Cows' milk	10	44	1
Goats' milk	8	35	3
Ewes milk	4	17	1
Other (e.g. buffalo)	1	4	-
Not recorded	-	-	-
Milk type			
Raw milk	17	74	5
Thermised milk	5	22	-
Not recorded	1	4	-
FSA/ADAS Specialist Cheesemakers Initiative			
Participated	17	74	4
Not participated	5	22	1
Not Known	1	1	-
Labelled as organic			
Yes	4	17	-
No	16	70	5
Not recorded	3	13	-
Display/Storage Temperature			
≤8°C	16	70	3
>8°C	4	17	1
Not recorded	3	13	1

Table 5. Microbiological quality of raw or thermised milk cheeses according to Recommendation 2004/24/EC[16] in relation to production premises details

Premises Details		No. Batches (n =23)	No. Batches (%)	No. Batches of Unsatisfactory Quality (n=5)
Premises Type				
On farm dairy producer		14	61	3
Dairy products producer (non-farm)		6	26	2
Not recorded		3	13	-
Inspection Rating Category				
Category	Minimum Frequency of Inspection			
A	At least every 6 months	9	39	3
B	At least every year	10	43	2
C	At least every 18 months	3	13	-
	Not recorded	1	4	-
Consumer at Risk Score				
0 (Very few)		-	-	-
5 (Few)		4	17	1
10 (Intermediate)		10	43	2
15 (Substantial)		8	35	2
Not recorded		1	4	-
Confidence in Management				
0 (High)		4	17	-
5 (Moderate)		6	26	1
10 (Some)		11	48	3
20 (Little)		1	4	1
30 (None)		-	-	-
Not recorded		1	4	-
Hazard Analysis Systems				
In place and documented		21	91	5
Not in place		-	-	-
Not recorded		2	9	-
Management Food Hygiene Training				
Received training and attended				
Basic 6 hour course		10	48	3
Intermediate course		2	9	2
Advanced course		3	13	-
Other recognised course		4	17	-
No training		-	-	-
Not recorded		3	13	-

Retail premises

A total of 1819 samples of cheeses were tested, of which 62 (3.4%) were unripened (fresh) soft cheese, 806 (44.4%) were ripened soft cheese, and 951 (52.2%) were semi-hard cheese samples.

Microbiological quality in relation to Recommendation 2004/24/EC

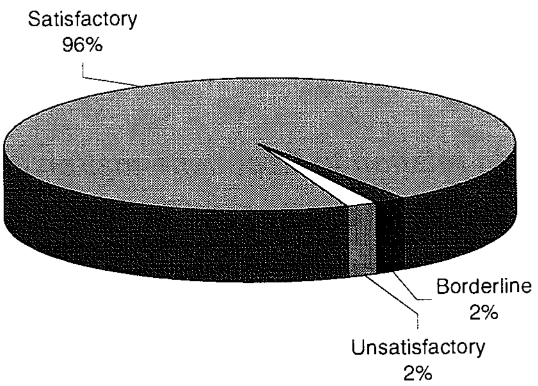
Applying the criteria in Recommendation 2004/24/EC[16], 96% (1742/1819) of samples were of satisfactory microbiological quality, 2% (40) were of borderline quality, and a further 2% (32) were of unsatisfactory quality due to high levels of *S. aureus* (ranging from 1.6x 10^5 to >10^7cfu/g) and/or *E. coli* (ranging from 1.1 x 10^5 to 4.6 x 10^6 cfu/g), the presence of *Campylobacter* *jejuni* (one sample), and *L. monocytogenes* present at over 10^2 cfu/g (220 cfu/g) (one sample) (Table 6, Fig. 1). *Salmonella* spp. was not detected in any samples examined. Overall contamination of *Listeria* spp. in cheeses was 3.1% (56). *L. innocua* was also present in one sample at over 10^2 cfu/g (8.3×10^3 cfu/g).

Table 6. Microbiological quality of cheeses made from raw or thermised milk according to Recommendation 2004/24/EC[16] from retail premises in the UK

Microorganism	Product Identification	Number of samples	Analysis results		
			Satisfactory	Borderline	Unsatisfactory
Salmonella spp. n=5 c=0 absent in 25g	Unripened soft (Fresh) Ripened Soft Semi-Hard	62 806 951	62 806 951	0 0 0	0 0 0
Campylobacter spp n=5 c=0 absent in 25g	Unripened soft (Fresh) Ripened Soft Semi-Hard	62 806 951	62 806 950	0 0 0	0 0 1
Staphylococcus aureus n=5 c=2 m=1000 cfu/g M=10,000 cfu/g	Unripened soft (Fresh) Ripened Soft Semi-Hard	62 806 951	59 787 947	2 9 2	1 10† 2
Escherichia coli n=5 c=1 m=10,000 cfu/g M=100,000 cfu/g	Unripened soft (Fresh) Ripened Soft Semi-Hard	62 806 951	60 773 935	0 17 9	2 16† 7
			***ND**	<100 cfu/g	≥100 cfu/g
Listeria monocytogenes n=5 c=0 absent in 25g	Unripened soft (Fresh) Ripened Soft Semi-Hard	62 806 951	61 798 943	1 8 7	0 0 1

*ND, Not detected in 25g
†Two samples had unsatisfactory levels of both *S. aureus* and *E. coli*

Figure 1. Microbiological quality of retail soft and semi-hard cheeses made from raw or thermised milk from retail premises using criteria in Recommendation 2004/24/EC[16] (n=1819)



Ten of the 13 cheeses containing S. *aureus* at 10^4 cfu/g or more were ripened soft cheeses, one was an unripened soft cheese, and two were semi-hard cheeses. Six of these cheeses were pre-packed, six were cut to order, and for one sample this information was not recorded. The sample containing *C. jejuni* (HS 8) was an Irish goats' fresh soft milk cheese sampled from a supermarket delicatessen. The sample that had *L. monocytogenes* (serotype/AFLP: 1/2a/IX) present in excess of 10^2 cfu/g was a cut-to-order semi-hard smear-ripened Scottish cheese sampled from a specialist cheese shop.

Genes for Staphylococcal Enterotoxin (SE) Production

S. aureus isolates from four of the 13 cheese samples where the bacteria was present at $\geq 10^4$ cfu/g all had genes for staphylococcal enterotoxin (SE) (Table 7). Five different SE gene fragments were amplified from these isolates, three of which were obtained from ripened soft cheese samples produced from raw milk.

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

Milk type	Cheese type	No. Samples	Staphylococcal enterotoxin gene fragments detected
Raw	Ripened soft	1	G, I
Raw	Semi hard	1	G, I
Raw	Ripened soft	1	D, J
Raw	Ripened soft	1	G, H, I

L. monocytogenes **isolates present in raw or thermised milk cheeses**

L. monocytogenes was detected in 17 (1%) of the 1819 samples. Seven of the nine 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 raw or thermised milk cheeses

Milk type	Cheese type	No. samples	*L. monocytogenes* subtype (Serotype/AFLP*)
Raw	Ripened soft	3	1/2a/VII
Raw	Semi hard	2	1/2a/IX
Not known	Ripened soft	1	
Raw	Semi hard	1	1/2a/XI
Raw	Semi hard Ripened soft	2	4b/V

*, 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 2004/24/EC[16] (Table 2).

Product details

Amongst the 1819 cheeses sampled, 52% were semi-hard cheeses (e.g. Emmental, Roquefort, Port Salut), 45% were ripened soft cheeses (e.g. Brie, Camembert), and 3% were unripened soft cheeses (e.g. cream cheese, Ricotta) (Table 9). More samples of unripened soft cheese (4.8%) were of unsatisfactory quality compared with ripened soft (2.9%) and semi-hard cheeses (1.2%) (Table 9). This finding was only significantly different when comparing unripened soft cheeses to semi-hard cheeses (p=0.0490).

Fifty-nine percent of samples collected were made using cows' milk, 19% from goats' milk, 8% from ewes' milk, and 1% were made from milk from other animal species (e.g. buffalo). This information was not recorded for 13% (Table 9). Four percent of goats' milk cheese samples were of unsatisfactory microbiological quality which was a higher proportion compared to cheeses made from milk from other animals (cows' (2.7%), ewes' (0.3%)) (Table 9). This finding was only significant when comparing goats' milk cheese with ewes' milk cheese (p=0.0044).

Of the 1819 samples sampled, 79% were made using raw milk, 6% from thermised milk: this information was not recorded for 15% (Table 9). The proportion of raw milk cheeses of unsatisfactory quality was higher (2.4%)

when compared to thermised milk cheeses (0.9%), although this finding was not statistically significant (p=0.5122).

Table 9. Microbiological quality of retail raw or thermised milk cheeses in relation to product details

Product Details	No. Samples n =1819	%	No. Samples of Unsatisfactory Quality (%)
Cheese type			
Unripened soft	62	3	3 (4.8%)
Ripened soft	806	45	23 (2.9%)
Semi-hard	951	52	11 (1.2%)
Milk species			
Cows' milk	1071	59	29 (2.7%)
Goats' milk	156	8	6 (3.8%)
Ewes milk	346	19	1 (0.3%)
Other (e.g. buffalo)	11	1	0
Not recorded	235	13	1 (0.4%)
Milk Thermal processing			
Raw milk	1428	79	34 (2.4%)
Thermised milk	116	6	1 (0.9%)
Not recorded	275	15	2 (0.7%)
Labelled as organic			
Yes	70	4	2 (2.9%)
No	1662	91	34 (2.1%)
Not recorded	87	5	1 (1.2%)
Packaging			
Pre-packed	964	53	23 (2.4%)
Cut to order	762	42	13 (1.7%)
Not recorded	93	5	1 (1.1%)
Pack size (n=964)			
<50 g	14	1	0
50–<100 g	188	20	2 (1.1%)
100–<200 g	543	58	11 (2.0%)
200–<300 g	162	17	8 (4.9%)
300–<400 g	16	2	0
≥400 g	19	2	2 (10.5%)
Not recorded	22		0
Display/ Storage Temperature			
≤8°C	1653	90	31 (1.9%)
>8°C	85	5	6 (7.1%)
Not recorded	81	5	0

Ninety-one percent of the 1819 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, 2.1% and 2.9% respectively. However, it should be noted that the proportion of samples labelled as organic examined was very small and that no statistical conclusions should be drawn from these results.

Fifty-two percent of the 1819 cheeses collected were pre-packed. Of the samples that were pre-packed, over half (58%) had a pack size of between 100 to 200g (Table 9). There was no significant difference in the proportion of unsatisfactory cheese samples between those that were pre-packed (2.4%) or cut to order (1.7%) (p=0.3973).

The majority (90%) of cheese samples were stored or displayed at or below 8°C (Table 9). A higher proportion of cheese samples (7.1%) that were stored above 8°C were of unsatisfactory microbiological quality compared to those stored below 8°C (1.9%) (p=0.0078).

Overall 75% of the cheeses sampled were labelled as having being produced from unpasteurised milk, 18% were not and for 6% of samples, this information was not recorded. A higher proportion of raw milk cheeses had this labelling (82%) compared to cheeses made from thermised milk (46%).

Country of origin

Cheeses collected from retail premises were produced in 14 countries (Table 10), with 47.2% produced in France, 19.3% in the UK, 7.0% in Switzerland, 6.2% in Denmark, and 5.8% in Italy. A higher proportion of cheeses produced in the Republic of Ireland were of unsatisfactory quality (6.7%) compared to those produced in the UK (3.4%), France (2.4%), Switzerland (1.6%) and elsewhere. However, it should be noted that the proportion of samples produced in the Republic of Ireland is comparatively small compared to those produced in, for example the UK and France. Therefore no statistical conclusions should be drawn from these results.

Table 10. Microbiological quality of retail raw or thermised milk cheeses in relation to country of origin

Country of origin	No. Samples		No. Samples of Unsatisfactory Quality (%)
	n=1819	%	
UK	**350**	**19.3**	**12 (3.4%)**
Other EU	**1,138**	**62.6**	**23 (2.0%)**
Austria	7	0.4	-
Cyprus	2	0.1	-
Denmark	112	6.2	-
France	859	47.2	21 (2.4%)
Germany	6	0.3	-
Greece	3	0.2	-
Italy	105	5.8	-
Netherlands	7	0.4	-
Republic of Ireland	30	1.6	2 (6.7%)
Spain	7	0.4	-
Non- EU	**131**	**7.2**	**2 (1.5%)**
Canada	2	0.1	-
Norway	1	0.1	-
Switzerland	128	7.0	2 (1.6%)
Not Known	**200**	**11.0**	-

Premises details in relation to microbiological quality

Type of Premises

Fifty-three percent of the 1819 cheeses sampled were collected from supermarkets and supermarket delicatessens. The remaining 47% were collected from delicatessens (23%), specialist cheese shops (8%), farm shops (5%), markets (4%; including farmers' markets), and for 6% of samples, this information was not recorded (Table 11). The proportion of cheese samples from farm shops and markets (8.4%) of unsatisfactory microbiological quality was significantly higher when compared to those collected from other premises (1.0% - 2.7%) (Table 11) (p=0.0002).

Food Hygiene Inspections

Fifty eight percent of samples were collected from premises categorised as inspection rating Category C (inspected at least every 18 months) (Table 11). More cheese samples of unsatisfactory microbiological quality were collected from premises with an inspection rating category B (3.1%) or C (2.2%) than premises with ratings of D (1.0%).

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

Retail premises details		No. Samples n =1819	No. Samples (%)	No. Samples of Unsatisfactory Quality (%)
Premises Type				
Supermarket (pre-packed)		735	(40)	7 (1.0%)
Supermarket (deli.)		237	(13)	5 (2.1%)
Delicatessen		427	(23)	9 (2.1%)
Specialist cheese shop		147	(8)	4 (2.7%)
Farm shop		98	(5)	7 (7.1%)
Farmers' market		9	(<1)	2 (22.2%)
Other market		60	(3)	1 (1.7%)
Other (e.g. butchers, health food shop, grocers		106	(6)	2 (1.9%)
Inspection Rating Category				
Category	Minimum Frequency of Inspection			
A	At least every 6 months	30	(2)	0
B	At least every year	224	(12)	7 (3.1%)
C	At least every 18 months	1053	(58)	23 (2.2%)
D	At least every 2 years	209	(11)	2 (1.0%)
E	At least every 3 years	55	(3)	0
F	At least every 5 years	32	(2)	1 (3.1%)
	Not recorded	216	(2)	4 (1.9%)
Consumer at Risk Score				
0 (Very few)		12	(1)	3 (25.0%)
5 (Few)		930	(51)	23 (2.5%)
10 (Intermediate)		590	(32)	6 (1.0%)
15 (Substantial)		53	(3)	1 (1.9%)
Not recorded		234	(13)	4 (1.7%)
Confidence in Management				
0 (High)		155	(9)	3 (1.9%)
5 (Moderate)		712	(39)	9 (1.3%)
10 (Some)		634	(35)	15 (2.4%)
20 (Little)		49	(3)	3 (6.1%)
30 (None)		6	(<1)	1 (16.7%)
Not recorded		263	(14)	6 (2.3%)
Hazard Analysis Systems				
In place and documented		1163	(64)	23 (2.0%)
In place and undocumented		209	(11)	4 (1.9%)
In place; document status not recorded		88	(5)	1 (1.1%)
Not in place		113	(6)	6 (5.3%)
Not recorded		246	(14)	3 (1.2%)
Management Food Hygiene Training				
Received training and attended		1581/1819	(87)	33 (2.1%)
Basic 6 hour course		826/1581	(52)	23 (2.8%)
Intermediate course		483/1581	(31)	7 (1.5%)
Advanced course		110/1581	(7)	1 (0.9%)
Other recognised		79/1581	(5)	1 (1.3%)
Not specified		83/1581	(5)	1 (1.2%)
No training		41/1819	(2)	1 (2.4%)
Not recorded		197/1819	(11)	3 (1.5%)

Most samples (86%) were obtained from premises with a consumer at risk score 5 (few numbers of customers, 51%) and 10 (intermediate number of customers, 35%) (Table 11). The proportion of cheeses of unsatisfactory quality collected from premises with a very small number of customers was higher (2.8%) when compared to other premises with larger numbers of customers (1.1%) (p=0.0300).

Most samples (74%) were collected from premises where there was a confidence in management score of 5 (moderate confidence in management/control systems, 39%) and 10 (some confidence in management/ control systems, 35%) (Table 11). Significantly a greater proportion of cheeses of unsatisfactory quality were from premises with high scores (7.3%) (i.e. little or no confidence in the management) compared those with a low score (1.8%) (i.e. some to high confidence in management) ((p= 0.0216) (Table 11).

Hazard analysis systems

Eighty percent of samples were collected from premises that had a hazard analysis in place (64% documented, 11% undocumented; 5% 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 (5.3%) compared to those collected from premises with hazard analysis in place (1.9%) (Table 11) (p=0.0308).

Food Hygiene Training

The majority of samples (87%) were collected from premises whose managers had received some form of food hygiene training (Table 11). The proportion of samples of unsatisfactory quality were similar from premises whether the manager had received food hygiene training (2.1%) or not (2.4%). However, it should be noted that the proportion of samples taken from premises where the manager had not received food hygiene training is comparatively small compared to those that had trained managers. Therefore no statistical conclusions should be drawn from these results.

Discussion

This study has shown that the vast majority (98%) of 1819 retail cheeses made from raw or thermised milk in the UK were of satisfactory or borderline microbiological quality according to criteria in EC Recommendation

2004/24/EC[16]. Likewise, in the following study in 2005 of pasteurised milk cheeses, 98% were found also to be of satisfactory or borderline microbiological quality according to Recommendation 2005/175/EC[17,28]. Only 2% of samples in the present study were unsatisfactory due to *S. aureus* ($\geq 10^4$ cfu/g, 13 samples), *E. coli* ($\geq 10^5$ cfu/g, 25 samples), *L. monocytogenes* ($\geq 10^2$ cfu/g, 1 sample), and the presence of *Campylobacter* spp. in one sample; 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 23 batches examined five were of unsatisfactory quality due to high levels of *S. aureus* (3 samples), *E. coli* (1 sample), and *L. monocytogenes* (1 sample).

The *Salmonella* and *L. monocytogenes* criteria used in Recommendation 2004/24/EC[16] are the same as the food safety criteria in Regulation (EC) No. 2073/2005[29] on the microbiological criteria for foodstuffs that came into force in January 2006. However, this Regulation contains different criteria for *S. aureus* in raw ($\geq 10^5$ cfu/g) and thermised ($\geq 10^3$ cfu/g) milk cheeses which 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[29]. 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. Although Recommendation 2004/24/EC only deemed levels exceeding 10^4 cfu/g as unsatisfactory, levels exceeding 10^3 cfu/g in hard and semi-hard cheeses on retail sale that have a long shelf life should also be viewed with suspicion due to the likely reduction in staphylococcal levels during storage. There are no criteria for *E. coli* in cheeses made from raw or thermised milk in Regulation (EC) No. 2073/2005[29] and it's therefore recommended that *E. coli* O157 be sought for in these cheese types.

S. aureus is the commonest cause of mastitis in dairy animals, and appears to be more common in raw goats' and ewes' milk than in cows' milk[30]. In this study significant numbers (≥10^4 cfu/g) of *S. aureus* were found more in goats' milk cheese (2%) compared with cows' milk cheese (1%), and almost a third of the isolates contained the genes for staphylococcal enterotoxin production. There is published evidence that a high proportion of isolates of *S. aureus* from both goats' and ewes' milk produce enterotoxins[31,32], and outbreaks of staphylococcal food poisoning in France and Scotland in 1984-5 were traced to cheese made from raw ewes' milk[12]. An outbreak in Norway in 2003 was associated with a product made with raw cows' milk containing *S. aureus* that subsequently produced sufficient staphylococcal enterotoxin H to cause food poisoning[33]. It should be noted that post-processing contamination by *S. aureus* is also possible through unhygienic handling of the product.

The prevalence of *L. monocytogenes* observed in retail raw milk cheese in the UK in 2004 (0.9%) was similar to that found in Ireland (0.2%; in 2004)[34] and lower than that previously found in the UK (1.4%; in 1995)[35], in Belgium (46.7%; in 2000-01)[36,] and in Sweden (42%; in 1994)[37]. The serogroups most often causing infection in the UK are serogroups 4b, 1/2a, and 1/2b[38], 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 VII and IX prevalent. Subtype 4b/V that caused the outbreak of listeriosis in England in 2003 attributed to consumption of butter[39] was recovered from one cheese sample in this study. The low prevalence of serogroup 4b in food isolates compared with clinical isolates has also been observed in other countries[40-42].

This study has also highlighted contributory factors likely to cause problems with the microbiological quality of cheeses made from raw or thermised milk. According to microbiological criteria within Recommendation 2004/24/EC[16] cheeses were of unsatisfactory quality more frequently if they were: unripened soft cheese varieties; from premises without hazard analysis system in place; from premises rated as having little or no confidence in management and control systems; from farm shops or markets; stored or displayed above 8°C. Appropriate hygienic measures to avoid contamination from the production environment and appropriate temperature control for soft and ripened cheeses are critical for minimising contamination with and growth of pathogens, such as *L. monocytogenes* and *S. aureus,* in cheeses. Storage of foods must comply with Regulation (EC) No. 852/2004 on the hygiene of foodstuffs[7], i.e. should not be kept at temperatures that might result in a risk to health.

The UK Advisory Committee on Microbiological Safety of Food in 1995 recommended that cheese made from raw milk from cows and other species be labelled with 'made from raw milk' so that consumers can identify it due to concerns that raw milk may contain organisms such as verocytotoxin-producing *E. coli* (VTEC)[43]. At the time of this study there was still no legal requirement to label raw milk cheese in this way. However, Regulation (EC) No. 853/2004 laying down specific rules for food of animal origin does now require that all cheeses made with raw milk and on retail sale must be clearly labelled with the words 'made with raw milk' so as to inform consumer choice[8]. This requirement does not extend to cheeses made with thermised milk i.e. using milk treated with a lower heat treatment than pasteurisation. In nearly a fifth (18%) of raw milk cheeses sampled in the present study there was no labelling information with the product to enable the purchaser to determine whether the cheese was prepared from raw milk. Raw milk cheeses should be clearly labelled as such at all retail outlets. In addition, vulnerable groups, such as pregnant women, are advised not to consume soft mould ripened cheeses such as Camembert, Brie or chevre (a type of goats' cheese), or others that have a similar rind, and blue cheeses as they may contain *L. monocytogenes*[15].

Although risks are attached to the production of cheese from unpasteurised milk, these can be managed provided the cheesemaker is aware of potential hazards and their control. In addition to the EU hygiene regulations that came into force in January 2006[8-9], 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[10].

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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	101
	Norwich	130
London	London FWEM[1]	171
South East	Ashford	68
	Brighton	132
	WEMS[2]	103
West Midlands	Birmingham	23
	Coventry	97
	Shrewsbury& Telford	34
	Hereford	22
North West	Chester	52
	Preston	133
	Carlisle	18
North East, Yorkshire & the Humber	Hull	50
	Leeds	32
	Newcastle	39
	Sheffield	65
South West	Bristol	102
	Exeter	35
	Gloucester	35
	Plymouth	18
	Truro	8
East Midlands	Leicester	20
	Lincoln	134
Total		**1622**

1, London Food, Water & Environmental Microbiology Laboratory
2, Wessex Environmental Microbiological Services

Table II: Participating Other Laboratories and number of samples

Nation	Laboratory	Number of Samples
Northern Ireland	Belfast City Hospital	63
Scotland	Aberdeen City Council Public Analysts	13
	Edinburgh A & S Services	2
	Glasgow Scientific Services	21
Wales	Cardiff	21
	Carmarthen	85
	Rhyl	15
Total		**220**

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

Local Authority Food Liaison Group	Number of Samples
Berkshire	16
Buckinghamshire	4
Cambridgeshire	60
Cheshire	36
Cumbria	25
Derbyshire	39
Devon	38
Dorset	21
Durham	8
East Sussex	68
Essex	49
Gloucestershire	35
LFCG[1] Greater London NE Sector	39
LFCG Greater London NW Sector	24
LFCG Greater London SE Sector	68
LFCG Greater London SW Sector	37
Greater Manchester	68
Hampshire & Isle Of Wight	37
Hereford & Worcester	32
Hertfordshire & Bedfordshire	29
Humberside	48
Kent	35
Lancashire	58
Leicestershire	20
Lincolnshire	60
Merseyside	12
North Yorkshire	30
Northamptonshire	44
Northern Ireland Food Group[2]	63
Norfolk	80
Nottinghamshire	40
Oxfordshire	22
Scottish Food Enforcement Liaison Committee[3]	35
Shropshire	29
Somerset	35
South West Yorkshire	33
Staffordshire	53
Suffolk	34
Surrey	36
Tyne & wear	20
Wales North Group	40
Wales South West Group	85
West Midlands	52
West of England	68
West Sussex	28
West Yorkshire	14
Wiltshire	35
Total	**1842**

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