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Health risks associated with unpasteurized goats' and ewes' milk on retail sale in England and Wales. A PHLS Dairy Products Working Group Study*

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SUMMARY

A pilot study to determine the microbiological quality of unpasteurized milk from goats and ewes sampled from farm shops, health food shops, and other retail premises found that 47%, (47/100) of goats' and 50% (13/26) of ewes' milk samples failed the standards prescribed by the Dairy Products (Hygiene) Regulations 1995. In addition, *Staphylococcus aureus*, haemolytic streptococci or enterococci, were present in excess of 10^2 c.f.u./ml in 9 (7%) 2 (2%) and 19 (15%) samples, respectively. Salmonella, campylobacter, verocytotoxin-producing *Escherichia coli* O157:H7 and *Listeria monocytogenes* were not detected in the samples. At the time of purchase approximately half of the milk samples (58%) were frozen, the rest were liquid. Farm outlets sold predominantly liquid milk, other retail premises sold a frozen product. The microbiological quality of goats' and ewes' milk, whether frozen or liquid, was not significantly different. Milk sold from farm shops was of lower quality than that from health food shops and other retail premises. In this pilot study most producers (92%) supplied, and most retailers (76%) sold unpasteurized goats' and ewes' milk that contained unacceptable levels of indicator organisms. The study was carried out during the winter when goats' milk production is reduced. The results indicate the need for a full representative study of unpasteurized goats' and ewes' milk on retail sale throughout the year.

INTRODUCTION

The public health problems associated with the consumption of unpasteurized cows' milk have been well documented [1–3] and there is no evidence that the risk from unpasteurized ewes' or goats' milk is any less. Pathogenic microorganisms can gain access to milk either from faecal contamination, particularly around the teats, or by direct excretion from the udder into the milk. *Salmonella* sp., *Campylobacter* sp., *Listeria monocytogenes* and enterotoxigenic *Staphylococcus aureus* are zoonotic pathogens of sheep and goats in the UK and acquisition of other pathogens such as *Toxoplasma gondii*, *Coxiella burnetti* and *Brucella melitensis* has also been associated with consumption of unpasteurized goats' milk and cheese in Europe, Canada and the USA [4]. Goats and sheep may also be a reservoir for verocytotoxin-producing *E. coli* O157:H7 [5–9] and this is of particular concern because of its extreme virulence and the low dose needed to produce infection [10]. Recent outbreaks in the UK (Scottish Centre for Infection and Environmental Health (SCIEH), unpublished) and in the Czech Republic [9] confirm the risk of infection with this organism.

There is a small, but growing, demand for unpasteurized goats' and ewes' milk in the UK. Within England and Wales there are some registered commercial producers [11] of unpasteurized goats' milk,

* The following laboratories belonging to the PHLS Dairy Products Working Group participated: Ashford, Carmarthen, Chelmsford, Epsom, Exeter, Hereford, Lincoln, Luton, Middlesbrough, Norwich, Plymouth, Poole, Portsmouth, Preston, and Shrewsbury/Telford.

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however most production and sale of this milk is by smaller, unregistered, producers. Unpasteurized goats' milk is used as a nutritional substitute for cow's milk particularly for young children, and also for cases of cows' milk sensitivity and allergy [12]. There is currently little information on the microbiological quality of unpasteurized goats' and ewes' milk other than that from a Public Health Laboratory Service (PHLS) study which examined 2477 samples between June 1982 and May 1983 [13]. In this study *Salmonella* sp. were not detected but *C. jejuni* and *Yersinia enterocolitica* were isolated from one and two samples, respectively.

Under the Dairy Products (Hygiene) Regulations 1995 [11], 'pathogenic microorganisms and their toxins shall not be present in quantities such as to affect the health of the ultimate consumer' in addition, unpasteurized goats' and ewes' milk sold directly to the ultimate consumer must not have aerobic plate or coliform counts exceeding 20000 and 100 c.f.u./ml, respectively.

The Advisory Committee on the Microbiological Safety of Food (ACMSF) has expressed concern at the high levels of faecal indicator microorganisms and in some cases, pathogenic organisms present in unpasteurized cows' drinking milk on retail sale in England and Wales [14]. The problems associated with unpasteurized cows' milk were further emphasized by the recent PHLS study [15]. Because of the lack of recent information on the microbiological quality of unpasteurized goats' and ewes' milk on retail sale, and the growth in demand, a pilot study was carried out on milk produced from unregistered producers and sold in England and Wales. For comparison the parameters examined were the same as that in the cows' milk study [15]. Despite the seasonal variation in goats' milk production with a peak in the spring/summer the pilot study was performed in the winter in order to obtain information quickly and to supplement the findings from a parallel Ministry of Agriculture, Fisheries and Food (MAFF) study of 111 samples mostly, from registered producers of goats' milk, so as to inform the current debate on unpasteurized milk.

METHODS

Sample collection

The study took place between January and March 1998 and involved local authorities and Public Health Laboratory Service laboratories (PHLSs) in England and Wales. Participating laboratories were those with more than ten accessible small-scale producers and/or retail outlets in their locality. A standardized protocol and reporting system was used. Samples were collected by staff from either the local PHL or environmental health department (EHD) in accordance with the Food Safety Act 1990, Code of Practice No. 7 [16]. Frozen and liquid samples of unpasteurized goats' and ewes' milk (one pint or half a litre) were collected from retail outlets, such as farm gate/shops, health food shops, and supermarkets. Information on the sample, including details about the producing establishment, was obtained by observation and enquiry and recorded on a standard proforma.

Isolation of bacteria

Frozen milk samples were thawed immediately prior to examination by placing the container in a waterbath at 37 °C until just melted. A phosphatase test on an undiluted sample of unpasteurized milk was performed either by a fluorimetric method according to British Standard (BS) ISO 11816-1 [17] or the Aschaffenburg–Mullen (A–M) method [18]. The procedures followed for aerobic plate count (APC) determination and enumeration of coliforms and *Escherichia coli* are reference procedures specified in the Dairy Products (Hygiene) Regulations 1995 [11].

APCs were determined according to British Standard (BS) 4285: Section 2.1 [19] by pour plating or by surface spiral plating [20]. Plates were incubated at 30 °C for 72 h. A 3×3-tube most probable number (MPN) method based on BS ISO 11866-2: Part 2 [21] and BS 5763: Part 3 [22] was used to enumerate *E. coli* and coliforms, with confirmation in brilliant green bile broth (BGBB; Oxoid, UK) in place of EC broth [20]. Isolation and enumeration of *Staph. aureus* was in accordance with BS 5763: Part 7 [23] by surface or spiral plating [20]. Isolation and enumeration of haemolytic streptococci were by surface plating on streptococcus selective medium (Oxoid, UK). Inoculated plates were incubated at 35 °C overnight in 5% carbon dioxide or anaerobically. The identity of colonies of each colonial type were confirmed by biochemical tests and Lancefield grouping. Isolation and enumeration of enterococci was in accordance with BS 4285: Section 3.11 [24] by surface plating. Isolation and enumeration of *Listeria* sp. and *L. monocytogenes* were based on BS 4285: Section 3.15 [25] with pre-enrichment in buffered peptone water

Table 1. *Type and source of unpasteurized goats' and ewes' milk*

Source	Raw milk		
	Frozen ($n = 76$)	Liquid ($n = 55$)	Total ($n = 131$)
(*a*) Outlet			
Farm (gate/shop)*	39 (51%)	44 (80%)	83 (63%)
Health food shop	28 (37%)	6 (11%)	34 (26%)
Other†	9 (11%)	5 (9%)	14 (11%)
(*b*) Container			
Glass bottle	11 (15%)	8 (15%)	19 (15%)
Carton	36 (47%)	15 (27%)	51 (39%)
Plastic bag	25 (33%)	19 (35%)	44 (34%)
Other‡	3 (4%)	8 (15%)	11 (8%)
Not recorded	1 (1%)	5 (9%)	6 (4%)
(*c*) Storage temperature			
Frozen	76 (100%)	0	76 (58%)
Refrigerated	0	38 (69%)	39 (29%)
Ambient	0	1 (2%)	1 (1%)
Other§	0	16 (29%)	16 (12%)

* Supplied by either own or other producers.
† Shop (11), delicatessen (2), supermarket (1).
‡ Plastic bottles (9), jar (1), jug (1).
§ For 29% of liquid samples the display temperature was not apparent to the Sampling Officer or customer.

(Oxoid, UK) in place of tryptone soya broth [20]. An incubation temperature of 30 °C was used throughout for *Listeria* sp. and *L. monocytogenes*.

Aliquots of 100 ml unpasteurized milk were cultured by enrichment methods for the presence of campylobacter, salmonella and *E. coli* O157:H7. *Campylobacter* sp. were detected in accordance with BS 5763: Part 17 [26] with campylobacter enrichment broth (Preston broth with cefoperazone selective supplement; Oxoid, UK) and modified charcoal cefoperazone deoxycholate agar (CCDA; Oxoid, UK) as selective media. *Salmonella* sp. were detected in accordance with BS EN 12824 [27]. *E. coli* O157:H7 was detected by enrichment in pre-incubated (42 °C) modified tryptone soya broth (MTSB) containing novobiocin (20 mg/l) with either subculture (100 μl) to cefixime tellurite sorbitol MacConkey (CT-SMAC) agar after 6 and 24 h, or Immunomagnetic Separation (IMS) after 6 and 24 h and selective plating on CT-SMAC. Inoculated plates were incubated at 37 °C for 20 ± 2 h [28, 29].

RESULTS

Prior to the study producers of unpasteurized goats' and/or ewes' milk in England and Wales were identified by local enquiry and a database produced. This database contains information on producers not registered with MAFF and currently contains information on 102 goats' milk and 20 ewes' milk producers who sell unpasteurized milk directly or indirectly to the public. A total of 131 unpasteurized milk samples were examined by 14 PHLS laboratories, of which 105 (80%) were goats' milk and 26 (20%) were ewes' milk. Inadvertently seven samples in this study were collected from two MAFF registered producers.

Type and source of unpasteurized milk

Milk samples were purchased from 79 retail outlets. Approximately half of the 131 samples (58%) were frozen, the rest (42%) were liquid. The type of sample examined and the source from which they were obtained are given in Table 1*a*. Details of storage temperature and the type of container in which the milk was distributed are also provided in Table 1*b*, *c*. The samples came from 65 producers, of which 56 (86%) produced goats' milk and 9 (14%) produced ewes' milk, approximately half (48%) sold unpasteurized milk directly to the final consumer. Two-thirds did not pasteurize any milk on the premises (43/65; 66%) or send milk elsewhere for pasteurisation (30/43; 70%). The total output of milk per

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Table 2. *Microbiological results of unpasteurized goats' and ewes' milk (n = 126)*

	n.d.* in 100 ml	n.d.	$< 10^2$†	10^2–$< 10^3$	10^3–$< 10^4$	10^4–$< 10^5$	10^5–$< 10^6$	10^6–$< 10^7$	$\geqslant 10^7$
(*a*) Goats' milk (*n* = 100)									
APC‡		5[a]		21	30	25	16	2	1
Coliforms		51[b]	38	5	2	2	2		
Escherichia coli		82[b]	18						
Enterococci		75[c]	13	4	5	3			
Staphylococcus aureus		85[c]	9	4	1	1			
Haemolytic streptococcus		96[c]	2	1	1				
Listeria sp.		100[c]							
Listeria monocytogenes		100[c]							
Salmonella sp.	100								
Campylobacter sp.	100								
Escherichia coli O157:H7	100								
(*b*) Ewes' milk (*n* = 26)									
APC‡		0[a]		4	10	10	1	1	
Coliforms		3[b]	19	4					
Escherichia coli		13[b]	13						
Enterococci		9[c]	10	6	1				
Staphylococcus aureus		17[c]	6	2		1			
Haemolytic streptococcus		20[c]	6						
Listeria sp.		26[c]							
Listeria monocytogenes		26[c]							
Salmonella sp.	26								
Campylobacter sp.	26								
Escherichia coli O157:H7	26								

* n.d., not detected.
‡ APC, aerobic plate count.
[a] Lower limit of detection 10 c.f.u./ml; [b] lower limit of detection 3 c.f.u./ml; [c] lower limit of detection 20 c.f.u./ml.
† c.f.u./ml.

producer ranged from 1–475 l/day (average; 37 l/day), of which milk for retail sale ranged from 1–50 l/day (average, sold; 10 l/day).

Microbiological examination and quality of unpasteurized goats' and ewes' milk samples

A total of 131 samples were examined. Five of these samples were phosphatase negative indicating that they had been pasteurized. Results on these samples were not included in the analysis (Table 2*a*, *b*). The APC exceeded 10^4 c.f.u./ml in 37% (46/126) of samples. Coliforms or enterococci in excess of 10^2 c.f.u./ml were present in 15 (12%) and 19 (15%) samples, respectively. *E. coli* was not present in excess of 10^2 c.f.u./ml; 31 (25%) samples contained *E. coli* at counts less than 10^2 c.f.u./ml. *Staph. aureus* and haemolytic streptococci in excess of 10^2 c.f.u./ml were present in 9 (7%) and 2 (2%) unpasteurized milk samples, respectively. The pathogens, *Salmonella* sp., *Campylobacter* sp., *E. coli* O157:H7 and *L. monocytogenes* were not detected in any of the milk samples. The 11 samples containing *Staph. aureus* (> 10^2 c.f.u./ml) or haemolytic streptococci (> 10^2 c.f.u./ml) came from 8 different producers and 8 separate retail outlets (2 of the producers were also the retailers).

Forty-eight per cent (60/126) of samples examined failed the legal standards [11] for aerobic plate and/or coliform counts and were therefore unsatisfactory (Table 3). These samples came from 76% (60/79) of retail outlets, and were supplied by 92% (60/65) of the producers. The APC for 3% (4/126) of samples (three different producers) also exceeded the threshold for milk prior to heat treatment ($> 3 \times 10^6$ c.f.u./ml) as prescribed in the Dairy Products (Hygiene) Regulations 1995. Multiple unpasteurized goats' milk samples were collected from 5 different producers (up to 7 each). Between 50 and 75% of all samples supplied by these producers, over the 3-month sampling period, were of unsatisfactory microbiological quality, i.e. failed the legal standards for

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Table 3. *Microbiological quality of unpasteurized goats' and ewes' milk as judged by legal standards (Dairy Products (Hygiene) Regulations 1995 [11])*

Unpasteurized milk	Passed	Failed*	Total
Total	66 (52%)	60 (48%)	126
Goats'	53 (53%)	47 (47%)	100
Ewes'	13 (50%)	13 (50%)	26
Frozen	40 (55%)	33 (45%)	73
Liquid	26 (49%)	27 (51%)	53

* Aerobic plate count $> 2 \times 10^4$ c.f.u./ml and/or coliforms $> 10^2$ c.f.u./ml.

Table 4. *Microbiological quality of unpasteurized goats' and ewes' milk in different containers as judged by legal standards (Dairy Products (Hygiene) Regulations 1995 [11])*

Milk container	Passed	Failed*	Total
Glass bottle	10 (53%)	9 (47%)	19
Carton	24 (50%)	24 (50%)	48
Plastic bag	21 (50%)	21 (50%)	42
Other†	9 (82%)	2 (18%)	11
Not recorded	2 (33%)	4 (67%)	6
Total	66 (52%)	60 (48%)	126

* Aerobic plate count $> 2 \times 10^4$ c.f.u./ml and/or coliforms $> 10^2$ c.f.u./ml.
† Plastic bottles (9), jar (1), jug (1).

aerobic plate and/or coliform counts. The total output of milk per producer was found not to be significant regarding the microbiological quality of milk. In proportion, significantly more samples collected from farm shops (58%; 48/83) were of unsatisfactory microbiological quality compared to those from health food shops (26%; 9/34) and other retail premises (21%; 3/14) ($P < 0{\cdot}01$). The microbiological quality of the sample was largely independent of the type of container (Table 4). There was no significant difference in microbiological quality between goats' or ewes' milks, frozen or liquid goats' milk, frozen or liquid ewes' milk (Table 3).

Shelf-life

The number of days between the date of production and the use-by-date was determined for both liquid and frozen unpasteurized milk samples. There was no apparent variation in the microbiological quality of liquid samples with remaining shelf-life, approximately two-thirds of samples with a remaining shelf-life of either 1, 2 or 3 days had unsatisfactory aerobic plate and/or coliform counts. Frozen milk samples with a shelf-life of 3 months remaining were more likely to be satisfactory as judged by the Dairy Product (Hygiene) Regulations 1995 [11] (62%; 18/29) than samples with a shelf-life of 2 or less months remaining (50% 15/30), or those for which no shelf-life was specified (45%; 9/20).

DISCUSSION

Although *Salmonella* sp., *Campylobacter* sp., *L. monocytogenes* and *E. coli* O157:H7 were not detected in our pilot study, *E. coli* was present in 25% of unpasteurized milk, and coliforms and enterococci, which are also indicators of faecal contamination, were present in 12 and 15% respectively, suggesting a potential risk. The hygienic quality of these milks as judged by aerobic plate count (APC) and the presence of coliforms was poorer than that found in the previous PHLS survey of unpasteurized goats' milk [13]. Furthermore, approximately half of the milk samples reported here failed the legal standards [11] for APC and/or coliform counts.

Staph. aureus appears to be more common in goats' and ewes' milk than in cows' milk [30] and our finding of significant numbers ($> 10^2$ c.f.u./ml) in 6% of goats' milks and 11·5% of ewes' milks compared with only 1% of cows' milks [15] confirms this. There is published evidence that a high proportion of isolates of *Staph. aureus* from both ewes' and goats' milk produce enterotoxins [30] and that some isolates of coagulase-negative staphylococci, which are a common cause of subclinical mastitis in these animals, also produce enterotoxins [4]. Outbreaks of staphylococcal food poisoning in France and Scotland in 1984–5 were traced to cheese made from unpasteurized ewes' milk [31].

Goats' milk production in the UK is seasonal which peaks during the spring and summer. The results from this study, which took place during winter, therefore indicate the need for a full representative study of unpasteurized goats' and ewes' milk on retail sale throughout the year. However, on the basis of the results from this small study together with published evidence we consider that the continuing retail sale of unpasteurized milk from cows, sheep or goats constitute an unacceptable risk to public health.

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