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A large outbreak of food poisoning of unknown aetiology associated with Stilton cheese

H. C. F. MAGUIRE[1], M. BOYLE[2], M. J. LEWIS[3], J. PANKHURST[4], A. A. WIENEKE[5], M. JACOB[6], J. BRUCE[1] AND M. O'MAHONY[1]

[1] *Public Health Laboratory Service (PHLS) Communicable Disease Surveillance Centre, 61 Colindale Avenue, London NW9 5EQ*

[2] *Eastern Health and Social Services Board, 12/22 Linenhall Street, Belfast BT2 8BS*

[3] *Department of Microbiology and PHLS Laboratory, University Hospital, Queens Medical Centre, Nottingham NG7 2UH*

[4] *Rushcliffe Borough Council, Housing and Health Department, Rushcliffe Civic Centre, Nottingham, Nottinghamshire*

[5] *PHLS Food Hygiene Laboratory, 61 Colindale Avenue, London NW9 5HT*

[6] *Department of Health, Eileen House-Room 103, 80–94 Newington Causeway, Elephant & Castle, London SE1 6EF*

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SUMMARY

Between November 1988 and January 1989, a total of 155 people in 36 reported outbreaks suffered gastrointestinal symptoms associated with eating Stilton cheese, produced from unpasteurized cow's milk in the English midlands. Symptoms were suggestive of a staphylococcal illness but extensive laboratory testing of cheeses implicated in several of the outbreaks failed to detect any pathogen, toxin or chemical. Control measures were implemented, and included a voluntary withdrawal of the implicated Stilton cheese from sale on 23 January 1989 and a subsequent decision to use pasteurized milk in production of the cheese.

INTRODUCTION

In January 1989, the Public Health Laboratory Service (PHLS) Food Hygiene Laboratory (FHL) received three separate requests for analysis of cheeses associated with gastrointestinal illness. The cheeses were all unpasteurized stiltons made at a small dairy cooperative in the English midlands. The PHLS Communicable Disease Surveillance Centre (CDSC) was informed and an investigation was carried out to determine if a gastrointestinal illness was associated with the consumption of this cheese. We describe the results of the investigation into 36 outbreaks of food poisoning.

METHODS

Epidemiological

A case of gastrointestinal illness was defined as any person who became ill with nausea, or vomiting, or diarrhoea defined as two or more loose stools in a 24-h period and who had been associated with a food poisoning incident in which cheese was served. A case search was carried out by placing a note in the Communicable Disease Report requesting information on food poisoning incidents believed to be related to Stilton cheese. Two studies were conducted. The first was a descriptive study designed to obtain information on symptoms, severity of illness, incubation period, as well as cheese consumed and this was carried out by Local Authority Environmental Health Officers, either in person or by telephone using a standard questionnaire. In the second study, three cohorts of people who became ill following separate meals were investigated using a telephone questionnaire administered by medical staff from CDSC. Information was requested on symptoms, incubation period and food consumed at the meals and analysis was carried out using the Epi-Info computer statistical package and the Fisher's exact 2-tailed test.

Environmental and microbiological

Following the initial report from the FHL, the dairy was inspected. At the time of the investigation, the dairy was the only one in England making Stilton cheese from unpasteurized milk. Each batch of cheese took approximately 7–8 weeks to complete processing. At each of five farms supplying the dairy, milk from the morning milking was added to the previous afternoon's milk which had been stored overnight in a holding tank. This milk was then delivered to the dairy.

Environmental swabs for culture were taken from equipment and surfaces at several sites and recordings made of temperture and pH levels at various stages of cheese processing at the dairy.

Samples of Stilton cheeses thought to be associated with illness as well as cheeses from the same dairy not associated with illness were examined for staphylococci, staphylococcal enterotoxin, histamine levels and fungi at the PHLS Food Hygiene Laboratory (FHL), and the PHLS Mycological Reference Laboratory, Colindale. Stilton cheeses from other producers were similarly tested. Five Stilton cheeses, including three suspect cheeses from the same dairy were also examined for heavy metals and chemical substances using gas liquid chromatography and mass spectrometry at the National Poisons' Unit, Guy's Hospital, London and the Ministry of Agriculture, Fisheries and Food, Agriculture and Food Research Council, Norwich respectively. Samples of milk from each of five farms supplying the dairy were tested for total viable counts (TVCs). In addition, samples of milk and cheese from different stages in cheese production at the dairy, during a trial run period after the outbreak, were obtained and were analysed for TVCs, staphylococci, streptococci and *Escherichia coli*.

Fig. 1. Location of 36 outbreaks of food poisoning related to Stilton cheese consumption within regional health authority districts.

RESULTS

Epidemiological

Thirty-six incidents of food poisoning involving 155 cases were reported to CDSC during January 1989 of which 26 were located in south-east England (Fig. 1). The first reported incident was associated with a meal consumed on 19 November 1988, and the last on 25 January 1989 (Fig. 2). The cheeses were bought at various times from 18 November 1988 to 21 January 1989. In a descriptive study, Environmental Health Officers obtained information using a structured questionnaire on 88 affected cases in 24 outbreaks. Of the 88 cases interviewed, 50 men and 38 women, 49 were aged 20–39 years and 33 were aged 40–59 years. Eighty-four cases complained of nausea while 78 experienced vomiting which was severe and forceful enough in two cases to result in blood-staining of vomitus. Abdominal pain and diarrhoea were reported by just over half the cases while feeling cold or shivery was reported by 45. Altogether 28 experienced other symptoms including lassitude, lightheadedness and weakness. The incubation

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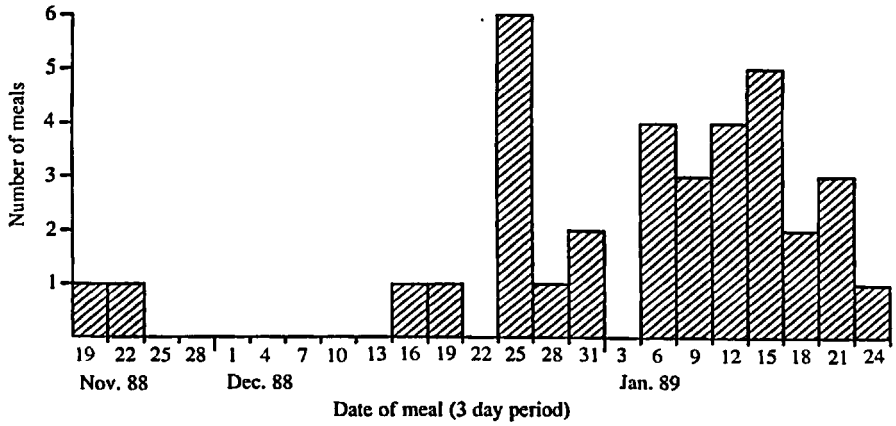

Fig. 2. Dates of meal when Stilton cheese was eaten in 35 outbreaks (date of meal uncertain in one outbreak).

Table 1. *Incubation periods reported by cases in descriptive study* ($n = 88$)

Hours	No.	(%)
2–6	71	(81)
7–8	11	(12)
9–13	5	(6)
14–18	1	—
	88	(100)

period ranged from 2·5 to 17·5 h with a median of 5 h and 82 (93%) reported an incubation period between 2 and 8 h (Table 1). The median duration of illness was 5 h and ranged from 1 h to 5 days. Symptoms abated in 24 h in 83 (94%) cases. Nine persons consulted their doctor and one was admitted to hospital for a short period. There were no deaths and all recovered uneventfully. Amongst a selection of possible cheeses, Stilton cheese was reported to have been eaten by 73 of these 88 cases.

In the second study a questionnaire was completed for all 71 members of three cohorts. In the first cohort a significant association was found between illness and the consumption of Stilton cheese originating from the suspect dairy (Table 2). Among 36 people in a further cohort a significant association was found between illness and eating three cheeses Yarg, Stilton and smoked Cheddar (Table 3). It was not possible to determine an independent association between illness and eating any individual cheese. The third cohort study ($n = 14$) failed to demonstrate an association between illness and any particular food item.

Environmental and microbiological

The temperature of milk on arrival at the dairy ranged from 4—10 °C. The milk was subsequently pumped to cheese vats via a heat exchanger set at 27 °C. A streptococcal starter culture, supplied from another local dairy, was then added to the vats with a powder form of the blue mould, *Penicillium roqueforti*. During the investigation the temperature in the vats was 30 °C and the pH varied from 6·5–6·7. Whey was drained off and curds were ladled into coolers and left to drain

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Table 2. *Cohort study (1). Association between illness and consumption of Stilton cheese (n = 21)*

Consumed Stilton cheese	Ill	Not ill	Total
Yes	4	0	4
No	3	13	16
Total	7	13	20*

* One respondent was unsure.

Relative risk of illness for consumption of Stilton cheese = 5·33 (95% confidence interval 1·92–14·79). 2-tailed Fisher's exact test, $P = 0·01$, significant.

Table 3. *Cohort study (2). Food-specific attack rates (n = 36)*

	Ate food item		Did not eat food item		Fisher's exact 2-tailed test
	Ill	Not ill	Ill	Not ill	*P* value
Yarg	4	3	2	20	0·04
Sharpham	4	3	4	19	NS
Stilton	6	5	2	17	0·03
Cheddar	4	5	3	16	NS
Smoked Cheddar	6	4	3	18	0·03

NS, not significant.

overnight with the temperature between 20 and 22 °C, and the pH between 4·7 and 4·9. The curds were then cut, milled, salted and mixed by hand and placed into hoops which were left to drain in a 'hastening room' for 1 week where their temperature ranged from 19 to 22 °C (pH 4·7–4·9). In the first of three 'maturing rooms' the cheese temperature was 8 °C and the pH was 4·7–4·9. After 7 days the cheeses were transferred to a second and later to a third 'maturing room' where the pH was found to vary from 4·7 up to 6·6. All vats, coolers and other equipment were well constructed and maintained.

Samples of Stilton cheese associated with illness in 23 separate outbreaks, and three Stilton cheeses from the same dairy but unassociated with illness, were tested for the presence of *Staphylococcus aureus*. Twelve samples of Stilton cheese thought to have caused illness and three Stiltons from the same dairy but unrelated to illness were tested for the presence of staphylococcal enterotoxin. A single *S. aureus* strain which produced enterotoxin D was isolated from one suspect sample by enrichment only. The dairy mould, *Geotrichum candidum* was present at high levels in all cheeses made at the dairy but was absent in Stilton cheese made from pasteurized milk by another producer. Histamine levels in 11 suspect and 3 Stilton cheeses unconnected with illness ranged from 4·5 to 51 mg/100 g. The levels in Stilton cheese from the suspect dairy were generally higher than those found in two further Stilton cheeses made from pasteurized milk by another dairy (3·9 and 6 mg/100 g). Environmental swabs failed to grow any potential pathogen.

Five separate days unpasteurized milk supplies to the dairy during February 1989 were followed through the entire cheese making process and sampled at

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various stages. TVCs in the in-coming milk ranged from $1{\cdot}0 \times 10^3$ to $2{\cdot}0 \times 10^4$ per ml and *E. coli* from none to 200 per ml. No *S. aureus* was detected. The maximum TVC in cheese was 5×10^6 per g; this value was obtained late in the cheese making process (i.e. in the 6th week of production). Other organisms detected were streptococci at a maximum concentration of 5×10^4 per g, *E. coli* at 1×10^4 per g and staphylococci at 1×10^3 per g. All staphylococci detected were *Staphylococcus epidermidis*.

Heavy metals were not found in any cheeses examined. An unusual pattern was found on gas chromatography of two suspect cheeses and subsequent analysis of cheeses by mass spectrometry confirmed the presence of the following compounds: acetone, 2-pentanone, 2-pentanol, methyl butanoate and 2-heptanone. These compounds appeared in all of the cheeses sampled.

There were no batch numbers on the cheeses and no record was held of cheese distribution to retail outlets. It was reported that the dairy had been operating to its maximum capacity in order to meet increased demand over the Christmas period.

Control measures included a voluntary withdrawal from sale of the suspect cheese on 23 January 1989 and a subsequent decision to use pasteurized milk in production of the cheese.

DISCUSSION

The results of one of the three cohort studies showed an association between illness and the consumption of the suspect unpasteurized Stilton cheese. An association between illness and consumption of several cheeses including Stilton was found in a second study where the cheeses had been served from a mixed platter.

In England and Wales during 1951–87, cheese was implicated as the vehicle of infection in 29 outbreaks of communicable disease reported to CDSC [1–5]. Of the 29 cheese related outbreaks 12 involved cheddar cheese and of the remaining 17; one in 1965, involved Stilton; another involved canned cheese from American; one farmhouse Cheshire; one homemade soft cheese; one Romanian hard cheese; one Camembert; one Gorgonzola; one Pecorino; and one 'red' cheese. The type of cheese was unknown in the others (CDSC unpublished data). *S. aureus* was implicated in 18 of the 29 cheese related outbreaks of food poisoning.

The illness in this reported outbreak, characterized by a rapid onset of nausea and severe vomiting with abdominal pain, was similar to staphylococcal enterotoxin food poisoning [6–10] although the incubation period and duration of illness was longer in some cases than might have been expected. Although a single *S. aureus* strain which produced enterotoxin D was isolated by enrichment it was felt unlikely to have been significant. A previous study at the FHL, Colindale, found that up to 11% of *S. aureus* which were isolated from cheeses unconnected with illness produced enterotoxin and that most of these produced enterotoxin D [11]. A survey of 20 varieties of cheese in the United States found that 7% contained coagulase-positive staphylococci [12], of which only some would be capable of producing enterotoxin. While it is sometimes difficult to extract and detect the enterotoxin from cheese, it is unusual to detect enterotoxin in a food associated with food poisoning from which *S. aureus* cannot be isolated [13, 14].

Wide variations in enterotoxin levels, pH, and bacterial counts have been shown to occur between and within blocks of certain cheeses [15]. Thus, it remains a possibility that a staphylococcal enterotoxin which was undetected on testing, or for which a test is presently unavailable, produced this illness. Although chemical contamination could also possibly have caused a similar illness, extensive tests failed to reveal any potentially harmful substance in cheeses.

Cheese starter bacteria are usually streptococci and act as competitive inhibitors of pathogenic bacteria. Reduced activity or failure of starter bacteria may lead to the proliferation of unwanted pathogens [16]. Although the number of streptococci detected on examination of this cheese, during a trial production run after the outbreak, did not suggest any lack of activity, expected levels in this cheese were unknown. The expected fall in pH following the introduction of starter culture and blue mould was found to take up to 6 h, which might possibly have favoured multiplication and toxin production by staphylococci if they were present. The high levels of *E. coli* detected did suggest that contamination may have occurred. Indeed, a relationship has been found between the presence of coliform organisms and the presence of pathogenic organisms including *S. aureus* in cheese [17].

Storage of cheese for an inadequate period prior to consumption has been found to favour bacterial multiplication [18]. In Canada and the USA, regulations exist in some areas which not only preclude the use of unpasteurized milk in cheese manufacture but also the sale of any cheese prior to the expiry of a minimum maturing period of between 60 and 90 days. Further regulations govern the temperature at which cheese is to be maintained during ripening; in most states in the USA, the recommended minimum temperature is 58 °F (19 °C) during the first 10 days of storage and 35 °F (11 °C) for the remainder [19]. Any pathogenic bacteria in cheese tend to die out more quickly at higher temperatures. The Stilton cheese implicated in this outbreak was stored for 42 days with the temperature at 19–22 °C during the first week of storage, and 8 °C during the remainder of maturing time.

Although a histamine-like illness with both flushing and a rash was reported in one case, histamine levels found in suspect cheeses were considered acceptable for blue cheese [20]. The presence of amines in other foods such as fish are thought to indicate bacterial spoilage [21].

The dairy mould *Geotrichum candidum* was found in all Stilton cheeses made at the dairy but not in other Stilton cheeses made from pasteurized milk. Previous reports of human illness related to this fungus in yoghurt, suggested that a longer incubation period and a diarrhoeal illness was more common [22]. Thus the significance of the finding is doubtful. The volatilizable substances found on mass spectrometry, have all been reported as major usual volatiles in cheese [23–25].

It was concluded that the vehicle of infection in these outbreaks was unpasteurized cow's milk Stilton cheese. The aetiological agent could not be identified. A staphylococcal enterotoxin may possibly have caused illness but the absence of enterotoxin or *S. aureus* organisms in implicated cheeses did not support this hypothesis.

Pasteurization of all milk both for human consumption and for the manufacture of cheese has been strongly recommended in England and Wales [26, 27] but there is currently no legislation prescribing such practice. This may need to be

reconsidered in the light of increasing concerns regarding the risks of human illness associated with eating cheese [13, 28, 29].

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REFERENCES

1. Galbraith NS, Forbes P, Clifford C. Communicable disease associated with milk and dairy products in England and Wales 1951–80. Br Med J 1982; **284**: 1761–5.
2. PHLS Communicable Disease Surveillance Centre. Disease attributed to dairy products. Br Med J 1982; **285**: 1664.
3. PHLS Communicable Disease Surveillance Centre. Disease associated with milk and dairy products: 1982. Br Med J 1984; **288**: 466–7.
4. Barrett NJ. Communicable disease associated with milk and dairy products in England and Wales 1983–1984. J Infect 1986; **12**: 265–72.
5. Anonymous. Communicable disease associated with milk and dairy products England and Wales 1985–86. CDR 87/49, pp. 3–4.
6. Hughes JM, Tauxe RV. Food-borne disease. In: Mandell GL, Douglas RG, Bennett JE, eds. Principles and practice of infectious disease: gastrointestinal infections and food poisoning. 3rd ed. New York, Edinburgh, London, Melbourne: Churchill Livingstone, 1990: 893–4.
7. Holmberg SD, Blake PA. Staphylococcal food poisoning in the United States. JAMA 1984; **251**: 487–9.
8. Woolaway MC, Bartlett CLR, Wieneke AA, Gilbert RJ, Murrell HC, Aureli P. International outbreak of staphylococcal food poisoning caused by contaminated lasagne. J Hyg 1986; **96**: 67–73.
9. Robinson M, Houghton A, Lau YK, Cawley CJ, Corfield DF, John HH. Outbreak of food poisoning in the City of London. CDR 89/02, pp. 3–4.
10. Bergdoll MS. *Staphylococcus aureus*. In: Doyle MP, ed. Foodborne bacterial pathogens. New York: Marcel Dekker Inc, 1989: 21–70.
11. Wieneke AA. Enterotoxin production by strains of *Staphylococcus aureus* isolated from food and human beings. J Hyg 1974; **73**: 255–62.
12. Mickelsen R, Foltz VD, Martin WH, Hunter CA. The incidence of potentially pathogenic staphylococci in dairy products at the consumer level. II. Cheese. J Milk Food Tech 1961; **24**: 342–5.
13. Bone FJ, Bogie D, Morgan-Jones SC. Staphylococcal food poisoning from sheep milk cheese. Epidemiol Infect 1989; **103**: 449–58.
14. Ahmed AAH, Moustafa MK, Marth EH. Growth and survival of *Staphylococcus aureus* in Egyptian domiati cheese. J Food Protect 1983; **46**: 412–5.
15. Todd E, Szabo R, Robern H, Gleeson T, Park C, Clark DS. Variation in counts, enterotoxin levels and TNase in Swiss type cheese contaminated with *Staphylococcus aureus*. J Food Protect 1981; **44**: 839–48.
16. Ibrahim GF, Radford DR, Baldock AK, Ireland LB. Inhibition of growth of *Staphylococcus aureus* and enterotoxin A production in cheddar cheese produced with induced starter failure. J Food Protect 1981; **44**: 189–93.

17. Keogh BP. Reviews of the progress of dairy science. J Dairy Res 1971; **38**: 91–111.
18. dos Santos EC, Genigeorgis C. Survival and growth of *Staphylococcus aureus* in commercially manufactured Brazilian minas cheese. J Food Protect 1981; **44**: 177–84.
19. Fabian FW. Cheese and its relation to disease. Am J Public Health 1947; **37**: 987–96.
20. Chambers TL, Staruszkiewicz WF. Fluorometric determination of histamine in cheese. J Assoc Off Anal Chem 1978; **51**: 1092–7.
21. Sen NP. Analysis and significance of tyramine in foods. J Food Sci 1969; **34**: 22–6.
22. Mackenzie DWR. Torulopsis and Geotrichum. CDR 76/24, p. 3.
23. Schwartz DP, Parks OW. Quantitative analysis of methyl ketones in blue cheese fat. J Dairy Sci 1963; **46**: 989–90.
24. Jolly RC, Kosikowski FV. Flavor development in pasteurized milk blue cheese by animal and microbial lipase preparations. J Dairy Sci 1975; **58**: 846–52.
25. King ED, Clegg GH. The metabolism of fatty acids, methyl ketones and secondary alcohols by *Penicillium roqueforti* in blue cheese slurries. J Sci Food Agric 1979; **30**: 197–202.
26. The Microbiological Safety of Food. Part I. Report of the Committee on the Microbiological Safety of Food. London: HMSO, 1990.
27. Milk Marketing Board (MMB). The Dairy Farmers Co-Operative. Guidelines for good hygienic practice for the manufacture of soft and fresh cheeses in small and farm based production units. February 1989.
28. Azadian BS, Finnerty GT, Pearson AB. Cheeseborne listeria meningitis in immunocompetent patient. Lancet 1989; i: 323.
29. Bannister BA. *Listeria monocytogenes* meningitis associated with eating soft cheese. J Infect 1987; **15**: 165–8.