

## The provision of bacteriologically safe infant feeds in hospitals

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### SUMMARY

Infant feeds, to be safe, must be free from potentially pathogenic organisms but not necessarily sterile. In-bottle terminal heating is the preferred means of producing such feeds and the advantages and disadvantages of high and low pressure heating methods, including the effect upon the food value of the feeds, are discussed. The safety of a low pressure method in use in Princess Alexandra Hospital, Harlow is described. The choice of method of provision of safe feeds; terminal heating in a central milk kitchen or obtaining a commercial supply should be decided on economic grounds. Hospitals using such commercial supplies, however, should make provision for training mothers in the hypochlorite method of disinfection of bottles and teats and also ensure that their trainee nurses and midwives still receive adequate instruction in the hygiene of feed preparation.

### INTRODUCTION

It has long been recognized that contamination of infant feeds plays an important part in the spread of epidemic gastro-enteritis in nurseries for the new-born (Lembcke, 1941; Cumming, 1949) and that means to control this disease should include encouragement of breast feeding, as gastro-enteritis is relatively rare in naturally fed babies (Hinton & McGregor, 1958; Bullen & Willis, 1971), and the provision of a central milk kitchen where safe feeds can be prepared to high bacteriological standards. These measures assume even greater importance now that the value of antibiotics in this disease is called in question (British Medical Journal, 1972).

The provision of safe feeds may be achieved by a cold, chemical method, which is synonymous with hypochlorite disinfection of bottles, teats and equipment (Farquhar, Gould & Schutt, 1965) and has the advantage of cheapness but has been criticized (Ayliffe, Collins & Pettit, 1970) for inadequate safety. Alternatively, prepared and bottled feeds with the teats already in place may be heat treated. This may be either a high or low pressure process and each has its advocates. In-bottle retort sterilized feeds are now available commercially at a competitive price and provide a safe alternative to the hospital processed product.

#### *Terminal heating processes*

The American Hospital Association Manual 'Procedures and layout for the Infant Formula Room' describes all aspects of terminal heating and considers both high and low pressure methods to be safe and satisfactory. Both methods are described by Perkins (1956) who gives an excellent account of the techniques,

Table 1. *Terminal heating processes compared*

<i>High pressure method</i>	<i>Low pressure method</i>
Bacteriologically safe	Bacteriologically safe
Time-temperature relationship 110–111° C. for 10 min.	Time-temperature relationship 90–100° C. for 5–30 min. (Various authors)
Total process time including slow exhaust of pressure. 30–40 min. (Perkins, 1956)	Total process time – no exhaust of pressure. 30–40 min. (Perkins, 1956)
Chemical changes produced in milk by coagulation of protein, caramelization and slight destruction of vitamins	Minimal chemical changes in milk. Slight destruction of vitamins
Over exposure produces exaggeration of physical and chemical changes	Moderate over exposure produces minimal increase in physical and chemical changes, except caramelization (Strachan, 1964)
Careful mechanical control necessary to prevent boiling, clogging of nipples, etc.	Minimal mechanical control needed. No boiling
No refrigeration of end product (Tomlin <i>et al.</i> , 1966)	Rapid cooling and refrigeration of end product essential
No pre-sterilization of bottles and teats (disputed by some authors). Minimal aseptic care needed in preparation room	Pre-sterilization of bottles and teats very advisable. Reasonable aseptic care needed in preparation room
Bottles and equipment must be clean	Bottles and equipment must be clean
Bottles and teats need not be decon- taminated before return to kitchen (Tomlin <i>et al.</i> , 1966)	Decontamination of bottles and teats not essential provided they are returned to a washing room separate from the prepara- tion room

organization and layout of facilities for each. He considers the low pressure method the more advantageous. A high pressure method is recommended by Bolton (1966) a hospital engineer, who also gives details of layouts for varying sizes of units, and is strongly advocated by Tomlin, Tomkin & Dorward (1966) although they differ from Bolton on a number of points.

The low pressure method is described by Rourke (1947*b*), by Strachan (1964) and by Hughes, Darmady & Drewett (1966), who also examined a commercial sterilizer-cooler. Both methods were thoroughly investigated by a team of workers in Illinois (Smith, Finley, Wright & Louder, 1948; Finley, Smith & Louder, 1948). These American workers regard exposure of feeds to steam at either 100° C. (212° F.) for 15 min. (low pressure) or 110° C. (230° F.) for 10 min. (high pressure) as safe and adequate. In one commercial process the vacuum capped bottles are held at 121° C. (250° F.) under water for 8 min.

There is general agreement with the Illinois workers' recommendation for the high pressure process but Perkins (1956) recommends 100° C. (212° F.) for 30 min. for the low pressure method while Hughes *et al.* (1966) feel the makers' recommended holding time of their commercial apparatus, 25 min. at 100° C. (212° F.) could be safely reduced to 10 min., twice the adequate period found in their experiments. Rourke (1947*a*) found 5 min. exposure provided a high percentage of sterile feeds.

A comparison of each system is summarized in Table 1, adapted from Perkins.

The appearance on the British market of commercial retort-sterilized feeds necessitates a re-appraisal by hospitals of the processes in use and the situation in Princess Alexandra Hospital, Harlow, can be taken as an example

#### METHODS AND RESULTS

##### *Process in use in Princess Alexandra Hospital, Harlow, at present*

In Harlow we have been using a low pressure method in a central milk kitchen for over 6 years with success. This process utilizes a short holding period controlled by a thermocouple inserted into a bottle which indicates the feed temperature on a dial mounted on the autoclave. When this indicates a temperature of 72.5° C. the flow of steam is cut off after 3 min. and the load immediately removed from the chamber. In practice the temperature of the feeds just reaches 100° C. when heating is discontinued. This is essentially a flash pasteurization process (71.5° C. for 15 sec.) with a prolonged holding time as an added safety factor. The feeds require air cooling, for 30 min., and subsequent refrigeration. The apparatus in use is a downward displacement autoclave with the addition of a free-steam facility and the thermocouple described above.

The cycles provided are:

1. Sterilization of bottles and teats – 121° C. for 15 min. – automatically controlled.
2. Free steam – manually controlled.

The refrigerator is a heavy duty model as advised by Perkins (1956).

The filled bottles are, of course, fitted with nipples before processing. The nipples were originally protected by paper bags held in place by rubber bands but latterly loosely fitting metal foil caps were found to be preferable in that they did not tend to stick to the teats while still allowing steam to reach them.

Previous testing had shown that after processing a proportion of feeds (approximately 14%) still contained aerobic spore-bearing bacilli, samples being taken from all parts of the autoclave chamber. As the need for the provision of completely bacteria-free feeds is debatable, tests were carried out on feeds deliberately contaminated with the following pathogens, *Staphylococcus aureus* from a breast abscess, yeasts from a case of infantile thrush, *Eschericia coli* from an infant's stool, Beta haemolytic streptococci from an adult sore throat and in addition, another feed was contaminated with adult stool. The results are summarized in Table 2. Aerobic spore-bearers were isolated from each sample but it was concluded that the process was capable of killing vegetative organisms including yeasts. It was also established that feeds would remain sweet and unspoiled in the refrigerator for a period of at least 12 weeks, although it was never intended that they would be kept for more than 2 days.

As it is realized that careful technique and maintenance of the apparatus by well-trained, conscientious staff is the only real safeguard of the quality of the product, 'in-use' bacteriological tests on the feeds are routinely carried out at only two-weekly intervals.

Table 2. *Treatment of artificially contaminated feeds*

Organism	Bacterial count before process	Bacterial count 24 h. after process	Bacterial count 3 weeks after process
Yeast	83,000/ml.	Nil	Nil
<i>Staph. aureus</i>	More than 250,000/ml.	Nil	Nil
<i>Esch. coli</i>	More than 250,000/ml.	Nil	Nil
Beta haemolytic streptococci	More than 250,000/ml.	Nil	Nil
Stool (no <i>C. welchii</i> )	—	Nil	Nil

*Bacteriological control*

Pour plate counts using Oxoid Blood Agar base, are made on feeds taken at random from the refrigerator 24 hours after processing. The mean count of two or three 1.0 ml. samples of neat feed is recorded. The teats are removed aseptically and immersed in honey pots of Oxoid broth for qualitative culture only. The pour plates are incubated at 37° C. for 24 hr. and at room temperature for a further 24 hr. before the counts are made, while the broths containing teats are incubated at 37° C. for 24 hr. and then subcultured on blood agar for another 24 hr. at 37° C. before reading.

The results from the feeds are very satisfactory. In no instance has an organism, other than an aerobic spore-bearing bacillus, been isolated and apart from a short period when the thermocouple was found to be faulty, counts have always been less than ten organisms per millilitre, only seven percent being above five organisms per millilitre. According to Perkins (1956) feeds containing less than 25 organisms per millilitre, tested after 24 hr. refrigeration, are acceptable; this is the standard also adopted by the American Hospital Association (1965). Lowe (1947) used two standards: (a) absence of coliform organisms and (b) less than 50 organisms per millilitre of feed. Cumming (1949) suggested 500 organisms per millilitre of feed after 24 hr. refrigeration. It is obvious that the process in use here meets the strictest of these requirements and equals the finding of Smith *et al.* (1948) that the low pressure method can destroy vegetative organisms and reduce the count of spore-bearers to less than ten organisms per millilitre.

The fault in the thermocouple already mentioned was associated with feed counts rising suddenly to 31, 36, 50 and over 100 organisms per millilitre. The counts fell to the usual level as soon as the fault was remedied.

The teats have less frequently been found to be sterile, although this possibly reflects the difficulty in their aseptic removal for testing, 33% being sterile and 67% growing either aerobic spore-bearers or *Staphylococcus albus* (coagulase negative). No quantitative testing methods have been used but a method has been described by Rourke (1947a) who studied the effect of the low pressure method and found 10 min. exposure was satisfactory. Unfortunately he did not record any results for teat tests after 5 min. exposure as he did for the actual feeds.

On three occasions only have our teat cultures revealed pathogens or potential pathogens, *Pseudomonas* spp. once and *Staphylococcus aureus* (coagulase positive) twice. These were isolated findings not found on testing further teats and not

associated with any upset in the babies. They did, however, stimulate a re-testing of the ability of the process to kill *Staph. aureus* and tests to show that *Pseudomonas pyocyanea* was killed in artificially contaminated milk.

It can be concluded that the Harlow process is safe and has been proved to be so by continuous use for over 6 years. Further factors, however, require consideration in the choice of method of providing safe feeds. Some of these will now be discussed.

#### DISCUSSION

##### *Retention of nutrient value of feeds*

Some paediatricians express misgivings about the destruction of vitamins in the heat processing of infant feeds. This question was studied by Hodson (1949) who concluded that the low pressure method conserved 95 % of ascorbic acid, 91 % of thiamine and 100 % of lysine. The high pressure method conserved the same amounts of thiamine and lysine and even greater amounts of ascorbic acid, 97 %. In view of these small losses of heat-labile nutrients there is little reason to fear significant loss of more heat-stable constituents. Excess vitamins could be added to the feeds to restore any postulated loss should it be necessary to keep babies in hospital for longer than the usual few days post partum when any loss of vitamin intake must be negligible.

##### *Training of mothers and nurses in bottle feeding*

One drawback to the central milk kitchen or the use of commercial supplies is that provision must be made to train mothers to prepare safe feeds once they have returned home. This involves the provision of a training room.

Home standards of hygiene of infant feeding utensils have been found deficient in surveys carried out in Britain. Gatherer & Wood (1966) found only 69 % of bottles and 46 % of teats 'satisfactory' in homes visited in Reading. Anderson & Gatherer (1970) found 'less than two-thirds of bottles and just over half the teats satisfactory' in four separate areas of the U.K. Wright (1951) testing feeds rather than bottles found home prepared feeds unsatisfactory even making allowance for the time lag between preparation and testing. Only 13 % of her sample had zero counts and 30 % contained over one million organisms per millilitre in feeds prepared by mothers attending out-patient departments, although those attending infant welfare clinics produced more satisfactory results. The hospital prepared feeds studied by this author also gave few grounds for satisfaction.

The first two studies stress that mothers do better with hypochlorite methods than heat. Graham (1961) studying teats, also states that dry sterilization (pressure cooking) preserves the rubber longer than wet procedures but hypochlorite solution causes less deterioration than boiling. Whether this point is still valid for Latex teats is doubtful but the conclusion to be drawn is that mothers are more likely to produce safe feeds at home if they are taught how to do so before leaving hospital and that they should be taught the hypochlorite method.

It is obvious also that provision for training of nurses and midwives in the hygiene of feed preparation must continue.

*Economics*

As hospital methods of heat treatment are safe and advantageous, the decision whether to provide a central milk kitchen or to use a commercial source of pre-sterilized baby feeds must be made on purely economic grounds. The economics of milk kitchen procedures require attention by hospital administrators. This problem has been little studied but two publications are relevant. Schenkweiler *et al.* (1960) concluded after a survey of methods in six American hospitals that a medium-sized hospital can prepare a bottle of infant feed as cheaply as it can be purchased from a service company but efficient production and handling methods and low cost labour for work not requiring trained nurses must be used. Hurst (1968) in Britain concluded that the majority of hospitals could usefully look into their present milk kitchens to ascertain whether the best use is being made of resources. He also found the greatest possible economy to lie in labour costs.

The Harlow process was costed in 1970 at 9.4d (3.9p) per feed which was only marginally less than a commercial preparation at that time available. Since then there have been several increases in labour costs and in 1973 our product probably costs marginally more than a commercially supplied feed as many costs are hidden and difficult to evaluate such as maintenance of equipment, electricity, refrigeration and cost of delivery to the consumers. In addition the autoclave is becoming increasingly difficult to maintain owing to obsolescence, nursing staff are increasingly difficult to find and must be deployed as productively as possible and the maternity department is shortly to be greatly increased in size. As a result of all these factors a decision to change to a commercial product in the near future appears to be correct.

Hospitals possessing milk kitchens must make this decision in the light of their own circumstances. Hospitals without central milk kitchens should consider well before tying up large sums of capital in the provision of equipment.

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