

Pretoria Pasteurisation: A Potential Method for the Reduction of Postnatal Mother to Child Transmission of the Human Immunodeficiency Virus

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Summary

HIV can be transmitted by breastfeeding. The virus is inactivated by heating. A simple and inexpensive method has been devised by which expressed breastmilk may be pasteurised in a domestic setting. The method uses the principle of heat transfer from 450 ml of water heated to boiling point in an aluminum pot to a smaller volume of milk in a glass jar placed into the water (Pretoria Pasteurisation). The aim of this study was to test the reliability of Pretoria Pasteurisation under a range of conditions. Pretoria Pasteurisation was performed using differing starting values for each of the following parameters: volume of milk (between 50 and 150 ml); initial temperature of milk (between 37°C and the ambient temperature); and ambient temperature. Each of the parameters was varied within the range indicated while all other conditions were kept constant. A graph of milk and water temperature against time was constructed with 95% confidence intervals. The ideal temperature range was considered to be between 56 and 62.5°C. Milk temperature remained between 56 and 62.5°C for between 10 and 15 min depending on the combination of variables. The peak temperature and duration of time in the ideal temperature range was minimally sensitive to volume of milk, starting temperature of milk, and ambient temperature. Pretoria Pasteurisation is feasible and reliable under a range of conditions. The method requires refinement and further testing under different conditions.

Introduction

Efforts to reduce the risk of vertical transmission of HIV infection have concentrated largely on antenatal and intrapartum measures such as antiviral agents and intrapartum interventions. Postnatal transmission remains a significant problem with the risk of a breastfed infant acquiring infection being in the region of 15 per cent.¹ In developed countries, women infected with HIV are advised to formula feed their infants, however, in developing nations neither women nor the health services can afford to purchase infant milk formulas. The World Health Organization advises that in areas where infection remains a significant cause of infant mortality, women should continue to breastfeed regardless of HIV status because of the immunological benefits derived from human breastmilk.^{2,3}

HIV is a fragile virus which is easily inactivated by heat. In antithrombin III concentrate, at a temperature of 60°C HIV infectious titre is reduced by 1 log within 24 s and by 3 log within 8 min.⁵ The time required to reduce

HIV infectivity by 1 log in culture medium at 56°C is 121 s.⁶ Heat inactivation of HIV in breastmilk is also effective. Holder pasteurisation used by human milk banks (62.5°C or 56°C for 30 min) when applied to samples of human milk inoculated with HIV, resulted in the inactivation of all detectable virus even following repeated culture.⁴ The advantage of pasteurisation at these temperatures is that it preserves most of the protective factors in the milk including secretory IgA. Pasteurisation of human milk at 56°C for 15 min allows preservation of activity of 90 per cent of the protective factors and effectively destroys pathogenic bacteria such as *Escherichia coli*.

A method allowing HIV-infected women to pasteurise their own expressed breastmilk in a domestic setting would offer their infants many of the benefits of breastmilk without the risk of HIV transmission associated with ordinary breastfeeding and without the cost of milk formula. The women and infants who would benefit most from the pasteurisation of breastmilk are resident in developing countries, thus any method of pasteurisation would have to avoid the use of inappropriate technology.

If a method is used which directly heats the milk (such as a heating element or direct flame) it would be difficult in a domestic environment to control the temperature and

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prevent the milk from becoming too hot and destroying immunological components. A thermostatically controlled mechanism is likely to be expensive and can malfunction.

Taking the above factors into account, a method was devised using a heat source which can be heated repeatedly to within a narrow temperature range in non-laboratory conditions without using a thermometer or thermostat. This heat source was then used to heat milk in a secondary container by passive transfer of heat. The heat source chosen was a container of water which had been heated to boiling point. The boiling point of water varies according to altitude and barometric pressure but will remain within a narrow range unless at extremely high altitude. By varying the volume of water and the sizes, shapes, and materials of the milk and water containers, it is possible to control the peak temperature of the milk and the time for which it remains above a certain temperature. The ideal temperature range was considered to be between 56 and 62.5°C. The process described will be called Pretoria Pasteurisation.

During the development phase of the project numerous different water and milk containers and different volumes of water were tested until a suitable combination of containers and volumes was found which kept the milk within the ideal temperature range for as long as possible without exceeding 62.5°C. Water containers tested included aluminum, glass, and stainless steel containers of various sizes. Milk containers tested included a variety of plastic, glass, and metal containers. All of these containers were chosen for their easy availability and low cost. Of all the containers tested, the combination giving the best results were a 1-l Hart

aluminum pot containing 450 ml of water and a glass peanut butter jar with a volume of 430 cm³ and a mass of 220 g. The correct volume of water could be easily measured without the use of a measuring jug by using a 450-ml aluminum soft drink can.

This study was undertaken to test the reliability of Pretoria Pasteurisation under different conditions.

Method

For this study cows' milk was used as a surrogate for human milk for both practical and ethical reasons. A known volume of milk at a known starting temperature was placed in a glass peanut butter jar with a volume of 430 cm³ and a mass of 220 g and the lid replaced. Water was heated in a 1-l Hart aluminum pot on the hot plate of an electric stove. When the water was boiling, the pot was removed from the heat source and the jar of milk placed into the water. A logging temperature probe with a precision of 0.1°C (Hanna HI92840C Hanna Instruments Woonsocket, RI, USA) was inserted through a close fitting hole made in the lid of the glass jar and suspended so that the bulb was submerged below the surface of the milk but did not touch the bottom or sides of the jar. A second temperature probe was suspended with the bulb submerged in the water but not touching the glass jar or the bottom or sides of the aluminum pot. The temperature of the milk and the water was then recorded at intervals of 1 min for a period of 20 min. The procedure was repeated using differing starting values for each of the following parameters: volume of milk (between 50 and 150 ml); initial temperature of milk (between 37°C and the ambient temperature); and ambient temperature. Each of the above parameters

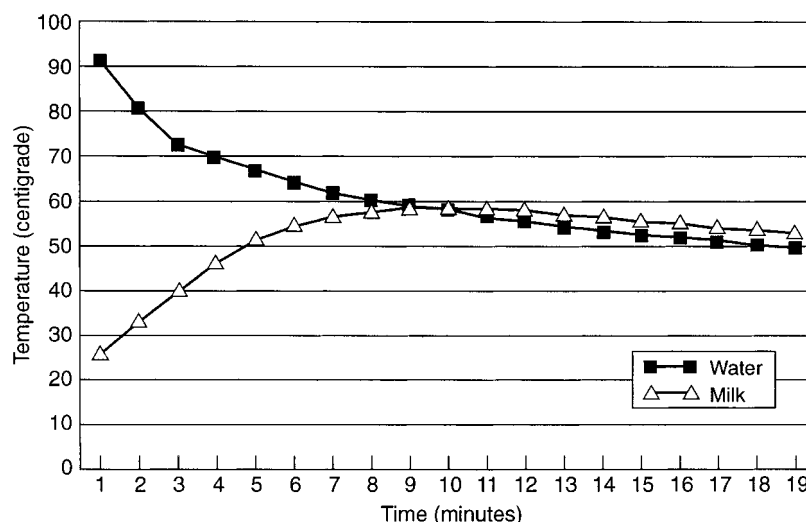


FIG. 1. Typical temperature interactions using passive heat transfer from a 1-l aluminum pot containing 450 ml of water to milk contained in a glass jar with a volume of 430 cm³ and a mass of 220 g (Pretoria Pasteurisation).

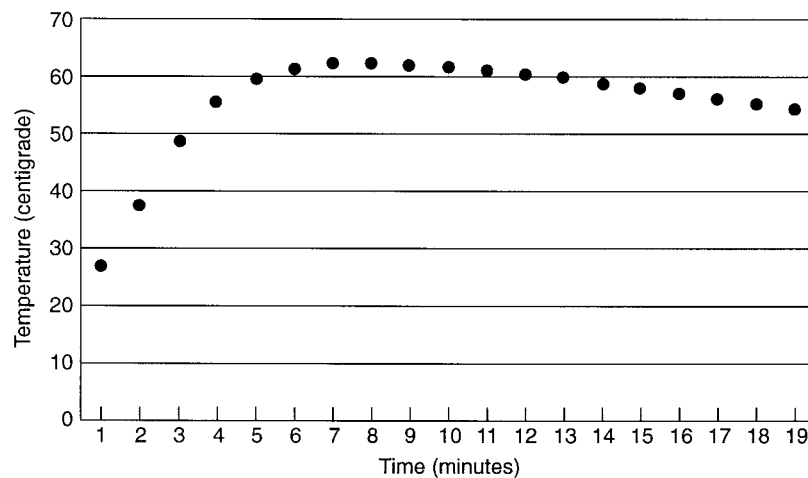


FIG. 2. Typical 95% confidence intervals for Pretoria Pasteurisation with a milk volume of 75 ml, milk starting temperature of 27°C and ambient temperature of 23°C.

was varied within the range indicated while all other conditions were kept constant.

The process was repeated 10 times for each set of starting values and a graph of the milk and water temperature against time was constructed with 95% confidence intervals (CI).

Results

The typical behavior of the system using the aluminum pot and glass jar and Pretoria Pasteurisation is illustrated in Fig. 1.

The process was found to be reliable, with narrow 95% CI for each set of starting conditions tested. The 95% CI for one set of parameters is shown in Fig. 2.

The temperature curves remained within a narrow range despite variation of the volume of milk or starting temperature of the milk. The milk temperature remained between 56 and 62.5°C for between 10 and 15 min depending on the combination of variables. Figure 3 illustrates the effect of different milk volumes on the temperature curve obtained.

Figure 4 illustrates the influence of different starting temperatures of the milk on the temperature curve obtained.

The ambient temperature had minimal effect on the temperature curves obtained, however, the investigators were unable to test as wide a range of ambient temperatures as was desired due to the typically warm summer weather during the study period. The temperature

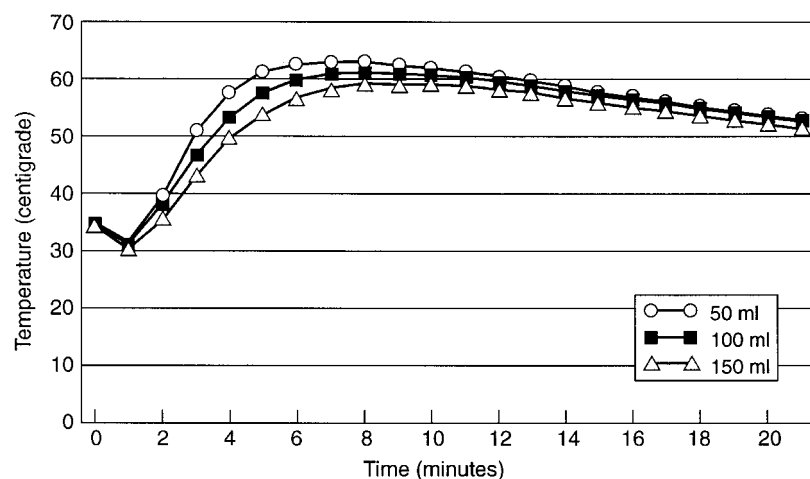


FIG. 3. Effect of volume of milk on milk temperature curves obtained by Pretoria Pasteurisation.

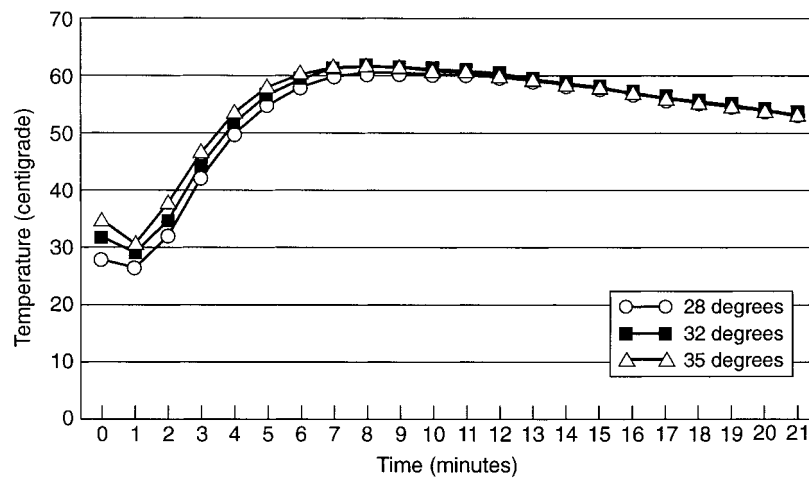


FIG. 4. Effect of starting temperature of milk on temperature curves obtained with Pretoria Pasteurisation.

curves for the two ambient temperatures tested is shown in Fig. 5.

Discussion

This study has shown that using a 1-l aluminum pot containing 450 ml of water and a glass peanut butter jar it is possible to heat between 50 and 150 ml of cows' milk to temperatures between 56 and 62.5°C for up to 15 min with a high degree of reliability. It is not yet known whether this length of time is sufficient to inactivate all cell-free and cell-associated HIV in the breastmilk of infected women. Extrapolation from the studies of heat inactivation of HIV in blood products and other media would indicate that this temperature for this length of

time would at least substantially reduce the infectious HIV titre. Human breastmilk also has intrinsic activity against enveloped viruses⁸. HIV-infected breastmilk left to stand for 30 min reduces the infective titre of cell-free HIV, but is not as effective against cell-associated virus. Heat inactivation is necessary for the inactivation of cell-associated HIV.

One of the concerns regarding the expression of breastmilk is potential contamination with bacteria from women's hands, however, pasteurisation of breastmilk at 56°C for 15 min is effective in destroying common pathogens including *E. coli* and *Staphylococcus aureus*.

The presence of cracked nipples and other lesions on the breasts of breastfeeding HIV-infected women are

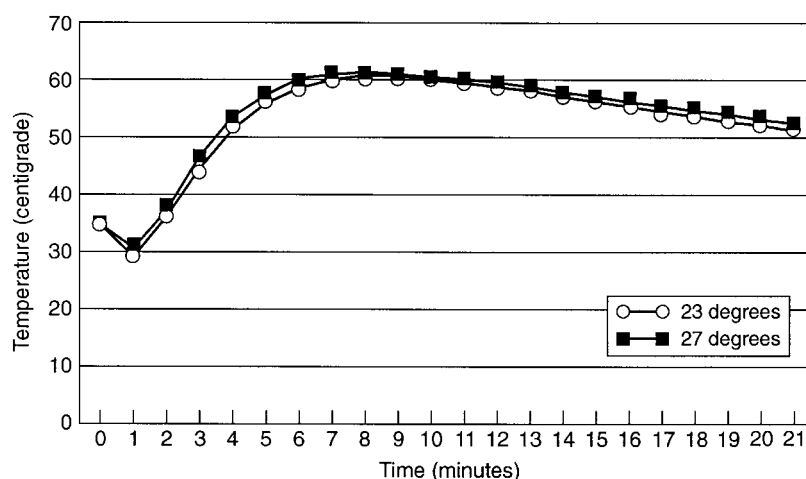


FIG. 5. The effect of ambient temperature on milk temperature curve obtained with Pretoria Pasteurisation.

theoretically potential sources of transmission of infection to suckling infants. Although there are no estimates available of the risk of mother to child transmission of HIV via such lesions, expression and pasteurisation of breastmilk instead of infants suckling directly from the nipple will avoid this possibility.

Although Pretoria Pasteurisation has been developed with women in resource-poor settings in mind, the method may also be welcomed by HIV-infected women in developed countries who are under pressure to formula feed their infants even if they would have preferred to breastfeed. This method may allow them the option of providing their infants the benefits of breastmilk without the risks of ordinary breastfeeding.

Conclusion

Pretoria Pasteurisation has been shown to be feasible and reliable under a range of conditions. The method still requires refinement and further testing. Once the process has been adequately tested it has the potential to offer an alternative method of infant feeding to women who do not have access to safe formula feeding and may reduce vertical transmission of HIV in resource-poor communities while retaining the benefits of breastfeeding.

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