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Infusion pasteurization of milk: Effects of different time-temperature combinations

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Introduction

Heat treatment of milk is applied in practice to obtain a microbiologically safe product with longer shelf life as compared to raw milk. A standard treatment for fresh milk is HTST pasteurization (72℃ x 15 s). Any applied heat treatment will affect the intrinsic as well as the functional properties of the milk. It is of interest to develop technologies for as gentle heat treatments of milk as possible. One possibility is infusion pasteurization, characterized by very short heating, holding and cooling times. This may result in less damage of the intrinsic attributes of milk, ensure the necessary bacterial inactivation and inactivate alkaline phosphatase (AP) as demanded by regulation.

The objective of this study was to investigate the effects of infusion pasteurization in different time-temperature combinations on selected chemical and physical properties of the treated milk.

Results

Figure 1a shows no obvious differences in the size distributions of casein micelles in raw milk and the infusion treated samples at 80℃, whereas the size distributions broaden towards higher micelle diameter for the samples treated at 120℃ as compared to the raw milk. The Z-average hydrodynamic diameter increased with increasing treatment temperature (Figure 1b). Heat treatment may cause an increase in casein micelle size as a result of interactions between denaturated whey proteins, in particular β-lactoglobulin, and κ-casein on the surface of the micelles (Anema & Li, 2003).

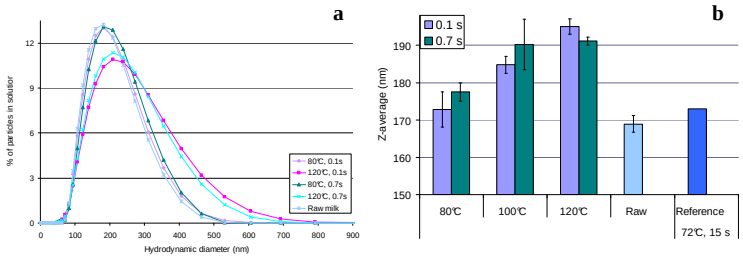

Figure 1. Size distributions of casein micelles samples infusion pasteurized at 80℃ and 120℃ for 0.1s and 0.7s and raw milk (a) and Z-average hydrodynamic diameter of casein micelles (b).

The total aerobic count of microorganisms (30℃) in the milk samples after 8 days of storage at 5℃ was lower for all the time-temperature combinations used for infusion pasteurization as compared to the reference and well within the typical shelf life limit of 20,000 CFU/ml (data not shown).

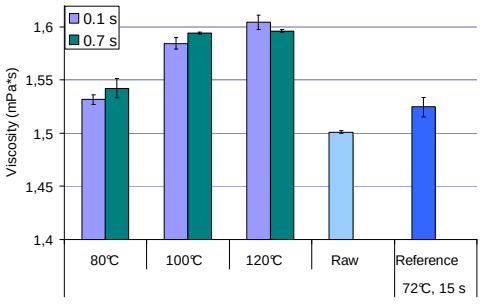

Figure 2. Viscosity of milk samples, infusion pasteurized at 80℃, 100℃ and 120℃ with holding times 0.1s and 0.7s, raw milk and reference samples.

The applied heat treatment affected the viscosity of skim milk (Figure 2), possibly as a result of changed interactions between casein micelles due to associated whey protein (Jeurnik & de Kruif, 1993). The raw skim milk had lower viscosity than all heat treated samples. No clear distinction was seen between the reference and the infusion treatment at 80℃, whereas infusion temperatures of 100℃ and 120℃ increased the viscosity.

Conclusions

Infusion pasteurization of whole milk ensures proper microbial elimination, however, the AP seems to be reactivated with increasing pasteurization temperature. XO activity is reduced at increasing temperature and time. Some time-temperature combinations indicate that infusion pasteurization may increase micelle size and milk viscosity more than those of milk subjected to a standard HTST pasteurization. This could have implications for the functional properties.

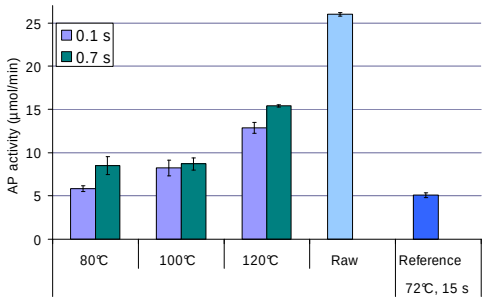

Figure 3. Activity of alkaline phosphatase (AP) in milk samples, infusion pasteurized at 80℃, 100℃ and 120℃ with holding times 0.1s and 0.7s, raw milk and HTST reference.

All heat treatments decreased the AP activity in milk skimmed 24 h after pasteurization compared with the raw milk (Figure 3). The reference HTST and samples pasteurized at 80℃ and 100℃ reach pro per inactivation. At 120℃, for both holding times, the AP reveals an increased activity. We suggest reactivation of the enzyme, which is possible in UHT milk but not in HTST milk (Fox & Kelly, 2006). When pasteurizing whole milk the AP in the MFGM (~50%) may be protected by the fat, and AP in un-homogenized milk has higher extent of reactivation than in homogenized milk (Fox & Kelly, 2006). The XO (Figure 4) shows reduced activity with increasing temperature, and at 80℃ the holding times differ significantly.

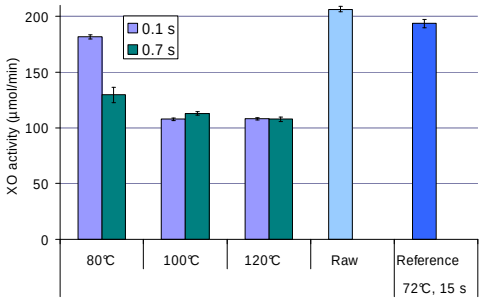

Figure 4. Activity of xanthine oxidase (XO) in milk samples, infusion pasteurized at 80℃, 100℃ and 120℃ with holding times 0.1s and 0.7s, raw milk and HTST reference.

Materials and methods

Infusion pasteurization was performed on raw milk with two holding times (0.1s and 0.7s) combined with three different temperatures (80℃, 100℃, and 120℃). All samples were cooled overnight and skimmed by centrifugation after 24 h. The infusion pasteurized samples were compared to untreated raw milk (control) and standard HTST pasteurization (reference). The size of the casein micelles were analyzed in skimmed milk using dynamic light scattering. The viscosity of skimmed milk samples was determined using a glass capillary viscometer. Enzymatic activities of AP and xanthine oxidase (XO) were analysed by spectrofotometric methods of *p*-nitrophenylphosphate and hypoxanthine/uric acid, respectively.

References
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