# Procedures to optimise pasteurisation and storage of colostrum


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**Report on procedures to optimise pasteurisation and storage of colostrum**

Calves have no natural immunity against disease (Barrington and Parish, 2001) and acquire immunity via the ingestion of colostral immunoglobulins (IgG) (i.e., passive immune transfer) within the first hours after birth (Godden et al., 2019). Failure to achieve passive immunity transfer (FPT) is associated with adverse outcomes for calves and older animals. Calves with FPT are more susceptible to diarrhoea (1.5 times) and respiratory disease (1.8 times) and twice as likely to die (Raboisson et al., 2016). For older animals, FPT has been associated with decreased growth rate, reduced first and second lactation milk production and an increased tendency for culling during the first lactation (DeNise et al., 1989; Faber et al., 2005). The reported prevalence of FPT in calves in several major dairy producing countries is relatively high, varying between 16 and 41% (e.g., Cuttance et al., 2017; Elsohaby et al., 2019; Lora et al., 2018; Todd et al., 2018; Urie et al., 2018).

Colostrum quality is one of the key determinants of successful immune transfer and is characterised by concentrations of two critical components: IgG, and infectious agents (Godden et al, 2019). Good quality colostrum is indicated by concentrations of IgG ≥ 50 g/L (equivalent to ≥ 22% Brix), bacterial counts ≤ 1 x $10^5$ colony-forming units (cfu)/mL and coliform counts ≤ 1 x $10^4$ cfu/mL.

Pasteurisation is an important tool to help improve the quality of colostrum. It does so in two ways: directly, by eliminating or reducing bacterial/other pathogen contamination; and indirectly, by increasing the efficiency of absorption of IgG (Godden et al., 2019). Feeding appropriately heat-treated colostrum (60°C for 60 min (60/60)) has been shown to improve calf health. In a large field trial in the USA, calves fed pasteurised colostrum had a reduced risk for diarrhoea (Godden et al., 2012). Feeding 60/60 pasteurised colostrum followed by pasteurised milk (heated to 63°C for 30 min) has been shown to reduce morbidity and mortality (Armengol and Fraile, 2016). Calves fed colostrum heated to 60°C for 30 min showed increased growth rates to weaning and less diarrhoea and pneumonia (Rafiei et al., 2019).

Colostrum contains other bioactive constituents including leukocytes, growth factors, hormones, nonspecific antimicrobial factors, and nutrients. These, and IgG levels, may be impacted by inappropriate pasteurisation and storage techniques. The credible scientific literature that has reported on procedures for optimising colostrum pasteurisation and storage was reviewed and is reported herewith. In particular, this report considered the effects of temperature and duration, preservation of antibodies and other constituents, kill rates of bacteria and other common pathogens, antibody absorption and short-term storage.

## 1. Methods for pasteurization

The main aim of pasteurisation is to minimise pathogen contamination whilst protecting the levels of IgG and other important constituents.

### a. Effects of temperature and duration on antibody preservation, kill rates of bacteria and kill rates of common pathogens

Several studies have shown that heating colostrum to **60°C for 60 min (60/60)** maintains IgG levels and fluidity and reduces bacterial and coliform counts well below the accepted threshold levels for good quality colostrum (Godden et al., 2019, Hesami et al., 2021). Further, 60/60 heating eliminates or significantly reduces key pathogens including *Escherichia coli, Salmonella enteritidis and Mycoplasma bovis*, and significantly reduces contamination by *Mycobacterium avium subsp paratuberculosis.* There may be a small loss of IgG from heating very high-quality batches of colostrum at 60/60 but the concentrations remain well within acceptable levels (Donahue et al., 2012).

Heating at **60°C for a shorter duration (30 min) (60/30)** does not affect colostrum IgG concentrations and the reductions in pathogen microorganisms are reported to be similar to those for the 60/60 protocol. For example, the reductions in total bacterial count and individual organisms (environmental streptococci, Streptococcus agalactiae, Staphylococcus aureus, coliform counts, non-coliform counts) were similar for 60/60 and 60/30 (Elizondo-Salazar et al., 2010).

Other organisms are less well controlled with 60/30 than 60/60. The 60/30 procedure was effective in eliminating *M. bovis, Listeria monocytogenes, E. coli O157:H7,* and *S. enteritidis* from colostrum, but a 60 min duration was required to completely control *M avium subsp paratuberculosis* (Godden et al., 2006). Hesami et al. (2020) also reported that 60/60 pasteurisation achieved much greater control of pathogens (*E. coli K99, Rotavirus, Coronavirus* and *Cryptosporidium parvum*) than 60/30.

Heating at **60°C for longer than 60 min i.e., 90 min**, does not provide any additional control of pathogenic organisms (Elizondo-Salazar et al.,2010; Hesami et al., 2020), and may have the disadvantage of reducing IgG concentrations (Hesami et al., 2020), although McMartin et al. (2006) observed no effect of heating at 60°C for up to 120 min on IgG concentrations.

One potential advantage of pasteurisation at a higher temperature i.e., **63°C for 30 min** (63/30) is the inactivation of bovine leucosis virus (BLV) (Sandoval-Monzón et al., 2021). However, heating colostrum above 61°C significantly decreases IgG levels and increases colostrum viscosity (McMartin et al., 2006, Elizondo-Salazar et al., 2010). Note, some authors have reported that heating to 63°C for 30 min does not affect serum IgG levels in calves (see Robbers et al., 2021). Furthermore, an alternative method is available to inactivate BLV in colostrum via freezing/thawing - due to loss of lymphocyte viability (Kanno et al., 2014; Roberts et al., 1983). As appropriate freezing/thawing of colostrum is not likely to affect colostrum quality (Morrill et al., 2015), using a 60/60 heating protocol together with freezing should inactivate BLV whilst preserving IgG viability. There appears to be no published reports on the effects of pasteurisation on clostridia.

**b. Preservation of other constituents**

In additional to IgG, fresh colostrum contains many other biologically active factors, both nutritive and nonnutritive. Heat treatment (60/60) has no adverse effects on colostrum dry matter (%), true protein (%), crude fat (%), solids-not-fat (%) and other solids (%) (see Godden et al., 2015)

Non-nutritive constituents include those with a potential influence on calf immune responses (e.g., leucocytes, cytokines, oligosaccharides), nonspecific antimicrobial factors (e.g., lactoferrin), proteins (e.g., growth factors such as insulin-like growth factor (IGF) I and II, fibrinogen, trypsin inhibitors) and metabolites.

The scientific evaluation of the effects of the recommended (60/60) colostrum pasteurization procedure on constituents other than IgG and pathogens is in its infancy. As with freezing, heat treatment kills most/all colostral leucocytes (Godden et al., 2019). The absence of leucocytes in colostrum on practical calf health outcomes during development (and later life) remain to be fully elucidated Godden et al., 2019).

The 60/60 heating protocol reduces IGF-I in colostrum (Mann et al., 2021a) but not in calf serum (Mann et al., 2021b). Further, 60/60 heating decreases the abundance of other proteins (mainly involved with immunity, enzyme function,

and transport-related processes (e.g., Tacoma et al., 2017). In addition, Xu et al. (2021) reported that pasteurisation reduced the concentration of a very small proportion of metabolites in colostrum but no changes in the metabolite profiles of calves fed the heat-treated colostrum were detected. Gelsinger and Heinrichs (2017) suggested that the immune response of young calves is not inhibited by heat treatment of colostrum, although more research on the practical health outcomes of changes in colostrum constituents following pasteurized is required.

**c. Antibody absorption in pasteurised and unpasteurised colostrum**

The apparent level of absorption of IgG (and serum IgG levels) is higher in calves fed pasteurized colostrum compared to animals consuming raw colostrum (Elizondo-Salazar and Heinrichs, 2009). High levels of bacteria in colostrum may restrict IgG absorption (e.g., Gelsinger et al., 2014; James et al., 1981). Gelsinger et al. (2015) provided convincing evidence that lower bacterial populations in heat-treated colostrum is a key factor underpinning improved IgG absorption. It has been hypothesised that high levels of bacteria in colostrum may bind to free IgG in the gut lumen, and/or directly block uptake and transport of IgG molecules across intestinal epithelial cells, thereby restricting antibody transfer (James et al., 1981; Godden et al 2019). Note, factors other than improved IgG absorption may contribute to the better health outcomes of calves consuming pasteurised colostrum. For example, there may be enhanced gastrointestinal tract colonisation by beneficial organisms (*Bifidobacterium*) as well as reduced colonisation by pathogens (*E coli*) (Malmuthuge et al., 2015).

**d. Short term storage options – justification and effects on quality**

Bacterial levels in unpasteurised colostrum begin to increase within hours of storage at ambient temperatures or under refrigeration at 4°C (Cummins et al., 2016). Depending on initial bacterial counts, under refrigeration the concentrations can exceed acceptable thresholds within 24 h to 48 h (Stewart et al., 2005; Cummins et al., 2016). Appropriate pasteurisation (e.g., 60/60) immediately reduces bacterial counts in fresh colostrum to very low levels, and if refrigerated in a clean covered container, the shelf life of heat-treated colostrum is at least eight days (Bey et al., 2007; Godden et al 2019). Adding a preservative (potassium sorbate) to pasteurised colostrum does not provide any further benefits for bacterial control under refrigerated conditions (Bey et al., 2007).

**Summary**

Bacterial contamination of fresh colostrum is common on dairy farms and often exceeds the accepted thresholds (e.g., Godden et al., 2012; Hesami et al 2020). Pasteurisation of colostrum immediately reduces bacterial levels to very low levels (and well below thresholds). The weight of scientific evidence strongly suggests that the optimal pasteurisation heat treatment is 60°C for 60 min, which preserves antibody concentrations, maintains colostrum fluidity and controls/inactivates bacteria and most common pathogens. Feeding pasteurised colostrum enhances antibody absorption and has been reported to reduce the risk of poor health in calves.

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