As group housing systems for calves have gained popularity in recent years, interest in acidified milk systems has also been renewed. This article describes reasons for acidifying milk or milk replacer and examines research on acidified milk feeding systems.

Why the interest in acidifying milk?

Milk provides a very favorable environment for bacterial growth. As an example, in a Minnesota study the total plate count of colostrum increased from 100,000 cfu/mL to over 18,000,000 cfu/mL when stored at approximately 73°F for 24 hours (Stewart et al., 2005). Low temperature and pH slow bacterial growth. Refrigeration of milk in a calf feeder is generally not practical, but lowering the pH can control bacterial growth and enable milk to be held without refrigeration for a short time. Preserving milk in this way allows larger quantities of milk to be provided for ad libitum feeding of calves. The initial amount and type of bacteria in milk will have an effect on how long milk can be stored before bacterial populations reach levels that can affect calf health. In addition, each calf’s level of immunity will impact susceptibility to infection. Milk or milk replacer feeding systems need to be cleaned daily and acidification of the liquid feed should not be done just to minimize cleaning.

Does acidification affect the nutritive value of milk or benefit the calf?

After reviewing the published research, we conclude there is little evidence that acidification affects the nutrients in milk or milk replacer or the utilization of these nutrients by calves. Much of the research with acidified milk was published in the 1970s and 1980s and evaluated effects of adding acid to surplus colostrum and transition milk. When this milk was stored for extended periods of time (7 to 28 days) acidification prevented degradation of protein compared to allowing the milk to ferment naturally. However, most of today’s acidified milk systems are feeding milk within 3 days, and protein degradation should be minimal.
Calf performance, whether calves are fed milk or milk replacer, has generally not been affected by the addition of acid. Some studies compared ad lib feeding of an acidified feed to restricted feeding (for example 2 times a day) of a “sweet” feed or compared feeding transition milk to milk replacer. Differences in calf growth or health cannot be attributed to the acid in such a comparison, because calves had much higher nutrient intakes on the ad lib or transition milk treatments. In studies where intake and composition of the treatments were similar, no difference in average daily gain has been observed (Woodford et al., 1987; Raeth-Knight et al., 2009; Ribeiro et al., 2009; Hill et al., 2013; Todd, 2013). Overall, it appears the addition of acid is neutral in terms of calf growth, neither improving nor hindering calf performance. More normal fecal scores (Jaster et al., 1990) or increased fecal dry matter (Woodford et al., 1987) have been observed in calves fed acidified milk, but in both of these studies fecal scores were well within normal ranges and did not indicate large differences in the health of calves. In most studies calf health has not been significantly affected by acidification of milk or milk replacer.

**What acids can be used to lower pH in milk?**

Numerous acids and preservatives have been studied as potential additives to milk (Chase, 2011). Citric acid and propionic acid are classified as “generally recognized as safe” by the US Food and Drug Administration (FDA), meaning they can legally be used without restriction. Citric acid is typically used in commercial formulations of acidified milk replacer. Canning et al. (2009) reported that adding citric acid to whole milk or milk replacer held pH at approximately 4.5 for 4 days at 73°F. Hill et al. (2013) found no differences between calves fed milk replacer with or without citric acid, but observed that calves refused less milk replacer at pH 5.2 than at pH 4.2. In this study, acidified milk replacer was offered fresh each day, though the pH 4.2 milk replacer was acidified 24 hours before being fed. Citric acid is available in powdered form, making it easier to handle than a caustic liquid. Citric acid dust can irritate the eyes, nose, and throat. Powder needs to be stored in an air-tight container to prevent absorption of moisture.

Propionic acid was studied by several research groups in the late 1970s. It was most often used at a rate of 1%, but the pH of the milk varied from 4.1 to 5.0. Some reports suggested that propionic acid treated milk was not well accepted by calves. This was perhaps due to adding a standard amount of acid rather than adding acid as needed in each batch to achieve a target pH. Propionic acid is a clear, colorless liquid with a pungent, rancid odor. Upon contact, it burns skin and its vapors
irritate mucous membranes. Propionic acid is corrosive to most metals. Its use is permitted by FDA, but propionic acid has safety and handling issues, as well as potential palatability issues, that may limit its usefulness. The use of formic acid in calf milk or milk replacer is currently not approved or permitted by the US Food and Drug Administration (FDA). Formic acid is a clear, colorless liquid with a pungent odor. The principal danger from formic acid is from skin or eye contact with the concentrated liquid or vapors. It will cause rapid skin irritation upon contact and serious damage to the eye can occur if exposed. Formic acid is also corrosive to metals. If your goal is to acidify milk or milk replacer in the US, do not use formic acid. With any concentrated acid product, always wear gloves, long sleeves, and protective goggles and handle the acid carefully. Wash hands thoroughly after handling. Be sure to read the information provided by the manufacturer for complete safety and storage instructions. Dilute the concentrated acid to make a weaker solution for mixing with milk.

Two other options to consider are the preservatives sodium benzoate and potassium sorbate. These compounds are both available in powdered form and are “generally recognized as safe” according to the FDA. Sodium benzoate is limited to levels not exceeding 0.1%. Dust from these preservatives can irritate the eyes, nose, and throat. Jenny et al. (1980, 1984) fed milk preserved with sodium benzoate (added at 0.5% by weight) with acceptable results. Milk pH was 5.1 when held an average of 10 days before feeding (Jenny et al., 1980). In a second study, pH averaged 5.5 when milk was held at 68°F and higher. Potassium sorbate was studied as a preservative for colostrum (Stewart et al., 2005), but there is no reason it could not also be used in milk. Potassium sorbate was added at 0.5% weight to volume (50 g/100 L) or not added and colostrum was stored at ambient (average 73°F) or refrigerated temperature for 3 days. The combination of potassium sorbate and refrigeration maintained the lowest bacterial populations and most stable pH over the 3-day period. In the first 2 days, bacterial growth in colostrum stored at ambient temperatures with potassium sorbate was similar to colostrum stored in the refrigerator. Sam Leadley has developed protocols for using potassium sorbate, which can be found in the “Calf Facts” section of www.atticacows.com.

**Tips for Managing an Acidified Milk Feeding System**

- Start with high quality milk that has low bacterial contamination. As much as possible, treat calf milk the same as salable milk; that means it needs to be collected with clean equipment, properly cooled immediately after milking, and stored in
closed containers. Adding acid to milk is primarily going to limit the growth of bacteria, not kill what is already present.

- For whole milk or milk replacers containing skim milk, it is important that acid be added to cooled milk (68 to 75°F) to avoid curdling.
- Add any acid or preservative at the time milk is collected to ensure all milk is treated before bacteria have a chance to start multiplying.
- Add acid slowly and stir the milk while adding acid.
- Test pH of the milk after acid has been added to ensure target pH is achieved. Reducing the pH by too much may limit palatability and cause calves to drink less milk. Not adding enough acid may affect the keeping quality of the product and lead to high bacteria counts or unpalatable spoiled milk.
- Stir acidified milk 3 or 4 times in a 24-hour period. Brief (one minute or less) stirring by hand or with slow agitation is preferable to brisk stirring for an extended period of time.
- Warm milk to 68 to 75°F before feeding to encourage calves to drink it. Offering milk at cold temperatures tends to reduce intake. Field experience in Canada (Anderson, 2013) shows that it is possible to increase milk feeding temperature to 100°F, but milk must be fed immediately at this temperature; holding acidified milk at temperatures above 75°F will often cause curdling.
- Some calves may reject acidified milk, particularly in the first week of life. If calves are fed individually or young calves can be started in a separate group, diluting the acidified milk with whole milk may help to make the transition. Feeding from nipples (whether nipple buckets, teat bars, or large reservoirs with tubes leading to multiple nipples) seems to work better than feeding from an open pail.

**Summary**

Research data show little to no added benefit of adding acid to milk or milk replacer, especially if it is used within a short period of time before bacterial growth is a problem. In warm weather there may be a place for adding acid if milk or milk replacer has to be left out at ambient temperatures, especially if it is of high bacteria count at the start. Otherwise, keeping feeding systems clean and feeding or filling milk containers twice a day will eliminate the need to use acid in your calf feeding system.

**References**


• Todd, C. G. 2013. An investigation into the effects of free-access acidified milk replacer feeding programs on the productivity and welfare of the calf. PhD Diss., University of Guelph, Guelph, Ontario.
