Microbial Hazards Associated with Feeding Colostrum

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SUMMARY

- Because microbial contamination of colostrum can contribute to calfhood disease and can interfere with passive absorption of colostral antibodies, producers should adopt management strategies to reduce bacterial counts in colostrum fed to calves.

- All producers should pay attention to hygiene and sanitation so as to minimize bacterial contamination during the colostrum harvest, storage and feeding processes.

- Producers should also take steps to avoid bacterial proliferation if storing colostrum. Methods to achieve this could include rapid refrigeration, freezing, rapid turnover of fresh colostrum (< 48 hrs) and possible use of chemical preservatives.

- Additional management tools that could further reduce pathogen exposure through colostrum can include feeding commercial colostrum replacement products or feeding pasteurized colostrum.

INTRODUCTION

First milking colostrum is an important source of nutrients, non-specific immune factors and passively absorbed maternal antibodies (immunoglobulins or Ig), critical to promote growth and to protect the newborn calf against infectious disease in the first weeks and months of life. However colostrum can also represent one of the earliest potential exposures of dairy calves to infectious agents. Experts have recommended that fresh colostrum fed to calves contain fewer than 100,000 cfu/ml total bacteria count and fewer than 10,000 cfu/ml total coliform count (McGuirk and Collins, 2004). Unfortunately, observational studies have indicated that average levels of bacterial contamination are significantly higher than this cutpoint for much of the colostrum fed on commercial dairies (Poulson et al., 2002). In one recent study of 12 Minnesota and Wisconsin dairies, the geometric mean total bacteria count and total coliform count in over 200 samples collected was 16.1 million and 2.7 million cfu/ml, respectively (Swan et al., 2007). The goal of this paper is to present information identifying the microbial risks associated with feeding colostrum and to discuss some practical goals and methods available to producers to reduce microbial contamination in colostrum fed to calves.

WHY THE CONCERN ABOUT MICROBIAL CONTAMINATION OF COLOSTRUM?

Colostrum can also represent one of the earliest potential exposures of dairy calves to a large variety of infectious agents including *Mycoplasma* spp., *Mycobacterium paratuberculosis*

(MAP), fecal coliforms, *Salmonella* spp., and bovine leukemia virus (Steele, 1997; Streeter et al., 1995; Walz et al., 1997; McGuirk and Collins, 2004). These pathogens can cause early calfhood morbidity or mortality caused by enteritis, septicemia, joint infections or ear infections, or could contribute to chronic subclinical infections that aren't clinically manifested until later in life (e.g. Johne's disease). The clinical and economic consequences of these diseases are well understood.

Microbial contamination of colostrum is also a concern because it is thought that bacteria in colostrum may interfere with passive absorption of colostral antibodies across the intestine and into the circulation, reducing passive transfer of immunity in the calf (James et al., 1981: Poulson et al., 2002). In a retrospective analysis of observational data collected in Wisconsin farm investigations, 82% of colostrum samples cultured had a total plate count (TPC) > 100,000 cfu/ml (Poulsen et al. 2002). In this study high bacteria counts in colostrum was positively associated with higher fecal consistency scores and negatively associated with passive transfer of IgG. In a recent observational study of 107 raw and pasteurized colostrum samples the mean (SD; Range) $\log_{10}$ total bacteria counts were 4.8 (1.3; 2.08 to 7.15). In this study there was a significant negative linear association between the total bacteria count in the colostrum fed and both the efficiency of absorption of IgG (%) and the serum IgG at 24 hours of age in calves (mg/ml) (Peterson et al., 2008). The results of this study suggest that bacteria in colostrum can contribute to poorer absorption of colostral IgGs, and so may contribute to the high levels of failure of passive transfer observed within the North American dairy heifer calves. Furthermore, these results suggest that there is no lower optimal cutpoint for bacteria levels in colostrum, at least in so far as it may affect absorption of IgG – the lower the better.

Given these concerns, producers should adopt steps prevent or reduce bacterial contamination of colostrum. This will require focussing on the 3 major areas or sources of microbial contamination of colostrum: 1) Infected mammary gland or fecal contamination during harvest, 2) Contaminated collection, storage or feeding equipment and 3) Bacterial proliferation in stored colostrum

PREVENTING BACTERIAL CONTAMINATION DURING COLOSTRUM HARVEST OR FEEDING

Methods to avoid pathogen contamination from infected glands or fecal contamination include preventing the calf from suckling the dam, careful attention to the udder preparation routine prior to harvesting colostrum and avoiding pooling of raw colostrum. It may also be useful to identify infected cows, an example being to test cows for infection with MAP prior to calving. However, given the poor sensitivity of diagnostic tests for MAP, the latter approach is likely to be imperfect. Development and strict adherence to protocols for cleaning and sanitation of milking,
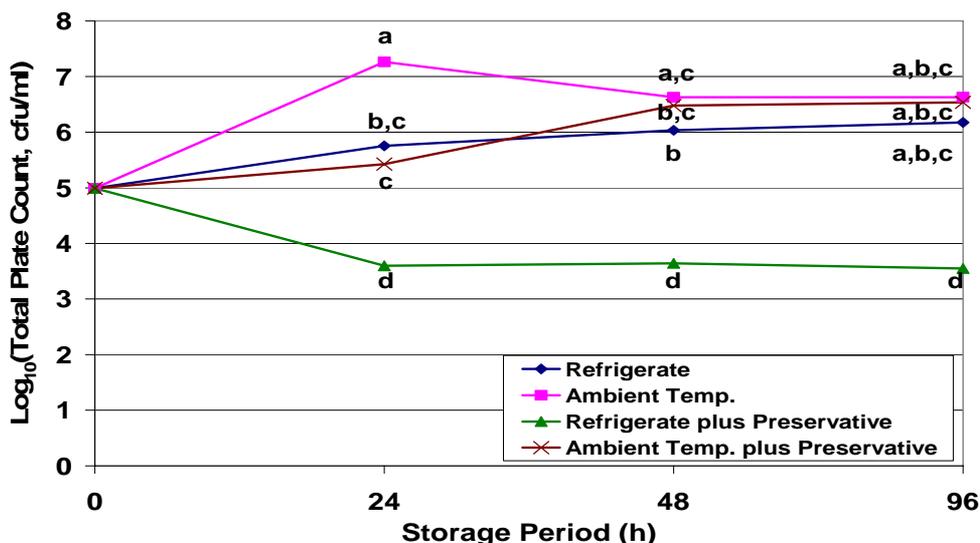
Stewart et al., (2005) emphasized the importance of udder preparation, equipment sanitation, and proper storage techniques in order to prevent bacterial contamination and proliferation in fresh colostrum. The first objective of this study was to identify control points for bacterial contamination of colostrum during the harvest and feeding processes. First-milking colostrum samples were collected aseptically directly from the mammary gland of 39 cows, from the milking bucket, and from the esophageal feeder tube. All samples underwent bacteriological culture for total plate count and total coliform count. Bacteria counts were generally low or nil in colostrum collected directly from the gland (geometric mean$_{udder}$ = 27.5 cfu/ml). However,

significant bacterial contamination occurred during the process of milking the colostrum into the bucket (geometric mean$_{bucket}$ = 97,724 cfu/ml). No additional bacterial contamination occurred between the bucket and the esophageal feeder tube. These results emphasize the importance of properly prepping and sanitizing udders prior to colostrum harvest, milking into a clean, sanitized bucket, and transferring colostrum into clean, sanitized storage or feeding equipment (Stewart et al., 2005).

PREVENTING BACTERIAL PROLIFERATION IN STORED COLOSTRUM

It is well understood that bacteria present in stored colostrum or milk can begin to multiply rapidly if stored at warm ambient temperatures, but will still multiply, albeit more slowly, in the refrigerator. If colostrum is not to be fed within 1-2 hours of collection, it should be quickly refrigerated (for up to 48 hours) or frozen. Use of potassium sorbate preservative may also delay bacterial proliferation in refrigerated colostrum. This effect was amply demonstrated by Stewart et al., (2005) with the completion of a second study to describe the effect of refrigeration (vs ambient temperature) and use of potassium sorbate preservative (vs no preservative) on bacteria counts in stored fresh colostrum. For this study aliquots of colostrum were collected from the milking bucket and allocated to one of four treatment groups: I) Refrigeration (approx. 40 °Fahrenheit) , 2) Ambient temperature (approx. 73 °Fahrenheit) , 3) Refrigeration with potassium sorbate preservative (0.5% solution) and 4) Ambient temperature with potassium sorbate preservative.

Subsamples from each treatment group were collected after 0, 24, 48, and 96 h of storage. Storing colostrum at warm ambient temperatures resulted in the most rapid increase in bacteria counts, followed by intermediate rates of growth in non-preserved refrigerated samples or preserved samples stored at ambient temperature. However, by 48 hours of age, bacteria counts in refrigerated, non-preserved samples (group i) or preserved ambient temperature samples (group iv), where just as high as for non-preserved samples stored at ambient temperature (group ii). The most effective treatment studied was the use of potassium sorbate preservative in refrigerated samples (group iii), for which total plate count and total coliform counts dropped significantly and then remained constant during the 96-h storage period (Figure 1).

Log₁₀ is shown on y-axis as Log_{10}(Total Plate Count, cfu/ml)

8
7
6
5
4
3
2
1
0

a
a,c
a,b,c
b,c
a,b,c
c
b
a,b,c
a,b,c
d
d
d

Refrigerate
Ambient Temp.
Refrigerate plus Preservative
Ambient Temp. plus Preservative

0   24   48   96

Storage Period (h)

Figure 1.   Effect of Storage Temperature and Use of Preservative on Total Bacteria Counts in Stored Fresh Bovine Colostrum (a,b,c,d: Different subscripts differ within given storage period. $P < 0.05$) (From Stewart et al., 2005).

The results of this research suggest that, at a minimum, producers should refrigerate colostrum as quickly as possible after collection, if it is to be stored for more than a couple of hours before feeding. These results also suggest that producers should try to feed up non-preserved stored colostrum as rapidly as possible (goal < 2 days). Though not widely adopted by the industry, these results show the benefits of combining the use of a preservative (approximate cost = $0.50 per gallon) to prevent bacterial proliferation in stored colostrum for at least as long as 96 hours. Studies describing the final shelf-life of preserved colostrum are ongoing. Information on potassium   sorbate   suppliers,   mixing   and   use   can   be   found   at: http://www.atticacows.com/orgMain.asp?orgid=19&storyTypeID=&sid=&.
While the use of preservatives looks promising, further research on preservatives is needed, as some preservatives may damage colostral immunoglobulins.

All producers should take steps to minimize contamination or bacterial proliferation during harvest, storage, or feeding. Additional steps producers may consider include discarding colostrum from high risk or known infected cows (e.g. Johne's test-positive cows) (McGuirk et al., 2004). Producers should also avoid pooling fresh colostrum, as this may increase the risk of transmitting infectious pathogens to more than one calf. Freezing colostrum is one additional method to prevent bacterial proliferation in stored colostrum. However, producers must be cautious not to overheat colostrum during the thawing process (keep ≤ 140 °F) or IgG denaturation could occur. Additional tools that some producers may consider using include the use of commercial colostrum replacers or feeding pasteurized colostrum.

Additional tools designed to reduce or eliminate pathogen exposure through colostrum include the feeding commercial colostrum replacers or pasteurizing colostrum. These two options will be discussed next.

COMMERCIAL COLOSTRUM REPLACERS

Commercial colostrum replacement (CR) products may provide a viable alternative to feeding maternal colostrum and could serve as a very effective management tool to prevent colostral disease transmission. These CR products contain bovine Ig that is typically either lacteal-derived or plasma-derived and are intended to completely replace maternal colostrum feedings. The CR should contain a minimum of 100 grams of IgG per dose, the minimum recommended dose in order for calves to receive to attain a predicted final serum IgG > 10 mg/ml (Quigley et al., 2001; Quigley et al., 2002), and must also contain a nutrient pack that provides a source of protein, energy, vitamins and minerals similar to levels found in maternal colostrum. If CR products prove to be an effective substitute for maternal colostrum while potentially reducing disease transmission, they could serve as one critical control point for preventing the transmission of several infectious diseases, including Johne's disease (*Mycobacterium avium* subsp. *paratuberculosis, MAP*). These products have the added benefit of being convenient to quickly mix and feed.

In a recent controlled field study of 12 Midwest dairy farms initiated in 2003, heifer calves were separated from their dams within 0.5 to 1 h after birth and systematically assigned (alternately for every other calf born) to be fed maternal colostrum (MC, n = 261) or colostrum replacer (CR, n = 236). The heifer calves were followed to adulthood and tested for MAP infection using a commercially available ELISA assay and the conventional bacterial fecal culture test for MAP at 30, 42, and 54 months of age. Results showed that calves fed the CR had an estimated 44% reduction in risk for testing positive to MAP (ELISA and /or Fecal culture) as compared with calves fed MC at birth (Haz. ratio = 0.559, *P* = 0.056) (Pithua et al., 2009). This study demonstrated that raw maternal colostrum can be an important source for transmission of MAP to newborn calves, and showed that colostrum replacement products can be an effective management tool in infected dairy herds that are attempting to reduce the prevalence of Johne's disease.

Despite their potential to control transmission of some diseases, the results of early CR product research has shown mixed results in their ability to consistently achieve successful passive transfer in calves (serum IgG < 10.0 mg/ml) (Quigley et al., 2001). However, studies seem to report better rates of successful passive transfer (serum IgG > 10.0 mg/ml) when calves were fed higher doses (IgG mass) in a CR product. This led Quigley to suggest feeding higher doses of CR, thereby increasing the IgG intake and improving the 24 hour serum IgG concentrations of calves. One example of this: Jones et al (2004) reported an average serum IgG concentration of 13.96 mg/ml in calves fed two doses of a CR product in two feedings (total dose = 249 g IgG for Holsteins or 186 g IgG for Jerseys). More recently a study reported that the average 24 hr serum IgG level for calves fed either 1 dose (100 g IgG) or 2 doses (200 g IgG) of a lacteal-derived commercially available colostrum-derived product were 11.6 ± 2.9 mg/ml and 16.9 (± 6.2) mg/ml, respectively (Land O' Lakes Colostrum Replacement. Land O' Lakes Inc. St. Paul, MN) (Foster et al., 2006). In a similarly designed study using the same commercial CR product, the average serum IgG for calves fed either 1 dose (100 g IgG) or doses (200 g IgG) was 9.6 mg/ml and 19.0 mg/ml, respectively. In this second study, feeding 2 doses (200 g IgG) of this CR product produced serum IgG levels similar to feeding 4 quarts of fresh maternal colostrum (20.7 mg/ml) (Godden et al., 2009).

In summary, CR products may offer producers a convenient way to provide adequate passive immunity to dairy calves while reducing the risk of pathogen exposure through colostrum. Feeding CR products is certainly recommended in situations where a sufficient volume of clean, high quality colostrum is not available from the cow and when stored colostrum is not available. Large scale, long-term studies are still needed to describe the health and economic-benefit of adopting this practice as a routine management tool. If using colostrum replacers, producers are advised to feed 150 to 200 g IgG in a colostrum replacer product that has been previously tested for efficacy.

PASTEURIZING COLOSTRUM

Early research pasteurizing colostrum using the conventional methods and temperatures as are typically used to pasteurize milk yielded unacceptable results: Batch pasteurization (145 °F or 63 °C x 30 min) resulted in only mild thickening. However, high temperature, short time continuous flow pasteurization (HTST; 161 °F or 72 °C x 15 sec) resulted in severe thickening or congealing of the colostrum and plugging of equipment. Both batch and HTST pasteurization resulted in denaturation of approximately $1/3^{rd}$ of IgG in colostrum, and lower serum IgG concentrations were achieved in calves that were fed pasteurized colostrum (Meylan et al., 1995; Green et al., 2003; Godden et al., 2003; Stabel et al., 2004). However, more recent research has determined that problems with thickening or IgG denaturation can be avoided by using a lower-temperature, longer-time approach to pasteurize colostrum. In most situations, heating colostrum at 140 °F (60 °C) for 60 minutes in a commercial batch pasteurizer should be sufficient to maintain IgG concentrations and fluid characteristics while eliminating or significantly reducing important pathogens including *Listeria monocytogenes*, *E. coli*, *Salmonella enteritidis*, *Mycoplasma bovis* and *Mycobacterium paratuberculosis* (McMartin et al, 2006; Godden et al., 2006).

Since previous research was completed in a laboratory setting, it was important to complete a study to prove if pasteurized could be successfully fed to calves in a commercial farm setting. In a study on a commercial transition management facility in Baldwin, WI, fresh colostrum was pooled and then split into two aliquots. One – half was pasteurized in an on-farm batch pasteurizer at 140 °F (60 °C) for 60 minutes, and then refrigerated. The other half was kept fresh and refrigerated. Forty-nine Holstein calves were enrolled into 2 treatment groups: 4 quarts raw colostrum (n=24) or 4 quarts of pasteurized (n=25) colostrum, fed within 2 hours of birth. The results showed that there was no significant difference in colostral IgG concentration between the raw and pasteurized colostrum. However, the geometric mean total bacteria counts at time of feeding were significantly lower in the pasteurized colostrum (813 cfu/ml) vs raw colostrum (40,738 cfu/ml). Calves receiving heat-treated colostrum had significantly higher serum total protein and 24 hr IgG levels (TP = 6.3 mg/dL and IgG = 22.34 mg/ml) than calves receiving raw colostrum (TP = 5.9 mg/dL and IgG = 18.07 mg/ml). This bump in IgG levels was due to significantly higher efficiency of absorption of IgG in calves fed pasteurized colostrum (35%) vs calves fed raw colostrum (27%). We hypothesize that this improvement is due to reduced bacterial interference with IgG absorption across the gut (Johnson et al., 2007).

The aforementioned research suggests that feeding pasteurized colostrum can reduce pathogen exposure and improve the efficiency of IgG absorption. The take home message from this study should be that producers should strive to feed clean colostrum to their calves. Pasteurization is only one of several possible management tools that producers could adopt to help them to achieve this goal. Producers should understand that a great deal more research needs to be completed before the practice of feeding pasteurized colostrum can be widely recommended to

the industry. For example, the potential economic and health benefits from adopting this practice on farms have not yet been described. A large multi-herd controlled field study was initiated in summer 2007 to address these questions. Despite the need for continued research, some producers have already adopted the practice of feeding pasteurized colostrum. Though our recommendations may change in future, pending the results of new research findings, the following is a list of general recommendations for producers wishing to adopt a pasteurized colostrum feeding system:

General Recommendations for On-farm Pasteurization of Colostrum.

‣ *Handling of raw and pasteurized colostrum*:

  ‣ Minimize contamination of raw colostrum by collecting colostrum from a properly prepped, disinfected udder into a clean sanitized bucket.

  ‣ If there is to be greater than a 2 hour delay between colostrum collection and pasteurization, refrigerate the raw colostrum in sanitized covered containers.

  ‣ After pasteurization is completed, quickly cool colostrum and then either feed to calves within two hours, refrigerate in covered sanitized containers, or freeze in clean containers or bags. This is to prevent recontamination and to delay or slow the regrowth of bacteria.

  ‣ Ensure proper cleaning and sanitation of the pasteurizer equipment plus colostrum collection, storage and feeding equipment.

‣ *Pasteurizing colostrum*:

  ‣ Use a batch pasteurizer design (not HTST).

  ‣ Pasteurize at 140 °F (60 °C) for 60 minutes. Do not allow temperatures to fluctuate above 141 °C or denaturation of IgG will begin to occur.

  ‣ Agitate colostrum continuously during the heating, pasteurization, and cooling processes.

  ‣ Routinely monitor times and temperatures during the pasteurization cycle.

‣ *Monitoring*:

  ‣ Record and monitor health records. Goals for preweaning treatment and mortality rates are < 25% and < 5%, respectively (McGuirk and Collins, 2004). Note: this monitoring should be done for all operations, even if pasteurized colostrum is not fed on the dairy.

  ‣ Monitor passive transfer of immunity. An excellent way to do this is to use a hand-held refractometer to measure serum total protein levels. This should be done in 12 or more clinically normal calves between 1 to 7 days of age. The goal is for $\geq$ 90% of calves tested to have a serum TP value $\geq$ 5.0 gm/dl. Note: This monitoring is encouraged for all operations, even if pasteurized colostrum is not fed on the dairy.

  ‣ Periodic culture of raw and heat-treated colostrum samples to monitor efficacy of the

heat-treatment process (Goal: Total Bacteria Count in pasteurized colostrum < 20,000 cfu/ml). Paired frozen colostrum samples can be sent to a microbiology lab for this. You must request that lab technicians to be prepared to do multiple dilutions of colostrum.

CONCLUSION

Because microbial contamination of colostrum can contribute to calfhood disease and can interfere with passive absorption of colostral antibodies, producers should adopt management strategies to reduce bacterial counts in colostrum fed to calves. All producers should pay attention to hygiene and sanitation so as to minimize bacterial contamination during the colostrum harvest, storage and feeding processes. Producers should also take steps to avoid bacterial proliferation if storing colostrum. Methods to achieve this could include rapid refrigeration, freezing, rapid turnover of fresh colostrum (< 48 hrs) and possible use of chemical preservatives. Additional management tools that could further reduce pathogen exposure through colostrum can include feeding commercial colostrum replacement products or feeding pasteurized colostrum.

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