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Colostrum: Getting Calves Off to a Good Start

Colostrum, the first milk produced by the mammary gland after calving, is rich in *immunoglobulins* (antibodies), growth factors, and several other nutrients and compounds that promote calf health (Godden et al., 2019). Thus, colostrum is critical for calf health. Due to a lack of transfer of antibodies across the placenta during pregnancy, calves are born with a naïve immune system and rely almost exclusively on consumption of colostrum for the transfer of passive immunity and subsequent immune system development (Godden et al., 2019; Lombard et al., 2020; NASEM, 2021).

Inadequate consumption of immunoglobulin-rich colostrum shortly after birth can result in poor immune system development, a condition known as failure of passive transfer. This condition is evaluated by measuring blood immunoglobulin G (IgG) levels within 24-48 hours of birth. Low blood IgG concentration (<15 g/L) is associated with the development of significant illnesses during the pre-weaning period (NASEM, 2021), reduced post-weaning growth rates, and lower first lactation milk production (Lombard et al., 2020; DeNise et al., 1989). Due to the importance of colostrum to the transfer of passive immunity alone, colostrum management is well-recognized as a critical component of newborn calf care.

Keys to Good Colostrum Management

Colostrum feeding standards have been developed based upon their importance to immune system development. There are three key components to successful colostrum management: timing, quality, and quantity.

1. Timing

Timing of colostrum consumption is a critical component of successful colostrum management. The ability of the calf's intestines to absorb the antibodies in colostrum greatly diminishes with time, and is essentially nonexistent by 24 hours after birth. Industry experts used to recommend feeding a single allotment of colostrum within the first 12 hours of life to ensure sufficient transfer of passive immunity. However, researchers at the University of Alberta recently showed that feeding calves at birth, or shortly after, dramatically increased antibody absorption, and that the rate of absorption for calves fed colostrum at six hours after birth is similar to those fed colostrum at 12 hours after birth (Fischer et al., 2018). Therefore, the new industry-accepted recommendation is to provide two feedings of colostrum. The first feeding should take place within two hours of birth and the second feeding should occur within 12 hours of birth (Godden et al., 2019).

Photo by Sarah Potts, University of Maryland Extension.

2. Quality

Colostrum quality is determined by assessing immunoglobulin concentrations, specifically, the concentration of immunoglobulin G (IgG). The IgG content of colostrum is highly variable depending on many factors, including the cow, harvest timing in relation to calving, volume produced, and lactation

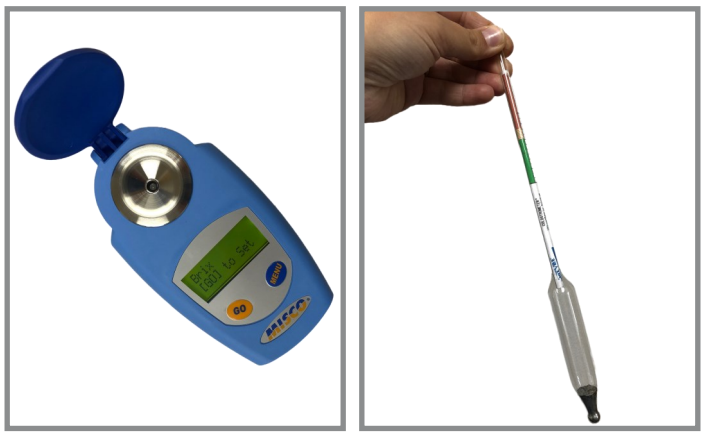

Figure 1. *Brix refractometer (left) and colostrometer (right) can both be used on-farm to determine colostrum quality. Photos by Sarah Potts, University of Maryland Extension.*

number (NASEM, 2021). Colostrum is considered to be good quality if IgG content is greater than 50 grams/liter (g/L; Godden et al., 2019).

While the direct measurement of colostrum IgG levels is expensive and time consuming, there are two on-farm tools available that can help producers quickly and economically assess colostrum IgG content through indirect means: a colostrometer and a Brix refractometer (Figure 1). A colostrometer measures specific gravity and a Brix refractometer measures total solids, both of which correspond to IgG content in colostrum (Fleenor and Stott, 1980; Quigley et al., 2013). Both are useful tools for estimating colostrum quality; however, the Brix refractometer has become popular in recent years because it is less fragile and less sensitive to fluctuations in temperature as compared to the colostrometer. A Brix reading of 21% or greater is indicative of good quality colostrum (Table 1). While it is tempting to forego assessment of colostrum using one of these two tools, producers should know that visual appraisal of colostrum quality is highly inaccurate because color and viscosity are not related to IgG content (Godden et al., 2019).

In addition to assessing the colostrum's antibody content, producers should also ensure that it is free from harmful bacteria or contaminants. As a rule of thumb, good quality colostrum should have a total bacteria count <100,000 cfu/mL and a coliform count <10,000 cfu/mL (Godden et al., 2019). To minimize bacterial growth, fresh colostrum should be fed within one hour; if this is not possible, it should be stored in the refrigerator (<35°F) for up to 24 hours or the freezer (<-5°F) for up to a year. Frozen colostrum can be thawed safely by submerging the container in a warm (<120°F) water bath and feeding within one hour of thawing. Using hot water (>120° F) to thaw colostrum can significantly reduce quality by destroying the antibodies.

Table 1. *Brix % readings and corresponding IgG content for bovine colostrum.*

Brix%	IgG (g/L)*
12	16.8
13	20.7
14	24.5
15	28.3
16	32.2
17	36.0
18	39.9
19	43.7
20	47.5
21	51.4
22	55.2
23	59.0
24	62.9
25	66.7

**Data generated using the equation presented by Bartier et al. (2015): y = -29.257 + 3.8393x; R2 = 0.43.*

3. Quantity

In addition to timing and quality, the quantity of colostrum fed is also important. Calves do not have a requirement for colostrum itself; their requirement is for the IgG in the colostrum. Therefore, the amount of colostrum that a calf needs is directly related to the IgG concentration of the colostrum, which, as discussed earlier, can be highly variable. Because of this, estimating the colostrum IgG content using a colostrometer or Brix refractometer is essential. Estimation of colostrum IgG content can help determine the volume that should be fed to ensure sufficient IgGs are provided. As a rule of thumb, calves should receive 200 grams of IgG during the first 24 hours of life with 150 grams of IgG supplied in the first feeding (Godden et al., 2019; NASEM, 2021).

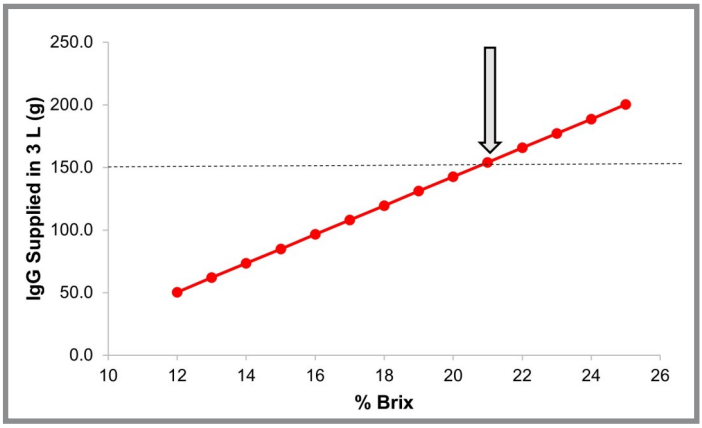

Figure 2. *Amount of IgG supplied by feeding 3 L of colostrum according to IgG content assessed using Brix. Figure adapted from Bartier et al. (2015).*

Figure 3. *Using an esophageal feeder can help ensure adequate delivery of colostrum when a calf will not completely consume its first or second colostrum feeding via bottle nipple. It is important to ensure the individual has been trained to utilize the tube-feeder safely. Photo by Sarah Potts, University of Maryland Extension.*

Generally speaking, it is recommended that Holstein calves be fed three liters (approximately three quarts) and Jersey calves be fed two liters (approximately two quarts) of good quality colostrum (≥21% Brix) at first feeding to ensure sufficient IgG consumption (NASEM, 2021). Figure 2 illustrates the amount of IgG that can be supplied by feeding three liters of colostrum at varying levels of quality. From this figure, it is clear that feeding poor quality colostrum (<21% Brix), provides inadequate IgG for the first feeding.

If a calf will not consume all of its allotted colostrum from a bottle, producers should use an esophageal tube-feeder to ensure all of the colostrum is consumed within the two hour timeframe. However, it is critical that the individual responsible for administering colostrum via the tube-feeder has been properly trained on how to safely utilize it (Figure 3).

Colostrum Replacer

If the supply of clean, good quality colostrum is insufficient to ensure adequate IgG consumption, producers can use commercially-available colostrum replacers to replace or supplement a colostrum feeding. Colostrum replacers can be useful if:

1. there is not enough colostrum volume (>3 liters for Holsteins, >2 liters for Jerseys);
2. colostrum is contaminated with bacteria or viruses (e.g., Johne's, Bovine Leukosis Virus, etc.);
3. freezer or refrigerator storage capacity is insufficient; or
4. there are consistency issues related to fresh/frozen colostrum collection, storage, and/or delivery.

When using colostrum replacers, it is important to follow the instructions on the package to ensure that the appropriate amount of nutrients and IgG are delivered to the calf. Be sure to note the amount of IgG that is contained within each pouch, as pouches contain anywhere from 50 to 100g of IgG, depending on the manufacturer. For example, if a colostrum replacer contains 100g IgG per dose, producers would need to provide two doses during the first feeding to ensure calves receive the recommended 150g IgG within two hours of birth. In contrast, if a colostrum replacer contains 60 g IgG per dose, producers would need to provide three doses during the first feeding to ensure that 150g IgG are consumed within two hours of birth.

Colostrum replacers can also be utilized to boost the IgG content of poorer quality colostrum (<50g IgG/L). If the IgG content of the colostrum is estimated using a colostrometer or Brix refractometer, simple math can be used to help determine how many doses of colostrum replacer are needed to provide the 150g of IgG recommended during the first two hours of life. For example, a Brix result of 18% corresponds to an IgG content of ~39.9 g IgG/L (Table 1), so feeding three liters would provide only approximately 120g of IgG. Thus, an additional 30 grams of IgG are needed to meet the 150g IgG target for the first two hours of life. Providing one pouch of colostrum replacer that supplies 60g IgG per pouch would be more than sufficient to meet this goal.

Feeding Transition Milk

Transition milk is milk that is produced by the mammary gland during the first 2-3 days after calving. This milk is an intermediate between colostrum and whole milk. The composition of transition milk can be highly variable, but in general, it contains more solids relative to whole milk. Milk from the second milking can contain 30% more fat, 170% more protein, 15% more calcium, 458% more vitamin A, and 406% more vitamin E than whole milk (Godden et al., 2019). Furthermore, milk from the third milking can contain 65% more protein, 15% more calcium, 232% more vitamin A, and 273% more vitamin E than whole milk (Godden et al., 2019) (Table 2).

In addition to greater nutrient content, transition milk and colostrum both contain higher levels of bioactive compounds, hormones, and growth factors. Some of these bioactive compounds may have an impact on the development of the calf gut microbiome (Godden et al., 2019). Other compounds, such as insulin and insulin growth-like factor 1 (IGF-1), may stimulate intestinal development and nutrient absorption in young calves (Godden et al., 2019; Pyo et al., 2020). While there are no concrete recommendations for the feeding of transition milk or extended colostrum feeding, recent studies have shown some benefits to these practices on pre-weaning growth and feed efficiency (Soest et al., 2020; Zwierzchowski et al., 2020) as well as health metrics (Karger et al., 2020).

Long-term effects of transition milk feeding have not been examined. However, research from Cornell indicating positive effects of pre-weaning plane of nutrition on first, second, and third lactation performance (Soberon and Van Amburgh, 2013) would suggest that this practice may have long-term effects on calf performance. The increase in pre-weaning growth for calves fed transition milk or colostrum-supplemented whole milk alone would also suggest a potential long-term impact on lactation performance since higher pre-weaning growth is associated with increased milk production (Soberon and Van Amburgh, 2013).

While there are currently no set standards for feeding transition milk, Pyo et al. (2020) showed that changes in intestinal physiology were impacted by just six additional feedings of colostrum or a 1:1 mix of whole milk and colostrum. Producers interested in trying this practice should first consider the risk for disease transfer on their farm, especially if there are known issues with leukosis or Johne's in the herd. Pasteurization of any raw milk (whole milk, waste milk, colostrum, etc.) before feeding can mitigate potential risk for disease transfer. Although supplementing milk replacer with colostrum replacer comes at a cost, recent research from Michigan State University (Soest et al., 2020) indicated that supplementing milk replacer with colostrum replacer can mimic transition milk and produce similar effects on pre-weaning growth when fed from day 2 through 4. Besides minimizing the risk for disease transfer from feeding raw transition milk, this option would also ensure nutritional consistency and uniformity.

Table 2. *Composition of colostrum and transition milk relative to whole milk.**

Component	Colostrum	Milking 2	Milking 3	Milk
Fat (%)	6.7	5.4	3.9	4.0
Protein (%)	14	8.4	5.1	3.1
Lactose (%)	2.7	3.9	4.4	5.0
Calcium (%)	0.26	0.15	0.15	0.13
Vitamin A (µg/100 mL)	295	190	113	34
Vitamin E (µg/g fat)	84	76	56	15
Vitamin B_{12} (µg/100 mL)	4.9	--	2.5	0.6
IGF-1 (µg/L)	341	242	144	15
Insulin (µg/L)	65.9	34.8	15.8	1.1

**Table adapted from Godden et al. (2019).*

Table 3. *Newly proposed standards for evaluating transfer of passive immunity in calves.**

Rating	Serum IgG (g/L)	Brix (%)	Goal (% of Calves)
Excellent	>25	>9.4	>40
Good	18-24.9	8.9-9.3	~30
Fair	10-17.9	8.1-8.8	~20
Poor	<10	<8.1	<10

**Table adapted from Godden et al. (2019).*

Evaluation of Colostrum Management

The colostrum program can be evaluated by assessing blood serum levels of IgG within 24-48 hours of birth. Traditionally, a colostrum program was considered successful if more than 80% of calves achieved serum levels above 10 g IgG/L. However, recent research by Lombard et al. (2020) suggests that four categories ("Excellent," "Good," "Fair," and "Poor") should be utilized to evaluate the effective transfer of passive immunity (Table 3). Producers familiar with testing colostrum quality can estimate levels of blood serum IgG levels on-farm through indirect means using a Brix refractometer. If choosing this approach, producers should verify that their Brix instrument is capable of analyzing blood serum. To assess colostrum management, it is not necessary to evaluate every calf born on the farm. Instead, evaluating 10-15 calves who appear healthy every few months should be sufficient to provide a snap-shot of the colostrum program.

Summary

Timing, quality, and quantity are three key components of a successful colostrum feeding program. Producers should always assess colostrum IgG content using a Brix refractometer or a colostrometer prior to feeding. Holstein calves should be fed three liters and Jersey calves should be fed two liters of high quality colostrum (>50 grams IgG/mL or ≥21% Brix) within the first two hours of life and an additional two liters within 12 hours. Colostrum replacers should be considered if the supply of good quality colostrum is insufficient or if disease transmission is a concern. New research related to the benefits of transition milk and extended colostrum feeding is forthcoming, but studies will likely divulge recommendations related to these practices.

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