Cow Factors That Influence Colostrum Quality

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Take Home Messages

- "High quality" colostrum is first-milking colostrum that contains at least 50 g/L of the antibody immunoglobulin G (IgG), contains a low concentration (<100,000 cfu/ml) of bacterial contaminants and is free of infectious disease agents.
- Transfer of antibodies (especially IgG) from the blood of the cow into colostrum starts about 5 weeks prior to calving, and is maximal in the last 2 weeks before calving.
- The older the cow, the better the colostrum – but there's lots of individual variation! On average, first-calf heifer colostrum is lower in volume and IgG concentration than that from older cows. However, many heifers produce very good quality colostrum. Don't automatically discard heifer colostrum; rather test and keep high quality colostrum from a cow of any parity.
- Don't automatically discard high volume first-milking colostrum if it was collected within a few hours of calving; colostrum should be tested and only discarded if low quality.
- Discard bloody colostrum, colostrum from sick cows, from cows with clinical mastitis, from cows that are known to be infected with chronic diseases such as Johne's disease or Mycoplasma, and from cows that leak colostrum extensively prior to calving.
- There is little evidence that nutrition, within the range of diets typically fed to dairy cows, has much influence on either the volume or quality of colostrum.
- Heat stress may reduce the quality of colostrum, especially in heifers.
- Dry period length should be at least 3-4 weeks to maximize colostrum quality.

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- Vaccinate cows against the calf diarrhea pathogens *E. coli*, rotavirus and coronavirus to maximize the amount of antibodies against these agents in colostrum. Make sure that cows are vaccinated at the appropriate time to optimize transfer of vaccine-induced antibodies into colostrum.

Introduction

It is well known that the early ingestion of an adequate volume of high quality colostrum is the single most important factor influencing the health and survival of dairy calves. The calf is born without protective antibodies and depends on the uptake of colostral antibodies (immunoglobulins) to protect it against common diseases; this is termed passive transfer of immunity. Immunoglobulins are absorbed across the small intestine from colostrum during the first 24 h after birth. Achieving adequate passive transfer is a function of quality and quantity of colostrum as well as the timing of colostrum feeding. Management, cow and calf factors all play a role in determining whether adequate passive transfer is achieved. In this presentation, current knowledge regarding cow factors that influence colostrum quality and volume will be reviewed.

What is Colostrum?

Colostrum is the first secretion from the mammary gland after birth. It is extremely complex and includes many immune factors, important nutrients and growth factors. Immunoglobulins (Ig) are the best studied components of colostrum, and in cattle the major colostral Ig is IgG (mainly IgG1). In addition to Ig, there are many other factors in colostrum that can influence the immune system of the calf. These include growth factors, hormones, live maternal immune cells, proteins that direct the immune response (cytokines) and non-specific antimicrobial factors (e.g. lactoferrin). This is a very active area of research, but as yet there are not specific recommendations on the importance of each of these factors or the amount that needs to be present in colostrum to promote the health and well-being of the calf. Because the importance of IgG for calf health is well known and because it is the predominant antibody present in colostrum, IgG concentration is the factor most commonly used to define colostrum quality.

What is “High Quality” Colostrum?

“High quality” colostrum has been defined as first-milking colostrum that:

- Has at least 50 g/L IgG
- Has a high concentration of IgG against specific diseases that calves born on that farm are likely to be exposed to

- Provides a highly nutritious meal to the calf (contains adequate fat, protein, vitamins and minerals to support calf health)
- Has a low concentration of bacterial contaminants (<100,000 cfu/ml total bacteria count and <10,000 cfu/ml coliform count).
- Is free of pathogens that could be transmitted in colostrum. These include *Mycobacterium avium* subspecies *paratuberculosis* (the agent that causes Johne's disease), *Mycoplasma* species, and *Salmonella* species.

Experts recommend that Holstein calves be fed a minimum mass of 100 g of IgG in the first feeding within 2 h of birth. Depending on the Ig concentration of colostrum, this may be met by feeding as little as 2L (if the colostrum had 50 g/L IgG) or as much as 4L (if the colostrum had 25 g/L IgG). Given that not all calves are fed within 2 h of birth, and Holstein colostrum often contains <50 g/L IgG, current recommendations are to feed 3.8L (4 L) of colostrum in the first feeding.

When is Colostrum Produced?

The process of colostrum production begins several weeks before calving and stops abruptly when the calf is born. During this time, large amounts of IgG and other immune factors are selectively transferred from the bloodstream of the cow into colostrum. This starts approximately 5 weeks prior to calving and is maximal in the last 2 weeks before calving.

Variation in Colostrum Quality

The reason that experts recommend testing the quality of each cow's colostrum is that there is huge variation in quality among individual cows on the same farm. For example, in a 2007 study of Holstein cattle in Wisconsin, cows in a 550-cow herd had colostral IgG concentrations ranging from 10 to 125 g/L; in the same study, the average quality of colostrum on 12 Holstein dairy farms ranged from 47 g/L on the farm with the poorest quality colostrum to 101 g/L (Swan et al., 2007). Another study by Kehoe et al. (2007), with data from 58 Pennsylvania dairies, found an average colostral IgG of 40 g/L with a range from 10 to 79 g/L. While there has been much recent research on the physiology, management and nutrition of the transition cow, there has been very little on factors accounting for this variation in colostrum quality. Some recent studies have suggested that perhaps the most important factor influencing colostral quality is the time between calving and colostrum harvesting. However, many other factors are thought to also play a role. The remainder of this paper reviews what is currently known on cow factors that influence the quality and volume of colostrum up to the time of calving; other speakers will cover factors after calving that can influence colostrum.

■ Interaction Between the Volume and IgG Concentration of Colostrum

It's quite common to hear that when a cow produces a large volume of colostrum, this is likely to be poor quality. However, multiple research studies have now shown that there is no predictable relationship between the volume of colostrum produced at the first milking and the concentration of IgG in colostrum when the first milking is completed immediately after calving (Maunsell et al., 1999; Baumrucker et al., 2010). When there is a delay between calving and first milking, the onset of milk production dilutes colostrum and leads to a decrease in IgG concentration and an increase in volume; this will be covered by another speaker. Producers should not automatically discard high volume first-milking colostrum that is collected within a few hours of calving, but should test individual colostrum and keep those that contain adequate IgG.

■ Dam Factors Affecting Colostrum Quality and/or Volume

Breed

Breed can affect colostrum quality, and traditionally Holsteins have been thought to have lower colostral IgG concentrations than other dairy breeds. However, a recent national survey of colostrum quality in the US did not find any significant difference in IgG concentration of colostrum of Holstein (74 g/L) and Jersey (66 g/L) cows (Morrill et al., 2012).

Parity

On average, first-lactation heifers produce lower yields of colostrum, lower total mass of Ig, and lower IgG concentration in colostrum than cows in their second or greater lactation. Colostral quality continues to increase with parity after the second calving, and older cows generally have the best quality colostrum (Morrill et al., 2012). However, some heifers produce very good quality colostrum and producers should not automatically discard heifer colostrum but should test and keep high quality colostrum from a cow of any parity.

Mammary Gland Size

The mass of IgG transferred into colostrum does not appear to be related to the size of the mammary gland (Baumrucker et al., 2010). So, the size of the dam's udder does not mean she'll produce higher or lower quality colostrum.

Mastitis and Other Illnesses

Chronic subclinical mastitis in the dry period is associated with reduced colostral volume but does not affect colostral IgG concentration (Maunsell et al., 1999). However colostral quality can be severely compromised during clinical mastitis and colostrum from mastitic cows can contain high numbers of pathogenic bacteria. Producers should discard colostrum from cows with clinical mastitis. Bloody colostrum should also be discarded. Many pathogens can be transmitted in the colostrum from sick cows; colostrum from any animal that is sick should be discarded.

▪ Dry Cow Management Factors Affecting Colostrum Quality and/or Volume

Prepartum Diet

There are many opinions on how to feed modern dairy cows to maximize colostrum volume and quality. However, there is actually very little research on the effects of various dairy nutrition approaches on the quality or volume of colostrum produced. Older studies in beef cattle showed that prepartum nutrition did not affect colostrum IgG content, even when protein and energy were severely restricted. However, when diets very low in protein were fed (less than 9% crude protein), the ability of the calf to absorb IgG was compromised.

Feeding to NRC recommendations in a single diet throughout the dry period versus a 2-stage far-off and close-up dietary strategy that exceeded NRC recommendations had no effect on volume, IgG concentration or total mass of IgG in first-milking colostrum (Richards et al, 2009). The effect of dietary protein in close-up rations on colostrum was evaluated by Santos et al. (2000). Heifers and cows were assigned to either 12.7 or 14.7% crude protein (36 and 40% rumen undegradable protein) diets for 3 weeks prior to calving. Feeding the higher protein diet had no effect on colostrum IgG concentration or volume in either cows or heifers.

Selenium and possibly other trace minerals and vitamins involved in immune function may influence colostrum quality when they are deficient. Cows fed a prepartum diet deficient in selenium and vitamin E produce less colostrum and lower total mass of colostral IgG than cows fed the same diet but supplemented with injections of vitamin E and selenium; there was no effect on IgG concentration (Lacetera et al., 1996).

In summary, there currently is little in the literature to support many of the strategies that are commonly recommended to increase colostral quality or volume, such as increasing protein in the close-up rations. Cows should be

fed to maximize health during the transition period; this should include meeting or exceeding NRC recommendations for all nutrients.

Heat Stress and Season

The effects of heat stress on colostrum quality are not well documented, although this is an active area of research. Some studies have reported no effect of mild to moderate heat stress on colostrum volume or quality while others have reported that colostrum quality is lower in summer than other seasons. Nardone et al. (1997) found that heifers subjected to heat stress for the last 3 weeks prior to calving produced colostrum with a much lower IgG concentration than non-heat-stressed controls. The volume of colostrum was similar between the 2 groups. Given the other negative effects of heat stress on the health of dairy cows in the transition period and the health of their calves, producers should use heat-abatement practices for dry cows that are similar to those for lactating cows.

Photoperiod

Manipulation of photoperiod during the dry period did not affect colostral IgG concentration or volume in Holstein cows in the one study that has evaluated this factor (Morin et al., 2010).

Length of Dry Period

Shortening the dry period to 28-40 days does not seem to have a substantial impact on colostrum quality in multiparous cows, although the volume of colostrum produced may be less in cows with a dry period <40 days (Rastani et al., 2005). However, short dry periods are associated with reduced colostral IgG concentrations in first lactation animals (Annen et al., 2004). Cows seem to need at least a 3-4 week dry period to produce good quality colostrum, and when dry period is very short (<21 days) or there is no dry period, colostrum is often poor quality (Rastani et al., 2005). Producers should probably not feed colostrum from cows with a very short (<3 week) dry period even if it has >50 g/L IgG, as there will have been inadequate time for proper response to dry period vaccines and transfer of those specific antibodies to colostrum.

Prepartum Milking

Extensive prepartum milking leads to premature onset of milk production, and secretions at the time of calving resemble normal milk rather than colostrum. Leakage of colostrum from the udder before calving will similarly reduce colostral quality, especially if it is severe or if it occurs repeatedly during the prepartum period. Colostrum from cows that have been milked prepartum

(e.g. due to severe edema) or from cows that have been noted to leak milk should not be fed to calves.

■ Cow Factors Affecting Pathogen-Specific Antibody Concentrations

Exposure to Pathogens

Cows produce antibodies from every day exposure to pathogens, and these are transferred into colostrum. Therefore, a calf could be expected to have better protection against the common pathogens in its environment if it is be fed high-quality colostrum from a cow on the same farm rather than from animals living in another environment.

Vaccination to Improve the Quality of Colostrum

Vaccination of the cow at 3-6 weeks prior to calving can lead to an increase in the amount of antibodies in colostrum against those specific antigens. The vaccines that this has been shown best for are the ones that cause calf diarrhea; specifically *E. coli*, rotavirus and coronavirus. There is also some evidence that *Salmonella typhimurium* vaccines can boost colostral antibody concentrations, although research showing that this protects calves from disease still needs to be done. These vaccines might be considered in specific situations. Producers should work with their veterinarians to create the best vaccination program for their farm, and most dry cow vaccination programs should include vaccination against *E. coli*, rotavirus and coronavirus. Don't forget to include heifers in the vaccination program as well; they will need an initial vaccination and a booster.

It is especially important that these vaccines are given at the recommended time prior to calving and that any recommended boosters are given. In fact, some research even suggests that vaccine-specific antibody concentrations in colostrum are actually lower in vaccinated cows if the vaccines or boosters are given too close (<3 weeks) to calving. IgG is transferred into colostrum over several weeks prior to calving, especially in the last 2 weeks. Cows need to be vaccinated far enough before calving to generate high serum antibody levels prior to these last few weeks of gestation, otherwise the "window of opportunity" when large amounts of antibodies produced in response to a vaccine can be transferred to colostrum will be missed.

Presence of Infectious Disease Agents in the Colostrum of Infected Cows

Pathogens such as *Salmonella* and fecal coliforms can contaminate colostrum during harvest, handling or storage and can cause diseases such as diarrhea and septicemia. However, other infectious agents can be transmitted directly from infected cows to calves in colostrum. These include Johne's disease (*Mycobacterium avium* subspecies *paratuberculosis*), *Salmonella* species and Mycoplasma species, as well as several viral diseases. In most cases, colostrum from animals that are known to be infected with any of these agents should not be used for feeding calves. For herds that are trying to eliminate transmission of these pathogens, there are several options including feeding of colostrum replacement products or pasteurizing colostrum.

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