

## COLOSTRUM: QUALITY AND QUANTITY

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### Introduction

Despite increasing awareness of the importance of passive immunity in calves to reduce disease prevalence, morbidity from calfhood diseases, days to first illness, sick days, days of viral shedding, viremia, growth and productivity(1-6), 20 to 30% of neonates will be hypo- or agammaglobulinemic. Failure of passive transfer of maternal immunoglobulins (FPT) occurs when there is a problem with 1 or more of the 3 phases of passive transfer: formation of colostrum with a high concentration of immunoglobulin, ingestion of an adequate volume of colostrum by the calf in a timely fashion, or efficient absorption of colostrum immunoglobulin. Some calves with FPT are healthy and productive neonates, which is a reflection of the importance of other factors including environmental conditions, management practices, pathogen load, pathogen virulence, and nutrition of the calf in addition to acquisition of passive immunity.

There is general acceptance that failure of passive transfer exists when calves between 36 and 48 hours of age have serum immunoglobulin concentrations less than 1000 mg/dl. Individual calf problems can occur when its serum immunoglobulin concentration is below 1000 mg/dl; herd problems occur with increased prevalence of scours and respiratory disease occur when large numbers of calves have FPT.

### Colostrum Quality

True colostrum is obtained from the first milking of a lactation. Milk from subsequent milkings for approximately 4 to 5 days is referred to as transitional milk. The appearance of colostrum can be an indication of quality, good colostrum being thick and creamy because of high total solids content. The immunoglobulin content of colostrum varies from 2 to 23% and is directly related to the percent of total solids, which may vary between 17 and 36%. (7)

Most calves should receive 200 to 300 g of immunoglobulin mass before 12 hours of age or up to 400 g by the time of gut closure at 24 hours of age(8,9) to assure successful passive transfer. IgG1 is the immunoglobulin of most importance to the newborn calf and accounts for greater than 80% of the immunoglobulin mass in colostrum. Dairy calves which consume less than 100 g of IgG1 will have a high rate of FPT, while 5% or fewer calves have FPT if there is consumption of 100 g or more of IgG1. Colostral immunoglobulin concentration is highly variable in dairy cattle, Holsteins demonstrating mean IgG1 levels from 45.9 to 73.4 mg/ml.(1,10,11) Fewer than 50% of colostrum samples from Holsteins contain adequate immunoglobulin mass to provide successful passive transfer in 2 L of colostrum. Administration of 4 L of good quality colostrum from a Holstein will assure adequate passive transfer of immunoglobulins in 85% of calves. Mature beef cows on an adequate plane of nutrition will provide an adequate immunoglobulin mass in 3 L of colostrum(12).

There is a negative correlation between the apparent efficiency of absorption and the immunoglobulin concentration in colostrum(13) but calves fed good quality colostrum (colostrum with high immunoglobulin concentration) have higher serum immunoglobulin concentration. Typical immunoglobulin absorption by a 90 lb Holstein calf which receives 2 L of good quality

colostrum (102 mg/ml immunoglobulin concentration) is 20% or 40.8 g of immunoglobulin.(7)

Compared to winter or spring, colostrum quality and efficiency of absorption is greater when cows calve in the Fall. Immunoglobulin concentration is highest in dairy cows if the dry period has been at least 40 days and not greater than 90 days(11). Prematurity decreases efficiency of absorption of immunoglobulins. Hypoxia delays absorption of immunoglobulins and time to gut closure but does not effect absorptive capacity.(14) There is a genetic component to the acquisition of passive transfer and the onset of active immunity in calves, the 24 to 36 hour and 4 week serum immunoglobulin concentrations, respectively, being the most accurate indicators of hereditary effects.(15)

Measurement of colostrum quality will assure selection of colostrum with an adequate immunoglobulin mass to be fed to calves for the first 2 feedings. A commercially marketed colostrometer, a hydrometer which incorporates the relationship between immunoglobulin specific gravity and immunoglobulin concentration(16), can be used to estimate colostrum immunoglobulin concentration. The colostrometer is color coded to provide guidance to colostrum selection; colostrum with specific gravity < 1.050 has less than 30 mg/ml IgG1. For greatest accuracy, colostrum concentration readings by the colostrometer should be made with the colostrum temperature at 20 C (68 F). At temperatures less than 20 C, uncorrected readings overestimate immunoglobulin concentration while measurements made in warmer colostrum underestimate the immunoglobulin concentration.(17) Producers who make it a practice to store frozen colostrum, particularly when it is pooled, should employ a colostrometer to assure that only good quality colostrum is saved.

Previous storage of good quality colostrum insures availability of adequate immunoglobulin mass to calves immediately at birth. Storage methods can affect colostrum quality. The author prefers to freeze colostrum in amounts (2 to 3 L for a Holstein calf) needed for a single feeding. Fresh colostrum can be stored at moderate (approximately 20 C) outdoor temperatures for 1 to 2 days, refrigerated for 1 week, or frozen for approximately 1 year without significant decline in immunoglobulin content. The addition of potassium-sorbate to a final concentration of 0.5% will extend storage time for 14 days and 3 months at moderate ambient temperatures or refrigeration, respectively.(18)

Frozen colostrum should be thawed slowly in warm water prior to use. Rapid thawing by hot water or moderate to high temperatures in a microwave oven can be detrimental to the immunoglobulin mass. Microwave thawing of good quality frozen colostrum of at least 2 L volume at low power settings can be used without significant loss of IgG1 mass(18) but there is some reduction in functional properties of the immunoglobulin (antibody-dependent cellular cytotoxicity)(20).

### **Colostrum Quantity**

The single most important factor in the calf's acquisition of passive immunity from colostrum is the volume of colostrum ingested or administered. This is most important in dairy calves, where calves left to nurse alone rarely ingest adequate colostrum volume and cows infrequently produce adequate colostrum mass in 2 L of colostrum.(1,11) Holstein calves should be administered a minimum of 4 L of good quality colostrum within 12 hours of birth. Provision of at least 4 L divided into 2 separate feedings within 12 hours is beneficial because the second feeding apparently displaces the first feeding to absorptive sites within the small intestine more rapidly. Beef calves are more likely to ingest an adequate colostrum volume without intervention. Presumably this is the result of the production of a higher immunoglobulin mass in a smaller volume of colostrum. An equivalent immunoglobulin mass in 1 L of colostrum is absorbed more efficiently than that mass in 2 L colostrum. In addition, there is a beneficial effect on apparent

efficiency of absorption of colostral immunoglobulins in beef calves by the presence of the dam. If FPT becomes a problem in beef calves, however, administration of a known volume of good quality colostrum within 6 hours of birth is recommended.

### **Age at First Feeding**

Early colostrum feeding increases the efficiency of absorption, with optimal absorption occurring when colostrum is fed immediately after birth. When 2 feedings of good quality colostrum are provided within 12 hours of birth, delay of the first feeding up to 6 hours after birth did not affect IgG1 concentration.(15) If the first feeding of colostrum is delayed to 8 hours after birth, however, apparent efficiency of absorption of immunoglobulins is reduced by 50%.

### **Feeding Method**

If high quality colostrum is fed, the method of feeding is not a major factor in determining the success of passive transfer. When 100 g or more of IgG1 is ingested, there is minimal FPT regardless of whether the calf suckles or is tube fed. In beef calves, unassisted suckling is a highly efficient means of acquiring passive immunity. On the other hand, 64.1% of the dairy calves left with their dam to suckle naturally for 72 hours had FPT.(11) In the same study, fewer calves which received their colostrum by esophageal feeder had FPT than calves fed colostrum by nipple bottle because an adequate volume of colostrum could be administered in a more timely fashion.(11)

Good quality colostrum should be fed undiluted because formation of a casein curd (abomasal clot) allows the immunoglobulin in the whey phase to escape digestion by leaving the abomasum shortly after feeding. With the retention of casein and fat in the abomasum, the immunoglobulin in the whey phase reaches the intestinal absorptive sites prior to its digestion by pancreatic enzymes.

### **Colostrum Supplements**

Immunoglobulins, which have been derived from cheese, milk or colostral whey are actively being commercially marketed. Compared to good quality, fresh colostrum, which may contain 100 mg/ml total immunoglobulins (88.7 g IgG1), most products contain less than 20 g and many provide less than 10 g of immunoglobulin mass in the recommended dose.(21) Furthermore, for some products, provision of an immunoglobulin mass equivalent to fresh colostrum is not physically possible for most calves. Veterinarians should be critical in evaluating product literature of colostrum supplements, scrutinizing such aspects as the source of immunoglobulins, quality of immunoglobulins, and field trials showing efficacy data. Although these products are colostrum supplements, statements which indicate that "when fed alone to calves as the only source of immunoglobulin within the first 10 hours of life, survival was equivalent to high-quality colostrum" imply that they are colostrum substitutes and, as such, can be very misleading to producers.

### **Fate of Absorbed IgG1**

The serum concentration of immunoglobulins in calves peak at 24 to 48 hours of age, then decline significantly to 3 to 4 weeks of age, followed by gradual increases until 7 weeks of age, though the onset of active immunity is dependent on such things as acquired serum immunoglobulin concentration, genetics, exposure to antigens and microbial agents, management, environmental factors, calf health and nutrition, and age of the calf. High concentrations of maternal IgG does not depress endogenous immunoglobulin production at later ages.(15)

Once absorbed, passively acquired antibodies circulate, where they may or may not be important to disease protection. Many agents which cause scours are noninvasive and it is thought that control of infection by these agents must be by antibodies which are present in the gastrointestinal tract lumen, for example. Serum-derived antibodies generally play a minor role in protection from enteric infection by the noninvasive viruses such as rota- and coronavirus, with little correlation demonstrated between neutralizing Ab titers in serum and protection against disease.(22)

The gastrointestinal tract is the major route of clearance of passively derived IgG1 antibodies.(23) The reverse transport of IgG1 puts antibody, which retains its antigen-binding ability, back in the lumen of the intestine where it may play an important role in enteric immunity.(23) Depending on the amount of IgG1 absorbed, the reverse transport may protect calves from rota- and coronavirus infection for several days after birth. Loss of effective concentration of antibodies which have been transported back into the intestinal tract may be the reason for the increased susceptibility of calves to enteric viral infection between 4 and 10 days of age.(9) Increasing the amount of time that antibodies are in the intestinal tract may increase immunity to viruses which infect villous epithelial cells but which do not usually cause systemic infection by protection of villous enterocytes. Colostrum supplements added to milk or milk replacer fed at 1% (vol/vol) concentration 2 or 3 times daily beginning shortly after birth and continuing for 5 to 7 days showed some protective effects from viral challenge, particularly when the colostrum source had high concentration of anti-viral antibodies.(22,24) Continued feeding of *Cryptosporidium parvum* antibodies in colostrum 6 times daily for 7 days did not protect against challenge infection in calves.(25) The role of fresh or fermented colostrum or transitional milk supplementation in milk or milk replacer for the prevention of enteric diseases of calves needs further investigation. As the sole source of milk, continued colostrum feeding to calves increased the severity of scouring, percentage of calf days scouring, days requiring treatment and calf days with elevated temperature but did result in the lowest mortality rate amongst all experimental groups.(15) A place for pasteurized colostrum has not been found because of difficulty dealing with consistency problems. While pasteurization will not destroy the immunoglobulins, its effect on immunoglobulin function is unknown.

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## Summary

The importance of colostrum and acquisition of passive immunity to calf health and productivity is well established. Colostrum quality and volume are the 2 most important determinants of passive transfer. Good quality colostrum is colostrum has a total immunoglobulin concentration > 60 mg/ml, an IgG1 concentration greater than 30 mg/ml, or which delivers 200 to 400 g of total immunoglobulin or 100 g of IgG1 in 2 to 4 L. Colostral quality can be adequately assessed using a colostrometer and only good quality colostrum should be fed to calves in the first 2 feedings or stored for future usage. Dairy calves should be administered 2 to 3 L of colostrum at each of 2 feedings provided prior to the calf reaching 12 hours of age. The first feeding should be administered as soon after birth as possible and colostrum not voluntarily suckled should be force fed. Beef calves can have successful passive transfer of immunoglobulins by unassisted natural suckling. Colostrum supplements do not provide adequate immunoglobulin mass to newborn calves. Once IgG1 is absorbed, it circulates and then is cleared into the intestinal tract where it may play a role in local enteric immunity. Continuous provision of colostral immunoglobulins is necessary to maintain immunity to non-invasive enteric viral infection.