Research article

Colostrum management for dairy calves

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Home Messages:

- Bovine placentas are classified as cotyledonary synepitheliochorial based on their morphological attributes at gross and microscopic levels.
- An intrauterine transfer of immunoglobulins is almost impossible, and calves are born with a naive immune system.
- If cows fail to produce enough colostrum their calves are more likely to have high incidences of morbidity and mortality.
- Several risk factors might be responsible for poor colostrum yield and quality in dairy cows.
- The “Three Q's” as a general guideline for providing colostrum: Quantity, Quality and Quickness of feeding
- Transfer of passive immunity (TPI) is evaluated or quantified by measuring calf serum or plasma IgG or total protein.
- Raising healthy calves depends on the correct management of colostrum and this process starts from the dam's pregnancy period and continues until sufficient absorption of immunoglobulins.
- The proposed TPI standard includes 4 serum IgG categories: excellent, good, fair, and poor with serum IgG levels of ≥25.0, 18.0–24.9, 10.0–17.9, and <10 g/L. At the herd level, it is proposed that >40, 30, 20, and <10% of calves are in the excellent, good, fair, and poor TPI categories, respectively.

Keywords: colostrum, dairy calf, passive immunity

Introduction:

Colostrum is a vital component in the raising of nearly all mammalian newborns, especially those reared domestically for agricultural purposes. Colostrum contains multiple immunoglobulins (Ig; IgA, IgM, IgG, etc.), with the most abundant Ig in colostrum generally being IgG. The various Ig molecules serve different purposes within the neonate. Immunoglobulin M is primarily made during the primary immune response and is usually found in higher quantities than IgA, which congregates on epithelial surfaces and is found in high content in saliva (Tizard, 2013). Immunoglobulin G, a large globular protein with a molecular weight of roughly 150 kDa, is the most commonly discussed Ig in calf-raising and is measured in calf serum around 24-h post-colostrum feeding to evaluate passive transfer of immunity (PTI). Passive transfer of immunity rates on a given operation is a critical benchmark to determine how well colostrum is managed. Producers, veterinarians, and consultants must understand how PTI is achieved to ensure this critical objective is achieved consistently by calves on the farm. The following review is intended to help summarize the understanding of how PTI is achieved, and what factors in maternal colostrum (MC) influence PTI.

Bovine placentas are classified as cotyledonary synepitheliochorial based on their morphological attributes at gross and microscopic levels. During early gestation, the bovine trophoblast layer has uninucleate trophoblast cells (UTCs) as well as trophoblast giant cells (TGCs). The UTCs are in contact with the trophectodermal membrane on the basal side and uterine epithelial cells on the apical side. These cells are cuboidal or columnar in shape and have microvilli interdigitate with corresponding structures on the maternal epithelial cells. The TGCs are mostly binucleated, initially round with no attachment to the basal lamina. Upon maturation, these cells accumulate cytoplasmic granules and migrate towards the apical side of the trophoblast layer, through the tight junctions of neighboring UTCs, using their pseudopodia. The characteristic feature of the bovine fetal-maternal interface is the presence of feto-maternal hybrid cells (trinucleated), formed by the fusion of the migrating TGCs with uterine epithelial cells. Hence, the term synepitheliochorial,

unlike in pigs and horses where it is epitheliochorial

Colostrogenesis:

Colostrogenesis (the prepartum transfer of immunoglobulins from maternal circulation into mammary secretions) begins 5–6 weeks pre-calving. The volume of colostrum produced by the dam (colostrum yield) may be affected by: nutrition; environmental conditions; time interval from calving to milking; parity; dry period length; degree of calving difficulty; calf weight; calf sex; calf viability; cow BCS/body weight; milk production in previous lactation and dam health. Individual cow colostrum yield is highly variable.

Endocrine control of initiation of colostrogenesis:

Placental transfer of Ig does not occur in many mammalian species, including cattle. Therefore, newborn calves must receive immunity from their dams via transfer of Ig, specifically IgG, from colostrum. This intake of a large mass of colostral IgG in the few hours shortly after birth assures calves receive PTI, which generally lasts for 2–3 weeks until the calf's active immunity can take over. Sufficient PTI is assumed as a serum IgG content 24-h post-feeding of 10 g IgG/liter of serum. When measuring PTI, IgG is generally used as IgG makes up roughly 90% of the Ig present in MC. It should be mentioned that two isotypes of IgG exist in maternal, bovine colostrum: IgG1 and IgG2. Immunoglobulin G1 exists in a much higher quantity in MC than IgG2. Immunoglobulin G1 and IgG2 are absorbed in the small intestine of the calf, via nonselective pinocytosis. The difference between IgG1 and IgG2 is that IgG1 is resecreted back into the lumen of the gastrointestinal tract to provide local immunity at the gut level, whereas IgG2 is not resecreted. Maternal colostrum and colostrum replacers (CR) would contain similar ratios of IgG1:IgG2 (roughly 95% vs. 5%), with the exception of CR based on animal plasma, where the ratio of IgG1:IgG2 is closer to 50:50.

Optimal on-farm colostrum management is essential to ensure adequate transfer of passive immunity and provide the best start for newborn calves. Many studies have been conducted to define optimal management strategies for colostrum feeding. Farmers, veterinarians and

feed advisors have adopted the "Three Q's" as a general guideline for providing colostrum (Figure 1): Quantity, Quality and Quickness of feeding. In addition, sometimes two "“Q” s" are added: "Quantifying the transfer of immunoglobulins" and "sQueaky clean

Figure 1: The 5 Q's of colostrum management. The 5 Qs consist of 1) Quality (>50 g of Immunoglobulin G (IgG)/liter of maternal colostrum), 2) Quantity (>150 g IgG fed per calf immediately after birth), 3) Quickness (feed calves and milk dam within 2 h of calving),

Evaluation of Factors Affecting Colostrum Quality and Quantity in Holstein and Jersey Dairy Cattle:

According to numerous studies in recent years by the author and other researchers,

The important factors affecting the colostrum yield and quality are summarized as follows:

- calving body condition score, breed, age of dam, nutrition in the periparturient period Season of calving, periparturient vaccination of the dam, dry period length, volume of colostrum produced at first milking, delayed colostrum collection, parity, singleton or twinning and diseases of dry period.

The decrease in colostrum yield, especially in Jersey cows, occurs to a greater degree due to the inability of this breed to provide the energy it needs in late pregnancy, as well as the inability to provide enough glucose as one of the main precursors of colostrum. Therefore, our study (doctoral thesis) was conducted with the aim of investigating the relationship between some blood metabolic parameters and colostrum yield and quality in Jersey cattle. This study was conducted on 18 Jersey cattle with Normal Colostrum (NC)

yield and 7 cows with Low Colostrum (LC) yield. Colostrum yield, disease history, total protein, NEFA, GGT, Brix index, calcium and magnesium levels were measured on the day of parturition and 2 days after calving. Results of our study revealed there was a significant difference in the characteristics of colostrum production, length of dry period, and calcium and magnesium concentrations in the two groups of NC and LC, and it was more in the NC group. There was no significant difference between the two groups of NC and LC in the characteristics of disease history, total protein and Brix index. In the present study, NEFA and GGT, as important indicators of passive immunity and negative energy balance, were higher in the LC group than in the NC group. The possible reason for this can be the individual differences of the first colostrum between cows, volume and time of lactation and insulin resistance to maintain plasma glucose concentration.

Evaluation of transfer of passive immunity:

Transfer of passive immunity (TPI) is evaluated or quantified by measuring calf serum or plasma IgG or total protein.

The traditional standard for categorizing an individual calf as having adequate or failed TPI was 10 g/L IgG (Gay, 1983), which corresponded with recommended serum total protein (STP) cut-offs of 5.2 g/dL (sensitivity = 76%, specificity = 89.3%) or 5.5 g/dL (sensitivity = 88.2%; specificity = 77.9%) depending on whether the goal is to rule in or out the presence of failed TPI (Buczinski et al., 2018). However, whereas the prevalence of failed TPI has decreased over the last decades, this decrease has not resulted in a paralleled reduction in calf morbidity before weaning. Thus, a group of experts recently recommended increasing the TPI threshold and the use of 4 categories of TPI (excellent ≥ 6.2, good = 5.8–6.1, fair = 5.1–5.7, and poor <5.1 g/dL STP) instead of the traditional dichotomous classification used previously.

Methods of Evaluating TPI

The TPI assessment methods by classified them according to the IgG evaluation method, operation principle, main characteristics, and statistics compared to the gold

standard, and the possibility of using these methods in the field.

Methods	IgG Evaluation	Main Characteristics of the Method	Statistics Compared to the Gold Standard	Using These Methods in the Field
RID	Direct	Gold standard, classic method, but time-consuming	-	No
Turbidimetric Immunoassays	Direct	Fast, does not require reagents from the user, can be expensive	R2 = 0.98	Yes
ELISA	Direct	Time-consuming, requires bench equipment and often needs repetition	R2 = 0.97 r = 0.90	No
Electrophoresis	Direct	Commonly used for serum protein fractionation, highly widespread in laboratories, and requires bench equipment	89% accuracy	No
CE	Direct	Fast, precise, accurate, fully automated, compatible with small sample volumes, inexpensive, and requires bench equipment	r = 0.97	No
Proteomics	Direct	Used to separate and individually quantify sample proteins;	We found no such studies	No

Methods	IgG Evaluation	Main Characteristics of the Method	Statistics Compared to the Gold Standard	Using These Methods in the Field
		expensive and not widespread in laboratories as it requires bench and expensive equipment		
AP-MALDI-MS	Direct	Ease to operate, fast, precise, robust, compatible with small sample volumes, inexpensive, and requires bench equipment	We found no such studies	No
Spectroscopic method	Direct	Simple and fast measurement that requires little or no sample preparation; expensive and requires expensive equipment	r = 0.93	Not yet
STIGA	Direct	High potential to be a direct analysis of IgG in calves for use in the field	R2 = 0.83–0.94	Not yet
Biochemical analysis of total proteins and fractions	Indirect	Highly widespread in laboratories and cheap; requires bench equipment	r = 0.83	Not yet
TP by refractometry	Indirect	Cheap, simple, fast, and can be used on farms, uses portable equipment	r = 0.93 [19]; r = 0.41	Yes

Methods	IgG Evaluation	Main Characteristics of the Method	Statistics Compared to the Gold Standard	Using These Methods in the Field
BRIX by refractometry	Indirect	Used in the field to assess both TPI and colostrum quality, uses portable equipment	r = 0.93	Yes
Zinc sulfate turbidity test	Indirect	Cheap, simple, fast, and can be used on farms	R2 = 0.78	Yes
Turbidity test for sodium sulfite	Indirect	Cheap, simple, fast, and can be used on farms	88% accuracy	Yes
Biochemical serum GGT analysis	–	Evaluates only unpasteurized maternal colostrum intake, requires bench equipment	r = 0.57	Not yet

Serum IgG measured at 24 to 48 h of age has long been used as the gold standard measure of TPI, and in dairy calves, a threshold of 10 g/L has been used to effectively reduce the incidence of neonatal mortality in the United States. The proposed TPI standard includes 4 serum IgG categories: excellent, good, fair, and poor with serum IgG levels of ≥25.0, 18.0–24.9, 10.0–17.9, and <10 g/L. At the herd level, it is proposed that >40, 30, 20, and <10% of calves are in the excellent, good, fair, and poor TPI categories, respectively. Implementation of the proposed standard should further reduce the risk of both mortality and morbidity in newborn calves.

CONCLUSIONS:

Raising healthy calves depends on the correct management of colostrum and this process starts from the dam's pregnancy period and continues until

sufficient absorption of immunoglobulins.

The constant monitoring of each of these stages (colostrogenesis, transfer and absorption of immunoglobulins) ensures the proper transfer of immunity to the neonatal calves.

Due to the importance of proper TPI to calves, the constant monitoring of colostrum management is required on farms. Several methods involving both direct and indirect analyses of serum IgG concentrations are available, with innovative applicability to TPI evaluation. Since, colostrum has several immunological components other than IgG, which are absorbed by the intestines of the calves and most likely present the biological functions in the immune system, new methods could aid in the more complete understanding of TPI in calves. Studies related to the colostrum components are warranted to further investigate the impact of its concentration on TPI and the health and survival of calves.

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