The importance of colostrum for dairy calves

Diego E Gomez[1], DMV, MSc, MVSc, PhD, DACVIM; Manuel F Chamorro[2], DVM, MS, PhD, DACVIM

[1]College of Veterinary Medicine, University of Florida, Gainesville, FL USA. [2]College of Veterinary Medicine, Kansas State University, Manhattan, Kansas, USA

Introduction

Ingestion and absorption of colostrum is essential to the health and thrive of neonatal ruminants. Calves are born profoundly agammaglobulinemic, making them susceptible to infection. Consequently, calves rely on early consumption of colostrum to acquire Igs (Godden, 2008). Bovine colostrum also contains maternal leukocytes, cytokines and growth factors and nutrients (e.g. fat, vitamins and minerals; Foley and Otterby, 1978). Recent studies also have demonstrated that colostrum have a positive impact on the establishment and development of the gut microbial communities (Malmuthuge *et al.,* 2015). In addition to the positive effects of colostrum on the newborn calves, there is growing evidence suggesting that colostrum also benefits the productivity of the future cow (DeNise *et al.,* 1989). This review aims to describe our current knowledge regarding the benefits of maintain an adequate colostrum management protocol in dairy calves.

Colostrum is a high-quality nutritional and energy source for the newborn calf

Birth in most mammalian species represents an abrupt change from a high-carbohydrate and low-fat diet to a high-fat and low-carbohydrate diet. Glycogen stores in the neonatal calf are very low and gluconeogenesis is insufficient, thus glycogen is used up very quickly and may induce hypoglycemia (Mersmann, 1974). In addition to the limited energy supply from glycogen, calves body fat at birth is low (20 g/Kg) and does not contribute significantly to the available energy supply (Swiatek *et al.,* 1968;

Mersmann, 1974; Girard, 1986; Lepine *et al.,* 1991). Approximately, 20% of the total solids in colostrum is highly digestible fat. This fat plays a major role in the supply of energy, in glucose homeostasis and protein synthesis in the neonatal calf (Girard, 1986; Lepine *et al.,* 1991). Additionally, calf temperature also is affected by colostrum intake. One study found that the body core temperature of the calf increases up to 15% 1 h after colostrum intake (Kurz and Willett, 1991). Interestingly, this effect was not observed when calves were fed milk replacers with similar fat content suggesting the effect of colostrum on temperature are beyond of the fat content.

Immunologic benefits of colostrum

Colostrum Igs are non-selectively absorbed by pinocytosis through epithelial cells of the small intestine during the first 16 h (Stott *et al.,* 1979). However, permeability is highest immediately after birth and declines after 6 h. Ingestion of colostrum appears to accelerate the closure of this intestinal permeability (Michanek *et al.,* 1989). Failure of the calf to ingest or absorb sufficient Igs from colostrum is referred as a failure in the transfer of passive immunity (FTPI). FTPI is the major determinant of sepsis in large animal species and also modulates the occurrence of mortality and severity of enteric and respiratory disease during the first months of life in the calf (Heinrichs and Jones, 2015). A negative association between FPTI and the calf survival has been demonstrated in different studies. It has been estimated that approximately 30% of preweaning calf mortality occurs during the first 3 weeks of life and can be attributed to FTPI (NAHMS, 1996). Some studies have documented incidence rates

of FPTI (<10 mg/mL) in dairy calves up to 41%. In a recent study in US, 19% of dairy calves presented evidence of FPTI, and 40% of the 394 participant dairy farms had a least one calf with FTPI (NAHMS, 1996). Other studies have suggested that serum IgG concentration below 2,400 mg/dL increases the risk of morbidity and mortality of beef calves before weaning (Dewell *et al.,* 2006). Currently, there is still a debate regarding as to what are the serum levels of IgG that should be established to determine the presence of FTPI. The FTPI has been variably defined as serum IgG concentration at 24 h of age of less than 10 mg/mL (NAHMS, 1996).

Other antimicrobial properties of the colostrum

Lactoferrin is a component of the innate immune response and a potent immunomodulator (Legrand, 2016) and it is found in significant concentrations in bovine colostrum. Lactoferrin has a broad-spectrum antimicrobial activity against bacteria (e.g. *Escherichia coli*), fungi, viruses, and protozoa. These antimicrobial properties of lactoferrin are attributed to its ability to bind iron, or may occur as a direct lytic effect on microbial cell membranes (Valenti *et al.,* 2005). Lactoferrin also modulates cytokine and chemokine production by the gut-associated lymphoid tissue and like other similar products in colostrum (prebiotics), creates an environment for growth of beneficial bacteria within the gut (Valenti *et al.,* 2005; Manzoni, 2016). Finally, lactoferrin has an important role in modulation of intestinal cell differentiation and proliferation. Lactoferrin supplementation decreased the onset of sepsis in children and reduced mortality and culling in calves with diarrhea (Still *et al.,* 1990; Manzoni, 2016).

Colostrum modulate the developments and establishment of calf gut microbiome

Colostrum also harbors apparently beneficial microflora, such as members of the *Bifidobacterium* and *Lactobacillus* genera (Fecteau *et al.,* 2002), which are widely used as probiotics. Colostrum harbors a rich and diverse microbial community, regardless of parity or early lactation infection status (mastitis). Feeding heat-treated colostrum soon after birth facilitated bacterial colonization in the small intestine in dairy calves within 12 h of life, compared with calves that did not receive colostrum within 6 or 12 h after birth (Malmuthuge *et al.,* 2015). Further, a single feeding of heat-treated colostrum after birth promoted colonization with *Bifidobacterium* and reduced colonization with *E. coli* suggesting that colonization of calf's gut with *Bifidobacterium* results from direct inoculation of this bacterium and a natural prebiotic property of colostrum (Malmuthuge *et al.,* 2015).

Colostrum benefit in the long-term productivity and longevity of the cow

One of the main benefits of adequate administration of colostrum to the claves is its impact on the productivity and longevity of cow. A positive correlation between serum IgG at 24-48 h of age and average daily gain at weaning (ADG) have been identified (Robison *et al.,* 1988; Massimini *et al.,* 2006) and therefore higher serum IgG levels might be associated with a reduction in the age at first service (Furman-Fratczak *et al.,* 2011) and calving (Zanton and Heinrichs, 205). These findings are particularly important because reducing the age at first calving by 1 month can lower the cost of a replacement program by 4.3% (Tozer and Heinrichs, 2001). In addition, administration of larger volumes (4 L) of colostrum decreases the culling rates up to 16% when compared with heifers that received low volumes (2L; Faber *et al.,* 2005). Moreover, reduction of 5% in culling rates caused the net costs of raising replacements for dairy herds to fall up to 24.6% (Tozer and Heinrichs, 2001). The administration of good quality of colostrum has also been associated with a larger milk production and fat content in the first lactation (DeNise *et al.,* 1989). Finally, feeding greater volumes of colostrum (4 vs 2 L) under the same management conditions translated into an advantage of 550 Kg of milk production per cow over the first two lactations (Faber *et al.,* 2005).

Factors influencing adequate colostrum intake

Ideally, calves should receive sufficient colostrum to provide >150 g of IgG. However, several factors affect the quality of maternal colostrum. Several factors have been suggested to have an effect on passive transfer of Igs including timing of ingestion, method and quantity of colostrum administrated, colostrum quality (e.g. Igs concentration and bacterial counts), and age of the dam (Weaver *et al.,* 2000).

Timing of ingestion. Macromolecular absorption in the newborn calf is maximal soon after birth and

decreases rapidly with approximately 22% efficiency at 3 h of life, decreasing linearly to 16 h (Chigerwe *et al.,* 2008). Calves fed soon after birth (<2 h) have significant higher serum IgG concentrations than those fed later when similar volumes of colostrum and mass of IgG are fed (Stott *et al.,* 1979).

Method and quantity of colostrum feeding. Contradictory results have been reported regarding the differences FPTI rates in calves fed colostrum by nipple bottle and oro-esophageal tubing. One study found that calves allowed suckling a nipple bottle had numerically but not statically higher average of serum IgG concentrations (Adams *et al.,* 1985), whereas a recent study fail to identify differences between groups (Chigerwe *et al.,* 2008). However, the volume of colostrum fed has a direct influence on the mass Igs ingested at first feeding. FTPI rates of 61, 19, 10% in dairy calves that received colostrum by suckling the dam, suckling a nipple bottle, and esophageal tubing were reported, respectively (Besser *et al.,* 1991). Clearly, esophageal tube administration can insure a lower rate of FTPI. This issue can be explained by the fact that Holstein calves nursing from the dam ingested only 2.4 L of colostrum in the first 24 h, and therefore a significant proportion of calves fail to ingest an adequate mass of Igs in farms that provide colostrum exclusively by allowing the calf suckling from the cow (Radostis *et al.,* 1991). One study documented that only 36% of colostrum samples would have provided and adequate IgG mass (>100 g IgG) to the calf if 2 L of colostrum was fed, whereas 85% of colostrum samples would have provided an adequate mass if 4 L were fed (Weaver *et al.,* 2000).

Quality of colostrum feeding. Poor quality colostrum with low immunoglobulin concentration is a common cause of FTPI (Stott *et al.,* 1979). Earlier studies suggested that colostrum from 1st lactation cows was lower in mass of Igs (Muller and Ellinger, 1981). However, more recent studies have failed to detect statistical difference in colostrum Igs between cows in the first and second lactation but cows in the 3th lactation or greater produce colostrum with higher IgG concentration (Pritchett *et al.,* 1991). Currently, evidence is lacking to avoid feeding calves colostrum from first-lactation cows (Weaver *et al.,* 2000). Larger-volume first-milking of colostrum (>8.5 Kg) tend to have a lower Igs concentration; however, a recent report of concentration of colostrum in first milking samples from more than 3,000 Holstein dairy cows demonstrated a mean concentration of IgG over 120 g (USDA, 2014). For this reason, the practice of not using first-calf heifer's colostrum or high-volume first milking colostrum is strongly discouraged. Practices of storing of maternal colostrum should be based on an adequate maternal colostrum-testing program. Additionally, pooling maternal colostrum from multiple dams is generally discouraged because larger volume of low-Igs colostrum can dilute smaller volume of high-Igs colostrum. Furthermore, pooling raw colostrum can increase the number of calves potentially exposed to colostrum-borne pathogens (e.g. Johne's disease, bovine leucosis, *Brucella abortus*, *Salmonella* spp, and *Mycoplasma bovis*). Pasteurization at 60 °C for 60 min adequately reduces over 90% of bacteria and viruses present in colostrum, while conserving IgG, and therefore it is an encouraged practice within colostrum management programs in dairy operations (Johnson *et al.,* 2007).

Vaccination of the dam. Although contradictory results have been reported regarding the effect of vaccinating the pregnant cow on colostrum quality, a body of research has established that vaccination 3 to 6 weeks before calving increases the concentration of protective colostral antibodies for common pathogens (Cortese, 2008).

Dry period length. The length of the dry period has not been associated with the mass of IgG in colostrum but with excessive short dry period (<45 d) or not dry period is associated with low-Ig colostrum. Persistent mastitis during the dry period has not been associated with altered IgG_1 concentration but with lower colostrum volume produced (Weaver *et al.,* 2000).

Conclusion

Colostrum management is the most important factor influencing the health of the calf and likely the productivity of the cattle. Different factors can influence the adequate transfer of Igs including farm- and calf-level factors. Practitioners and farmers should take into consideration those factors when planning a proper protocol for colostrum management in dairy farms.

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