# Minnesota Dairy Health Conference

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Introduction

The role of colostrum in supplying immunoglobulins (Ig’s) to the neonatal calf have been well described and efficient and timely delivery is an essential component of any dairy management standard operating procedure (Godden, 2008). The primary reason colostrum has been of such interest in neonatal ruminants is due to the need to supply the Ig’s because calves are born agammaglobulinemic and lack a mature immune system (Weaver et al., 2000) and without these Ig’s, morbidity and mortality rates are increased. However, there is a rich literature describing the role of factors in colostrum other than Ig’s and the role these compounds can have in development of the calf. Given that calves can produce their own Ig’s over time through exposure to bacteria and viruses, maternal antibodies from colostrum are transient and an argument could be made that they are not absolutely necessary. Some of the other components in colostrum, such as insulin, IGF-I, relaxin and other growth factors and hormones, might be important factors in developmental processes and a lack or shortage of them in early life might alter some developmental function which then leads to a change in nutrient utilization and efficiency.

Lactocrine Hypothesis

The concept of a “lactocrine hypothesis” has been recently introduced and describes the effect of milk-born factors, including colostrum in this definition, on the epigenetic development of specific tissues or physiological functions (Bartol et al., 2008). Conceptually this topic is not new but the terminology is useful and the ability of several groups to make a direct connection from a milk-born factor to a developmental function at the tissue or behavior level is significant (Nusser and Frawley, 1997; Hinde and Capitanio, 2010). Data relating to this topic has been described and discussed by others in neonatal pigs (Donovan and Odle, 1994; Burrin et al., 1997) and calves (Baumrucker and Blum, 1993; Blum and Hammon, 2000; Rauprich et al. 2000). The implication of this hypothesis and these observations are that the neonate can be programmed maternally and post-natally to alter development of a particular process. It is not very well understood if the lactation response is a function of total nutrient intake or if there are factors in whole milk that are responsible for the developmental function. In primates, Hinde and Capitanio (2010) were able to demonstrate that maternal milk
composition and yield impacted offspring behavior, which has implications for the dairy industry and early life human health and development.

In calves the effects of suckling, controlled intakes and ad-libitum feeding of calves from birth up to 56 days of life have found that increasing the nutrient intake prior to 56 days of life from milk resulted in increased milk yield during first lactation ranging from 450 to 1,300 kg compared to the milk yield of restricted fed calves during the same period (Foldager and Krohn, 1994; Bar-Peled et al, 1997; Shamay et al., 2005; Terré et al., 2009; Moallem et al. 2010; Soberon et al., 2012). In Moallem et al., (2010), the effects of pre-weaning nutrition on long term productivity were associated with the type and quality of nutrients fed. Moallem et al. (2010) observed significantly (10.3%) higher milk yields during first lactation from heifers fed whole milk ad-libitum compared to heifers fed milk replacer ad-libitum during the same period and suggested that milk replacer did not contain the same biologically active factors as milk and thus did not impart any lactocrine effects on the calves. However, the data of Soberon et al. (2012) and others suggest that the long-term effect is related to nutrient intake and pre-weaning growth rates and not some milk-born factor. A review of the studies conducted to date would suggest that the long-term milk response is related to protein synthesis, thus energy intake above maintenance coupled with adequate protein and amino acids are essential for the signaling mechanism important for long-term changes in productivity. Any signals from colostrum would only enhance this observation.

**Colostrum’s role**

Colostrum is known to be rich in a variety of molecules (ratio of colostrum composition to mature milk composition), including relaxin (>19:1 pig), prolactin (18:1 cow), insulin (65:1 cow), IGF-1 (155:1 cow), IGF-2 (7:1 cow), and leptin (90:1 humans) (Odle et al., 1996; Blum and Hammon, 2000; Wolinski et al., 2005; Bartol et al., 2008).

Colostrum is well known to have major effects on the development of the gastrointestinal tract for a long period of time, but the exact mechanisms are still not well understood. During the first few days of life in neonatal piglets, a notable increase in the length, mass, DNA content, and enzymatic activities of certain enzymes (lactase) occur in the small intestine for neonates fed colostrum/milk versus a control of water (Widdowson et al. 1976, Burrin et al., 1994). This was originally thought to be mediated by differences in nutrient intake between milk and water (Burrin et al. 1992), however other studies have demonstrated differences between animals fed colostrum, rich in growth factors, versus milk with comparable energy values (Burrin et al., 1995a). Although there are studies that don’t agree with Burrin et al., (1995a) and continue to promote nutrient intake as the driving factor (Simmen et al., 1990a; Ulshen et al., 1991), there is potential for non-nutrient factors to play a major role in the development of the gastrointestinal tract.
Further, Burrin et al. (1995) examined the effects of feeding colostrum, mature milk, formula (similar macronutrient composition to colostrum), and water on circulating metabolites and protein synthesis in piglets. The most significant finding was that the increased rate of protein synthesis in skeletal and jejunal protein synthesis of colostrum fed calves versus the other groups, although blood metabolite concentrations, including insulin, were not different. This is significant because it suggests other factors other than nutrient intake induced gastrointestinal and protein synthesis changes in the neonatal piglet. The group speculated that the reason for increased protein synthesis, regardless of treatment, was due to high circulating insulin levels postprandial during the first 6 hours, and then the protein synthesis was sustained by increased IGF-1 concentrations from 6-24 hours post-prandial resulting in treatment differences.

Bartol et al. (2008) demonstrated that neonatal piglets provided sow’s milk during the first 3 days of life had better reproductive performance later in life because of high levels of milk-borne relaxin concentrations. It was identified that there are relaxin receptors present at birth in uterine and cervical tissues, and the binding of these receptors by factors in colostrum induces estrogen receptor differentiation and proliferation through intermediates found in the stroma, called relaxomedans. After day 3, estrogen-mediated events are the basis for uterine and cervical development, and the excessive proliferation of estrogen-receptors induced by relaxin ensures that critical estrogen events are recognized and optimized and proper reproductive tissue changes are induced. The highest relaxin concentrations are found in a sow’s milk 24-48 hr after birth, correlating with production of colostrum. Detectable relaxin concentrations of 200 pg/mL are found in piglet blood plasma whereas relaxin concentrations are undetectable in piglets fed milk replacer. In addition, piglets that received relaxin versus piglets deprived of relaxin resulted in significant reproductive outcomes.

Work from Faber et al. (2005) in calves demonstrated that the amount of colostrum provided to calves at birth significantly influence pre-pubertal growth rate and showed a trend for milk yield through the second lactation. Further, Jones et al. (2004) examined the differences between maternal colostrum and serum-derived colostrum replacement. In that study, two sets of calves were fed either maternal colostrum or serum-derived colostrum replacement. Serum-derived colostrum replacer was developed to provide essential immunoglobulins to a neonatal calf, however the colostrum replacer does not generally contain the other bioactive factors that colostrum contains. These two groups were then further separated into calves fed milk-replacer with or without animal plasma, yielding four different groups. The results demonstrated that calves fed maternal colostrum had significantly higher feed efficiency compared to calves fed serum-derived colostrum replacement. The IgG status of the calves on both treatments were nearly identical suggesting that other factors in colostrum other than IgG’s were important in contributing to the differences. Soberon
(2011) continued to examine the effect of colostrum status on pre-weaning ADG and also examined the effects of varying milk replacer intake after colostrum ingestion. Calves were fed either high levels (4 liters) or low levels (2 liters) of colostrum, and then calves from these two groups were subdivided into two more groups being fed milk-replacer at limited amounts or ad-libitum. Comparing calves fed 4 liter of colostrum and ab libitum intake of milk replacer versus 2 liter of colostrum and ab libitum of milk replacer, calves fed 4 liters of colostrum had significantly higher average daily gains pre-weaning and post-weaning. Therefore, it can be logically concluded that if colostrum induces changes in feed efficiency, than the first feeding can possibly affect future milk production.

Finally, Steinhoff-Wagner et al. (2010) examined the effects colostrum has on the ability of neonates to regulate glucose, through both exogenous absorption and endogenous production. The results of this study demonstrated that calves fed colostrum had significantly higher plasma circulating glucose levels in comparison to formula fed calves, however the gluconeogenic ability did not differ between the two groups. This suggests that in colostrum-fed calves glucose absorption capacity are increased in comparison to milk-replacer fed calves, as mentioned above. These results were verified by significantly higher postprandial glucose concentrations, and ensuing higher insulin concentrations, in colostrum fed versus milk replacer fed calves. During post-prandial periods, colostrum-fed calves had higher liver glycogen concentrations and g6pase activities, indicating better glucose and galactose hepatic absorption. This has implications for lactose digestion and absorption. First pass uptake of [U-13C]-glucose, or the glucose utilization in splanchnic tissue (intestine and liver), was lower in colostrum fed calves than milk replacer fed calves. This indicates that glucose was either less absorbed or more utilized in splanchnic tissue in formula-fed calves, resulting in lower percentage use in colostrum-fed calves. Additionally, [U-13C]-glucose concentration was significantly higher in calves fed colostrum over milk-replacer, similar to the xylose absorption data presented earlier. Again, this supports the idea that glucose absorption is enhanced in colostrum-fed calves versus milk-replacer fed calves. Finally, plasma glucose concentrations were significantly higher in calves fed colostrum during feed deprivation of 15 hours and plasma urea concentrations were significantly higher in formula-fed calves. This suggests that calves fed colostrum had higher glycogen concentrations and did not utilize protein catabolism. If the glucose uptake differences were to persist, it would help us understand the role of factors in colostrum other than immunoglobulins important for long-term productivity.
**Summary**

Components of colostrum are important signals to the neonate from the mom that enhance feed efficiency and nutrient utilization, along with appetite. Previous work focused on Ig absorption evaluated these effects indirectly and associated them with the Ig's because that is what we measured. New work, and a more thorough review of the literature are suggesting that factors in colostrum other than immunoglobulins are important for long-term productivity and feed efficiency in dairy calves.

**References**


Foldager J, Krohn CC. 1994. Heifer calves reared on very high or normal levels of whole milk from birth to 6-8 weeks of age and their subsequent milk production. Proc Soc Nutr Physiol 3 (Abstr.).


