INFLUENCE OF COLOSTRUM INTAKE ON ENDOCRINE AND METABOLIC PROFILE OF BOVINE NEONATES - A REVIEW


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ABSTRACT

Bovine colostrum contains various essential nutrients, antibodies, hormones and growth factors that are important for nutrient supply, host defense, growth and general neonatal adaptation. Colostrum contains more protein, immunoglobulins, nonprotein nitrogen, fat, ash, vitamins, and minerals than milk. Because some vitamins do not cross the placental barrier, colostrum is the primary source of these nutrients for the calf after birth. Various metabolic and endocrine traits are influenced by colostrum intake, quality and the duration of colostrum feeding. Many blood constituents rapidly changing in neonate due to colostrum intake, which could be interpreted as abnormal. So extreme caution must be exercised when interpreting typical clinical chemistry components from young calves. This review focuses on the endocrine and metabolic changes in the neonates that influenced by colostrum intake.

Key word: Colostrum, Endocrine status, Metabolic profile, Neonatal calves.

Colostrum is the first milk-like fluid yielded from the mammary glands of mammals after parturition and is intended for ingestion by the newborn during the first hours of life. Bovine colostrum contains higher amounts of fats, proteins, peptides, fat-soluble vitamins, various enzymes, hormones, growth factors, cytokines, nucleotides and minerals than normal milk. Except for lactose, the levels of the above compounds rapidly decrease during the first 3 days of lactation to those typical for normal milk (Blum and Hammon 2000, Campana and Baumrucker 1995). Colostrum intake in neonatal calves is essential for passive immunity and influences metabolism, endocrine systems and the nutritional state. Furthermore, ingested colostrum stimulates the development and function of the gastrointestinal tract (GIT) in neonatal calves (Blum, 2006). The intake of colostrum during the first hours after birth has a considerable effect on metabolic and hormonal profile of neonatal calves, stimulates the systemic growth and development and contributes to the further adaptation and vitality of neonates (Blum and Hammon, 2000; Blum, 2006).

Significant higher blood concentrations of total protein, immunoglobulin G (IgG), essential and non-essential amino acids, triglycerides, phospholipids, cholesterol, essential fatty acids, fat-soluble vitamins (A, E, D) are reported in calves fed colostrum during the first 7 days after the birth compared to calves deprived of colostrum and receiving it with a 24-hour delay (Blum et al., 1997). In addition, significantly higher levels of insulin, insulin like growth factor-1(IGF-1), glucagon and GH were reported, whereas cortisol levels were reduced, and those of thyroid hormones and prolactin were unaltered (Blum et al., 1997; Hadorn et al. 1997; Hammon and Blum, 1997; 1998; Rauprich et al., 2000 a, b). Therefore, the intake of colostrum in the first hours of life is extremely important not only for supply of nutrients- proteins, carbohydrates, lipids, vitamins, minerals etc. but also for the normal growth and the morphological and functional maturation of the GI tract and thus, for the adequate systemic adaptation to the new environment after birth, including feeding. The research on this subject

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showed that this is due to the high content of various biologically active peptides, growth factors, hormones, cytokines etc. in colostrum that regulate the normal occurrence of these processes (Hammon and Blum, 1997; 1998; Hadorn et al., 1997; Blum and Hammon, 2000; Blum, 2006).

**Composition of bovine colostrum**

The chemical composition of colostrum changes very fast within hours and days. Ganovski (1979) reported that following calving; the dry matter, organic matter and proteins were reduced from 27.61%, 26.21% and 18.19% 2 h post calving to 16.85%, 15.88% and 8.50% respectively, on 7th day. Larson et al. (1980) quantified different fractions of immunoglobulins in colostrum of dairy cows. IgG constituted the principal fraction of total Immunoglobulins. IgG1 isoform accounted for approximately 80% of total IgG (Holloway et al., 2001). While the proportion of IgG, IgM and IgA was 85-90%, 7% and 5% in dairy cows (Larson et al., 1980), it was to the tune of 86%, 8% and 5%, respectively in buffalo colostrum (Dang et al., 2009). Weaver et al., (2000) showed that colostral IgG content was affected by volume of colostrum produced, parity, dry period length, vaccination and many other factors. Besides immunoglobulins, colostrum contains lymphocytes, cytokines, nucleotides and various growth factors which may affect the development of the immune system postnatally (Blum et al., 2001; Boutinaud and Jammes, 2002).

Colostrum contains numerous growth hormones (IGF-I and II, epidermal growth factor, transforming growth factor, and nerve growth factor) as well as insulin, cortisol, and thyroxine (Xu, 1996). It has been suggested that these components of colostrum may be beneficial for development and maturation of the digestive system (Davis and Drackley, 1998). Colostrum intake by calves within the first 24 h of life is needed not only for an adequate immune status, but also to produce the additional important and favorable effects on metabolic and endocrine traits for viability (Hadorn et. al., 1997). The colostral period lasts for about 1 week. Nutrition during this period can have effects later on in life. Morphological and functional changes are necessary in new born calves for their survival during extra uterine life (Egli and Blum, 1998).

**Influence of colostrum intake on plasma profile of energy substrates**

Glucose: In all species glucose is used by various tissues and organs for free energy (i.e. ATP) production. In addition, glucose may be converted either into glycogen or into triacylglycerols, which are subsequently stored within tissues (liver, adipose tissues, muscles etc.) for future use.

Quantity and timing of colostrum intake affects plasma glucose in neonatal calves. Kuhne et al. (2000) reported that plasma glucose level increased less after intake of the first colostrum than of milk replacer containing more lactose than colostrum. However, post-prandial plasma glucose concentrations on the following days increased more in calves initially fed colostrum than milk replacer, glucose or water, indicating prolonged effects of early colostrum intake on glucose metabolism. Rauprich, (2000a) reported a rise in glucose concentration from day 1 to day 3 in calves fed colostrum for 3 days followed by milk replacer. In case of colostrum feeding for 7 days, the prefeeding concentration tended to increase from day 1 to 7 (p<0.01). Other studies in calves (Grutter and Blum, 1991; Hadorn et al., 1997; Hammon and Blum 1998) have also reported a rise in pre-prandial plasma glucose concentration. Kurz and Willet (1991) found a
substantial increase in glucose concentration in cattle calves from birth to 24h. These authors also depicted a rise in insulin level with the time of first colostrum feeding. However, Piccione et al. (2010) did not find any effect on glucose levels during first week and first month in neonatal calves. Pandita and Madan (2010) recorded rise in glucose concentration following first colostrum intake at 24h post birth in buffalo calves. The concentration later fluctuated between 72.04±7.36 to 81.54±7.33 mg/dl upto 3 months of age. Thus colostrum intake immediately after birth might have prolonged positive effects on plasma glucose status during first week of life.

Non esterified fatty acids

The concentration of non esterified fatty acids (NEFA) in blood reflects the degree of adipose tissue mobilization. Greater the extent of negative energy balance, more NEFA will be released from body fat resulting in higher concentration of NEFA in the blood. Kuhne et al. (2000) reported that basal NEFA concentration decreased during first week of life. Others (Ronge and Blum, 1988; Vermorel et al., 1989; Baumrucker and Blum 1994; Hadron et al., 1997; Hammon and Blum, 1998) also found high concentrations of NEFA after birth followed by a rapid decline after the first meal. Lents et al., 1998 found greater initial NEFA concentrations in calves for mobilizing fat reserves for meeting energy demands. Piccione et al. (2010) reported that NEFA were also influenced by the age of calf, but only during the first month of life.

The plasma lipid status during the neonatal period is influenced by the amount and timing of ingested colostrum. Blum et al. (1997) found an increase in plasma NEFA if colostrum was withheld for the first 24 h after birth than in calves fed colostrum immediately after birth. Besides decreased intake, the mechanisms of absorption of fatty acids (FA) and fat-soluble vitamins in calves not fed colostrum on the first day of life might be responsible for the subsequent impaired FA and fat-soluble vitamin status. In addition, impaired post-absorptive transport and distribution of these substances is also possible if colostrum is not provided shortly after birth (Blum et al., 1997). Rauprich (2000b) observed a transient decline in NEFA concentration on day 2, 3 and 7 at 2 to 4 h after colostrum intake. Others have also reported a decrease in NEFA concentrations when calves receive the nutrients present in the milk (Quigley et al., 1991; Egli and Blum, 1998).

Influence of colostrum intake on serum enzymes

Lactate dehydrogenase: Lactate dehydrogenase (LDH) is a cytoplasmic enzyme that converts pyruvic acid into lactic acid. Benjamin (1961) has associated the activity of this enzyme with cellular damage. This enzyme was reported to be very high in first colostrum which was subsequently reduced to low levels in mature milk (Zanker, 1997). Plasma LDH transiently increased after intake of first colostrum in neonatal calf, thus indicating that this enzyme was absorbed from colostrum (Zanker, 1997). However, during the neonatal period, the changes that involve turbulent synthetic activities and growth are responsible for the progressive increase of the LDH serum levels in buffalo calves. Cavallina et al., (2003) reported lower values of LDH (1325 IU/l) for newborn buffalo calves. Piccioni et al. (2010) observed no significant effect of days of life on LDH activity during first week or first month of life. Kurz and Willet (1991) showed the levels of LDH to be increasing till 24h irrespective of time of colostrum intake followed by elevated levels even afterwards. The levels tended to increase from 421±14 to 706±25 IU/L and from 410±30 IU/L to 630±790 IU/L, respectively when colostrum were fed 1h and 12h after calving, which suggest that these changes are physiological rather than a response to colostrum intake.

Alkaline phosphatase

Alkaline phosphatase (ALP) is an enzyme made in the liver, bone, and the placenta and is normally present in high concentrations in growing bone and bile. It is released into the blood during injury and during such normal activities like bone growth and pregnancy. Abnormally high blood levels of ALP may indicate disease in the bone or liver, bile duct obstruction, or certain malignancies. However, higher values found in buffaloes during the first 40 days of life suggested its involvement in growing bone due to the more intense bone remodeling. (Cited by Borghese, 2005). Retskii et al. (2005) recorded peak ALP activity in newborn calves observed immediately after birth. Jenkins et al. (1982) found levels of 395 IU/L in calves at 4-8 weeks of age. Kurz and Willet (1991) reported lowest ALP activity (235±3 IU/L) immediately after birth.
enhancing to peak levels of 700±12 IU/L by 6h in response to colostrum feeding with in 1h followed by a decline till 24h. However, when colostrum was fed to these calves after 12h, peak ALP activity (1472±654 IU/L) was observed at 24h. Zanker et al. (2001) demonstrated that plasma ALP transiently increased after colostrum intake and was higher in calves fed colostrum within the first 12h of life than in those fed later after birth. Pandita and Madan (2010) found an increase in serum ALP concentration in buffalo neonates in response to colostrum intake at 24h after birth as compared to precolostral concentration. Kurz and Willet (1991) attributed these hiked levels to be the components of colostrum or intestinal sources and colostrum may be stimulating the intestinal ALP activity. However, Boyd, (1989) was unable to correlate serum ALP activity with other colostrum constituents. Therefore, increase in enzyme activity may not reflect intestinal absorption of colostral ALP. Fay et al. (1981) found considerable activity in both duodenum and ileum of newborn calves that never received colostrum. Thus, serum ALP appeared to be from intestinal sources and/or colostrum could be stimulating the intestinal ALP activity. Serum ALP of suckling lambs was correlated with a transient rise in intestinal ALP activity (Healy, 1975). Singh (2010) reported that serum ALP activity was significantly low in calves at birth with mean activity amounting to 26.43±2.47 and 29.36±2.75 IU/L in male and female calves, respectively.

Aspartate aminotransferase and Alanine aminotransferase

Aspartate aminotransferase (AST or GOT) transfers the amino group from aspartate to α-ketoglutaric acid forming glutamate and oxaloacetate. Alanine aminotransferase (ALT or GPT) transfers the amino group from alanine to ketoglutaric acid, forming glutamate and piruvate. In ruminants, AST is present in greater concentrations in the muscles and heart than the liver but ALT is present in small quantities in the liver and in various tissues, particularly in the muscles. It is in fact referred to, AST together with ALT, as an index of muscular integrity. Jenkins et al. (1982) reported normal levels of this enzyme in calves and mature bovines. The levels averaged 48 IU/L at 4 to 8 weeks of age. Piccioni et al. (2010) reported a significant effect of days of life on GOT levels but not on alanine aminotransferase (ALT or GPT) during the first week or first month of life. Kurz et al. (1991) found an increase in AST activity with first feeding with levels increasing from 23±2 to 80±7 IU/L upon feeding of colostrum after 1h suggesting that this enzyme was a component of colostrum. GPT level also increased significantly from 5±3 to 11±2 IU/L. Zanker et al. (2001) demonstrated that enzyme activity of AST transiently increased after colostrum intake but there was no association with time of first colostrum feeding, indicating that the rise of plasma AST activity was the consequence of enhanced endogenous production and was independent of colostrum intake. Retskii et al. (2005) found significantly higher AST activity after colostrum intake in the calves but ALT was within normal limits. Pauli (1983) found low levels of GGT in colostrum thus suggesting that the source of serum GGT was from the intestinal brush border. Singh (2010) reported slight but no significant increased activity of AST and ALT after colostrum intake.

γ-glutamyltransferase

γ-glutamyltransferase (GGT) is a membrane linked enzyme that cleaves C-terminal glutamyl groups from amino acids and transfers them to another peptide or to an amino acid. It is present in various tissues like kidney, pancreas, liver, mammary gland and so on. It is important in glutathione metabolism, amino acid absorption and protection against oxidant injury. Colostrum in all species, except for horses contains high GGT concentrations. Increases in GGT occur within 24 hours of suckling and are a sensitive indicator of passive transfer. Very high levels of GGT may be observed (up to 1000 x adult levels in 2-3 day old puppies) that gradually decrease with time (over 10 days in dogs, 4-6 weeks in lambs and calves) and is an expected finding in a neonate (i.e. does not indicate hepatobiliary disease). In calves, the increase in GGT has been used to predict efficacy of passive transfer. Center et al. (1991) reported that GGT < 200 U/L was 80% sensitive for a diagnosis of failure of passive transfer. Even though foals do not derive GGT from the colostrum of mares, GGT can be higher in neonates. GGT increased transiently (up to 169 U/L) during 7-28 days after birth, before decreasing to within reference intervals by 2 months of age (Thompson and Pauli, 1981). Note that elevations in ALP do occur after suckling. This is thought to be derived
from intestinal sources in the neonate and is not due to colostrum itself.

In water buffalo mature females, the enzyme GGT was significantly higher compared to that in immature females (Canfield et al., 1984). This has been verified by Borghese (1994) who found values of 24.7 U/L in buffalo heifers and by Bertoni et al. (1994), who recorded, in adult buffaloes, a GGT variation of 29, 35 and 41 U/L in the dry milk period, 30 and 230 days of lactation, respectively. In the early months of lactation, De Rosa et al. (2001) detected values ranging from 37 to 52 U/L. It is an important index in liver diseases as it is the first serum enzyme that increases even in mild liver disease. GGT decrease during the growth period has been recorded from 35 U/L (at 30 days) to 18 U/L (at 50 days of age). This progressive lowering in GGT and γ-globulines values, after the increase due to absorption during the colostral phase, is an index of good liver and kidney function (Campanile et al., 1997). Thompson and Pauli (1981) reported that calves achieve high levels of both GGT and ALP at the time of colostrum absorption and concluded that clinical interpretation of serum GGT and ALP levels in young calves is closely dependent upon parallel knowledge of their serum γ-globulin levels.

**Endocrine changes in response to colostrum intake**

Endocrine factors such as insulin, thyroid hormones and cortisol can also influence the time point of gut closure for protein and peptide absorption (Brugere, 1989). Ingestion of colostrum has marked effects on GIT development and function, and affects digestive enzymes and GI hormones (Guilloteau et al., 1997; Hadorn et al., 1997 and Le et al., 1998) and absorptive capacity (Hammon and Blum, 1997).

**Insulin**

Hugi et al. (1997) reported that secretory capacity of insulin is not fully developed in neonatal calves. Colostral insulin seemed not to be intestinally absorbed even if administered in pharmacological amounts (Grutter and Blum, 1991) in the calves. Kurz and Willet (1991) recorded highest concentration of insulin at 1h after birth declining substantially afterwards in calves that were fed colostrum after 12h. The concentration declined from $72\pm20.7 \mu M/ml$ at 1h to $14\pm5.4 \mu M/ml$ at 24h. Hammon et al. (2000) demonstrated that the plasma insulin concentration was markedly decreased in calves if colostrum feeding was delayed for 12 to 24 h. Previous studies (Kinsbergen et al., 1994 and Hadorn et al., 1997) have also shown plasma insulin concentrations to be decrease immediately after birth and changed more markedly if food was withheld for 24 h in 8-day old calves. Plasma insulin levels were highest at birth in the buffalo calves and registered a massive decline up to day 28; afterwards the levels were almost undetectable (Singh, 2010).

**Thyroidal hormones**

The thyroid hormones viz. thyroxine ($T_4$) and triiodothyronine ($T_3$), are tyrosine-based hormones produced by the thyroid gland. These act on the body to increase the basal metabolic rate, heat production and the $O_2$ consumption. Moreover, they affect carbohydrate absorption, glycogenolysis, gluconeogenesis, lipid metabolism and protein synthesis. The thyroid hormones are considered essential to counter balance the threat in terms of metabolism and energy requirement in new environment which neonates face after birth for their survival and maintenance of homeostasis. Grongnet et al., (1985) found high plasma $T_3$ and $T_4$ concentrations at birth in calves which then rapidly decreased. Sharma et al. (1985) reported thyroid hormones peaked during first week of life and thereafter gradually declined until two months of age in male buffalo calves. Sujata (1987) reported high values for thyroid hormones on day 3 after birth which gradually declined during first month reaching adult levels by day 30 in buffalo calves. Kumar and Rattan (1992) found low levels of plasma $T_3$ in growing buffalo calves (6-9 months old) and high plasma $T_4$ level in calves from day one to 1 month of age. Plasma thyroidal hormones concentration was, however, not influenced by feeding different amount of colostrum, or by delaying colostrum feeding or by fasting (Blum and Hammon, 2000). However, (Grongnet et al., 1985) reported that levels were influenced by quantity and timings of colostrum feeding. Singh (2010) reported that the thyroidal hormone levels in calves were not influenced by ante-partum supplementation of vitamin E to buffaloes. Sikka et al. (2002) have also recorded similar observation in newborn buffalo calves.

**Summary**

The transition of a calf at birth from a fetal environment to a neonatal environment is very
dramatic. This transition is from sole dependency on maternal sources to one in which the neonate must maintain homeostasis. Excerpts from this review suggest that age and colostrum intake, with the possibility of maturation of organs; play an important role in attaining homeostasis during the early hours of birth in the bovine. The extreme caution must be exercised when interpreting typical clinical chemistry components from young calves. Many of these blood constituents are adjusting rapidly or are related to events such as colostrum intake, which could easily be interpreted as abnormal. This neonatal response is due to the high content of various biologically active components in colostrum that regulate the normal occurrence of these processes. More intensive studies with newborn bovine animals are needed to elucidate glomerular filtration plus hepatic and gastrointestinal function.

REFERENCES


