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Review Article

Colostrum Composition and its Importance to the Health of Animals- A Review

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AMS,MY and MFHS conceived the study, gathered the data and wrote the manuscript. ARS, and WZS reviewed the final version of the manuscript.

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Abstract | Colostrum is the highly nutritious secretion of the mammary glands produced before parturition. It is recommended that neonates must ingest colostrum to develop passive immunity. Regardless of placental structure and transfer of immunity in utero, ingestion of colostrum after birth also confers additional protection by binding to intestinal receptors which could otherwise be bound by bacteria. Moreover, the adequate colostrum reduces neonatal mortality, strengthen immunity and increase animal lifespan. Delaying intake of colostrum in dairy calves causes decreased transport of both immunoglobulins as well as fat-soluble vitamins. In this review, an attempt has been made to study the composition of colostrum, *i.e.* fat, protein, immunoglobulin, lactose, oligosaccharide, vitamins, minerals, growth factors and nucleotides and its benefits to health of animals.

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Introduction

Milk is a liquid secreted by the different species of mammals, the chief purpose of which is to provide all the nutrients to the newborn animals, even though colostrum also serving numerous physiological functions. After the parturition, the mammary gland produces the Colostrum (McGrath *et al*., 2016). The colostrum is first fed for newborn babies rich in immunoglobulin and many other nutrients. It is also known as "foremilk" as it is regarded as the first diet for newly born babies. The composition of the colostrum is crucial to meet the nutritional needs of newborns (Godden *et al*., 2012). Dairy calves are born without any acquired immunity as there is no transfer of Immunoglobulin across the placenta from the dam to fetus, this means that newborn calves must acquire immunity passively through the consumption of colostral IgG (Shah *et al*., 2019). Neonates in their initial days of life require energy and protein, fat and growth factors for

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regulations of hormones and numerous other biological functions including maintenance of basal metabolic rate and muscle development. All of these requirements are fulfilled by feeding them an adequate amount of colostrum in the diet (McGrath *et al.*, 2016).

There are numerous factors which affect the composition and physical properties of colostrum such as, individual animal, sex, parity, breed, nutrition, dry period length and post-partum time (McGrath *et al.*, 2016). All together in the colostrum the percentage of fat, protein, vitamins ash minerals, growth factors, hormones, nucleotides and cytokines high and the lactose percentage is lower compared to mature milk, these all compounds are reduced after three days of parturition except the lactose (Sacerdote *et al.*, 2013; Uruakpa *et al.*, 2002). The importance of colostrum is high because of the presence of high level of immunoglobulin G (IgG), and this protein is essential for neonates guts and immunity (Stelwagen *et al.*, 2009). The calf must get a high quality of colostrum within 2 hours after birth to get passive immunity (Moore *et al.*, 2005). Moreover, intake of colostrum affects the metabolism, nutritional status and endocrine system of the newborn calf (Blum, 2006) and improve the development and function of the digestive tract (Rasmussen *et al.*, 2016). The amount of colostrum produced by a cow after parturition is about 0.5% of the total amount of the milk produced in lactation (Scammell, 2001). The quantity of colostrum produced by a cow is much higher than the requirement of the calf (McGrath *et al.*, 2016). The objective of the current review paper is to discuss the composition of the colostrum and its benefits to animal health.

Ruminant colostrum composition

Fat

The fat content in bovine colostrum is tremendously variable, ranging from 0.3 to 18%; however, most cows produce colostrum with much higher levels of fat compared to milk. Reported colostrum values range from 6.7% to 7.78% (Abdulrahman *et al.*, 2017). Research has been conducted to try and increase fat in colostrum using higher dietary fat. However, supplementing beef or Holstein cows with higher dietary fat during the end of gestation has shown no effect on levels of fat in colostrum (Weiss *et al.*, 1990). Effects of fat supplementation during the advanced gestation period on early lactation milk results in a numerical increase of fat composition (Bernal-Santos *et al.*, 2003). This may be due to ruminants using energy during gestation to increase fat reserves and improve body condition. Once lactation begins, animals with the previous supplementation can secrete more fat into milk due to a more massive established fat reserve to draw on. Colostrum is most likely unaffected because it is secreted before the beginning of lactation when the body reserves are still unused. Although dietary fat levels do not produce changes in the fat content of bovine colostrum, the composition of fatty acids (FA) may change. Linoleic acid (LA) is the primary fuel for brown adipose tissue heat production, and when rats are fed high levels of linoleic acid, heat production from the metabolism of brown adipose tissue is increased in rat pups (Nedergaard, 1983). Feeding beef heifers diets with safflower oil, which contains higher levels of LA, increases the ability of calves to sustain their body temperature (Dietz, 2003). Calves drinking colostrum with higher concentrations of linoleic acid may have increased metabolism of brown adipose tissue. The FA composition of colostrum has been compared between species and breeds. Colostrum from Holstein cows has lower concentrations of octanoic and decanoic FA compared with Nubian and Alpine goats (Attaie *et al.*,1993). The FA compositions of milk of bovines have been examined in similarity to butterfat, which is high in oleic acid and has lower concentrations of low molecular weight FA (Collomb *et al.*, 2002). These differences in FA composition are most likely due to differences in the needs of the neonates and have developed evolutionarily.

Table 1: Bovine colostrum composition.

Parameters	Quantity
Fat (%)	6.7-7.78
Lactose (%)	2.5
Protein (%)	16.51
Beta-lactoglobulin (mg/ml)	18.9
Alpha-lactalbumin (mg/ml)	2
Lactoferrin (mg/ml)	1.96
Albumin (mg/ml)	2.63
Transferrin (mg/ml)	1.07
Immunoglobulins	
Immunoglobulin G (mg/ml)	97
Immunoglobulin M (mg/ml)	2.0
Immunoglobulin A (mg/ml)	17.8
Minerals	
Ca (g/dl)	0.16
P (g/dl)	0.17
Co (ug/ml)	0.39
Fe (ug/ml)	1.9
Mn (mg/L)	0.16
Zn (µmol/l)	522.34
S (mmol/l)	57.53
Na (mmol/l)	32.05
K(mmol/l)	55.06
Growth factors	
IGF-I (ug/L)	289- 902
TGF-β (ng/ml)	12.4- 42.6

Ca= Calcium, P= Phosphorus, Co= Cobalt, Fe= Iron, Mn= Manganese, Zn= Zinc, S=Sulfur, Na=Sodium, K= Potassium, IGF-I= Insulin like growth factor 1, TGF- β= Transforming growth factor beta.

Protein

Colostral proteins consist of many different proteins, including immunoglobulins, which are either produced in the mammary glands or transported from the circulatory system of the dam. Two major proteins found in the colostral whey of ruminants are alpha-lactalbumin and beta-lactoglobulin. These proteins are created in the mammary gland at higher concentrations during colostrum production than during normal milk production (Stelwagen *et al.*, 2009). Beta-lactoglobulin levels in colostrum are 18.9 and 17.3 mg/ml for cows and sheep, respectively. In colostral secretions, beta-lactoglobulin is about five times higher than in milk and decreases rapidly and drastically as colostrum transitions into milk. Beta-lactoglobulin is thought to transfer passive immunity to the newborn (Kelly *et al.*, 2009). Beta-lactoglobulin also can bind long-chain FA and triglycerides in vitro and may be involved in the transport of lipid either in the mammary gland or calf intestine (Diaz de Villegas *et al.*, 1987). While the alpha-lactalbumin is the functional subunit of the lactase enzyme and is needed for lactose synthesis in the mammary gland (Bleck *et al.*, 2009). Alpha-lactalbumin concentrations in cow and sheep colostrums are 2 and 2.3 mg/ml, respectively, which are only about 1.5 times higher than whole milk (McGrath *et al.*, 2016).

Another important protein found in colostrum is lactoferrin, which is a glycoprotein that binds iron. Supplementation of lactoferrin in milk replacer fed to young dairy calves is reported to reduce morbidity and improve growth before weaning (Robblee, 2003). Although differences in quantifying lactoferrin levels may exist due to laboratory techniques, colostrum of bovine contains less lactoferrin amount compare to other species (Bar *et al.*, 2010). Yoshida *et al.* (2000) used chromatography and testified that 6 cows have an average of 0.34 ± 0.23 mg/ ml lactoferrin. On the other hand, Tsuji *et al.* (1990) used 45 Holstein cows and found an average of 1.96 ± 0.27 mg/ ml using radial immunodiffusion (RID). Sanchez *et al.* (1988) using DEAE-Sephadex chromatography, reported concentrations of 0.83 ± 0.58 mg/ ml. In comparison, human colostrum contains 10.58 mg/ ml lactoferrin (Fransson *et al.*, 1980). Other proteins found in colostrum are albumin and transferrin. Transferrin is a glycoprotein similar to lactoferrin and also functions in transporting and binding iron. Transferrin concentration in the first milking colostrum is 1.07 ± 0.45 mg/ ml and decreases with increased lactation (McGrath *et al.*, 2016). The albumin is most commonly found in plasma as a transport protein for many biologically active proteins (Peters, 1985). The amino acid sequence of bovine plasma albumin is identical to milk albumin and, therefore, was commonly believed to be a marker for the disruption of tight junctions in the mammary gland. However, Shamay *et al.* (2005) reported that along with many other tissues that secrete albumin, bovine mammary gland explants also express albumin mRNA and secrete albumin that is synthesised directly from the tissue into the medium. Although mastitic and dry mammary glands secrete higher levels of mRNA, healthy tissue also secretes an average of 1 ng/ mg of tissue. This indicates that using albumin as an indicator of infection is still applicable; however, the function of tight junctions may not be affected. Albumin in first milking colostrum is reported to average 2.63 ± 0.86 mg/ ml (Samarütel *et al.*, 2016).

Immunoglobulins

Immunoglobulins from ruminants generally have the same features as other mammalian immunoglobulins. Established classes of immunoglobulins are immunoglobulin G1 (IgG1), immunoglobulin G2 (IgG2), immunoglobulin M (IgM) and immunoglobulin A (IgA); all are secreted at high concentrations into colostrum (Zhaoa *et al.*, 2010; Donahue *et al.*, 2012). A secretory component of IgA (IgA) has also been classified (Pahud, 1970) indicating the small intestine of calves secretes IgA, which can aid in further protection. Past research has indicated that colostrum from first-calf heifers may be lower in the concentration of IgG when compared with colostrum of older cows. This may be due to multiple causes; however, a significant factor may be due to age, which would limit the time on the farm for exposure to pathogens and vaccinations. Lower pathogen load and vaccinations may reduce the number of circulating antibodies which would reduce the antibody conveyed into colostrum (McGrath *et al.*, 2016). Muller and Ellinger (1981) used a university herd to compare immunoglobulin levels across breeds, including Holstein, Brown Swiss, Guernsey, Ayrshire, and Jersey. Differences between breeds ranged from Holstein colostrum containing the lowest concentrations of IgG and Jersey containing the highest. First parity colostrum averaged 2.64% of IgG as a percentage of whole colostrum as compared with 5.52% for second parity, 7.69% and 6.9% for third and fourth parity. Kehoe *et al.* (2011) reported higher concentrations of IgG in fourth through seventh lactation colostrum compared to younger lactations (41.6 and 31.4 mg/ ml, respectively). Similarly, Tyler *et al.* (1999) collected colostrum samples from 77 Holstein cows at a university herd and found higher concentrations in third and greater lactations (97 mg/ ml IgG), but no differences between first and second lactation colostrum (66 and 75 mg/ ml, respectively). Although younger animals tend to produce less immunoglobulin in colostrum, it is not recommended to throw out this colostrum but to test all colostrum for quality since older animals may also produce colostrum with lower immunoglobulin content. Few groups researching colostral immunoglobulin concentrations have specified colostrum volumes produced, which significantly affect immunoglobulin concentration. Kehoe *et al.* (2011) reported significantly lower volumes produced by first lactation heifers (23.1 L) than by other lactation groups (ranging from 32.9 to 36.4 L). However, values reported were composites of the first four milkings. Larson (1980) reported significantly lower volumes produced by first-lactation heifers that averaged 10 kg, but only 8 animals were used. Other research reported differences in colostral immunoglobulin concentrations while maintaining all animals on similar diets. In a study utilizing 919 cows from one farm sampled over 4 years, Pritchett *et al.* (1991) stated that in first and second lactation of cow the IgG1 was less compare to cows of older lactations, and that volume (which averaged 8.5 kg) was a significant factor in dictating the concentration of immunoglobulins present in colostrum. Previous research indicates that in prepartum, nutrient availability does not influence IgG content in colostrum. Hurley and Theil (2011) described no change in IgG content and total protein of colostrum when cows (Beef) were fed three months before parturition on feed for successive 2 years with 65 to 125% of maintenance. Santos *et al.* (2001) fed Holstein cows different amounts of rumen un-degradable protein, which did not result in significant changes in IgG content of colostrum. Beef cows fed diets nutritionally restricted at 57 or 100% of NRC requirements for energy and protein also did not produce colostrum differing in IgG concentration (Hough *et al.*, 1990), further indicating lack of nutritional effect on colostrum quality. Concentrations of IgA in bovine colostrum are found in lower concentrations than IgG and research results are dependent on the assay used to be specific enough for such small concentrations. Hurley and Theil (2011) reported a concentration of 17.8 mg/ ml for IgA using micro diffusion discs as described by Masseyeff and Zisswiller (1969); however, most other researchers use RID assays and report values between 3 and 4 mg/ ml (Mach and Pahud, 1971). These differences may be due to the sensitivity of the micro diffusion discs compared to the radial immunodiffusion assay used by the majority of other labs. Concentrations of IgM are lower in colostrum than IgG but higher than IgA, and Stott *et al.* (1981) reported a concentration of 2 mg/ ml for IgM. Other work was variable, reporting values anywhere from 3 to 12 mg/ ml (Mach and Pahud, 1971). Kehoe *et al.* (2011) reported IgA tended to be lower for first parity cows, and Rzedzicki *et al.* (1982) reported no effect of first through third parity on IgM concentrations in colostrum. These subtypes of immunoglobulins should be affected similarly to IgG; the variation of IgM and IgA may also be affected by breed, health, vaccination, parity and other factors. However, this needs further research.

Lactose

Lactose concentrations in colostrum average of 2.5% (Uruakpa *et al.*, 2002). In colostrum the lactose concentration is low and acts contrariwise of additional components, for example, protein, solids and ash, these are all present in high level and reduce over time (Morrill *et al.*, 2012). Lactose is an osmotically active component of milk, which is a reason for the high concentration of water found in mature milk. Electrolytes, which are also osmotically active, are unable to compensate for the low amounts of lactose, which causes colostrum to be thicker with a lower concentration of water (Ontsouka *et al.*, 2003). In the newborn, at birth, the level of lactose is low and upsurges with the time, which coincides well with lactose concentrations in colostrum and milk (Houser *et al.*, 2008). In colostrum, the oligosaccharides concentration is about 0.7 to 1.2 g.mL−1 (Nakamura *et al.*, 2003), most of which are acidic; while milk comprises low quantity (Gopal and Gill, 2000). In bovine colostrum 40 oligosaccharides have been recognised (Tao *et al.*, 2008, 2009; Barile *et al.*, 2010) and bovine colostrum the total number of oligosaccharides differs amid in each cow because of exclusive genetic variability (Ninonuevo *et al.*, 2006). In other research, in colostrum of each cow, the number of total oligosaccharides ranged between 14 and 32 (Barile *et al.*, 2010). Colostrum contains 3′ Sialylactose (3′SL), 6′ sialylactose (6′SL), 6′ sialylactosamine (6′SLN) and disialyllactose (DSL), these are significant oligosaccharides, 3′SL accounts for 70% of the total oligosaccharide content (Martin-Sosa *et al.*, 2003; Nakamura *et al.*, 2003; McJarrow and van Amelsfort-Schoonbeek, 2004; Tao *et al.*, 2009; Urashima *et al.*, 2009). Nakamura *et al.* (2003) reported that concentration of 3′SL, 6′SL and 6′SLN in colostrum were maximum immediately after calving and reduced quickly by 48 h post-partum, while concentration of neutral oligosaccharides improved. McJarrow and van Amelsfort-Schoonbeek, (2004) reported that the levels of 3′SL, 6′ SL, 6′SLN and DSL to be 681, 243, 239 and 201 mg.mL−1, correspondingly, in colostrum of Holstein and 867, 136, 220 and 283 mg.mL−1, correspondingly, in colostrum of Jersey rapidly after calving.

Fat-soluble vitamins

In colostrum, the fat-soluble vitamins are a vital constituent. The onset of deficiency in the newborn is based on the diet of the dam, which affects the body stores of the young through both low colostrum concentrations and reduced placental transfer (Morrissey and Hill, 2009). While tocopherols cross the placenta and are stored by the fetus, young calves are stillborn with reducing levels and depend on colostrum feeding to replenish their body stores (Zanker, 2000). In newborn lambs, kids, and piglets, plasma tocopherol increases 4-fold before colostrum feeding if dams are supplemented with tocopherol during the last stages of pregnancy compared to those not supplemented. Colostrum from supplemented animals also contains 2 to 3 times more tocopherol, which further increases tocopherol storage in the neonate after colostrum ingestion. Selenium may also play a significant role in transporting vitamin E across the placental membrane and should be considered when formulating gestational diets (Malm, 1976). Concentrations of fat-soluble vitamins are highly variable between individuals and are also dependent on maternal reserve status, diet, and season. McGrath *et al.* (2016)

stated differences of retinol from 35 to 1181 IU/ 100 mL of colostrum in different cows on the similar management system; this highlights the inter-sample difference of fat-soluble vitamins. Wang *et al.* (2015) also reported a significant correlation between fat-soluble vitamin and fat content in colostrum. Due to the close connection of fat-soluble vitamin absorption with the presence of fat in the diet, fat needs to be accounted for when analysing fat-soluble vitamin concentrations in colostrum and other fluids. The levels of alpha-tocopherol in colostrum reported for cows fed without supplemental alpha-tocopherol and cows fed 1000 IU alpha-tocopherol were 95.6 and 125.4 ug/ g fat, respectively. Colostrum concentrations of beta-carotene from these same cows were 49.6 and 23.6 ug/ g fat, although the reason for the increase in betacarotene concentrations in un-supplemented animals is unknown (Wang *et al.*, 2015).

In colostrum, the concentration of vitamin is related to dietary levels of vitamin A, which impacts the level of vitamin A in the blood of cows before parturition. Plasma vitamin A in newborn calves is four-fold higher when dams are supplemented with vitamin A prepartum and two-fold higher when supplemented with carotene in the prepartum diet compared to un-supplemented cows (Debier *et al.*, 2005). Although the ruminant placental structure is non-invasive and fat-soluble vitamins are significant molecular weight substances, there must be some transport of vitamin A because cows supplemented with dietary vitamin A birth calves with higher plasma and liver stores of vitamin A than un-supplemented cows. Debier *et al.* (2005) reported vitamin A concentrations in colostrum for cows not supplemented with vitamin A to be 1245 to 1425 IU/ 100 ml. The colostrum of vitamin A supplemented cows contained 5850 IU of vitamin A/ 100 ml, assuming 1 IU was 0.25 micrograms of vitamin A (Spielman *et al.*, 1947). Other research reports similar values in cows without extra vitamin A supplementation, ranging from 280 to 1920 IU/ 100 ml in colostrum. There is also an effect of parity, where first parity cows produced colostrum with more than two times the amount of vitamin A, per 100 ml of milk, compared with the production of colostrum in their second parity (Kehoe *et al.*, 2011).

Water-soluble vitamins

In colostrum, the water-soluble vitamins have not been comprehensively investigated. Previous to high-performance liquid chromatography (HPLC), researchers attempting an analysis of water-soluble vitamins used methods such as rat growth, microbiologic assays, chemical, and fluorometric assays. Many of these methods lead to changeability between assays and technicians. For instance, Roderuck *et al.* (1945) concluded a 20% upsurge in the content of riboflavin through microbiological assays than with fluorometric analysis due to the trouble in replicating microbiological technique. Many researchers also combined different methods to measure different vitamins, which may increase variation. There is also variability in concentrations of water-soluble vitamins due to diet, season and individual animals. Houser *et al.* (2008) reported a high variation between seasons for niacin. Riboflavin content in milk can be affected by diet as well as breed. Holstein milk contains an average of 34% more riboflavin than Jersey milk (McGrath *et al.*, 2016). However, Jersey milk to be highest in riboflavin content with Guernsey, Brown Swiss, Ayrshire and Holstein following in respectively lower concentrations. Holstein colostrum is 3.6 times higher in riboflavin than milk, although it rapidly loses this high concentration of riboflavin within the first 24 hours. There is an inverse relationship between milk yield per day and riboflavin content, and this may extend to colostrum where higher volumes of colostrum produced may contain lower amounts of riboflavin (McGrath *et al.*, 2016). Dietary riboflavin may not play a large role in final colostrum concentrations. Cows that were fed low amounts of riboflavin in the diet still had milk concentrations of riboflavin only 25% less than cows that were fed adequate riboflavin diets, indicating that riboflavin that is produced in the rumen is transferred into milk to maintain riboflavin levels (Kehoe *et al.*, 2011). Research has shown that supplementation of B-vitamins causes huge ruminal losses, ranging from 40 to 99% depending on the vitamin, and intestinal absorption is unaffected by supplementation (Santschi *et al.*, 2005). Since the microbes in rumen synthesise the vitamins B, the concentrations of B vitamins are less prone to dietary influences than other vitamins, and this may extend to concentrations in colostrum; this needs to be further explored. Quantification of water-soluble vitamins in bovine colostrum has not been investigated in recent years. The main source of B vitamin concentrations in colostrum is from a review by Foley and Otterby (1978), which compiled data up through 1978. Although research has shown that supplementation of dairy cows with certain B vitamins, such as thiamin, niacin and folic acid, can improve milk production and components (Girard *et al.*, 1998).

Minerals

Most minerals are water-soluble and therefore easily pass through the placental membrane. The fetus can store minerals in utero and is born with sufficient stores. Only in areas with dietary deficiencies of minerals neonates have such problems. However, colostrum is also a good source of minerals for newborn calves. Mineral content is high in colostrum, and concentrations decrease over the following week to concentrations found in mature bovine milk. The average zinc content of cow colostrum is 13.57 mg/ L, similar to sheep and human colostrum (Jeong *et al.*, 2009). Calcium, phosphorus, copper, and iron are all high with concentrations at 0.16 g/ dl, 0.17 g/ dl, 0.39 ug/ ml and 1.9 ug/ ml, respectively, but drop to levels found in mature milk within 25 hours. Conversely, manganese, which has been reported at 0.09 ug/ ml and 0.16 mg/ L (Jeong *et al.*, 2009), is not found in greater level in colostrum compare to mature milk. Feeding cow with a high level of zinc at 2,000 ppm results in higher plasma zinc concentrations but lower milk concentrations, indicating that the udder may discriminate in zinc transport (Miller *et al.*, 1965). Supplementation of manganese in the diet increases manganese concentration in the milk, although concentrations of manganese in the diet approaching 2 ounces per day may cause feed refusal (Jeong *et al.*, 2009). Other mineral interactions may also cause problems. Addition of zinc to the diet in high concentrations (5,000 ppm) depresses copper, calcium, magnesium and phosphorus concentrations in both milk and colostrum (Hill *et al.*, 1983). Zinc can chelate other minerals and decreases intestinal absorption. Selenium and iodine are two minerals that can vary widely according to geographic location and the geochemical environment. Reviews have been published correlating concentrations of selenium and iodine in colostrum and milk according to the geographic location in both human and animal milk (Casey *et al.*, 1995). Much research has reported the effects of supplementing gestating animals with selenium and the increase of selenium in colostrum (Mahan, 2000; Weiss *et al.*, 2005). Austin *et al.*, (1980) reported that supplementing cows with iodine increased colostrum concentrations of iodine; however, calves received most of the iodine found in plasma from placental transfer in utero rather than colostrum ingestion.

Growth factors

Colostrum contains many bioactive compounds, such as transforming growth factors and insulin-like growth factors. Prolonged feeding of colostrum to calves has been reported to affect small intestinal development due to these growth factors compared with calves fed milk replacer. Feeding colostrum causes hyperplasia of the intestinal epithelium, resulting in a decrease in crypt depth: villus height ratios in calves (Curtis *et al.*, 2018), and rats (Berseth *et al.*, 1983), indicating an increase in differentiated cells. Absorption of xylose, a marker used to evaluate enterocyte function, is higher in calves fed colostrum for six feedings than in calves fed colostrum only once or only milk replacer, suggesting an increase in absorptive capacity due to increased numbers of differentiated enterocytes and greater intestinal surface area (Curtis *et al.*, 2018).

Insulin-like growth factors (IGF) are part of the insulin family of hormones and growth factors and include IGF-I, IGF-II, and relaxin. Concentrations of IGF-I are reported in the first milking colostrum from 289 to 902 ug/ L (Sparks *et al.*, 2003). Insulin-like growth factors are heat and acid-stable, allowing them to be ingested and to reach the small intestine intact (Baumrucker *et al.*, 1993). Schober *et al.* (1990) reported high numbers of IGF-I receptors present in the neonatal pig intestine, which enhances uptake of IGF-I into the systemic circulation. Hammon *et al.* (2013) also reported increases of IGF-I in the serum of calves after colostrum feeding, indicating that absorption of IGF-I occurs. Transforming growth factor-βs (TGF-β) are found in 3 types, together with TGF-β1, TGF-β2, and TGF-β3. Most mature cells can produce one of the isoforms of TGF-βs during tissue repair and inflammation (Urashima *et al.*, 2009). Concentrations of TGF-β1 in first milking colostrum are 12.4 to 42.6 ng/ ml. Cells have three receptor types (I, II, and III) that are capable of binding all three TGF-βs in mammals (Letterio, 1998) and increase circulating levels of TGF-βs in calves after colostrum consumption.

Nucleotides

Nucleotides are a part of the non-protein nitrogen portion of colostrum and consist of a purine or pyrimidine base, a pentose ring and one to three phosphate groups. Pyrimidine nucleotides include orotate monophosphate (OMP) and uridine monophosphate (UMP), and purine nucleotides include adenosine monophosphate (AMP), uridine monophosphate (IMP) and guanosine monophosphate (GMP). Nucleotides are found in high levels in colostrum compared with mature milk but exhibit different patterns depending on the stage of lactation. The high levels of pyrimidine derivatives such as UDP-glucose, UDP-galactose, and UMP but low levels of guanosine derivatives, AMP and CMP are available in colostrum (McGrath *et al.*, 2016). Levels of UMP and GMP decrease as colostrum transitions to milk while OMP increases to higher levels in mature milk than found in colostrum Nucleotides (Johnke *et al.*, 1962). Both colostrum and milk also contain 3'-5'-cyclic AMP (Kehoe *et al.*, 2011).

Somatic cell count

Numerous researchers have stated that in colostrum, the somatic cell count (SCC) is higher than the milk (Andrew, 2001). The high number of SSC in colostrum is not due to the bacterial or viral infection, but this is because of the physiological function and due to the penetration of the cells through a tight junction between the epithelium cells of mammary tissue (Nguyen and Neville, 1998). The level of SCC was highest in the first two weeks after parturition; McGrath *et al.* (2016) described a higher concentration of the SCC after the calving. Jeong *et al.* (2009) stated that the SCC concentration in colostrum is higher and reduced slowly over the 5 days after calving.

Conclusions and Recommendations

The composition of the colostrum and milk is changed, referring to a different function of two various secretions. Moreover, the formation of colostrum is different than the milk increasing the interest of the colostrum to the health-promoting product especially the higher levels of immunoglobulin which provide the passive immunity to the young born calf and improve the health and gut environment of neonates. This review has collected the

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published literature on the composition and health benefits of colostrum and from the published material we recommend that the farmers should provide the 10% of the BW colostrum to the newborn calves as soon as possible after birth.

Statement of conflict of interest
Authors have declared no conflict of interest.

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