

Review Article**A REVIEW on COLOSTRUM and NEONATAL CANINE HEALTH****Melek AYDEMİR^{I*}, Hidayet Metin ERDOĞAN^I**

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Abstract

Canines are regarded as one of the most domesticated and friendly animal species, and are the most popular pet animals in human life. The continuity of their breeds and the preservation and transfer of breed characteristics to the present are of great importance in ensuring the health of these creatures throughout their lives. The struggle for life, especially in the first weeks, is very important, as deaths in puppies often occur in the first week of the neonatal period. It is therefore vital that puppies receive sufficient colostrum intake during the neonatal period in order to survive and thrive. Colostrum, a unique food produced by mammals in the period close to birth, possesses a distinct composition and is enriched with immune stimulants.

Keywords: Colostrum, health, neonatal period, dog, puppy, IgG.

Introduction

The neonatal period in canines extends over the initial 21 days of life. It is characterised as the period with the highest risk of morbidity and mortality in neonates. The mortality rate varies between 5.7% and 35%, although it has been observed to reach as high as 70% (Gill, 2001; Veronesi et al, 2009; Mila et al., 2015). This period is characterised by significant challenges, which can prove to be both demanding and challenging for veterinarians and dog owners alike (Pereira et al., 2022).

The immune system of neonatal dogs is comparatively immature when compared to that of adults. That is to say, puppies are hypogammaglobulinaemic at birth and do not possess adequate passive immunity. The endotheliochorial placenta type that is characteristic of dogs means that it is impermeable to macromolecules.

Consequently, only 5-10% of maternal antibodies can be transferred to the foetus.⁵ Therefore, puppies must receive colostrum during the first week of life for a successful passive transfer (Evermann and Wills, 2011; Rossi et al., 2021).

The transfer of maternal immunoglobulins to offspring via colostrum is defined as passive immunity, which exerts a direct effect on morbidity and mortality in the neonatal period. The adequacy or inadequacy of passive immunity is assessed by serum immunoglobulin concentration. Serum IgG concentration was found to be 0.3 g/L when the puppies were first born, and the IgG concentration value for good-quality colostrum was calculated as 20 g/L (Gill, 2009; Mila et al., 2014).

Inadequate colostrum intake results in failure of passive transfer immunity that is associated with high mortality rates in the neonatal period (Mila et al., 2014; Mila et al., 2015). The prevalence of passive transfer immunity failure in canines is high, with an estimated occurrence of approximately 17.4% (Mila et al., 2014).

In the neonatal period, colostrum is the most important factor in protecting the puppy against infectious and non-infectious diseases. Perinatal mortality in canines is primarily attributable to pathogenic microorganisms, with the most prevalent source of infection being the dam and the environment. Consequently, it is imperative for the progeny to acclimatise to the prevailing environmental conditions. In addition to passive immunity, colostrum is abundant in energy and growth factors that are essential for the puppy's development (Sager and Remmers, 2007; Sorribas, 2007; Meloni et al., 2014; Pereira et al., 2022).

COLOSTRUM

Colostrum is a dark creamy, yellow-coloured liquid, enriched especially with immunoglobulins, necessary for the development and immunity of puppies, secreted from the udder immediately after birth and its composition is quite different from normal milk. It is richer in immunoglobulins, cytokines, growth factors, soluble receptors, proteins, lipids and carbohydrates than milk. It is accepted as the gold standard in the feeding of newborn puppies. The significance of colostrum, produced by the mammary gland shortly before birth, lies in its role in neonatal development, encompassing the passive transfer of maternal antibodies and antimicrobial agents, in addition to providing energy and facilitating microbiota maturation (Bebiak et al., 1987; Adkins et al., 2001; Wrigglesworth et al., 2020; Ge et al., 2021; Kalbermatter et al., 2021).

There is not much information about canine colostrum due to the lack of sufficient number of studies. In addition, there may be differences in the measurement of the basic components of colostrum due to breed diversity and individual differences between dogs (Adkins et al., 2001; Schäfer-Somi et al., 2005; Pereira et al., 2019; Del Carro et al., 2022).

Considering the individual differences in the immune systems of puppies at different stages of growth and development, the composition of colostrum and the nutritional factors that make up this composition are important. As puppies get older and start to grow, their main feeding habits change from colostrum/milk to semi-solid or solid food. In addition, as time

passes in the neonatal period, there is a transition from colostrum to milk and the concentrations of colostrum components decrease. Stress factors such as the decrease and termination of the passive transfer transition over time and the puppy's one-to-one encounter with environmental factors are among the other important factors to be considered during this period. Especially in puppies, new situations such as separation from milk, mother or sibling/siblings, the application of new diets and the quality of this diet, shelter or adoption are often stress factors. Due to these stress factors, an increase in morbidity and mortality rates can be seen in puppies in the neonatal period (Yu and Satyaraj, 2025). Giffard et al. (2004) found an increase in enteritis cases in newly weaned puppies as a result of stress and diet change (Giffard et al., 2004).

Colostrum is the main factor in the healthy survival of newborn puppies during both in the neonatal period and subsequent periods, as well as the quality and composition of colostrum (Giffard et al., 2004; Kajdič et al., 2021).

COLOSTRUM COMPOSITION

Colostrogenesis

It is well established that maternal antibodies bind to the specific receptor Fc γ Rn receptor in the final weeks of gestation, and that these antibodies enter the mammary tissue and begin to accumulate there. This process is known as colostrogenesis. It is known that the decrease in progesterone concentration in the blood during labour leads to increased prolactin secretion and initiation of lactation. Furthermore, it has been demonstrated that IgG accumulated in the mammary tissue passes into the mammary alveolar lumen and is released into colostrum (Hurley and Theil, 2011). IgA and IgM are produced locally in the mammary tissue and released into colostrum (Claus et al., 2006; Mila et al., 2015).

After oral ingestion, IgG is absorbed into the intestinal lumen and from there into the lacteal lymphatic vessels and then into the bloodstream via specific and non-specific pathways. The specific pathway is the one that is transferred to the circulation via the FcRn receptor. IgG is transferred to the circulation by loosely binding to the FcRn receptor localised on enterocytes. In addition, unlike milk, colostrum contains high concentrations of anti-trypsin (~1000 times more) and can be absorbed without digestion in the gastrointestinal system (Levieux and Ollier, 1999; Claus et al., 2006). It has been reported that the activation of enzymes in the digestive system,

differentiation of epithelial cells, and the formation of tight connections between enterocytes gradually reduce the intestinal passage of IgG. It has been reported that 40% of immunoglobulins are absorbed from the intestines just after oral intake of colostrum in puppies and 20% in the 4th hour of life; 12 to 16 hours after birth, the intestinal barrier is impermeable to immunoglobulins. The immune role of colostrum is not terminated with the closure of the intestinal barrier in the following hours. On the contrary, oral immunoglobulins have been shown to continue to be involved in the phagocytosis or opsonisation of pathogens (Levy et al., 2001; Chastant-Maillard et al., 2012; Chastant-Maillard et al., 2017).

Proteins

The values of immunoglobulins, amino acids, casein and albumin proteins in colostrum have been reported to give different results in studies (Coinus, 2014).

a. Immunoglobulins

While three types of immunoglobulins (IgA, IgM, IgG) are found in canine colostrum, IgE has been reported at undetectable concentrations (Chastant-Maillard et al., 2010). In canine colostrum, the proportion of IgG is 60%, IgA 35-40% and IgM 5% (Chastant and Mila, 2019).

It has been observed that the quality of colostrum depends on the immunoglobulins it contains, especially immunoglobulin G (IgG). IgG was also important for the acquisition of passive immunity during the neonatal period. The average IgG concentration value of a good quality colostrum is 20-30 g/L, whereas it is < 1-5 g/L in milk (Schäfer-Somi et al., 2005; Mila et al., 2014). In another study, the average IgG value was found to be 24.3 g/L. Maternal IgG bind to FcRn receptors in the last weeks of pregnancy and are transported to the mammary alveoli. Colostral IgG concentration is 3-4 times higher than milk and decreases rapidly after birth (Claus et al., 2006; Mila et al., 2015).

It was found that colostral IgG decreased by 50% in the first 24 hours; IgG concentration decreased to ~5 g/L on the 7th day and to <1 g/L on the 14th day (Chastant-Maillard et al., 2010; Mila et al., 2015). Schäfer-Somi et al. (2004) also measured the concentration of immunoglobulins and found that immunoglobulin concentrations constituted approximately 37% of total colostrum proteins 24 hours after birth and decreased to 28% 48 hours after birth. After birth, FcRn receptors are transported from glandular cell basal to apical direction (Schäfer-Hanson et al., 1980; Somi et al., 2005). After the

physiological process that develops after birth, the amount of colostral IgG gradually decreases on the third postnatal day and there is a gradual transition to the milk stage (Rossi et al., 2021).

It has been shown that the immunological quality of colostrum, especially IgG concentration, varies between bitches, even between different udder pairs of the same bitch (Mila et al., 2015). In a study, no congenital predisposition was found in the preference of puppies for udder pairs. Therefore, it has been reported that there may be individual differences in passive transfer between puppies born to the same mother (Arteaga et al., 2013; Mila et al., 2015).

Other immunoglobulins present in colostrum play an important role in the local immunity of the puppies' digestive tract. Immunoglobulin A (IgA) and, to a lesser extent, Immunoglobulin M (IgM) are known to provide local immunity against pathogens in the digestive tract of newborns, since they cannot be absorbed in the first hours of life, some of them remain in the intestinal lumen. Unlike IgG, the proportion of IgA in colostrum appears to increase over time (IgA concentration is 20% on the first day, whereas it is 50% on the 3rd day) (Heddle and Rowley, 1975). Because IgA is secreted locally from both maternal serum and mammary tissue, this ratio tends to increase over time (Hanson et al., 1980; Chastant and Mila, 2019; Rossi et al., 2021).

IgA has been shown to be resistant to proteases present in the gut (which degrade IgG and IgM) and therefore provides a primary defence against local infections (Hanson et al., 1980; Rossi et al., 2021). Colostrum also contains large amounts of immune cells, particularly lymphocytes, polymorph nuclear leukocytes and even macrophages. Although their role has not yet been clearly defined, lymphocytes are thought to provide local protection against intestinal infections by surviving for several hours in the intestine of the offspring. They pass through the epithelium of Peyer's plaques to reach the mesenteric lymph nodes, allowing passive immunity to be transferred from mother to offspring. Colostral immunoglobulins, after passing into the serum of the offspring, can be subsequently re-released into the digestive lumen for defence against any antigen and may play a role in local defence against digestive disorders. These immunoglobulins in the digestive lumen will be able to directly capture certain pathogens and induce immunity in the offspring (Hanson et al., 1980; Chastant and Mila, 2019; Rossi et al., 2021).

b. Amino acids, Casein and Albumin

Colostrum contains 20 amino acids that are commonly found in all organisms. It was observed that amino acid concentrations decreased rapidly during the first 3 days after birth (Adkins et al., 2001).

Albumin was very important for colostrum as it constituted approximately 25% of the proteins (Schäfer-Somi et al., 2005).

Casein was found to represent approximately 60% of the total proteins in colostrum 24 hours after birth and %75.4, 72 hours after birth. Casein concentrations decrease from 86.8 g/L to 45.8 g/L in the first 3 weeks of lactation and then increase until the 6th week, reaching 66 g/L (Adkins et al., 2001).

c. Lactoferrin, Lysozyme and Leucocytes

Lactoferrin and lysozyme are involved in the activation of leucocytes together with cytokines. Colostrum also contains leucocytes (macrophages, neutrophils and lymphocytes). After oral intake of colostrum, these proteins are absorbed by the newborn and transferred into the circulation before the intestinal barrier closes. Thus, they play a role in cellular, humoral or local digestive immunity (Stelwagen et al., 2009).

Lactoferrin constitutes 6% of the total proteins in colostrum. It protects puppies against many agents such as viral, bacterial and fungal and forms an important part of the immune system. Lactoferrin resists proteolytic action by trypsin and trypsin-like enzymes and plays an active role in the acquisition of passive immunity in the offspring. Lactoferrin also has many functions in the body such as participation in iron homeostasis, anti-inflammatory and anti-tumour activity, analgesic activity, regulation of bone metabolism, reproductive functions and regulation of embryonic development (Stelwagen et al., 2009; Beynen 2020; Yu and Satyaraj, 2025).

Lipids

It has been determined that 40% of the energy supplied to the offspring via colostrum is derived from lipids. The lipid level in colostrum is 132.2 g/L (Adkins et al., 2001). It tends to increase in the first 72 hours after birth. According to Bebiak et al. (1987), the lipid level in milk increases from 2.4% to 5.2% between 0-2 days. Although the coefficient of variation in colostrum energy variations obtained from udder pairs is not as high as that of immunoglobulins, a more limited variation rate has been mentioned in comparison to IgG. This variation rate was 42% for IgGs, while this rate was determined as 8% for energy gain (Mila et al., 2015; Chastant-Maillard et al., 2017).

Lactose

Colostrum was found to contain approximately 16.6 g/L lactose and this value reached 40.2 g/L in milk up to 28th day, then remained constant at 35 g/L (Adkins et al., 2001).

Minerals-vitamins and other components

Colostrum is particularly rich in calcium (1363 mg/L), phosphorus (935 mg/L) and magnesium (128.5 mg/L). It contains less zinc (5 mg/L), iron (3.7 mg/L) and copper (1.3 mg/L) (Adkins et al., 2001). Although milk contains the minerals found in colostrum, it is seen that the values are quite variable. Calcium value in milk was measured as 1929 mg/L, phosphorus 1359 mg/L and magnesium 93.6 mg/L and it was stated that these values may vary from mother to mother (Adkins et al., 2001).

Colostrum is also rich in vitamins (A, B1, B2, C) and contains phagocytic cells that play a role in IgA release and local immunity of the puppy. It contains enzymes such as antitrypsin, which allows immunoglobulins to escape from the intestines without being digested by trypsin, alkaline phosphatases or alpha glutamyl transferase. Colostrum has also been found to contain growth factors (Insulin-Like Growth Factors-IGF) and growth hormone (GH) (Crawford et al., 2003; Hurley et al., 2011).

THE EFFECT OF COLOSTRUM ON PUPPIES

It is imperative to be aware of the immunoglobulin and energy requirements of neonatal dogs in order to calculate the minimum amount of colostrum that should be received. For a successful passive immune transfer (i.e. puppy IgG serum levels of 2.3 g/L), the average amount of colostrum required within the first 8 hours of life has been determined to be 1.3 ml per 100 g of puppy body weight (40% digestive absorption rate, 35% haematocrit, colostrum IgG levels of 20 g/L) (Peterson and Kutzler, 2011).

The serum IgG value of born pups is approximately 0.3 g/L (Bouchard et al., 1973; Poffenbarger et al., 1991; Mila et al., 2015). Following colostrum intake, this value was found to be 6 g/L in serum 48 hours later. The difference between these two values showed that 85-95% of passive immunity is colostrum in origin (Chastant-Maillard et al., 2012). Furthermore, it has been observed that the higher the concentration of IgG ingested by the offspring in the first 48 hours, the lower the incidence of disease and mortality in the neonatal period (Mila et al., 2015).

Role in Supply of the Energy Requirement

It is known that the energy source of colostrum is mainly proteins and lipids (Mila et al., 2015).

While energy is provided by colostrum in the first two days, this energy source is then replaced by milk. In this process, the energy value in colostrum decreases gradually (Adkins et al., 1997; Adkins et al., 2001). The energy value of colostrum was calculated as 1831 kcal/L at birth. The energy requirements for puppies have been determined to be 212 kcal/kg per day when fed a quality colostrum. In other words, 12 ml colostrum is sufficient to meet the energy requirement of a 100 g puppy (Adkins et al., 2001; Chastant-Maillard et al., 2017).

The Role of Live Weight Gain

Puppies have low fat tissue reserves and glycogenolysis activity is limited due to the incomplete development of the liver. Therefore, energy intake with colostrum is very important. Growth is only possible if the energy intake exceeds the puppy's care and nutritional requirements. The puppy's growth during the first two days has been shown to have a direct effect on its chances of survival. Supplemental feeding is recommended for such puppies as it is known that weight loss should not exceed 4% of birth weight, otherwise the puppies are at increased risk of hypoglycaemia and hypothermia, which can endanger their lives (Chastant-Maillard et al., 2017).

Role on Organ Development

Colostrum has been found to contain significant amounts of hormones (cortisol, insulin, thyroid, growth hormone) and various growth factors (insulin-like growth factors, epidermal growth factor, nerve growth factor) (Heinze et al., 2014). These hormones and growth factors play a role in the development and maturation of various organs, especially the digestive system, liver, kidney, pancreas and thyroid. As organs develop and mature, intestinal absorption of other nutrients and metabolic activation have been shown to improve (Heird et al., 1984).

Role on Intestinal Mucosal Development

Colostrum is thought to contain growth factors that support the development and enzymatic equipment of the intestinal mucosa. It has been reported that the mucosal membrane develops as a result of cell hyperplasia and hypertrophy in puppies receiving colostrum. This was not observed in puppies not receiving colostrum. There was a 75% increase in mucosal mass, 56% increase in total nuclear DNA and 93% increase in protein. Although the pups that did not receive colostrum seemed to have the same body development as the others at first, it was observed that their intestinal mucosa remained the same as when they were born and they could not gain enough weight

in the following period. This results in regression in growth and development (Crawford et al., 2003).

Intestinal passage of IgGs is progressively limited as the intestinal mucosa differentiates, villi enlarge and tight junctions between enterocytes are established. Because of these changes, an early suckling time is required for the acquisition of effective passive immunity. This is because 40% of the absorption of colostral IgG occurs immediately after birth, while 20% is absorbed after 4 hours and 9% after 12 hours. It has been reported that intestinal absorption of IgG is highest in the first four hours and absorption is zero 24 hours after birth (Chastant-Maillard et al., 2012; Chastant-Maillard et al., 2017).

Role of Passive and Local Immunity

The IgG antibodies transferred to the offspring through colostrum are absorbed by the epithelial cells of the intestinal lumen via the mechanism of pinocytosis and are then transported to the lymphatic circulation through exocytosis. IgG antibodies that bind to FcγRn receptors are transferred into the offspring's lymphatic circulation via enterocytes and subsequently enter the bloodstream, providing passive immunity. The high antitrypsin enzyme levels in colostrum, along with the offspring's immature digestive microbiota and weak proteolytic activity, allow colostral immunoglobulins to pass into the bloodstream without degradation (Levieux et al., 1999).

The intestinal epithelium of newborns retains its ability to absorb macromolecules for only a few hours. The precise mechanisms underlying changes in permeability have not been clearly defined. It has been suggested that factors such as the depletion of enterocytes' pinocytosis capacity, differentiation and maturation of epithelial cells, enzyme and bacterial development, and the closure of the intestinal barrier under the influence of hormones (insulin, corticosteroids, thyroxine) contribute to this process (Poffenbarger et al., 1991; Levieux et al., 1999). Therefore, early nursing by the mother is recommended to optimize passive immune transfer in offspring. In dogs, intestinal closure has been reported to begin 4–8 hours after birth and to be completed within 16–24 hours. The ideal timeframe for effective passive immunity is considered to be the first four hours. Since immunoglobulin M (IgM) concentrations continue to increase between 4 and 48 hours after birth, a definitive conclusion regarding the closure time for this immunoglobulin could not be drawn. In contrast, the absorption rate of immunoglobulin A (IgA) was observed to decrease approximately 16–24

hours after birth, as indicated by the absence of an increase in serum concentration (Casal et al., 1996). Despite the closure of the intestinal barrier, the immunological role of colostrum does not entirely cease; rather, its local immunological effects persist. By providing local immunity in the digestive system (IgG and IgA), colostrum aids in the recognition of antigens by erythrocytes and the capture of pathogens (Chastant-Maillard et al., 2017).

The estimated gastric capacity of neonates is 4 mL per 100 g of body weight, with an average gastric emptying time of 3–4 hours. Therefore, frequent feeding of neonates is recommended. While the average serum IgG level required for adequate passive immunity in neonates is 2.3 g/L, a high-quality colostrum is estimated to contain an average IgG concentration of 20 g/L (Casal et al., 1996; Chastant-Maillard et al., 2017).

FACTORS AFFECTING COLOSTRUM QUALITY

The amount and quality of colostrum received are two closely related concepts. This is because high-quality and sufficient colostrum should meet the needs of the newborn puppy, particularly in terms of immunity and energy. The nutritional capacity of a newborn puppy is limited. The stomach volume is 8–10 mL for a 200-gram puppy, and gastric emptying takes 3–4 hours. Therefore, frequent feeding is necessary. High-quality colostrum is primarily associated with IgG concentration. Since absorption and colostrum IgG levels decrease within the first 48 hours, it is essential to ensure that puppies nurse from their mothers as early as possible. Additionally, sufficient and high-quality colostrum provides the necessary energy, another critical factor in the survival of the puppies (Chastant-Maillard et al., 2017; Yu and Satyaraj, 2025).

Maternal Age

For young dogs, the average IgG concentration is 24.3 g/L (\pm 12.9 g/L), ranging between 7.8 and 55.25 g/L. For older dogs, the average IgG concentration is 39.9 g/L (\pm 16.5 g/L), with a range of 16–68.8 g/L. Gonnier and Rossig (2013) found that maternal age was not associated with IgG concentration. However, in a study conducted by Chastant-Maillard (2014), it was reported that IgG concentration was influenced by maternal age. The study indicated a significant difference in the average IgG concentration of colostrum between young and older females, with higher IgG concentrations found in older female dogs (Chastant-Maillard et al., 2010; Chastant-Maillard et

al., 2012; Chastant-Maillard et al., 2019; Grellet 2015; Mila et al., 2015).

Maternal Size and Breed

There is significant variability in size among different dog breeds. Studies have shown that large breeds produce a greater volume of colostrum compared to small breeds (Hemmings et al., 2018; Zakošek Pipan et al., 2024). The average IgG concentration for large breed dogs was calculated to be 34.9 g/L (\pm 16.7 g/L), with a reported range of 16–68.8 g/L. For small breed dogs, the average IgG concentration was 25.5 g/L (\pm 13.7 g/L), with values ranging from 7.8 to 48 g/L. However, studies have concluded that body size does not have a significant effect on colostrum IgG concentration (Hemmings et al., 2018).

Litter Size and Birth Weight

Gonnier and Rossig (2013) reported that the number and size of live-born puppies did not affect serum IgG concentration (Chastant-Maillard et al., 2012; Chastant-Maillard et al., 2017; Chastant and Mila, 2019).

Mammary Pair

There is limited data on the effect of mammary gland count on milk and colostrum composition in dogs. Gonnier and Rossig (2013) demonstrated that colostrum IgG concentration varied between mammary pairs within the same female dog. However, the number of mammary glands producing the best colostrum differed from one mother to another (Chastant-Maillard et al., 2012; Chastant-Maillard et al., 2017; Chastant and Mila, 2019).

Parity

Research in cattle has shown that colostrum IgG concentrations are higher in multiparous cows compared to primiparous cows (first-time mothers). However, no data on this topic are available in the literature for dogs (Chastant-Maillard et al., 2012; Chastant and Mila, 2019).

Nutritional Status During Pregnancy

There is limited data on the effect of nutrition on milk and colostrum composition in dogs. Daggs (1931) examined the effect of different protein sources on milk production in dogs between the 3rd and 5th postpartum weeks and observed a positive effect on colostrum and milk composition. However, there is no available data on the effects of hormonal status, lactation number, maternal health status, or maternal IgG concentration in dogs (Daggs 1931).

Maternal Health Status

It is hypothesized that the health status of the mother negatively affects colostrum quality; however, no data

have been found in the literature regarding this effect.

NEONATAL PUPPY HEALTH

The endotheliochorial placental type in dogs causes puppies to be born hypogammaglobulinemic. During the neonatal period, puppies are defenseless against infectious agents since they cannot produce antibodies (Bouchard et al., 1973; Poffenbarger et al., 1991; Mila et al., 2014; Mila et al., 2015). The average serum IgG concentration of a newborn puppy is approximately 0.3 g/L, whereas in an adult dog, this value ranges from 8 to 25 g/L (Bouchard et al., 1973; Poffenbarger et al., 1991; Mila et al., 2014; Mila et al., 2015). Following colostrum intake, the average serum IgG concentration in a puppy can reach 6–16 g/L within 48 hours. The difference in these values over 48 hours demonstrates that 85–95% of passive immunity is acquired through colostrum (Poffenbarger et al., 1991; Schäfer-Somi et al., 2005; Greene and Carmichael, 2006; Chastant-Maillard et al., 2012). When evaluating serum IgG concentrations at 48 hours, it is observed that immunoglobulin concentrations and specific antibody titers remain lower compared to an adult dog (Mila et al., 2014).

Colostrum provides passive immunity to puppies through its immunoglobulin content, ensuring high antibody titers (Mila et al., 2014; Mila et al., 2015). However, for passive immunity to be effective, colostrum must be consumed within the early hours postpartum. This is because colostrum absorption is limited by the maturation of intestinal mucosa and the activation of digestive enzymes (Chastant-Maillard et al., 2012).

The hypogammaglobulinemic nature of newborn puppies and the failure of passive transfer are major causes of morbidity and mortality, particularly during the first weeks of the neonatal period (Köse and Tekeli, 2013; Pereira et al., 2022). Since neonatal puppies lack a robust immune defense against encountered antigens, they are at a higher risk of illness and death. Diagnosing neonatal diseases is challenging due to the presence of numerous infectious and non-infectious causes with overlapping symptoms (Köse and Tekeli, 2013; Pereira et al., 2022). Among non-infectious causes, Respiratory Distress Syndrome (RDS)/hypoxia, hypothermia, hypoglycemia, and dehydration are the most commonly observed factors, predisposing neonates to infections (Pereira et al., 2022; AregaTafere and Ayele, 2023). Bacterial and viral infections are among the most significant secondary causes of neonatal mortality (Day 2007; Pereira et al., 2022).

TRANSFER OF PASSIVE IMMUNITY AND NEONATAL MORTALITY

Studies have determined that the serum IgG concentration threshold for successful passive immunity transfer (PIT) is 2.3 g/L (Mila et al., 2014). In one study, the mortality rate was found to be 44.4% in puppies with serum IgG concentrations below this threshold, whereas the mortality rate was only 4.9% in puppies with IgG levels above this value. This finding establishes a direct correlation between IgG concentration and neonatal mortality (Mila et al., 2014). Consequently, serum IgG concentration has been proposed as a criterion for assessing the quality of passive immunity transfer (Albert et al., 2016). Inadequate colostrum intake has also been linked to mortality due to hypoglycemia or hypothermia, further emphasizing the importance of passive immunity transfer (Kaçar et al., 2007; Alçam 2008; Marti 2008).

Hypoxia at birth, genetic or teratogenic defects, malformations, maternal illnesses, the mother's vaccination status, low birth weight, environmental conditions, or infectious agents increase neonatal mortality risk. Prolonged and difficult labor has been identified as one of the most significant contributors to neonatal deaths (Day 2007; Pereira et al., 2022).

Non-infectious factors such as hypoxia, bacterial proliferation, failure of passive transfer, endotoxins, and hemorrhagic shock allow pathogenic agents to easily infect neonates. Infectious causes include bacterial, viral, and parasitic infections. If a pregnant dog is exposed to the Herpes virus during the last three weeks of gestation, it may result in abortion or neonatal death within the first three weeks of life. Parvovirus and Distemper virus infections can also be fatal for infected puppies. *Campylobacter* spp. has been associated with abortions and neonatal illness (Hoskins 2001; Namputhiri 2004; Münnich and Küchenmeister, 2014; AregaTafere and Ayele, 2023). Neonatal mortality is primarily attributed to infectious diseases, with *Escherichia coli*, *Staphylococcus* spp., *Streptococcus* spp., and Canine Herpes Virus type 1 being the most frequently identified pathogens. Additionally, *Mycoplasma* and *Ureaplasma*, which are part of the normal vaginal flora of the mother, can infect neonates, leading to septicemia. *Toxoplasma gondii* and *Neospora caninum* have also been implicated in fatal neonatal infections (Zimmer and Pollack, 1987; Zschöck et al., 1989; Ogbu et al., 2016). Puppies with inadequate passive immunity are also more susceptible to infectious diarrhea

(Kaçar et al., 20007; Rota et al., 2011; Münnich and Küchenmeister, 2014). Maternal infections caused by Canine Parvovirus, Herpes Virus, Distemper, Brucella canis, and Toxoplasma have been reported to contribute to both fetal and neonatal mortality as well as neonatal diseases (Namputhiri 2004; Root Kustritz 2012; de Paula Antunes et al., 2016; AregaTafere and Ayele, 2023).

Studies have also identified E. coli as a primary cause of neonatal diarrhea, with Salmonella, Klebsiella, and Staphylococcus spp. occasionally implicated. Newborn puppies have an intestinal epithelium that is more permeable to bacteria, particularly E. coli, which not only plays a role in gastrointestinal infections but can also cause systemic infections and sepsis (Kaçar et al., 20007; Zimmer and Pollack, 1987; Zschöck et al., 1989). Campylobacter jejuni has also been identified among potential infectious agents (Namputhiri 2004; Root Kustritz 2012; Münnich and Küchenmeister, 2014; de Paula Antunes et al., 2016; AregaTafere and Ayele, 2023).

Importance of Colostrum in Neonatal Health

Effective passive immunity acquired through high-quality colostrum during the neonatal period can protect puppies against both infectious and non-infectious diseases while significantly reducing mortality risks associated with these infections (Zimmer and Pollack, 1987; Greene and Carmichael, 2006; Münnich and Küchenmeister, 2014).

CONCLUSION

Colostrum is an essential and unparalleled first source of nutrition for neonatal puppies, as it is for all mammals. It contains all the micro- and macronutrients, as well as immunological factors, required by newborn puppies. Colostrum plays a crucial role in the immune development and organogenesis of hypogammaglobulinemic newborn puppies. Compared to milk, colostrum is richer in bioactive molecules such as immunoregulators, cytokines, hormones, and growth factors, in addition to macronutrients and micronutrients.

In neonatal puppies, passive transfer via colostrum is vital for immune competence, environmental adaptation, and minimizing the impact of stress factors. The ability to survive the critical first three weeks of life is closely tied to adequate and high-quality colostrum intake. Therefore, as in all species, neonatal puppy health, growth, development, energy acquisition, organogenesis, and immune competence are directly dependent on sufficient and high-quality colostrum intake.

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