

Importance of Colostrum for Calf Health and Development: A Brief Review

Yanuartono^{1*}, D. Ramandani², A. Nururrozi¹, and S. Indarjulianto¹

¹Departemen Ilmu Penyakit Dalam, Fakultas Kedokteran Hewan Universitas Gadjah Mada.

²Departemen Teknologi Hayati dan Veteriner, Sekolah Vokasi, Universitas Gadjah Mada.

Tel : +62-274-560862, Fax +62-274-560861

Corresponding author: yanuartono@ugm.ac.id

ABSTRACT

Colostrum is a form of milk produced by the mammary glands at the end of pregnancy. Passive antibody intake through the Colostrum during the early hours of birth is very important for calf survival. Consumption of high-quality Colostrum could reduce mortality, strengthen immunity, and increase the livability of calves. Therefore, calves must ensure their passive immunity by consuming Colostrum as soon as possible after their birth. This paper aims to review the benefits of Colostrum for calf health development.

Key words: Colostrum; passive antibody; calves; passive immunity

INTRODUCTION

Cow colostrum is milk secreted from the udder of female cows for 1-7 days after the calf birth process and is a very important source of nutrition for the calf after birth (Gopal and Gill, 2000; Biemann et al., 2010; Furman-Fratczak et al., 2011). Weaver et al. (2000) and Hernández-Castellano et al. (2015) added that the physiological characteristics of cows can provide passive antibody supply through Colostrum during the early hours of birth be very important for calf survival. Likewise, Floren et al. (2006) emphasized that consumption of Colostrum in the first hour after birth is very important to calves as they receive immunoglobulins to increase resistance to harmful pathogenic microbes in the postnatal period until the calves can synthesize their own body's active immunity. In addition, immunoglobulins present in Colostrum, especially IgG can protect from various diseases (Besser et al., 1991; Godden, 2008).

Playford et al. (2000) stated that Colostrum is a passive immunization substance in newborn calves because it contains various combinations of specific (immunoglobulin, Ig) and non-specific (humoral and cellular) immunity components. These anti-microbial factors play a role in protecting against disease attacks during the early days of life. According to El-Kashef et al. (2012), cow colostrum contains more than 90 nutritional components beneficial for newborn calves. The content of Colostrum, in general, is not only in the form of protein, fat, lactose, essential fatty acids, essential amino acids but also contains bioactive components and

antimicrobial factors which are all utilized for calf growth after birth (Reiter, 1978a; Foley and Otterby, 1978; Quigley, 1978, 1997; Georgiev, 2005; Kleinsmith, 2011). In addition to these contents, Colostrum also contains various specific components such as hormones (Sparks et al., 2003), immune components (Murphy et al., 2005), vitamins (Kehoe et al., 2007), minerals (Strusińska et al., 2004) and various enzymes that are needed by the body (Blum and Hammon, 2000). Because the colostrum content is so complete, every newborn calf should receive Colostrum in sufficient quantities to secure its health and develop optimally when it becomes an adult cow.

The availability of Colostrum to the calf sooner after birth is very important because it can meet complete nutritional needs, for normal growth and development of morphology and function of the digestive tract to make it easier to adapt when there is a sudden change in maternal nutrition after birth (McGuirk and Collins, 2004; Gomez and Chamorro., 2017). The provision of antibodies from the mother to the calf through Colostrum is called the transfer of passive immunity, which takes a very short time and is a critical stage so that if a failure occurs, it will adversely affect the survival of the calf to adulthood (Aydogdu and Guzelbektes, 2018). According to Besser et al. (1991), methods that can be used to give Colostrum to calves such as giving the calf the freedom to breastfeed directly from its mother, but if the calf is not able to breastfeed directly, it can be fed using a bottle or esophageal feeder (Elizondo et al., 2011). These administration methods have different effects on the volume that can be administered and the

efficiency of Ig absorption (Quigley, 2002; Kaske et al., 2005). Although these methods give different results, basically these differences can still provide optimal results for calf development (Besser et al., 1991). This paper aims to review the benefits and importance of giving Colostrum for post-natal calf, health and growth of the calf so that it can develop optimally.

Content and Benefits of Colostrum

The basic components of ruminant Colostrum are divided into 3 factors: nutrition, immunity, and growth (Macy, 1949; Gauthier et al., 2006; Gulliksen et al., 2008). The provision of high-quality Colostrum can reduce calf mortality, strengthen immunity, and increase livestock viability and optimal appearance (Quigley and Drewry, 1998). On the other hand, delaying the intake of Colostrum in calves can reduce the amount of passive immunoglobulin transfer and delay the provision of nutrients with near-perfect nutritional values, thereby increasing the risk of calf mortality. This is because the physiological characteristics of ruminant broodstock passively supply antibodies through Colostrum in the calf during early postnatal life, which determines the overall health condition of life into adulthood (Weaver et al., 2000). Although there have been many studies of passive antibody supply through Colostrum, however, according to Wheeler et al. (2008), hormonal regulation of immunoglobulin transport into Colostrum and milk has not been fully elucidated. Kamel et al. (2015) added that

high protein concentrations in Colostrum are closely related to high immunoglobulin concentrations, decreasing until they reach an average level during lactation.

The above facts make colostrum administration very important for every newborn calf because Colostrum also contains sources of nutrients such as protein (Pecka-Kiełb et al., 2018), carbohydrates (Davis and Drackely, 1998), fat (Foley and Otterby, 1978), vitamins (Zanker et al., 2000), minerals (McGrath et al., 2016) and immunoglobulins (Zarei et al., 2017). Colostrum consists of growth factors (Gauthier et al., 2006), cytokines (Hagiwara et al., 2000), and various hormones (Pakkanen and Aalto 1997; Baram et al., 1977) that contribute to the development of the calf. In addition, Christiansen et al. (2010), Van der Strate et al. (2001) added that Colostrum also contains antibacterial, anti-viral, anti-fungal, and immunoregulatory substances. Gulliksen et al. (2008) and Godden (2008) stated that all components of colostrum act as antibodies and are the main antimicrobial factors that play a role in the protection of newborn calves. Kehoe et al. (2007) and Stănciuc and Rapeanu (2010) in their research stated that Colostrum contains antibodies such as IgG1, IgG2, IgA, IgM, lactoferrin lactalbumin, lysozyme, proline-rich polypeptide (PRP). Lactalbumin (α -LA) and lactoglobulin (β -LG). The nutritional value of Colostrum from the results of the study is presented in table 1.

Table 1. The nutritional value of Colostrum for various types of cattle

Animal	Fat (%)	Protein (%)	Lactose (%)	IgG mg/mL	Lactoferrin mg/mL	References
Holstein Cow	6.7	14	2.7	32	-	Foley and Otterby, 1978
Holstein Cow	6.04	5.76	-	22.7	-	Andrew, 2001
Holstein Cow	6.7	14.9	2.5	35	0.8	Czerniewicz et al., 2006
Holstein Cow	4.6	18.5	2.0	35.8	-	Zarei et al., 2017
Holstein Cow	7.46	16.51	-	73.81	-	Aydogdu and Guzelbektes, 2018
Simmental	8.50	16.72	3.21	105.1	-	Yaylak et al., 2018
Brown swiss	8.53	16.62	3.05	104.9	-	Yaylak et al., 2018
Simmental	6.5	13.4	2.6	164	1.71	Halik et al., 2019
<i>Crossbred Hereford</i>	7	18.1	2.1	153.7	-	Hare et al., 2019

Table 1 shows that there are variations in the content of fat, protein, lactose, IgG and lactoferrin. Although it is rich in nutritional value, the quality and composition of the Colostrum produced is strongly influenced by

various factors (Kuczyńska et al., 2011; Pecka-Kiełb et al., 2018). Table 1 also shows that there is a difference in colostrum content between dairy cows and beef cattle, although it seems that the difference is not too big. The difference is

probably due to the volume and type of feed given and maintenance management. Table 1 is in line with the statement of Puppel et al., (2019) that the breed of cattle affects the nutritional composition of Colostrum. Mulder et al. (2017) stated that various factors can affect the quality of Colostrum produced by the parent. Factors that can influence are the type of feed during the dry period (Winkelman et al., 2008), breed of cattle (Puppel et al., 2019), age of cattle (Wasowska and Puppel, 2018), environmental factors (McGrath et al., 2016) and the health status of cattle (Ferdowski et al., 2010).

Meanwhile, according to Weaver et al. (2000) and Gavin et al. (2018), the Ig content in Colostrum can be influenced by various factors such as the amount of Colostrum produced, birth conditions, dry period, and vaccination. Calves need fat and protein for energy needs, muscle development, growth factors, and other nutrients which are concentrated in the Colostrum of the mother (Otterby and Linn, 1981; Puppel et al., 2019). Apart from being a source of feed with a complete nutritional composition, Colostrum also

contains a group of proteins that are very beneficial for the calf's body defense (Kertz et al., 2017; Nikolic et al., 2017). These components have non-specific bacteriostatic antibiotic properties (Hooijdonk et al., 2000), antioxidants and Fe transfer such as lactoperoxidase (Liang et al., 2011), lysozyme (Tripathi and Vashishtha, 2006), cytokines (Yamanaka et al., 2003). leukocytes (Godden et al., 2019), lymphokines (Thapa, 2005), lactoferrin (Tsuda et al., 2000; Baker and Baker, 2009), Lactoperoxidase-thiocyanate enzyme (Seifu et al., 2005), xanthine enzyme oxidase (Harrison, 2006) and the oxidized peroxidase enzyme (Bafort et al., 2015). However, the main and dominant content in bovine Colostrum is lactoferrin and lactoperoxidase and until now the best used as in vitro research material for its ability as a non-specific antimicrobial and has been shown to be able to fight all types of microorganisms. Table 2 is a brief summary of various research results showing the content of Colostrum which has anti-microbial and non-specific antiviral properties.

Table 2. Various research results show that Colostrum has anti-microbial, antifungal, immune response regulation, anti-inflammatory and non-specific antiviral properties

Content	Ability	References
Enzim <i>xanthine oxidase</i>	Anti-microbial	Cerbulis and farrell Jr, 1977
lysosim	Anti-bacterial gram +, Anti-bacterial gram -	Pakkanen and Aalto, 1997; Rainard and Riollet 2006
Lactoferrin	Antineoplastic, anti-inflammatory, anti-viral	Harmsen et al., 1995 ; Manzoni, 2016 ; Bagwe et al., 2015
Lactoferrin	Antifungal <i>Candida albicans</i> , immunomodulator	Kirkpatrick et al., 1971; Legrand, 2016
Lactoferrin	Anti protozoa	Valenti and Antonini 2005
Cytokines	Immune response regulation, strengthen T cell activity, immunomodulator, increase anti-inflammatory	Bagwe et al., 2015; Hagiwara et al., 2000; Stelwagen et al., 2009
Enzyme <i>Lactoperoxidase-thiocyanate</i>	Antimicrobial peptide	Reiter, 1978b; Playford et al., 2000
Casein	Stimulates the immune system and prevents udder infections	Silanikove et al., 2005
Peroxidase enzyme	oxidize Anti-microbial	Przybylska et al., 2007
Leukocytes	Stimulation of interferon production, slowing viral multiplication	Thapa, 2005
lymphocytes	Anti-microbial	Wilson et al., 1982
transferrin	Inhibits bacterial growth	Pakdaman et al., 1998
lymphokine	immunomodulator	Thapa, 2005

The Role of Colostrum in Calf Health and Growth

The benefits of giving Colostrum for calf health began to be widely studied and known in 1937 (Kertz et al., 2017). The importance of Colostrum for newborn calves is due to the content of food elements that are considered the most complete, namely active substances for immunity such as immunoglobulins, antimicrobials such as lactoperoxidase, lactoferrin, lysozyme, leukocytes, vitamins, minerals and fats. According to Godden (2008), the ingestion and absorption of Colostrum are very important in maintaining health because when a newborn calf does not have gammaglobulin, it is very susceptible to infection. Therefore, calves really need early Colostrum to gain immunity (Gomez and Chamorro, 2017). Malmuthuge et al. (2015) added that Colostrum also has a positive impact on the development of microbial groups in the digestive tract. Giving Colostrum is also associated with the development of the digestive tract in calves. Optimal development can affect the ability to absorb nutrients after adulthood. Research on the effects of Colostrum microscopically has also been carried out to support deeper knowledge about the benefits of Colostrum on calves (Guilloteau et al., 1997; Blum and Hammon 2000; King et al., 2008).

The results of Yang et al. (2015) also supported the results of previous studies, which stated that colostrum administration would affect the length and width of the villi and the thickness of the intestinal mucosa, on the other hand, calves fed milk from bulk tanks without Colostrum showed atrophy of the intestinal villi. Further research results by Blattler et al. (2001) also showed that Colostrum had an effect on the development of villi size and increased proliferation of epithelial cells which mostly occurred in the duodenum. According to Massimini et al. (2006), another important benefit of giving Colostrum to calves after birth is increased productivity and a longer life span. Research by Robison et al. (1988) also showed a positive relationship between serum IgG from Colostrum consumed by calves at the age of 1 to 2 days and a high Average Daily Gain (ADG) at the time of weaning. It is understood that after birth, calves not only obtain more than 90% of nutrition during the first 2 days of birth but also acquire immune and growth factors such as IgA, IgM, IgG, IGF-1, lactoferrin, and lysozyme

derived from Colostrum (Parrish et al., 1953). However, although Colostrum contains very complete nutrients, the efficiency of absorption by the calf's digestive tract can be influenced by several factors such as the quality of Colostrum (Yang et al., 2015), the age of the calf at the time of colostrum administration for the first time (Windeyer et al., 2013) and the method of administration (Quigley and Drewry, 1998).

These factors can influence the success or failure of maintaining the health of calves until adulthood. The results of the study stated that calves were considered to have failed to obtain passive transfer of IgG from the Colostrum of the mother if at the time of blood sampling at 24 hours of age, they did not have sufficient IgG concentrations ($> 10 \text{ g/L}$) in their serum (Furman-Fratczak et al., 2011). Several other studies have shown that the passive failure of IgG from parental Colostrum is closely related to a greater percentage of mortality, worsening health conditions, and reduced weight gain and will ultimately reduce productivity as adults (Robison et al., 1988; Donovan et al., 1998; Furman-Fratczak et al., 2011). The health and growth of calves to adulthood are also influenced by quality (Elizondo-Salazar and Heinrichs 2009), quantity (Morin et al., 1997) and the speed at which Colostrum is obtained from the mother (Patel et al., 2014). Furthermore, Quigley (2007) added that the quality of Colostrum is usually influenced by the concentration of immunoglobulins. Low levels of immunoglobulins in the calf digestive tract indicate a failure of passive transfer (FPT) which in turn can lead to a high risk of calf morbidity and mortality (Besser and Gay 1994; Hardy et al., 2016; Lora et al., 2018).

The results of Virtala et al. (1999) showed that calves receiving $< 12 \text{ g/L}$ IgG from Colostrum had a 2-3 times higher risk of developing bovine respiratory disease (BRD). Colostrum is a perfect food source for newborn calves, however, there is something that needs careful attention because giving Colostrum at low quality can lead to health problems for calves who consume it sooner after their birth. However, in a forced situation, if Colostrum cannot be obtained, milk replacer can be used whose quality is not much different from high-quality Colostrum from the parent (Sudarman et al., 2019). According to Walz et al. (1997) and Godden et al. (2019), one of the earliest potential exposures for calves is to infectious agents such as *Mycoplasma* spp, *Mycobacterium avium*

subspecies paratuberculosis and *Salmonella* spp. The high number of bacteria in Colostrum can interfere with the absorption of immunoglobulins so that it can directly affect the immune system of newborn calves (James et al., 1981; Nielsen et al., 2009). Godden, (2008) and Stable et al. (2004) also agree that Colostrum can be contaminated by microorganisms which in turn can reduce the performance of calves while increasing the morbidity and mortality rates. According to Stewart et al. (2005), the pathogens most likely originate from the mammary gland. Briefly, it can be explained that the quality of Colostrum is influenced by several factors (Pechova et al., 2019) such as seasons (Martins

et al., 2020), genetics (Kessler et al., 2019), Body Condition Scoring (Gransworthy, 1998), dry period (Rastani et al., 2005; Silva, 2009), the amount or volume of Colostrum first released (Pritchett et al., 1991) of microbial contamination (James et al., 1981; Stewart et al., 2005). Thus, even though Colostrum is the perfect food for newborn calves, it is also necessary to pay attention to factors that can affect the quality of Colostrum so that we can prevent the decrease to a minimum. Consequently, it can be optimally beneficial for the overall health development of the calf. The role of Colostrum on calf health and growth is summarized in table 3.

Table 3. The role of Colostrum on ruminant health and growth

Cattle type	Feeding	Health and growth	References
Simmental × Red Holstein, Brown Swiss and Holstein Friesian	Breastfeeding mother	Improved health status, body weight and feed intake	Rauprich et al., 2000
Simmental × Red Holstein, Holstein Friesian, Holstein Friesian × Limousine, and Braunvieh × Brown Swiss	Breastfeeding mother	Improves metabolic profile, endocrine status, intestinal absorptive capacity and better growth performance immediately after birth.	Kuhne et al., 2000
Holstein calf	Breastfeeding mother	Significant weight gain from 40.9 kg to 61.2 kg	Franklin et al., 2003
Jersey calf	Nipple bottle feeding	Increased intake and absorption of IgG by giving high quality colostrum	Jaster, 2005.
Lamb	Breastfeeding mother	Increased productivity and long life as an adult	Massimini et al., 2006
Holstein calf	Nipple bottle feeding	Significant weight gain from 45.4 kg to 47.6 kg in one day. The villi of the duodenum, jejunum, and ileum become longer, increasing the absorption capacity	Yang et al., 2015
Holstein calf	Nipple bottle feeding	Reduce the incidence of failure of passive transfer (FPT) colostrum	Williams et al., 2014
Holstein Friesian calf	Breastfeeding mother	Significant weight gain from 35.19 kg to 65.12 kg for 45 days	Shah et al., 2019

Table 3 shows the very important role of Colostrum in the healthy development and growth of calves and young ruminants of various breeds of cattle as a whole. Although the quality of IgG in Colostrum is adequate, in order to achieve optimal development, it is necessary to pay attention to several methods of administration so that passive IgG transfer can take place optimally. Methods that can be applied include the appropriate timing of colostrum administration (Weaver et al., 2000; Chigerwe et al., 2008), the quality of Colostrum

given (Johnson et al., 2007), the quantity of Colostrum shown (Jaster, 2005), the origin of Colostrum (Kehoe et al., 2007) and method of administration of Colostrum (Gomez and Chamorro, 2017). In the end, the role of the Colostrum in calf development and growth is still influenced by various factors. Therefore, farmers need training on knowledge of the colostrum quality and the method of giving it needs to be improved, especially by practitioners working in the field.

CONCLUSION

After birth, colostrum administration to the calf is the most critical stage since it significantly impacts the calf's health and appearance as an adult. Colostrum contains many nutrients, including immunoglobulins, lactoperoxidase, lactoferrin, lysozyme, leukocytes, vitamins, minerals, and lipids. This is why it is critical to pay close attention to the quality and amount of Colostrum in order to provide the best possible care to calves.

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