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GOAT COLOSTRUM – COMPOSITION AND IMPACT

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Abstract

Colostrum is the first milk that a newborn receives immediately after birth. Its quality and timely intake are the main factors influencing the survival chances of the newborn. The composition of goat colostrum depends on the breed, age, diet and health of the animal. Immunoglobulins from the blood of the mother goat do not cross the placental barrier during pregnancy, at birth the kid does not have antibodies against the surrounding infectious agents. These immunoglobulins are concentrated in the colostrum and provide the passive immunity that the kid acquires. Goat colostrum has been shown to contain twice as much immunoglobulin G, as cattle colostrum. The specific biological properties of colostrum make it a valuable material for the development of food supplements. In recent years, these supplements have become increasingly popular on the world market as a powerful immunostimulant. The objective of the present review is to give a brief overview of the physicochemical and immunological properties of goat colostrum as well as the differences in the different breeds.

Key words: *colostrum, goats, immunoglobulins, immunity, physicochemical parameters.*

INTRODUCTION

Goats are animals distributed all over the world with an exceptional adaptive capacity. Over the years, they have become highly productive animals, transforming low-quality fodder into high-quality products intended primarily for the market.

Unlike cow's milk, goat's milk is characterized by better digestibility, alkalinity and buffering ability (Rashid et al., 2012). In this regard, the specific biological properties of colostrum make it a valuable raw material for the development of food supplements. In recent years, these supplements have become increasingly popular on the world market as a powerful immunostimulant.

Colostrum milked in the first 24 hours is the richest in fats, proteins and immunoglobulins. Moreover, there are higher values of titratable acidity in this period than in the next few days of early lactation. Colostrum is considered to have passed into milk after day 5, when all measured values meet the normal limits described in the goat's milk references. After the first to the fifth day, milk secreted by the mammary gland can be considered as transitional goat's milk, which is not quality colostrum due to low and immunological quality and is unfit for processing dairy products due to its high acidity, immunoglobulin and fat content. (Sánchez-Macías et al., 2014).

Under the legislation of many countries, milk intended for human consumption cannot contain colostrum (European Commission Regulation (EC) 1662/2006) (Romero et al., 2013), the same author notes the claims of Raynal-Ljutovac et al. (2005), which affect the negative impact of the presence of large amounts of protein in milk intended for the production and standardization of certain dairy products. It is important for the dairy industry that milk does not contain colostrum. However, the EU defines colostrum as an animal product for human consumption (Hodulová et al., 2014), in the form of food supplements.

According to Sánchez-Macías et al. (2014), the transition period (transition from colostrum to milk) is marked by nutritional, metabolic, hormonal and immunological changes that affect the incidence of infections and metabolic diseases. During this period, gradual or sometimes sudden changes in the composition and properties of colostrum can be observed (Arain et al., 2008; Sánchez-Macías et al., 2014).

Sánchez-Macías et al. (2014) cite the claims of Feagan (1979), who described the higher content of IgG in colostrum as a prerequisite for changing some physicochemical properties that make it difficult to process milk for different types of product. Less efficient pasteurization, reduced thermal stability of milk, the unpleasant tastes after pasteurization of milk, as well as reduced yield of cheese and cottage cheese associated with increased protein content are cited as such.

RESULTS AND DISCUSSIONS

Timely suckling with colostrum is essential for the survival of newborn kids. Colostrum contains sufficient nutrients and immuneglobulins that act as natural antimicrobial agents and actively stimulate the development of the newborn's immune system (Arguello et al., 2006). Colostrum suckling within a few hours after birth plays a vital role in the health and survival of the kid, as well as in building its passive immunity (Rashid et al., 2012).

In order to suckle successfully, the kid must be able to get up and move to the udder, and the mother's behavior serves only as a stimulus and guide to the udder, but in itself cannot ensure suckling, which depends on neonatal motor activity of the kid (Dwyer et al., 1999). The time it takes to stand up and find the udder is extremely important for timely suckling. The highest neonatal mortality is observed in the first 3 days, suggesting that events occurring during this period are of particular importance for survival (Nowak et al., 2000; Martinez et al., 2009).

Normal colostrum suckling and absorption is a major vital determinant of health (Khan et al., 2006) and normal growth during neonatal development and is more significant than birth weight (Chen et al., 1998).

Stoycheva et al., (2017) found in goats of Bulgarian White Dairy breed that 56% of singles and 56% of twins tried to suckle as 31% of singles and 25% of twins were suckling during the first hour after the birth.

Arguello et al., (2006) summarize the writings of Morand-Fehr, (1989) and Dos Santos et al., (1994) and confirm that the survival rate of newborn kids is related to the amount of colostrum taken in the first two days after birth and that the rectal temperature of colostrum-fed kids is higher than that of milk-fed kids. Getting enough high-quality colostrum immediately after birth is one of the most important practices in raising kids.

Colostrum synthesis

Linzell & Peaker (1974) studied changes in colostrum composition and mammary gland permeability during late pregnancy and birth in goats. Of interest are the mechanisms responsible for the ionic composition of colostrum and its conversion into milk later. The authors refer to their previous scientific publications (Linzell, 1959; Linzell & Peaker, 1971a,b), and confirmed that milk secretion begins before birth, but because milk is not milked, the pressure in the mammary gland increases to such an extent that there is a partial balance between the two phases of milk - the released milk (rich in calcium and lactose) and the extracellular fluid (rich in sodium chloride). Some evidence suggests that the increase in pressure may not be the only mechanism responsible for the ionic composition of colostrum. It is possible, in contrast to the lactation period, that there is some rupture of the epithelial tissue of the mammary gland, which at a later stage of lactation allows substances to pass directly (i.e. in both directions between extracellular fluid and milk). According to the authors, this mechanism may explain the ionic composition, but not the content of immuneglobulin in colostrum. Colostrum is rich in protein and antibodies, but contains less fat and carbohydrates than mature milk.

Colostrum composition and breed dependence

Breed dependence in the composition of goat colostrum has been proven.

Zaharia et al. (2011) followed the change in the **fat** content of colostrum from 0 to 7 days in local breeds of Romanian goats. The authors found 4.2% fat per hour 0, followed by an increase to 8.08% at 6 hours, a decrease after 12 hours (5.14%) and an increase of 6.02% again after 24 hours, followed by a continuous decrease to average value of 2.3% on day 7. For Murciano-Granadina goat breed, Romero et al. (2013) reported 9.53% fat content in colostrum at hour 0, while for goats of Majorera-breed, the values are 7.7% (Sánchez-Macías, et al., 2014). In Beetal goats (Rashid et al., 2012), they reported a much lower fat content on the first day of 3.8%, followed by a continuous increase on the second (4.5%) and third day (5.2%).

For Bulgarian White Dairy, Zunev et al. (2004) reported 5.72% and 6.65% in crossings with Toggenburg breed for the entire colostrum period.

According to Rashid et al. (2012), low fat content of colostrum milked immediately after birth could be explained by the lower content of fatty acids, triglycerides, phospholipids and cholesterol compared to colostrum milked twenty-four hours later. This is a kind of mechanism that protects the digestive tract of the newborn.

Lactose is a compound that is absorbed faster than fats (Arguello et al., 2006). Rashid et al. (2012), studied the composition of colostrum in Beetal goats and found that when switched to milk, the amount of lactose increases. Lactose promotes intestinal absorption of calcium, magnesium, phosphorus and vitamin D3 (Chilliard et al., 2003; Rashid et al., 2012). This is confirmed by a number of authors who report an increase in lactose during lactation (Akinsoyinu et al., 1979, in West African dwarf goats, Hadjipanayiotou, 1995, in Damascus goat, Arguello et al., 2006, in Majorera-breed, Hodulová et al., 2014 in Czech White Shorthair goats). Romero, et al. (2013) reported 2.9% lactose per hour 0 and an increase to 4.48% per 156 hours in samples of colostrum from Murciano-Granadina goats. Sánchez-Macías et al. (2014) found that lactose increased from 2.44% per hour 0 to 5.44% over a 90-day period in Majorera-breed goats.

Zunev et al. (2004) reported 4.73% lactose both for Bulgarian White Dairy and its crossings and with Toggenburg breed for the whole colostrum period and 4.90% for mature milk on 14 days.

At birth, the kid does not have antibodies against the surrounding infectious agents because the antibodies in the mother goat's blood do not cross the placental barrier (Arguello et al., 2006; Hernández-Castellano et al. 2015). Goats receive antibodies through the first colostrum they suckle, which is why first-time suckling is essential because of the highest permeability of the intestinal mucosa in the first 24 hours after birth (Nordi et al., 2012, Moretti et al., 2013). Colostrum has a laxative effect, it helps the first defecation of the newborn kid - meconium (Rashid et al., 2012).

One of the main **proteins** in colostrum and milk is casein (Rashid et al., 2012, Soloshenko et al., 2020). The content of the main components of colostrum varies significantly during the postpartum period, at the highest concentration of proteins, including lactoferrin and immunoglobulins, is observed in the first 24 hours after birth (Soloshenko et al., 2020). Rachman et al. (2015) reported a drastic drop in lactoferrin levels in the first 48 hours after birth in three goat breeds in Indonesia.

The protein is a source of antimicrobial peptide precursors that increase the newborn's natural defenses against pathogens. The high protein content of colostrum is due to the presence of immunoglobulins, leukocytes, lactoferrin, lysozyme, polypeptides, cytokines, growth hormones, insulin-like growth factors, fibroblast growth factors, epithelial growth factors and some amino acids (Pellegrini et al., 1994; Rashid et al., 2012).

Sánchez-Macías et al. (2014) studied the colostrum of ten Majorera goats that gave birth to twins, and found that the percentage of protein in colostrum decreased by 45% by the second day after birth. From the third to the fifth day, no significant differences were observed. Which, according to them, is due to higher amounts of casein and immunoglobulins (Tsioulpas et al., 2007). In the course of the study, the percentage of protein in milk decreased, being 3.49% on the 15th day after birth and remaining at these values for up to 90 days.

Both lactose and protein are dependent on differences among breeds.

Sánchez-Macías et al. (2014) summarize their previous studies (Sánchez-Macías et al., 2010b) in the Majorera breed, as well as those of other authors, like Csapó et al. (1994) found 16.2% total protein in colostrum from White Hungarian goats, Hadjipanayiotou (1995) in turn found 16.0% protein in colostrum from Damascus goat, and Chen et al. (1998) found 16.5% in colostrum from Nubian goat. This summary confirms the presence of differences among breeds, which are more pronounced in dairy breeds, as the total protein is content lower in highly productive breeds (Pritchett et al., 1991;

Quigley et al., 1994, Sánchez-Macías et al., 2014).
According to Zazharska & Samoylenko (2016), the quality of colostrum depends mostly on the concentration of IgG. Shao et al. (2021) examined the concentration of IgG in goat colostrum and found a significant decrease from 1 to 7 days after birth. The amount of IgG decreases dramatically in the first 24 hours after birth, as it continues until the third day and remains relatively constant until day 7. The studies of Moreno-Indias et al. (2012) in Majorera goat breed found a decrease in the amount of IgG in the first 10 hours after birth by 37.4 mg/ml.
Csapó (2013) describes a very strict relationship between serum protein and colostrum IgG content.
Kessler et al. (2019) found the presence of more IgG in goat colostrum compared to sheep. They also prove differences among ten breeds of goats and sheep. Moreover, beef breeds synthesize more IgG than dairy breeds.
Castro et al. (2009) reported that birth weight and number of kids born also affected the acquisition of immunity. According to them, triplets and kids with lower birth weight (<2.8 kg) are at risk of failure of passive immunity and need special attention immediately after birth.
Keskin et al. (2007) found that sheep colostrum contained more protein, fat and lactose than goat colostrum, which was confirmed by Kessler et al. (2019) for ten breeds of sheep and goats.
Colostrum contains 4 to 10 times more **vitamins** A, D and E than milk and is a major source of these nutrients for newborns immediately after birth, as some vitamins do not cross the placental barrier (Uruakpa et al., 2002; Debier et al., 2005; Zarcula et al., 2010, Hodulová et al., 2014).
Hodulová et al. (2014) found a 14-fold higher concentration of vitamin A and a 5-fold lower concentration of vitamin E in goat colostrum in the first hour after birth than in 132 hours.
The density of colostrum and milk depends on indicators, such as fat, protein, total solids (TS) and dry fat-free residue. The higher the percentage of these physicochemical parameters, the higher the density.
Romero et al. (2013) found that colostrum density of Murciano-Granadina goat breed, studied immediately after birth was 1.0528 (g/ml) and at 156 hours decreased to 1.0303 (g/ml), while Sánchez-Macías et al. (2014) reported a density value of 1.0480 (g/ml) in Majorera-breed, decreasing to 1.0280 (g/ml) ninety days later.
Hernández-Castellano et al. (2015) summarizes information from some publications (Ahmad et al., 2000; Banchero et al., 2004; da Nobrega et al., 2005; Nowak & Poindron, 2006; Morales-delaNuez et al., 2011) that kids that are bottle-fed and have enough colostrum in the first days of life receive adequate, passive immune transfer, which favors their growth, development and productivity. The influence of factors such as feeding, maternal health, number of offspring on the quality of colostrum should not be overlooked.
Knight & Peaker (1982) found that single goats secreted less milk than those born to two or more kids.
According to Romero et al. (2013), pH, protein and lactose are significantly affected by the number of kids born. While chemical and physical indicators are strongly influenced by the time after birth and less by the number of born kids and the sequence of lactation (Arguello et al., 2006).

Colostrum quality

As already mentioned, the first-time suckling is of utmost importance. Equally significant and essential for the acquisition of passive immunity is the provision of quality colostrum (Hue et al., 2021).
Unlike expensive standard methods, the easiest, most affordable and practical device for determining the quality of colostrum in the field is the manual optical refractometer. It is used in dairy farms to measure solids. However, it can be used to assess the IgG content of colostrum, based on comparison with standard methods such as ordinary RID and ELISA.
These methods require special knowledge and consumables, and are also expensive and require technological time (Zobel et al., 2020). Therefore, the measurement of IgG using an optical refractometer is becoming more and more popular as a practical method for measuring it in the field. When using a Brix refractometer to assess the quality of goat colostrum, Brix% values less than 18.5% -

21.5% identify it as poor (Buranakarl et al., 2021).

Zobel et al. (2020), also, consider determining the quality of goat colostrum on the farm to be extremely important and a first step in improving the assessment of goat colostrum quality at the farm level. The ability to quickly determine the quality shows how well it is suitable for feeding newborn kids, and thus, facilitates the implementation of immune transfer. The authors are working on the validation of Brix refractometers and a hydrometer to determine the quality of goat colostrum. According to them, when read with a refractometer, goat colostrum shows lower values than beef. They indicate values of % Brix less than 19% for colostrum, as a reason to consider it low quality.

Rudovsky et al. (2008) measured the concentration of immunoglobulins in the colostrum of Weiße Deutsche Edelziege goats. According to them, the hydrometer allows immediate assessment of the concentration of immunoglobulin in the colostrum of goats. The method is cost-effective and easy to apply, but to be accurate, an adjustment must be made to the temperature in the barn.

Application of goat colostrum

There are few studies in the available literature on the functional side of goat colostrum. Functional foods made from goat's milk have antioxidant, anti-inflammatory, cardioprotective, antihypertensive and antiatherogenic effects in the human body (Voloshyna et al., 2021). The authors define goat colostrum as a unique product that can be used to create cosmetics for maintaining healthy skin and treating skin diseases, as well as for the production of functional foods with antioxidant and anti-inflammatory properties and baby foods. These foods are very digestible and are an alternative source of milk oligosaccharides (van Leeuwen et al., 2020) for baby foods.

Bioactive peptides in goat's milk protein and their effects on human health, mitochondrial diseases and brain malignancies have been studied (Sharma et al., 2017).

Hyrslova et al. (2016) studied the possibility of combining goat colostrum with probiotics and recommended it as a raw material for the production of dietary supplements with bifidobacteria.

Balagayathri et al. (2021) evaluate the in vitro antimicrobial, antioxidant and anticancer activity of bioactive peptides from goat colostrum and found that they are effective against both gram-positive *(Bacillus subtilis* and *Staphylococcus aureus)* and Gram-negative *(Escheresia coli, Klebsiella pneumo)* have potent cytotoxic activity.

Romero et al. (2013), in goats of Murciano-Granadina goat breed, and Hodulová et al. (2014) in Czech White Shorthair goats, note that transitional milk after the fourth day can be used as a raw material for the food industry without affecting the quality of the product.

CONCLUSIONS

In conclusion, despite the differences among breeds in the colostrum composition from goats, it is an indispensable source of antibodies and nutrients for the newborn kid.

There are easy and relatively accurate methods for determining its quality.

Determining and controlling the quality of goat colostrum is of a great significance for the survival and health of the newborn kid, as well as the future productivity and economic efficiency of the farm.

Goat colostrum is a valuable raw material for the pharmaceutical industry and enables the development of new food supplements and immunostimulants.

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