The impact of colostrum intake on the serum protein electrophoretic pattern in newborn ruminants

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ABSTRACT
The objective of this study was to evaluate the influence of colostrum intake on the serum protein electrophoretic pattern in clinically healthy calves, lambs and kids during the first two weeks of life, as well as differences in the protein profile between these species of ruminants. The study included three groups of clinically healthy calves (n = 12), lambs (n = 10) and kids (n = 7). The first blood sampling was performed before the colostrum intake (day 0) and then at 1, 2, 7 and 14 days of age. Blood serum was analysed for the concentrations of total proteins, serum protein electrophoretic fractions and albumin/globulin ratio. Serum protein electrophoresis identified in calves 6 (albumin, α1-, α2-, β1-, β2-, and γ-globulins) and in lambs and kids 5 (albumin, α1γ, α2γ, β1γ, β2γ, and γ-globulins) distinct bands. Significant changes were observed in the analysed parameters during the evaluated period in all groups of ruminants. Except of the concentration of total proteins in precolostral serum significant differences in the results were found also between ruminant species. The present study showed significant effect of colostrum intake on concentrations of total proteins and also relative and absolute concentrations of the major of protein fractions in all evaluated species of young ruminants. The results, analysis of which began already in precolostral time, indicate that colostrum feeding is the starting point for significant changes in protein profile in ruminant neonates followed by longer-lasting changes in the following days and weeks of their life.

1. Introduction
Hundreds of different proteins can be demonstrated in the blood serum, which vary in their concentration, molecular size and function (Racek 2006). Collectively, serum proteins perform a nutritive function, exert colloid osmotic pressure, participate in immune responses and aid in the maintenance of acid-base balance. Individual proteins serve as enzymes, antibodies, coagulation factors, hormones, acute phase proteins and transport substances. The major site of serum protein synthesis is the liver, and the second major contributor is the immune system (Evans 2003). Measurement of plasma or serum protein concentrations often yields important information that can be helpful in narrowing the list of diseases to be considered and, in some cases, in revealing the presence of a specific disease (Allison 2012). A standard method for fractionation and quantification of serum proteins in clinical biochemistry is electrophoresis (Piccione et al. 2011a). Serum proteins are separated according to their electric charge using cellulose acetate electrophoresis into four fractions (Bossuyt et al. 2006; Alberghina et al. 2010). Each band is made up of a group of individual proteins, each of which is characterized by independent metabolic properties. Concentrations of serum proteins are influenced by many physiological (species, age, gender, gravidity, lactation, etc.) and pathological (malnutrition, renal and liver diseases, etc.) factors (Kaneko 1997). Considering that laboratory evaluation of serum proteins and serum protein electrophoretic profile is one of the most useful diagnostic aids available to clinicians, it would be invaluable to have species-, age- and gender-specific reference intervals (Tschuor et al. 2008).

According to several studies the most significant changes in serum protein fractions were observed a short time after birth (Piccione et al. 2011b; Nagy et al. 2014). The most intensive adaptive changes of the newborn ruminants occur during the first week of their life. The neonatal period, known as ‘adaptive period’, is a transition phase during which all organ functions must adapt to the extra-uterine life. In fact, the birth and the subsequent 24 h are crucial for the newborn’s survival because they represent a critical stage for the detection of health problems (Piccione et al. 2008, 2010). The relationship between colostrum intake and newborn ruminant survival has been extensively characterized (Argüello et al. 2004; Castro et al. 2005, 2009, 2011; Rodríguez et al. 2009). Colostrum is the first source of nutrition in neonatal ruminants, supplying not only nutrients, but having also a fundamental biological function, promoting immunoglobulin (Ig) transfer from the dam to the newborn. Moreover, colostrum contains a mixture of diverse components, such as fat, lactose, vitamins and minerals, which have a high nutritional importance (Ontsouka et al. 2003). Beyond the nutritional function, colostrum actively participates in the protection of the neonate against pathogens and other post-partum environmental challenges by a complex

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mixture of proteins (Bendixen et al. 2011). However, studies dealing with the changes in the serum protein pattern and in concentrations of protein fractions in young ruminants after colostrum intake as well as studies dealing with differences in protein profile between calves, lambs and kids are still limited.

The objective of this study was to evaluate the influence of colostrum intake on the serum protein profile and changes in the serum protein electrophoretic fractions in clinically healthy calves, lambs and kids during the first two weeks of life, as well as differences in the protein profile between these species of ruminants.

2. Material and methods

2.1. Animals and blood sample collection

Three groups of young ruminants were used in this study. The first group included 12 calves of a Slovak spotted breed, low land black spotted breed or their crossbreeds. In the second group there were 10 lambs – crossbreeds of Slovak merino and Cigája. The third group included 7 kids of white short-haired goat. All young ones were born at the Clinic of Ruminants and were kept together with their mothers. Within 30 min after birth the ‘zero’ blood sample was collected from the animals before the first colostrum feeding. The calves received the first colostrum within 2 h and small ruminants within 1 h after birth. During the first day of life the calves, lambs and kids were fed colostrum, and later whole milk by voluntary sucking of their dams. During the monitored period they were allowed to suck freely on their dams and had free access of water, hay and concentrates during the time of the study. The average birth weight of calves was 35.3 ± 2.9 kg, lambs 3.1 ± 0.4 kg and kids 3.0 ± 0.4 kg. The average body weight on day 14 of life of calves was 46.2 ± 3.4 kg, lambs 5.9 ± 0.3 kg and kids 5.4 ± 0.4 kg. The young ones were observed daily. All animals were clinically healthy and in good general health condition without any obvious clinical signs of diseases during the time of the study. The first blood sampling in animals was performed before the colostrum intake (day 0) and then at 1, 2, 7 and 14 days of age. Blood was collected by direct puncture of venae jugularis into tubes with serum clot activator (Meus, Piove di Sacco, Italy). Blood samples were allowed to clot at room temperature and then centrifuged at 3000 g for 30 min to separate the serum. The serum samples were neither lipaemic nor hemolysed. The separated serum was stored at −20°C until analysed.

2.2. Laboratory analyses

Blood serum was analysed for the concentrations of total proteins (TP, g/l) and serum protein fractions. Total protein concentrations were assessed on an automated biochemical analyser Alizé (Lisabio, Pouilly-en-Auxois, France) by the biuret method using commercial diagnostic kits (Randox Laboratories Ltd, Crumlin, UK). Serum protein fractions were separated by zone electrophoresis on a buffered agarose gel at pH 8.8 on an automated electrophoresis system Hydrasys (Sebia Corporate, Evry, France) using commercial diagnostic kits Hydragel 7 Proteine (Sebia Corporate) according to the procedure described by the manufacturer. The electrophoretic gels were scanned, and the serum protein fractions were visualized and displayed on a densitometry system Epson Perfection V700 (Epson America Inc., Long Beach, CA, USA) by light transmission and automatic conversion into an optical density curve presentation. Protein fractions were identified and quantified by computer software Phoresis version 5.50 (Sebia Corporate) and, if necessary, corrected by visual inspection of the electrophoretogram. Serum proteins were separated into fractions including albumin, alpha (\(\alpha\)-), beta (\(\beta\)-) and gamma (\(\gamma\)-) globulins in order of fastest to slowest mobilities. The relative concentrations (%) of the protein fractions were determined as the percentage of the optical absorbance and absolute concentrations (g/l) were calculated from the total protein concentrations. Albumin/globulin (A/G) ratios were computed from the electrophoretic scan.

2.3. Statistical analyses

Arithmetic means (\(x\)) and standard deviation (SD) expressed as relative and absolute concentrations for each evaluated variable and sample collection were calculated using descriptive statistical procedures. One-way Friedman ANOVA with Dunn’s multiple comparison tests were used to evaluate the effect of sampling time on the obtained results in each group of ruminants and the significance of differences of the values recorded in precolostral and postcolostral serum samples (\(P\)-value). One-way Kruskal-Wallis ANOVA with Dunn’s multiple comparison tests was applied to evaluate the significance of differences in results between different species of ruminants. All statistical analyses were carried out using the programme GraphPad Prism V5.02 (GraphPad Software Inc., California, USA).

3. Results

The data referring to the relative and absolute concentrations of serum protein fractions in the evaluated groups of ruminants expressed as means and SDs (\(x ± SD\)), including the analysed significances, are presented in Tables 1 and 2. Serum protein electrophoresis identified 6 distinct bands in calves, comprising albumin, \(\alpha_1\)-, \(\alpha_2\)-, \(\beta_1\)-, \(\beta_2\)- and \(\gamma\)-globulins. For the statistical analysis the values of \(\beta_1\)- and \(\beta_2\)-globulin fractions were summed to the \(\beta\)-globulin fraction. Serum proteins in lambs and kids were separated into 5 fractions including albumin, \(\alpha_1\)-, \(\alpha_2\)-, \(\beta\)- and \(\gamma\)-globulins. Significant changes were observed in all analysed parameters during the evaluated period in all groups of young ruminants. Significant differences were found between calves, lambs and kids as well. Among the evaluated young ruminant species after colostrum intake the most significant changes in all evaluated parameters were recorded in calves.

The most prominent protein fraction in all of the evaluated ruminants was albumin with significant changes of values during the monitored period (Table 1). On day 1 after colostrum intake this fraction decreased significantly in all groups of ruminants (\(P < .05\)) and a gradual increase of values was observed from the 2nd to the 14th day of life. Significant differences were found between the groups of animals at each blood sampling (\(P < .001\)). The fraction of albumin was significantly lower in calves than in lambs and kids (\(P < .05\)). Significant
Table 1. Relative concentrations (%) of the evaluated parameters in calves, lambs and kids during the first two weeks of life (mean ± SD).

| Variables/animals | Evaluated period (days) | P-value |
|-------------------|-------------------------|---------|
|                   | 0 ± 2                   | 1       | 2       | 7       | 14      |
| Albumin           | 57.5 ± 2.4              | 26.5 ± 3.8 | 27.7 ± 3.9 | 32.4 ± 3.7 | 37.5 ± 3.4 | <.001 |
| Lambs             | 68.7 ± 1.1              | 49.7 ± 10.9 | 51.0 ± 9.3 | 56.3 ± 7.1 | 58.8 ± 7.6 | <.001 |
| Kids              | 64.4 ± 3.8              | 56.4 ± 3.6 | 56.4 ± 3.5 | 58.5 ± 3.8 | 61.6 ± 3.7 | <.01  |
| α1-globulins      | 27.6 ± 2.1              | 17.3 ± 2.6 | 16.6 ± 2.3 | 13.0 ± 1.8 | 10.7 ± 1.6 | <.01  |
| Lambs             | 15.6 ± 2.0              | 13.0 ± 3.3 | 12.0 ± 2.5 | 8.3 ± 2.0  | 6.9 ± 1.4  | <.01  |
| Kids              | 20.9 ± 3.1              | 19.5 ± 3.9 | 18.3 ± 3.0 | 13.4 ± 2.5 | 10.7 ± 1.9 | <.01  |
| β-globulins       | 8.8 ± 1.5               | 9.8 ± 2.3  | 11.5 ± 2.0 | 15.6 ± 2.1 | 16.1 ± 1.7  | <.01  |
| Lambs             | 1.9 ± 0.4               | 2.9 ± 0.6  | 3.1 ± 0.7  | 5.0 ± 3.5  | 5.8 ± 3.4  | <.01  |
| Kids              | 1.5 ± 0.3               | 1.9 ± 0.5  | 2.1 ± 0.5  | 3.6 ± 1.0  | 3.8 ± 1.0  | <.01  |
| γ-globulins       | 1.4 ± 0.6               | 33.8 ± 5.5 | 31.0 ± 5.0 | 24.8 ± 3.3 | 21.3 ± 2.5  | <.01  |
| Lambs             | 2.4 ± 0.8               | 23.5 ± 13.6 | 21.3 ± 11.3 | 15.5 ± 8.6 | 12.4 ± 5.9  | <.01  |
| Kids              | 2.3 ± 1.0               | 9.7 ± 3.3  | 9.2 ± 3.7  | 6.7 ± 1.9  | 5.9 ± 0.8  | <.01  |

Notes: Values with different superscript alphabets mean significant differences of values between species of ruminants (P < .05). P – significance of differences.

Table 2. Absolute concentrations (g/l) of the evaluated parameters and A/G ratio in calves, lambs and kids during the first two weeks of life (mean ± SD).

| Variables/animals | Evaluated period (days) | P-value |
|-------------------|-------------------------|---------|
|                   | 0 ± 2                   | 1       | 2       | 7       | 14      |
| TP                | 40.9 ± 3.2              | 79.2 ± 11.9 | 77.3 ± 8.6 | 73.4 ± 9.7 | 70.5 ± 8.0 | <.001 |
| Lambs             | 43.2 ± 4.5              | 62.4 ± 15.9 | 59.5 ± 13.5 | 56.6 ± 9.8 | 57.1 ± 8.1 | <.001 |
| Kids              | 42.4 ± 4.4              | 43.4 ± 4.2 | 43.5 ± 4.2 | 46.9 ± 3.7 | 47.8 ± 6.2 | <.01  |
| Albumin           | 23.5 ± 2.4              | 20.2 ± 1.8 | 21.1 ± 1.6 | 23.6 ± 8.1 | 26.3 ± 3.4 | <.01  |
| Lambs             | 29.5 ± 2.7              | 29.3 ± 2.1 | 29.2 ± 2.7 | 31.4 ± 3.8 | 32.9 ± 5.0 | <.01  |
| Kids              | 27.4 ± 3.5              | 24.4 ± 2.6 | 24.8 ± 2.5 | 27.5 ± 3.2 | 29.5 ± 4.5 | <.01  |
| β-globulins       | 11.3 ± 0.7              | 13.4 ± 0.8 | 12.7 ± 0.6 | 9.4 ± 0.9  | 7.4 ± 0.7  | <.001 |
| Lambs             | 6.6 ± 0.8               | 7.6 ± 1.1  | 6.9 ± 0.8  | 4.5 ± 0.5  | 3.8 ± 0.4  | <.001 |
| Kids              | 8.8 ± 0.1               | 8.4 ± 1.3  | 8.0 ± 0.9  | 6.2 ± 1.0  | 5.0 ± 0.6  | <.001 |
| γ-globulins       | 1.4 ± 0.4               | 2.3 ± 0.4  | 3.2 ± 0.5  | 4.7 ± 0.8  | 5.1 ± 0.7  | <.001 |
| Lambs             | 4.9 ± 0.7               | 6.9 ± 1.6  | 7.5 ± 1.7  | 8.4 ± 1.2  | 8.9 ± 1.0  | <.001 |
| Kids              | 4.7 ± 0.9               | 5.5 ± 0.9  | 6.1 ± 0.9  | 8.3 ± 1.1  | 8.7 ± 1.8  | <.001 |
| A/G               | 0.6 ± 0.2               | 27.3 ± 8.3 | 24.3 ± 6.4 | 18.4 ± 4.3 | 15.2 ± 3.2 | <.001 |
| Lambs             | 1.0 ± 0.4               | 16.8 ± 12.6 | 14.1 ± 10.0 | 9.6 ± 6.6 | 7.3 ± 4.0 | <.001 |
| Kids              | 1.0 ± 0.5               | 4.3 ± 1.4  | 4.1 ± 1.8  | 3.2 ± 1.1  | 2.8 ± 0.8  | <.001 |

Notes: Values with different superscript alphabets mean significant differences of values between species of ruminants (P < .05). TP – total proteins; P – significance of differences; ns – not significant.

changes were also found in the α1-, α2- and β-globulin fractions (P < .001). The highest percentages of α1-globulins were observed in all evaluated ruminants immediately after birth and then the values gradually decreased significantly till the 14th day of life. Significantly lower relative concentrations of α1-globulins were found in lambs (P < .05). The fraction of α2-globulins showed an opposite trend of changes. An increase of the percentage of α2-globulins was observed from the day 2 after birth with significantly highest values at the age of 7 and 14 days (P < .05). The values in calves were significantly lower than in lambs and kids at each blood sampling (P < .05). The lowest values of β-globulins were found before colostrum intake and then the values gradually increased. The significantly highest values were recorded at the age of 7 and 14 days (P < .05). In calves the relative concentrations of β-globulins were significantly higher (P < .05). After birth the γ-globulins’ fraction was the lowest among the serum protein pattern. The values significantly increased on day 1 after colostrum intake
in all groups of ruminants \( (P < .05) \). From day 2 to day 14 of life a gradual decrease of values was observed till the end of the monitored period. Significant differences in the values of γ-globulins were found between the species of ruminants at each blood sampling \( (P < .01 \) and \( P < .001 \). The relative concentration of γ-globulins after colostrum intake was higher in calves than in small ruminants.

The concentration of total proteins in relation to colostrum intake in young ruminants showed significant changes during the first two weeks of life (Table 2). The lowest concentration of TP was observed at birth. In calves and lambs after significant increase of values on day 1 \( (P < .05) \) the values gradually slightly decreased. The concentration of TP in kids during the monitored period gradually slightly increased. Except for the sampling before colostrum intake significant differences in the values were found between the species of ruminants at each blood sampling \( (P < .001) \). Significant changes during the evaluated period were found in the absolute concentrations of albumin in all groups of ruminants. The concentration of albumin decreased on day 1 in all groups of ruminants and in the following days the values gradually increased. The values on day 14 were higher than before colostrum intake. The concentrations of albumin were significantly higher in lambs than in calves \( (P < .05) \). Significant changes were found also in absolute concentrations of \( \alpha_1 \)- and \( \alpha_2 \)-globulins in all evaluated groups of ruminants \( (P < .001) \). The highest values of \( \alpha_1 \)-globulins were observed on day 1 after birth in calves and lambs with subsequent decrease of concentrations till the end of the monitored period and the significantly lowest values at the age of 14 days \( (P < .05) \). The values of \( \alpha_1 \)-globulins in kids gradually significantly decreased from birth to 14 days \( (P < .05) \). The absolute concentrations of \( \alpha_1 \)-globulins were significantly higher at each blood sampling period in calves than in lambs and kids. The values of \( \alpha_2 \)-globulins gradually increased significantly from the day of birth to 14 days of age \( (P < .05) \). In lambs as well as in kids the concentrations of \( \alpha_2 \)-globulins were significantly higher than in calves at each sampling time \( (P < .05) \). Concentrations of the \( \beta \)-globulins showed significant changes during the first two weeks of life in all species of ruminants \( (P < .001) \). The lowest values were found after birth before colostrum intake and then the concentrations increased significantly to the end of the monitored period \( (P < .05) \). Significantly higher absolute concentrations of \( \beta \)-globulins were found in calves at each blood sampling time. The intake of colostrum had a significant effect on the concentrations of γ-globulins \( (P < .001) \). The lowest mean values were detected at birth in all evaluated groups of ruminants. Twenty-four hours after colostrum intake their concentrations increased significantly \( (P < .05) \) with a subsequent decrease till the end of the second week of life. The significantly lowest concentration of γ-globulins at birth was found in calves, the highest mean value was recorded in lambs \( (P < .05) \). The concentrations of γ-globulins after colostrum intake were significantly higher in calves in all monitored periods \( (P < .05) \). No significant differences were found between lambs and kids at any blood sampling time.

Significant changes were found during the evaluated time also in A/G ratios (calves, lambs \( - P < .001 \); kids \( - P < .01 \)). The highest mean values were recorded at birth and the lowest on the first day after birth in all evaluated groups of young ruminants. Significant differences were found between calves, lambs and kids in all evaluated periods \( (P < .001) \). The values of A/G in calves were significantly lower than in lambs and kids \( (P < .05) \). No significant differences were found between the group of lambs and kids at any time of blood sampling.

4. Discussion and conclusion

The first few days after birth, known as the neonatal period, represent a critical phase during which the numerous functional and morphological changes necessary to adapt to extrauterine life take place (Piccione et al. 2006). In this period, colostrum is a vital food for the newborn of all ruminants. The early mother-young interaction is crucial for the survival of young ruminants because it provides them with colostrum to satisfy their metabolic needs, to protect them from infection and help them to adapt to the external environmental condition. Colostrum, which is produced few days before parturition, contains dense nutrients as well as high levels of immunoglobulins, growth factors, neuroendocrine peptides, enzymes and hormones (Nowak & Poindrond 2006). In this case colostrum is the unique source of food for the neonate and insufficient uptake is the second major factor (after body reserve) that causes neonatal losses. Sufficient colostrum uptake on the first day of life plays an essential role in survival rate and in protection from infections of newborn ruminants (Napolitano et al. 2002).

Intake of colostrum and protein absorption play an essential role in passive immune transfer and ultimately in newborn survival (Stelwagen et al. 2009; Danielsen et al. 2011). It is very important to know the impact of colostrum intake on the serum protein electrophoretic fractions, in order to be able to distinguish the physiological changes in serum protein electrophoretic pattern from the pathological conditions.

Our results showed a significant effect of colostrum intake on the concentrations of total serum proteins and the values of protein fractions in all evaluated groups of young ruminants, as well as significant differences between calves, lambs and kids in samplings after colostrum intake. No significant differences were found between individual species of young ruminants in total protein values before the first colostrum feeding. At birth the concentration of serum proteins in most animals is quite low, due to minimal quantities of immunoglobulins and lower concentrations of albumin (Kaneko 1997). After colostrum intake total protein concentration rapidly increases (Loste et al. 2008) and the intensity of changes is dependent on colostrum composition (Hashemi et al. 2008). In our study the highest mean concentrations of TP were observed 24 h after birth in calves and lambs. Similar results were reported by Šlosářková et al. (2014) in dairy calves and Nagy et al. (2014) in lambs. A different dynamics of TP concentration was observed in goat kids; the values progressively increased from the 0th to the 4th sampling. In contrast to our results, Piccione et al. (2011b) detected a gradual decrease of the concentrations of serum proteins from birth to the 14th day after birth, probably due to a different sampling protocol.

For better interpretation of the total protein values the A/G ratio is commonly used. Increased A/G ratio is usually observed in case of a lack of immunoglobulins, which is normal in neonates before the first intake of colostrum (Evans 2003). In the
present study a significant decrease of A/G on the first day of life was observed due to higher concentrations of globulins, especially immunoglobulins, in the serum of all evaluated groups of neonate ruminants compared with values measured before colostrum intake. From day 2 the values of A/G subsequently increased to the 14th day of life. These findings correspond with results reported by Šlosárková et al. (2014) and Tóthová et al. (2015) in calves and by Nagy et al. (2014) in lambs. In contrast to these findings Piccione et al. (2011b, 2013) reported a subsequent decrease of A/G in comissana lambs and goat kids from the first day after birth to the 13th day of life. According to Alberghina et al. (2010) A/G ratio must be interpreted carefully, paying attention to which part of the ratio has changed, because it provides systematic classification and identification of dysproteinaemias.

The presented results suggested the differences in composition of serum protein electrophoretic fractions between different species of young ruminants. In calves serum proteins were divided into 6 fractions (albumin, α₁-, α₂-, β₁-, β₂- and γ-globulins) whereas in lambs and kids there were only 5 fractions (albumin, α₁-, α₂-, β- and γ-globulins). The findings correspond with results reported by Tóthová et al. (2014) in calves, Piccione et al. (2013) in lambs and Piccione et al. (2011b) in goat kids. Contrary to the present study, Kaneko (1997) determined only one α- and one β-globulin fraction in all ruminants, but these differences may occur due to different electrophoretic techniques (Keren 2003). Differences between the concentrations of individual fractions of serum proteins in evaluated groups of young ruminants were observed as well. Generally the highest values were detected in calves compared to lambs and kids. According to Kraft and Dürr (1997) cattle have higher normal concentration of total proteins than sheep and goats. In this case the concentrations of individual fractions have to be also higher. Besides this fact dairy cows give birth usually to one calf (Kinsel et al. 1998); ewes and goats have commonly twins or even more newborns (Apka et al. 2010; Mohammadi et al. 2013). In that case the colostrum is distributed to more lambs and kids. Our results showed higher concentrations of individual serum protein fractions in lambs compared to goat kids. According to Banchero et al. (2004) sheep’s colostrum contains 17.2% of proteins immediately after parturition, whereas goat’s colostrum contains only 10.4% of proteins (Moreno-Indias et al. 2012). Therefore goat kids intake less proteins than lambs and their concentrations in the serum can be lower.

In our study significant changes were detected in the mean concentrations of albumin during the first 2 weeks of life in all evaluated groups of animals. The relative values of albumin decreased significantly 24 h after birth. From the second day after birth the concentrations of albumin started to increase with the highest values in the last sampling. Similar results were reported by Šlosárková et al. (2014) in calves and Nagy et al. (2014) in lambs. In contrast to our results Piccione et al. (2013) determined in comissana lambs the highest values of mean albumin concentration on day one of the study; the values decreased on day 4, and after the subsequent rise on day 7 the values were approximately stable. Piccione et al. (2011b) detected a gradual decrease of albumin concentrations in goat kids from birth to 14th day of life. In contrast to their results, our study showed similar to calves and lambs decrease of values on day 1 and then gradual increase of values until the 14th day. According to Davis et al. (1998) after intake of amino acids from colostrum, liver of young animals start to produce higher amount of albumin, which leads to increase of the concentration of serum albumin.

In previous studies Nagy et al. (2014) and Tóthová et al. (2015) reported significant increase of the concentration of α₁-globulin fraction 24 h after birth and subsequent decrease of values in lambs and calves to the end of the first month of life, which is consistent with the results in the present study in all groups of ruminants. This increase gives evidence that intake of colostrum affects the concentration of α₁-globulins in the evaluated animals. According to Bendixen et al. (2011) colostrum contains a complex mixture of proteins like lactoferrin, lactoperoxidase and lysosyme that actively participate in the protection of the neonate against pathogens and other post-partum environmental challenges and some of them migrate in the alpha fraction. A gradual decrease was observed in the present study in the mean concentrations of α₁ globulins in goat kids from birth to the 14th day of life. Similar results in kids till the age of 7 days were reported by Piccione et al. (2011b). According to Kaneko (1997) blood sera of newborn animals contain large amounts of α-globulins due to higher concentrations of some of the proteins from this fraction, which have to protect young animals from immunologic attacks. Bishop et al. (2010) reported that α₁-fetoprotein represents one of these proteins, which is synthesized by foetus hepatocytes. After birth its serum concentrations progressively decrease and at the age of 8–12 months normal adult values are achieved (Mizejewski 2001).

In the present study similar dynamics of mean concentrations of α₂- and β-globulins were observed in all evaluated groups of animals. The lowest values were detected after birth, followed by subsequent increase to the 14th day of life. The increase of concentrations of α₂-globulins was significant on day 2 of age in calves and lambs and on the 7th day of life in goat kids. However, mean concentration of β-globulins significantly increased on day 2 in calves, and in lambs and kids only on day 7. According to Kaneko (1997) and Keren et al. (1999), α₂-macroglobulin, haptoglobin, ceruloplasmin and serum amyloid A (SAA) migrate in α₂-globulin fraction and β-fraction contains transferrin, complement proteins, ferritin and C reactive protein. Most of them are important acute-phase proteins, especially haptoglobin, SAA and complement proteins in ruminants. Toman (2009) reported that bovine colostrum is not only a source of immunoglobulins, but also inflammatory proteins like complement and other nonspecific opsonize factors.

A significant effect of colostrum intake was observed on the mean concentrations of γ-globulins in all groups of evaluated ruminants. The mean values of γ-globulin fraction were significantly the highest on day 1 of age. Similar results were reported by Šlosárková et al. (2014) and Tóthová et al. (2015) in calves, Piccione et al. (2013) and Nagy et al. (2014) in lambs. Piccione et al. (2011b) reported similar values of concentrations of γ-globulin in goat kids on days 0 and 7, which is in contrast with the present study. Our results showed the highest values of γ-globulins on day 1 compared with concentrations measured at birth and days 2, 7 and 14. These differences in the dynamics of the results may be due to the fact that our trial was started.
before the intake of colostrum (day 0) compared to Piccione et al. (2011b) who started the monitoring and blood sampling after the first intake of colostrum. Immunoglobulins usually migrate into the γ-globulin fraction (Kaneko 1997; Evans 2003). In newborn ruminants, precolostral serum normally contains no γ-globulins due to syndesmochorial placenta of the ruminants. After the first colostrum intake, protein fractions are absorbed from the intestine and their concentrations in the serum of ruminants increase (Egli & Blum 1998; Castro-Alonso et al. 2008; Piccione et al. 2009). However, the permeability of intestinal mucosa for immunoglobulins dramatically decreases during the first hours of life (Godden 2008). The changes in γ-globulin fraction and the serum protein electrophoretic pattern after birth reflect the absorption of immunoglobulins after colostral intake during the first 24 h after birth.

In conclusion, the present study showed a significant effect of colostrum intake on concentrations of total proteins and also relative and absolute concentrations of the major of protein fractions in all evaluated species of young ruminants. The results, analysis of which began already in precolostral time, indicate that the colostrum feeding is the starting point for significant changes in protein profile in ruminant neonates followed by longer-lasting changes in the following days and weeks of their life. Besides, significant changes in the analysed variables during the monitored period in each species of ruminant differences were found between calves, lambs and goat kids. The present study suggests that colostrum is not only an important source of immunoglobulins, which play an essential role in passive immunity of newborn animals, but also other bioactive proteins. The dynamics of the developments of metabolic processes are not the same in all ruminants, and probably they depend on the species’ different composition of colostrum and the amount of colostrum intake. The electrophoretic profile in the ruminants during the neonatal period can be used to aid the diagnosis and treatment of neonatal diseases. Our study also emphasizes the importance of establishing different reference intervals for these parameters in different species of ruminants.

**Disclosure statement**

No potential conflict of interest was reported by the author.

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