

Dynamical changes of basic chemical indicators and significant lipophilic vitamins in caprine colostrum

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Abstract

Colostrum is currently used as a food supplement. It has been sought after by an increasing number of consumers for its unique composition. Its use is supported by EU legislation that defines colostrum as an animal product for human consumption. Therefore, information on its chemical properties and the content of lipophilic vitamins are important when evaluating colostrum quality and safety. The aim of this study was to assess the dynamic changes of basic chemical properties (protein, fat, lactose, and dry matter) and the content of selected lipophilic vitamins (vitamin A and vitamin E) in white short-haired goat's colostrum. Attention was paid to the first milk from the first hour to the sixth day after parturition as the initial milk composition changes rapidly during this period. Protein, fat, and lactose concentrations were measured by near infrared spectroscopy, vitamins were analysed simultaneously by ultra-high performance liquid chromatography with detection in the ultraviolet part of the spectrum. The most significant changes in chemical indicators occurred during the first three days ($P \leq 0.01$) *post partum*. The highest decrease was observed in protein concentrations. It was $\times 2$ lower than in the first hour *post partum*. The concentration of vitamin A rapidly decreased during 36 h. In the following hours, gradual changes were observed ($P > 0.05$). The analysed components in caprine colostrum were similar to mature milk after 132 h *post partum*.

Goat's colostrum, composition, vitamin A, vitamin E

Colostrum is the initial mammary secretion after parturition. It is secreted for approximately first 5–7 days after delivery. Considering its unique composition and current legislation, colostrum has attracted a great deal of attention in the pharmaceutical industry and has been used as a food supplement for promoting health and enhancing the immune system. Colostrum is an excellent supplement recommended especially for the elderly, sportsmen and in some specific conditions, e.g. stress, illness and the gastrointestinal tract disorders. Colostrum increases cell proliferation and migration, enhances gut immunity, and therefore can be used to treat or prevent infections of the gastrointestinal tract (Antonio et al. 2001; Gill and Indyk 2007; Gill et al. 2012).

This first mammary secretion is considered as an important nutritional supplement. It contains more dry matter, mineral salts, and proteins but less lactose than mature milk. Furthermore, the fat content is often, but not always, higher than that of milk. The proportion of whey proteins is substantially higher in colostrum than in milk. The foremost protein fraction in colostrum consists of immunoglobulines (IgG, IgM and IgA). Changes in the composition of fatty acids are mostly qualitative; colostrum usually contains more polyunsaturated fatty acids, phospholipids and cholesterol than mature milk (Roginski et al. 2002; Uruakpa et al. 2002; Fox and Kelly 2006).

Concentrations of fat soluble vitamins A, D, E, and carotenoids and water soluble vitamins B₁, B₂, B₆, B₁₂, C, and folate are higher but biotin and pantothenic acid concentrations are lower. Colostrum contains $\times 4$ – $\times 10$ more A, D and E vitamins than milk and is the primary,

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essential source of these nutrients for the young after birth because some vitamins do not cross the placental barrier (Uruakpa et al. 2002; Debier et al. 2005; Zarcula et al. 2010).

In the Czech Republic, the use of colostrum is stipulated by current legislation, mainly by the Commission Regulation (EC) No. 1662/2006 amending Regulation (EC) No. 853/2004 of the European Parliament and the Council, laying down specific hygiene rules for food of animal origin; and Decree No 225/2008 Coll., laying down requirements on food supplements and fortified foods to the Act No 110/1997 Coll., on foodstuffs and tobacco products and on amendments and supplements of certain related acts, which placed colostrum among food supplements with possible unrestricted daily intake.

Several papers have been published on the quantification of retinol and tocopherol in milk and milk products (Salo-Väänänen 2000; Hulshof 2006; Raynal-Ljutovac 2008; Plozza 2012), but values regarding colostrum are missing or outdated. Therefore, the purpose of this study was not only to evaluate basic chemical properties but also to analyse the lipophilic vitamins A and E in individual colostrum samples.

Materials and Methods

Seven white short-haired goats of the most common dairy breeds in the Czech Republic were used in this study. For the experiment, 50 ml of colostrum was obtained by manual milking 1, 18, 36, 60, 84, 108, and 132 h *post partum*. All goats were in the same lactation phase, but different size litter (2–3 kids). Goats were kept at the University's Department of Ruminants. The diet consisted of 3 kg of hay per day, granulated feed mixture for goats 1 kg per day and 0.5 kg of oat groats. Hay, water and salt lick were provided *ad libitum*, the feeding mixture was divided into 3 doses.

All chemical analyses were carried out using fresh colostrum samples; measurements were taken in duplicate.

Basic chemical indicators

Protein, fat, and lactose concentrations were measured by a routine laboratory procedure using near infrared spectroscopy with Fourier transformation (FT-NIRs), NIR Nicolet Antaris (Thermo Electron Corporation, Madison, USA). Calibration models were created using PLS algorithm and their accuracy was checked by validation and cross validation. Spectra of the samples were measured on the integration sphere in reflectance mode with the use of transmittance cell (0.1 mm) in the spectral range of 10 000–4 000/cm with 100 scans.

Dry matter was measured gravimetrically by halogen moisture analyser (HB43-S, Mettler-Toledo, Greifensee, Switzerland)

Lipophilic vitamins analysis

The sample preparation procedure consisted of direct saponification with methanolic potassium hydroxide and liquid-liquid extraction in n-hexane. Separation of lipophilic vitamins retinol and tocopherol was provided by the analytical reverse phase UPLC system Acquity with a dual wavelength absorbance detector (Waters, USA). Chromatographic column Acquity BEH C8 (Waters, USA) was used. The analysis was performed in isocratic mode, the mobile phase consisted of methanol and water (93:7) at a flow rate of 0.4 ml/min, injection volume was 4 µl, run time 2.7 min. The UV detection was performed at the wavelength of 205 nm for tocopherol and 325 nm for retinol.

Statistical analysis

Values of colostrum components were expressed as mean ± SD. Microsoft Office Excel was used for data analysis, statistical analysis was performed by ANOVA, Excel (2007). Significance was set at $P \leq 0.01$.

Results

The chemical changes observed in this study in terms of fat, protein, lactose, and dry matter are given in Table 1. Dynamic chemical changes are summarized in Fig. 1. Protein concentration was the most variable component, which showed double reduction after 18 h compared to its initial value. As the experiment proceeded, changes were gradually observed in each component and they were significant ($P \leq 0.01$, Table 2) until 84 h *post partum*. The dry matter (DM) content in colostrum was 10% higher in the first hours than in 132 h due to a higher content of solids compared to mature milk. The fat was the only variable component that decreased by 1% from 6.93% in 84 h *post partum* and then again

Table 1. Chemical composition of caprine colostrum during the first 132 h *post partum*.

Hours <i>pp</i>	Protein (%)	Fat (%)	Lactose (%)	Dry matter (%)
1	13.46 ± 1.25	8.88 ± 1.45	3.7 ± 0.94	24.73 ± 3.19
18	7.93 ± 1.38	7.08 ± 1.05	4.15 ± 0.48	19.33 ± 1.75
36	6.86 ± 0.81	6.32 ± 1.76	4.25 ± 0.55	17.26 ± 1.6
60	5.24 ± 0.88	6.93 ± 1.58	4.51 ± 0.21	16.86 ± 1.95
84	4.71 ± 0.7	5.83 ± 1.43	4.7 ± 0.15	15.67 ± 1.58
108	4.46 ± 1.01	6.03 ± 0.97	4.69 ± 0.17	15.20 ± 1.53
132	5.02 ± 2.17	4.83 ± 1.23	4.63 ± 0.38	14.11 ± 2.03

pp – *post partum*

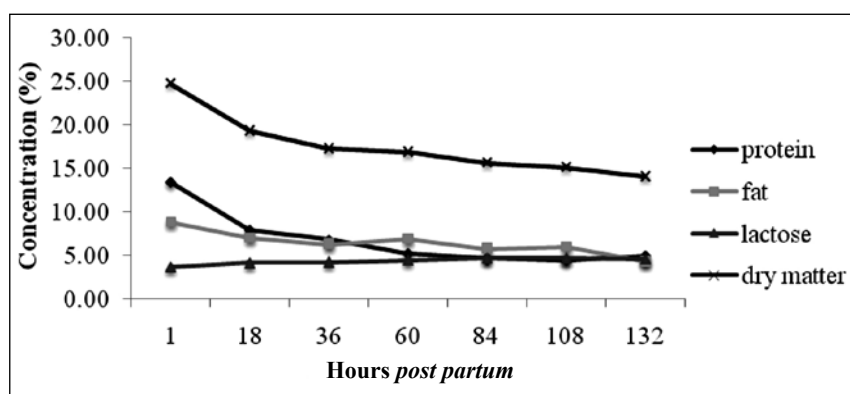


Fig. 1. Dynamic changes of chemical composition in caprine colostrum from parturition to 132 h *post partum*

Table 2. Significance of all analysed indicators during the first 132 h *post partum*.

Hours <i>pp</i>	1	18	36	60	84	108	132
1		p, dm, r	p, f, dm, r	p, dm, r, t	p, f, dm, r, t	p, f, dm, r	p, f, dm, m, r, t
18				p	p, dm	p, dm	p, f, dm, r
36					p	p	
60							f
84							
108							
132							

pp – *post partum*, significance ($P \leq 0.01$), p - protein, f - fat, dm - dry matter, r - retinol, t – tocopherol

increased in 108 h *post partum* to 6.03%. Lactose revealed the lowest and non-significant changes. Its concentrations increased by 1% in 84 h *post partum* and then remained stable during the whole early lactation period.

Table 3. Concentration of vitamin A and E in caprine colostrum during the first 132 h *post partum*.

	Hours <i>post partum</i>						
	1	18	36	60	84	108	132
Vitamin A							
Mean (mg/kg)	14.42	9.92	5.11	2.90	1.60	1.20	1.00
SD (mg/kg)	4.26	5.82	2.23	1.57	1.00	0.37	0.58
Vitamin E							
Mean (mg/kg)	5.47	4.35	2.98	2.34	2.36	3.29	1.50
SD (mg/kg)	3.28	2.68	1.40	1.28	1.16	2.57	0.50

The variability of vitamin A and E concentrations is presented in Table 3. In our study, we observed $\times 14$ higher concentration of vitamin A in the first hour *post partum* than in 132 h *post partum*. The decrease in vitamin E was lower and revealed $\times 5$ lower concentration than on the first day.

Discussion

The rapid decrease of protein concentrations was caused by lower amounts of IgG (Georgiev 2005, 2008). Immunoglobulines (Igs) account for more than 50% of the total amount of colostrum proteins. Most of them come from maternal blood, and about 90% of colostrum Igs are of the IgG₁ type (Georgiev 2008). The colostrum period lasts for about one week. However, the gut closure ceasing transport of protein macromolecules occurs within 24–36 h *post partum*. Georgiev (2005) reported that the protein concentration on the 3rd day was more than twice lower compared to the first dose of colostrum. This corresponds to the highest protein decrease during 36 h after parturition in individual colostrum samples. Yang et al. (2009) analysed the chemical composition of Saanen goat colostrum. The dynamic changes observed in their study corresponded to our results.

Unlike other chemical components, lactose concentrations in colostrum are lower than in milk. Lactose has osmotic effects, and a lower value of lactose in colostrum ensures a high viscosity of colostrum and prevents diarrhoea in newborns (Zarcula et al. 2010).

The concentration of all measured indicators after 132 h *post partum* is similar to mature milk. Roginski (2002) reported the mean content of protein 3.8%, fat 5.6%, lactose 4.8% and dry matter 14.8% in caprine milk. However, colostrum composition is affected by the age, breed, nutrition, and health status of the animals (Zarcula et al. 2010).

Ruminants are born with very low serum concentrations of lipophilic vitamins. Lipophilic vitamins do not cross the placental barrier and therefore newborns are dependent on maternal exogenous intake. This is convenient for food supplements made from colostrum, which is a very good source of lipophilic vitamins, as shown by our results.

To date, no information about lipophilic vitamins concentration in colostrum from ruminants has been published, therefore the results can be compared with bovine milk in terms of nutrition. The concentration of vitamin A in milk ranged from 0.257 to 0.329 mg/l. This concentration represents 38% of recommended daily intake. The mean vitamin A concentration in our study during the first 36 h *post partum* was 9.8 mg/kg, which represented $\times 32$ higher concentration than in mature bovine milk. Caprine colostrum can be therefore regarded as an important vitamin A supplement (Roginski et al. 2002; Fox and Kelly 2006). The concentration of vitamin E in colostrum was $\times 5$ higher than in mature milk, which contains 1.0 mg/kg and represents 10% of recommended daily intake. This makes colostrum a significant source of exogenous natural antioxidants.

Our results imply that caprine colostrum is a very good source of vitamin A and E. From the perspective of natural antioxidants, colostrum intake represents their significant source in diet. The demand for colostrum supplements has been steadily increasing and therefore more up to date information on their quality are needed. Further studies should focus on evaluation of the properties of colostrum that has been processed into the form of food supplements and compare them with the properties of raw colostrum.

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