EFFECT OF GOAT MILK ANALYTICAL PROPERTIES ON ITS VISCOSITY AND CONDUCTIVITY

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Abstract: In this paper were analysed viscosity and conductivity of individual samples of goat milk. Milk samples were characterised by chemical analysis such as content of fat, dry matter, protein content, lactose, and titratable acidity. Viscosity was studied using a concentric cylinder viscometer. Results of milk samples viscosity were in range from 1.634±0.166 to 1.850±0.167 mPa·s. The range of conductivity results was from 0.377 to 0.445 $S \cdot m^{-1}$. Viscosity of goat milk was significantly depended on content of fat, proteins, and/or dry matter. Increasing titratable acidity of goat milk caused its conductivity increase. However, other parameters such as content of fat, proteins, lactose, and/or dry matter lead to decrease of goat milk conductivity.

Key Words: milk, goat, viscosity, conductivity, dry matter, fat, proteins

INTRODUCTION

Goats have been associated with people since the domestication of animals and development of agriculture. Goats and sheep are included in the group called small ruminants. Goat milk is very important source of nutrients in underdeveloped countries. Cow milk is unavailable in these countries (Solaiman 2010). Goat milk contains important components for human nutrition such as proteins, fat, minerals, and vitamins. The nutritional, organoleptic and technological characteristics of milk and its products are strongly influenced by milk lipids (Cannas et al. 2005). The smaller fat globules in goat milk (average 3.5 μm) are provided the better dispersion in the milk and better digestibility compared with the cow's milk. Goat milk has higher levels short- and medium- chain length fatty acid than cow and human milk. These properties have had a very good effect on the human nutrition and health (Solaiman 2010).

Viscosity is one of the parameters which had influence on rheology of fluid milk. Milk viscosity is twice as high as water due to the friction of fat in milk. Viscosity is influenced by content of fat, proteins, temperature, pH, and age of milk. Milk behaves as a Newton liquid, meaning that the shear stress is proportional to the share rate (Park 2007).

MATERIAL AND METHODS

The goat milk was obtained from conventional farm in the northern part of Moravian Karst. In this experiment were involved milk samples from 15 White short-hair goats. The individual samples of milk were obtained from goats on the second and third lactation. These goats were grazing on the pasture. In winter, goats were fed with hay and mineral lick.

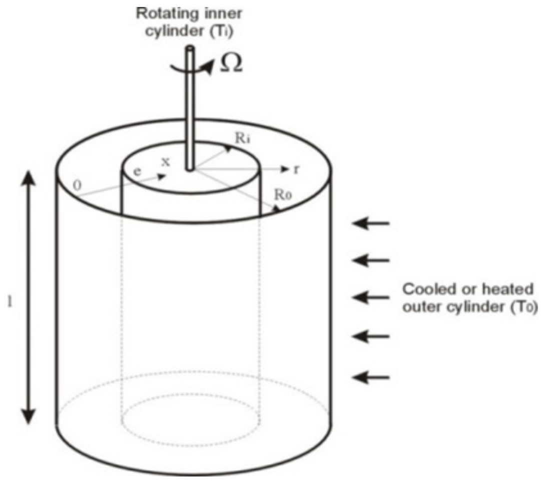
The morning milking milk was collected in August 2015. For this experiment, goats were milked by hand. Milk samples were cooled to 8°C immediately after milking and transported to the laboratory. Standard laboratory methods were used to analyse of goat milk.

Milk samples were equilibrated prior to analysis at 40°C and cooling to 20°C due to the better dispersion of the fat globules. The content of fat was determined by Gerber's method (ISO 2446:2008), protein content by Kjeldahl's method (EN ISO 8968-1:2002), dry matter content (gravimetry) (ISO 6731:2010), lactose was determined by polarimetry (Czech state standard No 570530), titratable acidity by Soxhlet-Henkel.

The conductivity of goat milk samples was carried out using Greisinger electronic conductometer GLF 100 for liquids with integrated temperature sensor.

The viscosity of goat milk samples was carried out using rotary viscometer Brookfield DV2T with concentred cylinders system, see Figure 1. It was used standard spindle SC4–18, which is he most suitable for measuring low-viscosity fluids (water, milk, whey, etc.). Shear rate was set equal to 100 s^{-1}. The samples of goat milk were measured on the constant temperature 20°C.

Figure 1 Schematic of the measuring device geometry (Kumbar and Nedomova 2015)



RESULTS AND DISCUSSION

At first, there were laid down analytical characteristics of all samples of goat milk using special methods which are described above. Detailed analytical results are shown in the Table 1.

Table 1 Analytical characteristics of goat milk (results are presented as mean ± standard deviation)

Sample	Fat content (wt%)	Dry matter content (wt%)	Protein content (wt%)	Lactose content (wt%)	Titratable acidity (°SH)
1	2.39±0.045	9.872±0.285	2.35±0.030	4.79±0.210	4.96±0.598
2	2.49±0.028	9.543±0.306	2.20±0.038	4.38±0.240	4.17±0.399
3	2.44±0.030	9.996±0.350	2.40±0.040	4.58±0.215	3.76±0.451
4	3.69±0.021	11.283±0.367	2.49±0.032	4.42±0.314	4.70±0.612
5	3.16±0.029	11.168±0.345	2.54±0.037	4.64±0.288	5.22±0.513
6	3.12±0.026	10.499±0.316	2.50±0.036	4.58±0.254	5.22±0.498
7	2.25±0.033	9.997±0.344	2.39±0.032	4.37±0.279	4.96±0.445
8	2.44±0.031	10.123±0.457	2.54±0.041	4.00±0.385	5.74±0.582
9	2.49±0.034	10.175±0.415	2.48±0.037	4.40±0.344	5.74±0.574
10	3.21±0.029	10.792±0.345	2.32±0.032	4.29±0.284	5.22±0.467
11	2.73±0.037	10.191±0.335	2.53±0.029	4.47±0.269	5.22±0.566
12	2.97±0.041	10.361±0.350	2.27±0.028	4.21±0.281	6.78±0.573
13	4.08±0.033	13.776±0.372	2.82±0.038	4.67±0.301	3.76±0.584
14	3.55±0.029	11.463±0.315	2.60±0.039	4.14±0.247	5.22±0.551
15	3.74±0.024	11.344±0.435	2.42±0.045	4.07±0.366	4.96±0.475

The results of analytical characteristics correspond with Monaci et al. (2006) and Bergillos-Meca et al. (2015).

The selected physical properties were determined for all 15 samples of different goat milk. As the most essential and descriptive properties for goat milk were chosen viscosity and conductivity according of Boziková and Hlavac (2013).

Each selected milk components can cause changes of its viscous properties (Kumbar and Nedomova 2015). The highest effect on viscous changes of goat milk revealed fat, dry matter and/or protein content in milk as can be seen in the Figure 2. Lactose content and/or titratable acidity effect is not too significant.

Table 2 Viscosity and conductivity of goat milk (results of viscosity are presented as mean ± standard deviation)

Sample	Viscosity (mPa·s)	Conductivity (S·m^{-1})
1	1.701±0.179	0.425±0.200
2	1.634±0.166	0.445±0.198
3	1.690±0.200	0.407±0.157
4	1.786±0.151	0.408±0.166
5	1.752±0.150	0.377±0.187
6	1.777±0.148	0.416±0.193
7	1.692±0.164	0.404±0.181
8	1.661±0.177	0.440±0.192
9	1.740±0.211	0.412±0.167
10	1.831±0.174	0.415±0.174
11	1.726±0.174	0.426±0.185
12	1.706±0.194	0.422±0.192
13	1.850±0.167	0.378±0.203
14	1.814±0.159	0.412±0.171
15	1.763±0.158	0.414±0.204

Along with increasing content of fat, dry matter and protein in goat milk increased its viscosity. These dependences can be modelled using basic model – linear function:

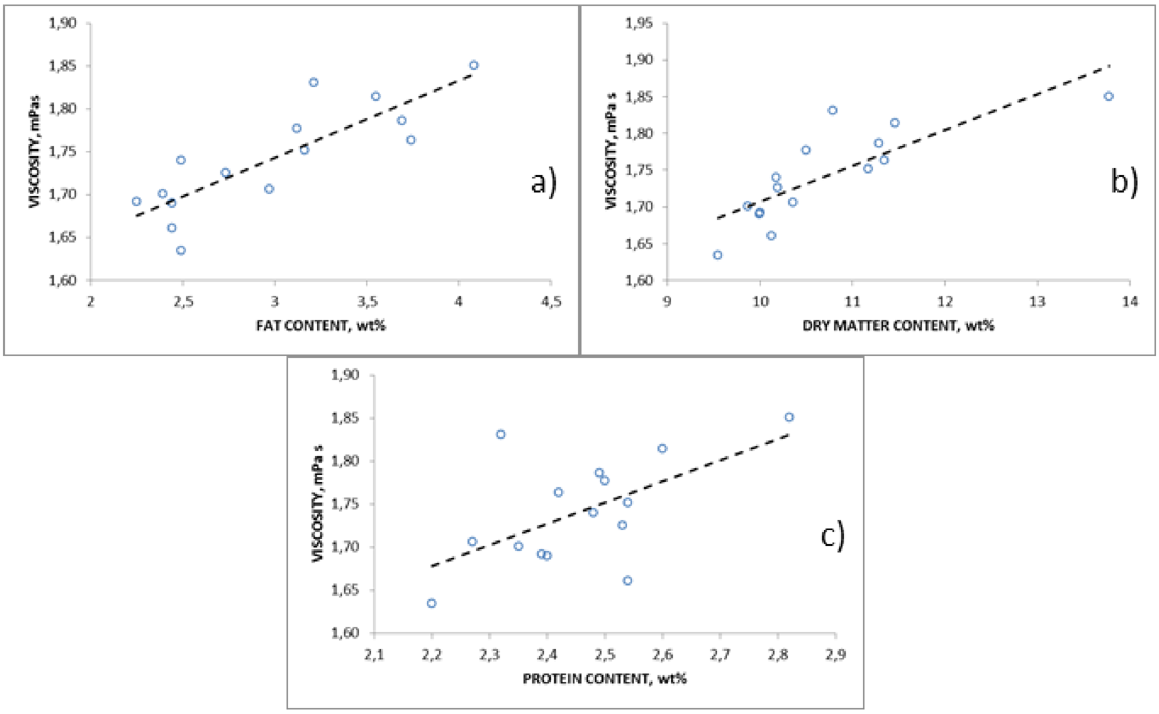
$$\eta=kx+q, \quad (1)$$

where η is the viscosity, x is the fat content or dry matter content or protein content, k and q are parameters. Parameters of fit functions for viscosity modelling are shown in the Table 3.

Table 3 Parameters of fit functions for viscosity modelling (R^2 denotes Coefficient of determination)

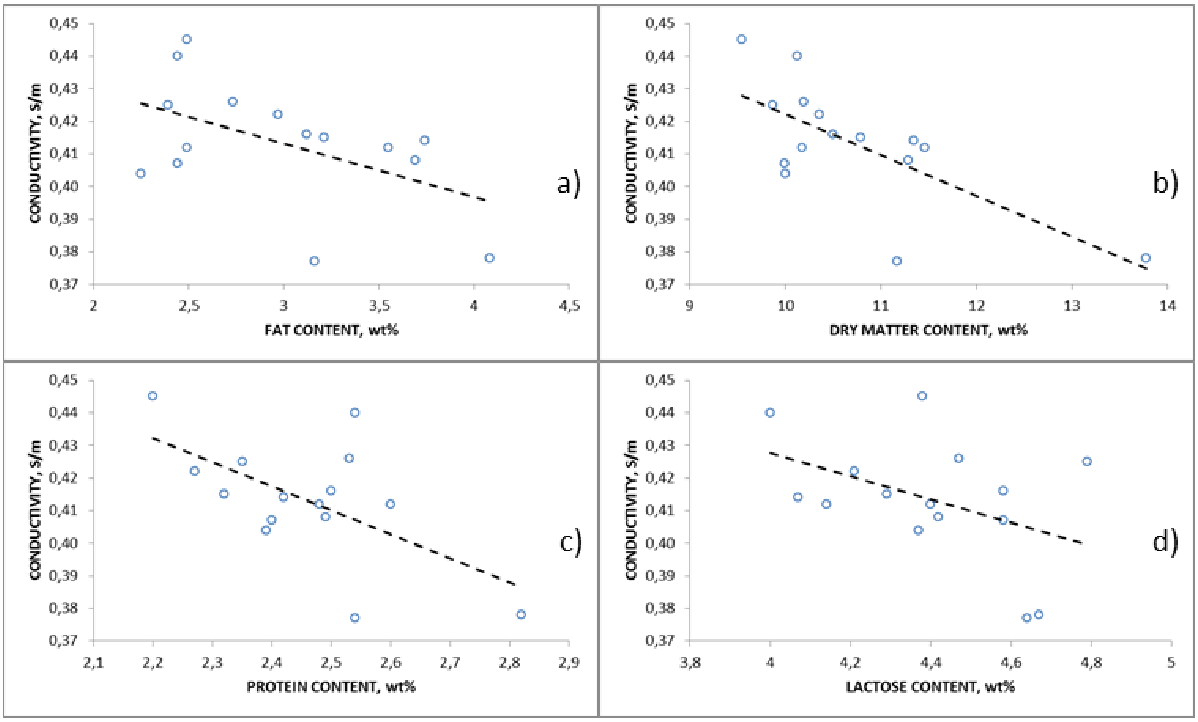
	k (mPa·s·wt%$^{-1}$)	q (mPa·s)	R^2
Fat content	0.0902	1.4725	0.8963
Dry matter content	0.0487	1.2206	0.8458
Protein content	0.2465	1.1360	0.6466

Figure 2 a) Effect of fat content on viscosity of goat milk, b) Effect of dry matter content on viscosity of goat milk, c) Effect of protein content on viscosity of goat milk



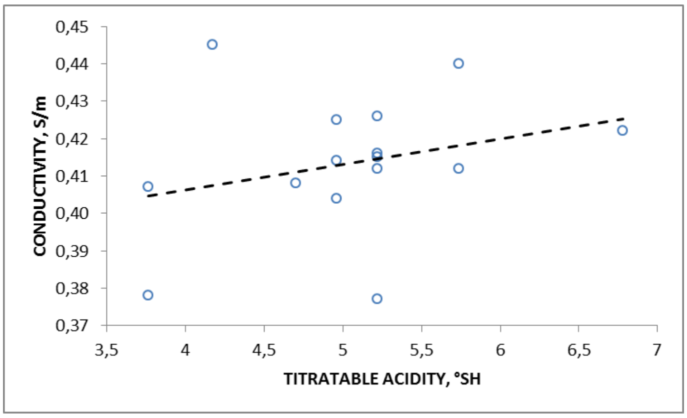
Each selected components of milk can affect its conductivity (Romero et al. 2014). The effect of fat, dry matter, protein and lactose content on goat milk conductivity can be seen in the Figure 3.

Figure 3 a) Effect of fat content on conductivity of goat milk, b) Effect of dry matter content on conductivity of goat milk, c) Effect of protein content on conductivity of goat milk, d) Effect of lactose content on conductivity of goat milk



With increasing content of fat, dry matter, protein and/or lactose decreased the conductivity of goat milk samples. It is nearly similar as results of Tangorra et al. (2010). Only with increasing titratable acidity of goat milk increased the conductivity of samples, see Figure 4.

Figure 4 Effect of titratable acidity on conductivity of goat milk



These dependences can be also modelled using linear functions, see Eq. (1). Parameters of fit functions for conductivity modelling are shown in the Table 4.

Table 4 Parameters of fit functions for modelling conductivity (R^2 denotes Coefficient of determination)

	k (S·m^{-1}·wt%$^{-1}$)	q (S·m^{-1})	R^2
Fat content	–0.0165	0.4625	0.6658
Dry matter content	–0.0126	0.5478	0.6923
Protein content	–0.0738	0.5947	0.6559
Lactose content	–0.0356	0.5702	0.6943
	k (S·m^{-1}·°SH^{-1})	q (S·m^{-1})	R^2
Titratable acidity	0.0068	0.3793	0.6792

The dependence between viscosity and conductivity of goat milk was not proved.

CONCLUSION

The viscosity properties of goat milk were changed by its selected characteristics. The significant effect on viscosity of goat milk had content of fat, dry matter, and/or proteins. On the other hand, content of lactose and/or titratable acidity had not effect on the viscosity of samples. The conductivity decreased with the increasing content of fat, lactose, proteins, and/or dry matter. However, increasing titratable acidity of goat milk leads to increase of its conductivity.

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