FACTORS AFFECTING GOAT MILK YIELD AND ITS COMPOSITION IN LATVIA

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Abstract
The aim of the present research was to evaluate the affect of genetic and environmental factors on the variability of the goat milk yield, fat and protein content in goat milk in Latvia. Data of 6067 lactation records from 2400 goats of six different breeds were analysed in the period of 2001 to 2010. The highest milk yield (662.7±14.58 kg) was obtained in 2002, the highest fat content (40.7±0.05 g kg^{-1}) – in 2004, but highest protein content (32.7±0.19 g kg^{-1}) – in 2008 ($p<0.05$). Basically there are two goat breeds in Latvia: Latvian goats and Saanen goats. In the research, 3261 Latvian and 2032 Saanen goats in closed lactations were analysed. It was found that Saanen goats gave the highest milk yield (579.3±5.01 kg), but Alpine goats – the highest fat and protein content (respectively 41.7±0.63 and 32.3±0.30 g kg^{-1}; $p<0.05$). It was observed that most of all the goats kidded in winter (2379) and spring (3378). The highest milk yield (583.8±7.39 kg) was determined for goats kidded in winter season, but the highest fat content (41.8±0.06) and protein content (32.3±0.03) – for goats kidded in summer season. The average milk yield in the first lactation (1636) was significantly lower than in the third lactation (578.0±8.34; $p<0.05$) when the goats produced the highest milk yield in the research.
Key words: goats, milk productivity traits, breed, environmental factors.

Introduction

The productivity of goat milk is characterized by the quantity of produced milk and its quality in a fixed period of time – by day, by month, by lactation, by year, or by the whole goat lifetime.

The quantity of goat milk and its content vary depending on animal breed traits, genotype, age, the stage of lactation, the speed of milking, the functional condition of hormonal system, illnesses, gestation, season and many other factors (Mioč et al., 2008).

The productivity of the goat milk in lactation mainly depends on a goat breed and conditions of feeding. The milk yield can range from 400 up to 1000 kg, for separate goats of German Noble breed the milk yield can reach up to 1900 kg (Sambraus, 2001). The goat milk contains approximately 87% of water and 13% of dry matter.

The most important of milk chemical content is the proportion of fat and protein which may vary for different goat breeds – from 3.00 to 4.65% and from 3.00 to 3.50% monthly (Gall, 2001).

According to FAOSTAT (2008) data there are 862.9 million of goats in the world and 18.0 million of them are in European countries. The dairy goats constitute 80% of the total number of goats in the world. The largest number of goats is in Greece (4.1 million), in Spain (1.4 million), and in France (0.8 million). In total, there have been found about 110 different goat breeds in the world and just about 10 breeds are used for milk production. The most popular dairy goat breeds are Saanen, Alpinen, Thuringian, Toggenburgs, and Anglo Nubian goats (FAOSTAT, 2008).

The breeding of milk goats is one of livestock breeding branches in Latvia. Sixty-five percent of the goats in Latvia are Latvian goats (LVK), 15% - Saanen goats (ZK), but the rest of 20% include Alpine (AK), German Noble (VBD), and Thuringian (TIR) goats imported from Germany in the period of 2004 to 2006. The milk recording was done for 1158 dairy goats in Latvia in 2010: on average, milk yield was 529 kg, fat content – 3.93%, protein content – 3.21%, and somatic cell count (SCC) – 1056 thousand ml^{-1} (The State Agency (S/A) Agricultural Data Centre).

The aim of the present research was to evaluate the affect of genetic and environmental factors on the variability of the goat milk yield, as well as on fat and protein content in goat milk in Latvia.

Materials and Methods

During the research we used goat herds where the milk recording had been done. The milk yield (kg) and the fat and protein content (g kg^{-1}) of the most popular goat breeds in Latvia were analysed: AK, LVK, TIR, VBD, ZK, and different crossbreeds (XX).

The information of the State Agency (S/A) Agricultural Data Centre of about 2400 goats in 6067 closed standard lactations (240 – 305 milking days) kidded in the period of 2001 to 2010 was used for the analysis of goat milk productivity traits.

To measure the milk yield in farms, electronic scales or the measuring instruments of half-automatic milking equipment of milk measurement were used.

Up to 2004 the milk samples were analysed in the milk control laboratory in Kurzeme Artificial Insemination Station, and starting from 2005 – in the milk control laboratory in Sigulda Artificial Insemination Station. The content of fat and protein was identified according to the method of ISO 9622:1999 with device Milko-Skan 133 B in both laboratories.

In 10 years the milk recording was done in 63 herds of different size. For the goats in Latvia, the seasonal kidding is observed therefore the factor

'kidding season' was as follows: winter (December, January, February), spring (March, April, May), summer (June, July, August), and autumn (September, October, November).

As duration of goat milking varies from the first to the tenth lactation, we made five gradation classes for the fixed factor 'lactation'. It included the animals from the fifth and later lactations.

The statistical data were processed using SPSS program package and Microsoft Excel for Windows. Data in tables and figures are presented as least square mean ± standard error of means (SEM). The coefficient of variation (CV) was used to describe the variability. The linear model of variable factors (GLM – General linear model) was used to identify factors which significantly affected the changes in traits of the goat milk yield productivity.

The model which includes fixed factors as well as random and covariate factors was as follows:

$$y_{ijklm} = \mu + \check{S}_i + L_j + ATG_k + ATS_l + G_m + (ATG_k x\, ATS_l x\, G_m) + DZn + AV_o + e_{ijklmnop},$$

where

$y_{ijklmnop}$ - i-the trait of the animal milk productivity;
μ - the average value of the population;
$\check{S}_i$ - the fixed factor 'breed' (i=1- 6);
L_j - the fixed factor 'lactation' (j=1- 5);
ATG_k - the fixed factor 'milking year' (k=1-10);
ATS_l - the fixed factor 'milking season' (l=1- 4);
G_m - the fixed factor 'herd' (m=1- 63);
DZ_n - the random animal effect (n=2400);
AV_o - kidding age in months, as covariate factor;
$e_{ijklmnop}$ - random residual.

The validity of factors included in the model was identified according to the significance level $\alpha = 0.05$; 0.01; 0.001.

Results and Discussion

The recording of milk goats was started in 2001. It was organised according to the joint rules of the International Committee for Animal Recording (ICAR). These rules prescribe the individual milk yield registration and the analysis of the milk content. The average of the goat milk productivity is represented in Table 1.

It was found that the average milk yield in standard lactation was 547.6 kg, the average milk fat content – 39.3 g kg^{-1}, and the average protein content – 31.8 g kg^{-1}. The greatest variability of milk productivity traits was determined for Latvian dairy goats. It was indicated by high values of the variation coefficient which for the milk yield was 31.3%, for the fat content – 16.8%, and for the protein content - 10.7%.

The great variability of the milk productivity traits shows that there were animals with both high and low productivity in the herds of milk goat breeds in Latvia in the analysed period of time. It means the selection should be done.

Evaluating the affect of the influence of genetic and environmental factors on the goat milk productivity, we concluded that the milk yield variability is affected by all analysed factors ($p<0.001$; Table 2). The milk fat and protein content variability was affected by the goat breed, lactation, goat kidding year and season as well as by the herd the animal lived. The interaction effect of the three fixed factors (a year of kidding, a season of kidding and a herd) was significant too ($p<0.05$, $p<0.01$, and $p<0.001$ respectively).

The quality of the linear model is described by the determination coefficient (R^2). The factors included in the model characterised the changes in the goat milk productivity traits precisely enough: the highest R^2 was for the protein content (64.0%), but the lowest – for the fat content (58.3%). In linear models offered by other authors, when analysing the affects of similar goat milk productivity factors, the determination coefficient values were between 55% and 68% (Crepaldi et al., 1999).

During the analysis of the fixed factors it was found that significantly highest milk yield in standard lactation (662.7±14.58) in the period of 2001 to 2010 was obtained for goats kidded in 2002. The lowest milk yield was obtained in 2005, 2007 and 2008 when it did not reach 500 kg and differed significantly from the milk yields in 2001 and 2002 ($p<0.05$; Figure 1).

Table1

Descriptive statistics of the goat milk productivity traits (n=6067)

Trait	$\bar{x} \pm s_{\bar{x}}$	CV, %	Minimum	Maximum
Milk yield, kg	547.6 ± 2.22	31.7	187.0	1290
Fat content, g kg^{-1}	39.3 ± 0.81	16.8	23.7	71.7
Protein content, g kg^{-1}	31.8 ± 0.42	10.7	21.4	51.9

Table 2

The influence of researched factors on goat milk productivity traits

Factors	Milk yield, kg	Fat content, g kg^{-1}	Protein content, g kg^{-1}
	p-value		
Breed	***	***	***
Lactation number	***	**	***
Year of kidding	***	**	***
Season of kidding	***	*	***
Herd	***	***	***
Herd ×year ×season	***	***	***
Age of kidding	***	n.s.	n.s.
R^2	0.633	0.583	0.640

*p<0.05; ** p<0.01; *** p<0.00; n. s. p>0.05.

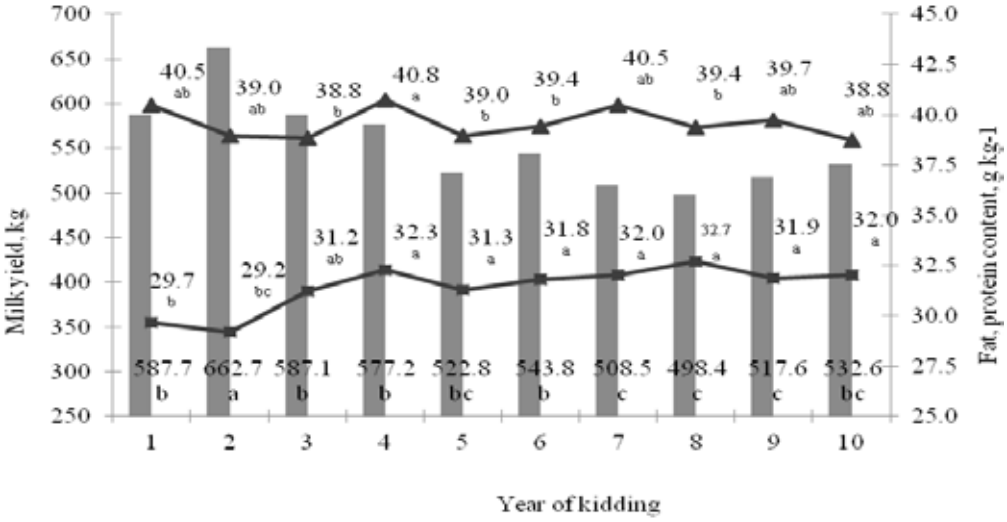

Figure 1. Least squares means of milk yield, and the fat and protein content in the period of 2001 to 2010.
▬ – Milk yield, kg; ▲ – Fat content, g kg^{-1}; ■ – Protein content, g kg^{-1}.
$^{a;b;c}$ – traits with different superscripts significantly differ among the research years (p<0.05).

At the beginning (in 2001 and 2002), goat milk recording was done only for a small number of goats a year (respectively 133 and 258) and only for the goats whose owners were interested in a systematic selection, therefore the best animals were chosen. Gradually the control of milk amount and content was done for a greater and greater number of goats, and finally 1156 goats were included in our research in 2009. The significant differences in the milk yield among the research years can also be explained by unfriendly environmental conditions in 2005 and 2007. These years were characterised by lasting periods of dryness and increased air temperature in the grazing period. Several scientists (Lough et al., 1990; Huth, 1995) who have studied the affect of external environment (regarding temperatures and relative humidity) on cow milk productivity have found that the animals react individually to climatic condition changes; however the behaviour of animals changes with the increase in environmental temperature.

Depending on the heat stress intensiveness and the duration of heat, the dry matter consumption decreased from 5% to 25%, which induces energy deficit.

The animal has troubled rumination when the dry matter consumption decreases therefore the separation of saliva and pH in the rumen decreases. The acidic ambience of the rumen badly affects the formation of evaporable fatty acid, which induces decrease in the milk yield and fat in cows (Osītis, 2005). Goats are ruminants too therefore their reaction to environmental changes and the need for well-balanced feeding could be similar to cows (Sprūžs and Šelegovska, 2003; Korn et al., 2007). The milk productivity decreases significantly also on rainy days because the animal's feed consumption is reduced. It has been found that decrease in temperature below +10 °C reduces the goat milk yield reduces per day (Brito, 2011).

Our research suggests that reduction in goat milk yield in 2008 could be affected by the increase in the number of the first lactation goats.

Table 3

Least squares means (± SEM) of the goat milk productivity traits in different kidding seasons

Season	n	Milk yield, kg	Fat content, (g kg^{-1})	Protein content, (g kg^{-1})
Winter	2379	583.5±7.39^{a}	39.0±0.31^{b}	31.1±0.15^{b}
Spring	3378	526.9±7.20^{b}	39.1±0.30^{b}	31.4±0.15^{c}
Summer	270	441.6±13.50^{c}	41.8±0.63^{a}	32.3±0.25^{a}
Autumn	40	583.8±22.44^{a}	38.5±0.92^{b}	32.0±0.45^{c}

^{a,b,c}- milk productivity traits with different letters differ significantly between different seasons ($p<0.05$).

The goat milk content significantly differed among the research years. The highest milk fat content was (40.8±0.05 g kg^{-1}) for goats kidded in 2004. The milk protein content was between 32.7 g kg^{-1} in 2008 and 29.2 g kg^{-1} in 2002.

Goats, in common with sheep, are polycyclic animals with well-marked rutting time which starts at the end of July and ends at the beginning of August. The productivity of goat kidded at the beginning of summer and autumn could be affected by two important factors – the goat rutting time, and the changes between the grazing period and the period goats spend inside the stables.

The goats are in heat from 2 to 3 days during the rutting time. The rut repeats after each 19 – 21 days, and if the goat does not become pregnant it repeats regularly till January. Besides, the grazing time ends in autumn and the conditions of feeding and keeping are changed, which makes stress for the goats and in such a way affecting the milk productivity.

According to several authors' researches (Crepaldi et al., 1999; Zoa-Mboe et al., 1997), the goat kidding month significantly affects the variability of the milk productivity traits. The group of scientists in Croatia during their research of Alpine and Saanen goats have found that the highest milk productivity was reached by the goats kidded in winter – 627.75±4.06 kg (Mioč et al., 2008). The analysis of the goat kidding seasonality in France has shown that 68.3% of goats kidded in winter and spring (Institut de l'Elevage, 2010).

The results of the present research are summarized in Table 3.

The significantly highest milk yield in standard lactation was determined for goats kidded in winter and spring (583.8±22.44 and 583.5±7.39 kg) from October to March; the lowest milk yield – for the goats kidded in summer (441.6±13.50; $p<0.05$).

The significantly highest fat and protein content was determined for the goats kidded in summer (41.8±0.63 and 32.3±0.25 g kg^{-1}; $p<0.05$). During the research, a negative correlation between the milk yield and the milk fat and milk protein content was observed.

The goat milk yield gradually increases with each succeeding lactation. The maximum can be reached in the third to the fifth lactation if the feeding and keeping conditions are set correctly, but in later lactations it starts to decrease. In the first and the second yield the milk yield reaches 65% – 85% of the grown-up goat milk yield. Starting with the third lactation the fluctuations of the milk yield affected by age are small and the goats could be considered as grownups (Gall, 2001).

The significantly highest average milk yields in the standard lactation were determined for the goats of the third (578.0±8.34 kg) and the fourth (572.2±8.34 kg) lactations. Croatian scientists have observed similar results when investigating productivity traits of Alpine and Saanen goats (Mioč et al., 2008). They found that the lowest milk yield (477.6±7.41 kg) was for the first lactation goats, and it did not reach even 500 kg ($p<0.05$).

In our research, the goat milk content significantly differed among the lactations. The highest milk fat content (from 39.6±0.34 to 39.9±0.39) was determined for the goats in the fourth and later lactations. The milk protein content was between 31.3±0.16 g kg^{-1} in the fourth lactation and 32.1±0.15 g kg^{-1} in the first

Table 4

Least squares means (± SEM) of the goat milk productivity traits in different lactations

Lactation	n	Milk yield, kg	Fat content, g kg^{-1}	Protein content, g kg^{-1}
1	1636	477.6±7.41^{c}	39.4±0.30	32.1±0.15^{a}
2	1521	546.3±7.25^{b}	39.2±0.30^{b}	31.6±0.14^{b}
3	1142	578.0±8.34^{a}	39.2±0.31^{b}	31.5±0.15^{b}
4	827	572.2±8.34^{a}	39.6±0.34	31.3±0.16^{b}
5 and >	941	549.8±9.48^{b}	39.9±0.39^{a}	31.7±0.19^{a}

^{a,b,c}- milk productivity traits with different letters differ significantly between different lactations ($p<0.05$).

Table 5

Least squares means (± SEM) of the milk productivity traits of the goat breeds in Latvia

Breed	n	Milk yield, kg	Fat content, g kg^{-1}	Protein content, g kg^{-1}
AK	384	511.4±15.50^{c}	41.7±0.63^{a}	32.3±0.30^{a}
LVK	3261	560.8±3.86^{b}	38.9±0.16^{b}	31.8±0.08^{a}
TIR	81	543.8±14.88^{b}	36.9±0.61^{c}	30.1±0.29^{b}
VBD	218	533.8±15.21^{b}	41.3±0.62^{a}	32.0±0.30^{a}
XX	91	539.6±15.09^{b}	39.5±0.61^{b}	32.1±0.30^{a}
ZK	2032	579.3±5.01^{a}	39.0±0.21^{b}	31.7±0.10^{a}

^{a,b,c}- milk productivity traits with different letters differ significantly between different breeds ($p<0.05$).

lactation. German scientists have found (Bömke, 2004) that WBD and AK goats reach the highest milk yield in the third lactation. According to them the increase in protein content was determined from the fourth to the thirteenth lactation, but the highest milk fat content was determined in the first lactation. The milk recording results in France in 2010 show that most of all milk is produced during the second and third lactations (from 903 to 906 kg); however also reduced milk fat and protein content is determined in the same lactations (Institut de l'Elevage, 2010).

Analysing the affect of the researched factors on the milk productivity traits variability, it was found that in ten years Saanen goats gave the significantly highest milk yield (579.3±5.01 kg), while Latvian goats reached the second highest milk yield (560.8±3.86 kg) (Table 5)

The highest milk fat and protein content was for AK goats (41.7±0.63 and 32.3±0.30 g kg^{-1}). The milk recording results in Germany show that the highest milk yield in 2010 was reached by German Noble (the milk yield was 717 kg and 33.4 g kg^{-1}), but the highest fat content has been determined for Thuringian goats (36.3 g kg^{-1}) (Milchleistungsprüfung bei Ziegen, 2010).

Milk recording results in France show that the average milk yield of ZK goats was 861 kg, the milk fat content – 35.8 g kg$^{-1,}$ and the protein content – 31.6 g kg^{-1}, but the AK milk yield was 833 kg, the milk fat content – 37.8 g kg^{-1}, and the protein content – 32.8 g kg^{-1} (Institut de l'Elevage, 2010).

Conclusions

1. The goat milk yield, and the fat and protein content varied depending on the year and season of kidding, herd, lactation, breed and interaction between year, season and herd ($p<0.05$; $p<0.01$; $p<0.001$). The determination coefficients were estimated from 0.583 for fat content, to 0.640 for protein content.
2. The significantly highest milk yield (662.7 kg) was determined in 2002, the highest milk fat content (40.7 g kg^{-1}) – in 2004, but the highest protein content (32.7 g kg^{-1}) was determined for the goats kidded in 2008 ($p<0.05$).
3. The goats kidded in autumn and winter seasons gave the significantly highest milk yield (respectively 583.8 and 583.5 kg), but the goats kidded in summer season had the highest milk fat and protein content (41.8 and 32.3 g kg^{-1}; $p<0.05$).
4. The highest milk yield was determined for the third and fourth lactation goats (578.0 and 572.2 kg), but the highest milk fat content (39.9 g kg^{-1}) – for the goats in the fifth and later lactations. The significantly highest protein content (32.1 g kg^{-1}) was determined in the first lactation ($p<0.05$).
5. The Saanen goats reached significantly highest milk yield (579.3 kg) but the highest milk fat and protein content was determined for the Alpine goats (the fat content – 41.7, and the protein content – 32.3 g kg^{-1}; $p<0.05$).

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