

## MILK COMPOSITION OF DIFFERENT GOAT BREEDS

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### Abstract

*High performance of goat milk yield ensures genetic potential of breeding work which has been achieved through targeted animal selection, assessment, as well as improving goat nutrition. Our objective was to compare milk composition of four different breeds of goat (Alpine, German White Noble, Thuringia and Latvian Local). During accounting period goats received feed produced in the farm; five goats were randomly selected from each group. Milk samples were analyzed on milk fat and milk proteins concentrations and evaluated on milk cytological and immunological indices. During the trial the highest milk protein content reach German White Noble goats (3.05%), but the highest milk yield reaches Alpine goats – in average 2.24 kg per day. Statistically ( $p \leq 0.05$ ) the highest amount of segmentnucleus were found in Thuringia and Alps goat milk (resp., 199 and 187  $\mu\text{L}^{-1}$ ), also the highest total amount of monocytes and histocytes were found in Alps goat milk (11  $\mu\text{L}^{-1}$ ). Alps and Latvian Local goats milk present increasing of milk active T-, B-, D-cells count and decreasing of O-cells and this indicates a high immune cell functional state. Examining goat milk cytological and immunologic parameters, the goat breeds can be ranked as follows: The Alpine - Latvian Local – Thuringia - German White Noble.*

**Key words:** Goat, milk, milk cells, chemical composition.

### INTRODUCTION

Interest in the milking goats has increased considerably during the last years in the world (Ahuya et al., 2009). Over recent years the tendency has been a slight reduction in the number of animals bred, while at the same time there has been a general increase in the volume of milk produced. The milk quality and composition are of interest not only to producers and dairy companies but most of all to consumers. High hygiene milk quality requirements are aimed at the protection of human health, maintaining the natural biological value of the raw material and ensuring the right course of technological processes throughout milk processing. Improving of goat breeding, care and feeding in farms, goat milk yields increase and highly productive goat's reach of more than 800 kg of milk in lactation. Such high rate of milk provides genetic potential, which has been achieved through targeted animal selection, selection and assessment, as well as improving goat feeding (Piliena K., Sprūžs J., 2007, Sprūžs J., 1996).

According to study of Neven et al. (2001), breed had a significant effect on the content of total solids, solids-non-fat, protein, lactose, ash, calcium and phosphorus, all of which were found to be higher in milk of Alpine breed compare to Saanen goats.

Goat milk contains on average a higher somatic cell count (SCC) than cow milk which is due to the apocrine character of milk secretion in goats, namely involving the destruction of the milk-producing cell and its reaching the light of milk-producing alveolus. High milk production was accompanied by low SCC, which might be associated to a dilution effect (Fernandez et.al, 2008).

Albenzo et al. (2004) found, that the HSCC (high SCC) resulted in higher pH values in milk and in higher moisture and lower fat contents in fresh cheese curds. Moreover, a lower recovery of fat and whey proteins was obtained from the HSCC than from the LSCC (low somatic cell count raw milk).

The crude protein and casein contents were higher in the HSCC than in the LSCC curds during early and midlactation; an opposite trend was observed in late lactation.

There are significant correlation between the level of milk somatic cell counts (SCC) and polymorphonuclear neutrophilic leukocytes (PMN), lower correlation coefficients were found between SCC and PMN for samples of bulk tank milks than for milk samples from individual animals. There is also a significant seasonal influence on milk PMN content and higher proportions of PMN are found in milk where animals calving in the spring than in milk from autumn calving cows (Kelly et al., 2000).

The presence of cells in bovine milk, so called somatic cells has been recognized and studied for many years. Somatic Cell Count (SCC) is the total number of leukocytes cells per milliliter in milk (Miller et al., 1986). SCC in the milk of a healthy cow is normally  $2\sim 3 \times 10^5 \text{ mL}^{-1}$  and is often used as an indirect measure of mammary infection status (Shook and Schultz, 1994; Caraviello et al., 2005). These cells originate from blood cells and play an important role in the metabolism of the mammary gland (Burvenich et al., 1994). The majority of the cells in somatic cell counts are leukocytes and others are cells from the udder secretory tissue (epithelial cells) (Bradley and Green, 2005). The epithelial cells are shed and renewed in the normal body processes. The white blood cells serve as a defense mechanism to fight disease infection and assist in repairing damaged tissue (Ma et al., 2000). The white blood cells are mainly composed of Macrophage (MAC), Lymphocyte (LYM) and Polymorphonuclear Neutrophil leukocytes (PMN) (Dosogne et al., 2003; Bradley and Green, 2005). A lot of factors such as season, parity, lactation stage, nutrition, sanitation, environment, management and genetic factors could influence the level of SCC in bovine milk (Green et al., 2006, 2008; Heuven et al., 1988; Sheldrake et al., 1983). High levels of SCC in milk could result in great loss of milk yield and have negative effect on quality, life time and processing traits of milk (Barbano et al., 1991; Jones et al., 1984). SCC is mainly composed of leukocytes produced by the cow's immune system to fight an inflammation in the mammary gland or mastitis. SCC provides an indication of the healthy condition of mammary gland in an individual cow or in the herd if bulk milk is used and it is a hot topic in recent studies.

Our objective was to compare milk composition of four different breeds of goat - Alpine, German White Noble, Thuringian and Latvian Local.

## MATERIALS AND METHODS

This study investigated the milk yield and composition of four different breeds of goats namely the Alpine (AG), the German White Noble (GWN), the Thuringian (THU) and the Latvian Local (LLG) which were all raised in the same environmental conditions. The experiment was a one way (feeding system) analysis of variance where five goats were randomly selected from each breed for the measurement of milk yield and components. Twenty dairy goats (5 AG, 5 GWN, 5 THU and 5 LLG) were raised at the organic farm „Livi”.

The study was carried out for 123 days totally (from May to August). Feeding, keeping and rearing conditions were equal for all 20 goats included in the trial. In the groups were included second and third lactation goats with a similar live weight (50 - 60 kg), body composition, and nutritional level. During accounting period, goats received feed produced in the farm – pasture grass, straw and concentrated feed (70% barley and 30% wheat), also KNZ mineral salt (Table 1).

Measurements	Pasture grass	Straw	Concentrated feed	Total	Requirement	Balance + or -
Total, kg	6.0	0.5	0.3	x	x	x
DM, kg	1.14	0.40	0.26	1.80	1.90	-0.10
CP, g	205.2	28.8	39.26	273.26	289.55	-16.29
NDF, kg	0.61	0.27	0.09	0.97	0.60	+ 0.37
Ca, g	8.55	2.36	0.15	11.06	11.45	-0.39
P, g	5.70	0.40	1.17	7.27	8.01	-0.74
NEL, MJ	7.38	2.05	2.08	11.51	14.00	-2.49

Table 1. Feed nutrients in feed ration

Nutrient requirement in goats was determined according to animal live weight and milk yield following the normative regulations adopted in Latvia and United States (Spruzs, 2005; Nutrient Requirements..., 1981). According to the catalogues of feedstuffs (Ositis et al. 2000; Latvietis, 1996) by the amount of neto energy (NEL), crude protein (CP), calcium (Ca), phosphorus (P) and main biologically active substances feed rations for the goats of all groups were practically of equal value. During the trial goats received mineral supplement KNZ – 100, containing 99% NaCl

During trial, milk yield produced by each goat was measured with a precision to  $\pm 0.05$  kg. Milk fat, protein, lactose content was determined by a daily average sample once a month using *Milko Scan 133* according to the IDF standard 141C:2000 requirements and somatic cell count (SCC) - in accordance with standard LVS EN ISO 13366-3:1997 requirements.

Hematological study and cytological analysis of milk were carried out using a microscope. To assess the immune status of goats the following parameters of milk were investigated: T- and B-cell count (Гришина et al., 1978); phagocytic activity (Федосеева et al., 1993); number of adhesive A-cells (Wottawa et al., 1974); lysozyme level (Грант et al., 1973); circulating immune complex (CIC) content (Riha et al., 1979). Specific preparation of milk samples was used. To analyze cell composition milk was washed by Eagle solution, centrifuged and re-suspended. Humoral immunity in organism was characterized using natural resistance indices – amount of lysozyme and circulating immune complex (CIC) in milk. For analysis, milk samples of 40 ml were centrifuged at 3000 rev/min for 25 minutes. Lysozyme was determined by spectrometric method (Грант Г. Я. et.al., 1973). The CIC level was determined spectrophotometrically by precipitation reaction with polyethylenglucole (Riha J., 1979). CIC is the antigen-antibody compound, where gradually phagocyte the macrophages. In case of the inflammatory process the concentration of CIC is increased.

Results were statistically processed using Microsoft Excel, Student t – test ( $p \leq 0.05$ ).

## RESULTS AND DISCUSSIONS

The milk yield obtained during experiment is presented in Tab. 2. The highest milk yield was obtained in Alps goats: the daily milk yield was 2.24 kg or by 3.2 % more compare to the native Latvian local goats.

Group	Milk yield per animal per day, kg	Milk fat,%	Milk protein, %	SCC, thous. mL <sup>-1</sup>
AG	2.24	4.42 ± 0.25 <sup>b</sup>	2.95 ± 0.04	579 ± 35 <sup>a</sup>
GWN	2.11	4.49 ± 0.16 <sup>b</sup>	3.05 ± 0.12	393 ± 89 <sup>a</sup>
THU	2.14	4.45 ± 0.25 <sup>b</sup>	3.04 ± 0.10	616 ± 67 <sup>a</sup>
LLG	2.17	4.74 ± 0.35 <sup>a</sup>	2.99 ± 0.09	1094 ± 48 <sup>b</sup>

<sup>a,b</sup> $p \leq 0.05$

Table 2. Goat milk yield and quality during the trial

The highest milk fat was observed in Latvian local goats (4.74%;  $p \leq 0.05$ ), but there were also the highest somatic cells count (1094 thous. mL<sup>-1</sup>;  $p \leq 0.05$ ). Protein level, however, was higher in German white noble and Thuringian goat milk (resp. 3.05% and 3.04%) and SCC in German white noble goats milk was only 393 thous. mL<sup>-1</sup>. According Bernacha (2007) an average content of cell elements in the milk of the goats is 600 thousand cell elements 1 mL<sup>-1</sup> in average, ranging from 10 thousand to 10,000 thousand, depending on the lactation month, which demonstrates that the hygiene quality of the examined milk is good. However, the maximum values of the somatic cell count are distressing, and thus the goats in which the highest content of cell elements in milk kept repeating should be culled from breeding in the future in order not to deteriorate the quality of the raw material obtained. Bernacha found that increase in the somatic cell count in milk was accompanied by an increase in the daily milk yield as well as its content of fat, and the same coherence we found in our investigation with Latvian local goats. The present research showed no effect of the somatic cell count on the content of protein in goat milk.

The activity of phagocytosis, the concentration of lysozyme and circulated immune complexes determine the innate and specific immune response. Immunological investigations allowed estimation of the immune properties of milk in experimental animals. Advantageous immunity status of Alps goats over other ones is shown in Table 3.

According of milk phagocytosis goats are ranked as follows: Alpine goats, Latvian local goats, Thuringia and German noble white goats. Dairy cows whose milk supported a high level of phagocytosis were more resistant to mastitis following either a natural or experimental challenge of mastitis pathogens (Paape et al., 1978; Guidry et.al., 1980). Variation among goats in the ability of their milk whey to support phagocytosis and in their polymorphonuclear neutrophils (PMN) to phagocytose was an important finding from the M.J. Paape et.al. (2004) study and may contribute to differences among goats in resistance to mastitis.

Circulated immune complexes (CIC) are the integral indicator of antigen load and immune system. Increasing of CIC content indicates to the potential for humoral immunity. The highest amount of circulated immune complexes was in the Alpine goat's milk, but as individual figures were scattered, statistically significant differences among the four groups of animals could not find. Lysozyme is a non-specific humoral immunity integral indicator, and it was significantly higher in the Alpine goats milk (73.0 µg mL<sup>-1</sup>) compared to the amount of lysozyme observed in GWN and LLG goat milk ( $p \leq 0.05$ ). Ruminants are comparatively lacking in lysozyme in tears, saliva, and milk (Prieur, 1986). Bovine milk contains 0.13 µg of lysozyme mL<sup>-1</sup>, whereas goats and sheep produce 0.25 and 0.10 µg mL<sup>-1</sup>, respectively (Chandan et al., 1968), but our present study shown higher amount of lysozyme in goat milk. Because lysozyme limits the growth of some bacteria that cause intestinal infections and diarrhea

and also encourages the growth of other beneficial intestinal bacteria, it is considered to be one of the main components of milk that contribute to the health and well-being of milk consumers.

Groups	Phagocytosis, %	Lysozyme, $\mu\text{g } 100 \text{ mL}^{-1}$	CIC, Units $\times 100$
AG	$11.0 \pm 0.38^a$	$73.0 \pm 1.35^a$	$5.00 \pm 0.96$
GWN	$6.2 \pm 0.39^b$	$47.8 \pm 5.96^b$	$2.64 \pm 0.69$
THU	$8.4 \pm 0.58^b$	$69.3 \pm 3.17^a$	$2.04 \pm 1.31$
LLG	$10.2 \pm 0.80^a$	$38.0 \pm 12.69^c$	$2.20 \pm 0.92$

$^{a,b,c}p \leq 0.05$

Table 3. Indices of nonspecific and humoral immunity of goat milk

The white blood cells are mainly composed of Macrophage, Lymphocyte and Polymorphonuclear Neutrophil leukocytes (Bradley and Green, 2005). Neutrophils and macrophages are the predominating leucocytes in the somatic cells in goat milk (Le, 1996). The proportion of lymphocytes in goat milk may be as high as 10% or even 17% (Boutinaud et al., 2002; Bergonier et al., 2003). In present study we found that the percentage of lymphocytes reached 18 – 25%. It was shown in Schmaltz et al. (1996) study on dairy cows that the number of these subpopulations may increase in mastitis. Bergonier et al. (2003) earlier study on dairy goats showed that the percentage of lymphocytes did not depend on the presence of bacteria and reached only 2.5%. The percentage of monocytes and eosinophils in goat milk ranged between 10 - 15% and 2.5 - 7%, respectively, depending on health status of the mammary gland (Bergonier et al., 2003). In present study the percentage of monocytes and eosinophils in goat milk ranged between 2.0 – 3.3% and 0.4 – 0.7 % respectively (Table 4).

Groups	Ep	Fo	Hi	He	Eo	Ba	Ly	Mo
AG	$1.3 \pm 0.6$	$1.8 \pm 0.8$	$1.2 \pm 0.2$	$76.0 \pm 5.8$	$0.4 \pm 0.04$	$0.3 \pm 0.05$	$19.5 \pm 5.0$	$3.3 \pm 0.4$
GWN	$1.2 \pm 0.8$	$1.4 \pm 0.8$	$0.6 \pm 0.2$	$75.8 \pm 2.3$	$0.6 \pm 0.1$	$0.4 \pm 0.1$	$21.2 \pm 2.3$	$2.0 \pm 0.8$
THU	$1.1 \pm 0.7$	$1.5 \pm 0.4$	$0.8 \pm 0.6$	$78.3 \pm 6.4$	$0.7 \pm 0.1$	$0.6 \pm 0.1$	$18.0 \pm 1$	$2.2 \pm 0.4$
LLG	$1.2 \pm 0.8$	$1.3 \pm 1.8$	$0.9 \pm 0.6$	$71.0 \pm 2.7$	$0.5 \pm 0.1$	$0.5 \pm 0.1$	$25.0 \pm 3.1$	$3.0 \pm 0.8$

Ep – epithelium cells; Ly – lymphocytes; Mo – monocytes; Hi – histiocytes; He – heterocytes; Fo – foamy cells; Eo – eosinophils; Ba - basophils

Table 4. Relative amount of milk cells, %

No significant differences were found between four groups of goats according to the relative number of cells. The relative cell count data showed that all goats were healthy.

According Józwick et al. (2012) in case of an infection of the mammary gland by pathogenic microorganisms polymorphonuclear cells are transferred from the blood to the inflammation sites in the udder, what in turn increases the somatic cell count of milk. An excess of neutrophils, macrophages, cells from

the epithelium of the glandular tissue, lymphocytes and eosinophils is recognized as a measure of the rate of infection of the mammary gland by micro-organisms causing an inflammatory condition (Knnapen et al., 1999).

Group	Segmentnuclear cells	Lymphocytes	Monocytes	Histiocytes
AG	187±5 <sup>b</sup>	48±4	8±0.8 <sup>a</sup>	3±0.1 <sup>a</sup>
GWN	174±6	48±2	5±0.4 <sup>b</sup>	1±0.1 <sup>b</sup>
THU	199±7 <sup>b</sup>	45±3 <sup>b</sup>	7±0.4	2±0.1 <sup>b</sup>
LLG	161±3 <sup>a</sup>	57±3 <sup>a</sup>	7±0.5	2±0.1 <sup>b</sup>

<sup>a,b</sup> $p \leq 0.05$

Table 5. Count of milk cells in 1  $\mu$ L

Paape and Capuco (1997) claimed that neutrophils made up 50-70% of the somatic cell count in milk from goats free of intramammary infection whereas neutrophils only made up 5 – 20 % of the total cell count in bovine milk. During inflammation the major increase in SCC is due to the influx of segmentnucleus (neutrophils) into the milk to fight infection and have been estimated at over 90 % (Harmon, 1994). Morgante et al. (1996) reported the SCC from healthy primiparous Comisana ewes was  $56.7 \pm 45.2 \times 10^3 \text{ mL}^{-1}$  consisting of 30.6% polymorphonuclear leukocytes, 57.3% macrophages and 8.2% lymphocytes. However, reports about the cellular composition of somatic cells in bovine milk are rare and there is no evidence to indicate the same composition that occurs in ewe's milk occurs in the dairy cow. In our case (Table 5) segmentnucleus made up 15 - 44 % of the somatic cell count. The absolute count of lymphocytes in Latvian local goats milk was significantly ( $p \leq 0.05$ ) higher than the count of lymphocytes observed in Thuringian goats milk. Count of monocytes was statistically ( $p \leq 0.05$ ) different in Alps and German white noble goat milk. Milk leukocytes play an important role in defending the mammary gland from aggression of pathogenic microorganisms. The number and relative proportion of each type of leukocyte is influenced by various physiological and pathological states of the udder (Cuccuru et al., 1997).

Immunological investigations allowed estimation of the immune properties of milk in experimental animals. Advantageous immunity status of Alps goats and Latvian local goats over other ones is shown in Table 6.

Group	T-cells	B-cells	D-cells	0-cells
AG	20.0±0.9 <sup>a</sup>	12.0±0.6 <sup>a</sup>	7.0±0.5 <sup>a</sup>	61.0±1.2 <sup>a</sup>
GWN	15.0±0.8 <sup>b:B</sup>	6.0±0.5 <sup>b:B</sup>	4.0±0.4 <sup>b: B</sup>	75.0±1.7 <sup>b</sup>
THU	17.0±0.4 <sup>b</sup>	8.0±0.6 <sup>b</sup>	5.0±0.6 <sup>b</sup>	70.0±1.4 <sup>c</sup>
LLG	19.0±0.8 <sup>A</sup>	9.0±0.8 <sup>b: A</sup>	6.0±0.5 <sup>A</sup>	66.0±1.2 <sup>d</sup>

<sup>a,b,c,d,A,B</sup> $p \leq 0.05$

Table 6. Immunological indices of goat milk, %

Lymphocytes are the only cells of the immune system that recognize a variety of antigenic structures through membrane receptors, which define their specificity, diversity and memory characters (Boyso et al, 2007). T-lymphocytes and B-lymphocytes are two subsets of lymphocytes that differ in function and protein products and play specific immune functions (Harmon, 2001). B-lymphocytes are bursa-dependent lymphocytes; the precursors of antibody-producing cells and the cells primarily responsible for humoral immunity. T-lymphocytes are thymus-dependent lymphocytes; those that pass through or are influenced by the thymus before migrating to tissues; they are responsible for cell-mediated immunity and delayed hypersensitivity. According to immunological indices (Table 6) the lowest relative amount of T-and B-cells was found in the milk of German white noble goats (resp. 15.0 % and 6.0 %), but highest amount – in Alps goat milk (resp. 20.0 % and 12.0 %;  $p \leq 0.05$ ).

T-and B-cells are the main immune cells, which provide the specific immune response. D-cells are lymphocytes with the highest activity because they have more cell membrane receptors, which are the first to be activated in immune response. German white noble goat group present reducing of milk active T-

B-, D-cells count and increasing of O-cells and this could show to the changes in immune system.

O-cells are lymphocytes that do not respond to T-, B-cell receptors, indicating a low activity of lymphocyte. If less inactive lymphocytes (O-cells) compared with active lymphocytes (T- and B-cells), the immune defense is higher. Relative number of inactive lymphocytes (O-cells) was lower of Alpine goat group ( $p \leq 0.05$ ), indicating the high immune cell functional state.

## CONCLUSION

The highest milk yield was obtained in Alps goats: the daily milk yield was 2.24 kg or by 3.2 % more compare to the native Latvian local goats. The highest milk fat was observed in Latvian local goats (4.74%;  $p \leq 0.05$ ), but there were also the highest somatic cells count (1094 thous.  $\text{mL}^{-1}$ ;  $p \leq 0.05$ ). Protein level, however, was higher in German white noble and Thuringian goat milk (resp. 3.05% and 3.04%) and SCC in German white noble goats milk was only 393 thous.  $\text{mL}^{-1}$ . Statistically ( $p \leq 0.05$ ) the highest amount of segmentnucleus were found in Thuringia and Alps goat milk (resp., 199 and 187  $\mu\text{L}^{-1}$ ), also the highest total amount of monocytes and histocytes were found in Alps goat milk (11  $\mu\text{L}^{-1}$ ). Alps and Latvian Local goats milk present increasing of milk active T-, B-, D-cells count and decreasing of O-cells and this indicates a high immune cell functional state. Examining goat milk cytological and immunologic parameters, the goat breeds can be ranked as follows: The Alpine - Latvian Local – Thuringia - German White Noble.

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