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Production, quality and fatty acid composition of milk of Serbian White goat

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Abstract

This paper investigates the duration of the first and the second lactation, total and daily milk yield and chemical composition in Serbian White goat. Standard examination methods were used. Total and daily milk yields were significantly higher in the second lactation. Total solids, fat, lactose, crude protein, casein, serum protein and ash content in both lactations were similar and did not show statistically differences. Saturated fatty acid (SFA) content was 70.92 % in the first lactation and 72.01 % in the second; unsaturated fatty acid (USFA) content was 26.73 % and 23.50 %, respectively. Unsaturated and saturated fatty acid relation was 0.38 in the first lactation and 0.33 in the second; polyunsaturated (PUFA) and monounsaturated fatty acid (MUFA) relation was 0.13 and 0.13, respectively. It was concluded that Serbian White goat in half-intensive breeding system can produce milk of good quality for consumption as well as good raw material for cheese production.

Keywords: goat, Serbian White, lactation, milk quality, fatty acid composition

Zusammenfassung

Milchleistung, Milchinhaltstoffe und Fettsäurespektrum bei der Serbischen Weißen Ziege

Untersucht werden die Dauer der ersten beiden Laktationen, der Milchertrag, die Milchinhaltstoffe sowie die Fettsäurezusammensetzung mit Hilfe von Standardmethoden bei Weißen Serbischen Ziegen. Sowohl die Laktationsleistung als auch der tägliche Ertrag war in der zweiten Laktation signifikant höher als in der ersten. Keine signifikanten Unterschiede fanden sich bei den untersuchten Milchinhaltstoffen. Der Gehalt gesättigter Fettsäuren betrug 70,92 % in der ersten Laktation und 72,01 % in der zweiten, der Anteil ungesättigter Fettsäuren in der ersten Laktation 26,73 % und 23,50 % in der zweiten. Das Verhältnis ungesättigter zu gesättigten Fettsäuren betrug in der ersten Laktation 0,38 und in der zweiten 0,33, das der einfach ungesättigten zu mehrfach ungesättigten Fettsäuren jeweils 0,13 und 0,13. Zusammenfassend wird festgestellt, dass die Serbische Weiße Ziege in halbintensiven Haltungssystemen Milch mit hoher Verbraucherqualität liefern kann.

Schlüsselwörter: Ziege, Serbische Weiße, Laktation, Milchinhaltstoffe, Fettsäurespektrum

Introduction

Goat milk is topic of interest in the recent years. Milk composition has fundamental importance for its nutritive and marketing value, as well as for its technological characteristics (HAENLEIN 2004). It depends of endogenous (breed) and exogenous factors (feeding, season variations, age, oestrus, pregnancy, body weight, lactation phase and number of lactation, environmental conditions and health) (PARK 1990, ANTUNAC *et al.* 2001a, b, WOJTOWSKI *et al.* 2001, WALISIEWICZ-NIEDBALSKA *et al.* 2004, STRZALKOWSKA *et al.* 2004, GUO *et al.* 2004, BÖMKES *et al.* 2004, PALA and SAVAS 2005, STRZALOWSKA *et al.* 2004, MEMISI *et al.* 2007).

Variability of amount and chemical composition of milk are under influence of dominant genetic background (55 %), while other variations (45 %) are influenced by paragenetic factors (feeding).

One of the most important components of milk is fat. Milk fat is composed mostly of triacylglyceroles (98 % of total milk lipids). Fatty acids with short and medium chain (C4-C10 and C12-C16) present approximately 30 % of milk fat. Long chain fatty acids are originated from the feeding stuffs and make 40-60 % of milk fat, depend of the type of feed (WALISIEWICZ-NIEDBALSKA *et al.* 2004, STRZALKOWSKA *et al.* 2006). About 50 % of the fatty acids presented in milk fat are synthetized by mammary glands, while the second part present fatty acids from blood.

Fatty acids, particularly C6:0-C10:0 influence the development of desirable sensoric properties of milk (GUO *et al.* 2004). Presence of desirable odor and taste in cold, fresh goat milk is the result of increase of free fatty acids C6:0-C9:0 and branchy chain fatty acids C9 and C10 (methyl- and ethyl-C8) that are more significantly represented in milk of small ruminant in regard to cow milk (DELACROIX-BUCHET and LAMBERET 2000).

Lipids of goat milk are rich in the medium chain fatty acids (MCT) composed of fatty acids with 6-10 carbon atoms. These fatty acids are known as capronic (C6:0), caprilic (C8:0) and caprinic (C10:0) and represent 15-18 % of total fatty acids, while in cow milk only 5-9 % (CHILLIARD *et al.* 2006).

Fatty acids are of particular therapeutic importance due to its specific metabolism and have use in the therapy of some metabolic diseases (HAENLEIN 2004, CHILLIARD and LAMBERET, 2001).

On the base of earlier investigations (ZUJOVIC 1993, ZUJOVIC *et al.* 1998) it was found out that domestic White goat bred in Serbia presents the population of expressed genetic background for milk yield. Due to its characteristics and because of importance in nutrition this race breed has gain the popularity for breeding in Serbia.

The aim of this paper was to investigate the milk production in the first and the second lactation, chemical composition and fatty acid composition of Serbian White goat.

Material and methods

In this experiment, the milk of Serbian White goats was examined. Goats were breeding semi-intensive (pasture and indoor system) in area of Stara Planina (Old Mountain) in the southern Serbia at 600-750 m altitude. It were examined 293 goats in the first lactation and 219 goats in the second lactation. The number of samples for chemical examination was 12

(Samples of milk were collected from 12 households. One sample for chemical examination was represented as total quantity of milk from one household milked for one day). Milk samples for chemical examination were taken every three week. During investigation goats were clinically healthy. After milking, milk was refrigerated at 4 °C and before examination heated at 40 °C.

Milk yield was controlled every day during the both lactations and measured by scale with accuracy 10^{-3} kg.

Total solids were obtained after drying to constant weight at 102 °C. Fat content was determined by the butyrometric Gerber method with a calibrated butyrometer (ISO 11870:1991). Total nitrogen, non-casein nitrogen (NCN) and non-protein nitrogen (NPN) were determined by standard procedures using the Kjeldahl method. Casein nitrogen was calculated as the difference betwen total nitrogen and NPN (multiplied by a conversion factor of 6.38) and serum protein as the difference between NCN and NPN (multiplied by a conversion factor of 6.38). Lactose was measured by infrared analysis using the Milkoscan apparatus according to the IDF method (IDF 141B:1996). Ash was determined by weight after burning at 525 °C.

Obtained data were statistically analyzed by calculating of mean value, standard deviation, coefficient of variation, as well as range. The differences among mean value were determined according to Student's test (equal means hypothesis). The significant level of test was set at $P<0.05$ and $P<0.01$.

Lipids from milk samples were separated according to international standard ISO 14 256-IDF 172:2 001 using n-pentane and diethyl ether with addition of ammonium hydroxide solution. Extracts were dried under stream of nitrogen and dried lipids frozen at –18 °C until analysis (ISO 14156:IDF 172:2001).

An aliquot of lipids, 50-60 mg, was transferred to 15 ml glass test tube with 5 ml of 0.5 M methanolic sodium hydroxide. The test tube was heated on a stream bath for 8-10 min. Then 3 ml of 5 % BF_3 methanolic solution was added and left on a stream bath for another 3 min. After the cooling to the mixture was added saturated sodium chloride solution to float up the methyl esters.

To accelerate devotion of two layers and to dissolve solid lipids too, 5 ml of n-hexane was added with vigorously shaking. After 30 min n-hexane upper layer was avoided with pipette and dried under anhydrous sodium sulphate to auto sampler vial and analyzed (METCALFE *et al.* 1966).

The analysis of fatty acid methyl esters were performed on HP 5 890 Series II gas chromatograph (Agilent Technologies, USA) fitted with column DB 23 60m, ID 0.25mm, film thickness 0.25 µm (J&W Scientific). The chromatographic conditions were described in details in work of BECHTEL and OLIVEIRA (2006). Chromatograms were analyzed by ChemStation software using external standard method.

Results and discussion

Table 1 shows duration of the first and the second lactation and data about daily and total amount of milk during lactation.

Table 1
Duration of the first and the second lactation, total and daily quantity of milk
Milchleistung der ersten und zweiten Laktation, Milchertrag je Laktation und Tag

	Lactation	n	Mean	SD	CV	Range
Lactation, days	I	293	261.91	27.93	10.66	181.00 - 304.00
	II	219	269.00	26.84	9.98	189.00 - 299.00
Quantity, kg	I	293	283.61^{x}	82.17	28.97	116.46 - 550.74
	II	219	385.21^{y}	100.36	26.05	114.47 - 660.14
Daily quanity, kg	I	293	1.10^{x}	0.32	28.93	0.448 - 2.118
	II	219	1.48^{y}	0.39	26.06	0.440 - 2.539

^{x,y} $P<0.01$

The first lactation lasts average 261.91 day (181-304) and the second 269 days (189-299). Between means did not ascertain statistically difference ($P>0.05$). Total average quantity of milk during the first lactation was 283.61 L (1.10 kg/day) that is significantly less than 385.21 L (1.48 kg/day) in the second lactation ($P<0.01$).

Duration of lactation could be different and depends of many factors. The most important are goat raising and feeding (EKNÆS *et al.* 2006). Obtained results about duration of the first and the second lactation in this experiment are better than 239.36 days for the first and 237.20 days for the second lactation (MEMISI *et al.* 2001). According to these authors the total milk production in the first lactation of Balkan domestic goat is 175.28 L (0.729 kg/day) and in the second lactation 172.47 L (0.722 kg/day) that is less than results in this experiment.

BÖMKES *et al.* (2004) cited less lactation, approximately 234.1 days, but more milk per day (2.87 kg).

However, EKNÆS *et al.* (2006) found out higher milk production in Norwegian dairy goats. In the first lactation it was 1.97-3.52 L per day. Also MIN *et al.* (2005) noted 2.95-4.12 kg/day in goat bred in farms.

Average values of total solids of 12.63 % in the first and 12.46 % in the second lactation were similar and did not show significant differences ($P>0.05$), as well as fat (4.39 %, 4.36 %) and lactose content (4.26 %, 4.13 %). Dry matter content was less than 13.31-14.02 % that found by FERNÁNDEZ *et al.* (2004), but higher than 9.52-11.27 % that established by EKNÆS *et al.* (2006).

Milk fat content was similar in both lactations and these results are in accordance with findings of STRZALKOWSKA *et al.* (2006) and FERNÁNDEZ *et al.* (2004) in Murciano-Granadina dairy goat. Significantly less milk fat of 3.67-3.74 % noted by MEMISI *et al.* (2001) in domestic Balkan goat, 2.61-3.80 % by EKNÆS *et al.* (2006) in Norwegian dairy goat, 3.8 % by PARK *et al.* (2007), 3.0-3.2 % by MIN *et al.* (2005), 3.08 by BÖMKES *et al.* (2004) and 3.77 % that found out by ZAN *et al.* (2006) in alpine goats.

Table 2 shows the chemical composition of milk of Serbian White goat.

Data about lactose content in literature are different. Higher values of 4.36 % cited STRZALKOWSKA *et al.* (2004) and ZAN *et al.* (2006), also 4.57-4.93 % that found out by FERNÁNDEZ *et al.* (2004). Less lactose content in goat milk of 3.96-4.63 % noted by EKNÆS *et al.* (2006) and MIN *et al.* (2005) that found 4.06-4.24 % and STRZALKOWSKA *et al.* (2006) found 4.75 %.

Table 2
Chemical composition of milk, %
Chemische Zusammensetzung der Milch, %

	Lactation	n	Mean	SD	CV	Range
Total solids	I	12	12.63	0.29	2.32	11.94 - 13.64
	II	12	12.46	0.42	3.33	12.14 - 13.05
Fat	I	12	4.39	0.27	6.14	4.00 - 4.66
	II	12	4.36	0.35	8.05	3.89 - 5.20
Lactose	I	12	4.26	0.09	2.23	4.14 - 4.43
	II	12	4.13	0.11	2.70	3.93 - 4.32
Crude protein	I	12	3.10	0.15	4.78	2.84 - 3.32
	II	12	3.08	0.17	5.56	2.87 - 3.38
Casein	I	12	2.30	0.14	6.15	2.04 - 2.48
	II	12	2.23	0.10	4.64	2.12 - 2.43
Serum protein	I	12	0.83	0.06	6.72	0.73 - 0.92
	II	12	0.82	0.05	5.51	0.74 - 0.89
Ash	I	12	0.92	0.02	2.69	0.86 - 0.95
	II	12	0.94	0.03	3.50	0.89 - 1.01

Crude protein content was 3.10 % in the first and 3.08 % in the second lactation, casein content 2.30 and 2.23 %, and serum protein 0.83 and 0.82 %, respectively. Between means of these parameters did not found statistically difference ($P>0.05$).

Milk protein content was similar in both lactation. Higher level of milk protein was found in investigations of ZAN *et al.* (2006) that noted 3.40 %, BÖMKES *et al.* (2004) that found 3.38 % and PARK *et al.* (2007) that established 3.53-3.60 %. Less values of 2.56-2.86 % found by STRZALKOWSKA *et al.* (2006) and EKNÆS *et al.* (2006), 2.99-3.17 % by MIN *et al.* (2005). Serum protein (0.83 and 0.82 %) had higher level related to investigations of PARK *et al.* (2007) that found 0.6 %.

Ash content in milk was 0.92 % in the first and 0.94 % in the second lactation, which were less than 0.8 % cited by PARK *et al.* (2007) and of 0.71-0.83 % by FERNÁNDEZ *et al.* (2004). pH value of milk was similar in both of lactation (6.50 and 6.51) and between means did not found significant differences ($P>0.05$). pH value of milk was less than 6.69-6.72 (FERNÁNDEZ *et al.* 2004).

Tables 3 present data about fatty acids content in milk of Serbian white goat. Butyric acid content was less in milk in the first lactation (2.03 %) in regard to 2.20 % that found in the second lactation ($P<0.05$). Obtained results were in accordance to data of PARK *et al.* (2007) that noted 1.97-2.44 %. Other authors (MAREE 2003, EKNÆS *et al.* 2006) found higher values (2.65-4.09 % and 2.6 %, respectively).

Also, it was found less quantity of capronic and caprilic acid content in milk of the first lactation (2.24 and 2.51 %) in regard to 2.35 and 2.79 % found in milk of the second lactation ($P<0.05$). Similar levels of capronic acid content of 2.03.2.70 %) for both of lactation noted by PARK *et al.* (2007) and of 2.3 % by MAREE (2003), while less values of 1.56 % were found by FERNÁNDEZ *et al.* (2004) and higher of 2.57-2.89 % by EKNÆS *et al.* (2006). Analogous values for caprilic acid content of 2.28-3.04 % found by PARK *et al.* (2007), 2.23-3.07 % by EKNÆS *et al.* (2006), 2.80 % by FERNÁNDEZ *et al.* (2004) and 2.7 % by MAREE (2003).

Table 3
Fatty acid composition of milk, %
Fettsäurespektrum der Milch, %

	Lactation	Mean	SD	CV	Range
C 4:0	I	2.03[a]	0.05	2.64	1.91 - 2.10
	II	2.20[b]	0.12	5.56	1.97 - 2.34
C 6:0	I	2.24[a]	0.10	4.42	2.08 - 2.44
	II	2.35[b]	0.15	6.22	2.11 - 2.65
C 8:0	I	2.51[a]	0.14	5.67	2.28 - 2.71
	II	2.79[b]	0.37	13.32	2.37 - 3.68
C 10:0	I	9.41[x]	0.32	3.38	8.81 - 9.96
	II	10.03[y]	0.37	3.66	9.24 - 10.77
C 12:0	I	4.96	0.49	9.93	4.12 - 5.98
	II	5.05	0.36	7.21	4.55 - 5.70
C 14:0	I	10.87	0.39	3.61	10.21 - 11.69
	II	11.03	0.29	2.65	10.61 - 11.57
C 16:0	I	30.58	1.13	3.71	28.59 - 33.09
	II	30.21	1.18	3.92	28.62 - 33.06
C 16:1	I	1.79	0.32	17.99	1.11 - 2.38
	II	1.69	0.32	18.86	1.18 - 2.34
C 18:0	I	8.32	0.34	4.11	7.61 - 8.93
	II	8.35	0.39	4.63	7.55 - 8.98
C 18:1	I	21.87[x]	1.12	5.12	20.04 - 23.85
	II	19.07[y]	0.69	3.61	17.92 - 20.04
C 18:2	I	3.07[x]	0.22	7.25	2.71 - 3.41
	II	2.74[y]	0.21	7.71	2.41 - 3.16
SFA	I	70.92			
SFS	II	72.01			
UFA	I	26.73			
UFS	II	23.50			
MUFA	I	23.66			
EUFS	II	20.76			
PUFA	I	3.07			
MUFS	II	2.74			
UFA : SFA	I	0.38			
UFS : SFS	II	0.33			
PUFA : MUFA	I	0.13			
MUFS : EUFS	II	0.13			

[a,b] $P<0.05$, [x,y] $P<0.01$

Caprinic acid content was significantly different in milk in the first (9.41 %) and the second (10.03 %) lactation that presented significant difference ($P<0.01$). Equivalent content of caprinic acid of 8.85-11.00 % found by PARK *et al.* (2007), 5.64-10.81 % by EKNÆS *et al.* (2006) and 10.05 % by FERNÁNDEZ *et al.* (2004).

Lauric acid content was similar in both lactations (4.96 and 5.05 %), also miristic acid (10.87 and 11.03 %), palmitic acid (30.58 and 30.21 %) and palmitoleic acid content (1.79 and 1.69 %). Between average values of these fatty acids contents no significant differences were found ($P>0.05$).

Content of medium chain fatty acids was similar in milk in both lactations. Results related to lauric acid content agree with data of PARK *et al.* (2007) that noted 3.85-6.18 % and EKNÆS *et al.* (2006) that found 2.60-5.42 %. Lower values of 3.69 % and 4.5 % found FERNÁNDEZ *et al.* (2004) and MAREE (2003). Miristic acid content was in accordance with results of PARK *et al.* (2007) that found 1.71-11.20 %, EKNÆS *et al.* (2006) that found 6.81-13.69 % and MAREE (2003) that noted 11.1 %, but was lower than 7.27 % that found FERNÁNDEZ *et al.* (2004). Similar palmitic acid content of 23.2-34.8 % found PARK *et al.* (2007), 23.02-31.11 % found EKNÆS *et al.* (2006); 29.82 % FERNÁNDEZ *et al.* (2004) and 28.9 % MAREE (2003). Palmitoleic acid content found by other authors was similar with our results. PARK *et al.* (2007) found 1.0-2.7 %. Fewer values of 0.39-0.92 % found EKNÆS *et al.* (2006) and 2.15 % FERNÁNDEZ *et al.* (2004).

Stearic acid content of 8.32 % in the first and 8.35 % in the second lactation were similar and did not show significant differences ($P>0.05$). Oleic and linoleic acid content in milk was higher in the first lactation (21.87 and 3.07 %) than those found out in the second lactation (19.07 and 2.74 %) that was statistically significant difference ($P<0.01$).

Values of stearic acid content are in accordance to PARK *et al.* (2007) that found 5.77-13.2 % and EKNÆS *et al.* (2006) that found 5.32-16.25 %. Fewer values of 7.85 % found MAREE (2003). Obtained results for oleic acid content was similar with data of PARK *et al.* (2007) that found 15.4-27.7 % and 18.36-30.78 % that found EKNÆS *et al.* (2006) for cis isomers of this fatty acid. Higher values found FERNÁNDEZ *et al.* (2004) and MAREE (2003), 25.0 % and 27.0 % respectively. Linoleic acid content was significantly higher in the first lactation that is in accordance to data of EKNÆS *et al.* (2006) that found 1.91-2.90 %. Higher values of 5.25 % and 2.6 % were found by FERNÁNDEZ *et al.* (2004) and MAREE (2003), respectively. Content of this fatty acid depends of feeding that was improved by GALINA et HAENLEIN (2004) that found it is more represent in milk lipids with 1.0 % if goat are bred indoor and with 3.5 % if are in pasture feeding system.

Duration of the first and the second lactation in Serbian White goat is similar. Daily and total quantities of milk were significantly higher in the second lactation. Basic chemical milk composition is similar in milk in both of lactation. Saturated fatty acid content (C4:0-C10:0) was significantly higher in milk in the second lactation. Saturated (C12:0-C16:0) and unsaturated (C16:1) fatty acid content was similar in milk in both of lactation. Unsaturated fatty acid content (C18:1 and C18:2) was significantly less in milk in the second lactation. Proceeding from conclusions it can be recommended that white Serbian goat in half-intensive breeding system can produce milk of good quality for consumption as well as good raw material for cheese production.

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