

Effect of goat breed on the meat quality

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Abstract

The quality of goat meat has recently become an important aspect in the marketing of goats in Serbia. The aim of this study was to compare some goat meat quality parameters of various races and to determine the differences between them. Goat breeds were Balkan goat and Serbian white goat, both female in the age of four years. Analysis of quality parameters: chemical composition (moisture, protein, total fat, ash,), pH value, fatty acids, amino acids, microelements content, tenderness, cooking loss and colour measurements were done. Statistically significant difference was found between the samples of two groups of goat meat ($P < 0.05$) in relation to: live weight (kg), water (%), fat (%), protein (%) and ash (%), among 11 of 15 tested fatty acids, amino acid leucine, sensory examination of fresh meat for the palpability evaluated firmness and in the content of copper and zinc. Statistically significant differences between the groups did not exist regarding the pH value, fatty acids eicosenoic, cis-heptadecenoic, t-elaidic, t-linolelaidic and amino acids alanine, arginine, aspartic acid, cysteine, glutamic acid, glycine, histidine, isoleucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine and valine. Also there was no statistically significant difference in instrumental testing of the meat color, sensory evaluation of surface color, visual evaluated structure, olfactory evaluated odor and iron and manganese. These results suggest that the race of animal has an impact on meat quality.

Keywords: chemical composition, goat, meat, quality, race.

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Goat meat has about the same nutritional value as meat of sheep (more precisely, more protein and less fat compared to sheep meat). Anaeto *et al.* [1] consider that, due to its molecular structure, goat meat is easier to digest. The goat meat in the human diet, according to Anaeto *et al.* [1] is a healthier alternative compared to other types of red meat as it contains low levels of saturated fatty acids and cholesterol. According to Devendra [2], the polyunsaturated fatty acids are prevalent in meat of goats, and a diet rich in unsaturated fatty acids is correlated with a reduced risk of stroke and coronary diseases. In addition, the essential amino acids such as lysine, threonine and tryptophan are present in the meat of goats. Regardless of the nutritional value, it is still less appreciated due to the specific scents and flavors, even more so if the animal is older [3].

Growing and goat meat consumption, despite this qualitative composition, is conditioned by religion, traditions and customs, as well as by market and consumer habits [4]. According to official data of the Ser-

bian Chamber of Commerce in 2011, the number of goats in Serbia is 130.000. They are grown in the mountainous, less economically developed areas, with 1–2 animals per household, or in mini farms (20, 30, 50 and more goats). Regarding composition of the present breeds of goats, Alpino (2–3%), Serbian white breed (15%), various hybrids (35%) and Balkan (47%) goats are present. The production of goats in Serbia is focused on milk and meat production, where the milk is a priority [5]. In the world, especially in Asia and Africa, the goat and kid meat is of great importance in human nutrition. The goat meat is increasingly required in developed countries due to its high nutritional value [6–8].

Since the testing of fattening and slaughter characteristics of Balkan goats, purebred grown in Serbia (Alpine, Sanen, Bunte Deutsche Edelziege and others), are not so common, there is really little literature data regarding these properties of goats and kids [9]. This paper presents the characteristics of production, as well as some carcass characteristics of domestic Balkan goat and Bunte Deutsche Edelziege race. Balkan goat still in a large percentage (about 47%) participates in the racial composition of the population of goats being raised in Serbia [10]. In Serbia, little is known about the quality of goat meat compared with other species, par-

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ticularly the lack of knowledge of the meat quality of autochthonous goat breeds and there is practically no information on the characteristics of meat of goats and kids of Serbian White and Balkan goat. In addition, the quality of goat meat has recently become an important aspect in the marketing of goats in Serbia.

The aim of this study was to collect and compare data on the quality of meat of domestic Serbian white and Balkan goat of the same age.

MATERIALS AND METHODS

Source of goat meat

Material was used from two races of goat meat (20 goats from each), Balkan goat and Serbian white goat, both female in the age of four years. The goats were got from private farms in the rural area of Stara Planina. The goats were raised at the same time. Objects for the goats were with conditions that were satisfactory for goat breeding. Watering was *ad libitum*.

Plane of nutrition

Diet of goats during the winter consisted of hay which was collected from natural pastures (3.5 kg per day) and concentrate (0.25 kg per day). In the summer months, the goats were pastured and fed with concentrate in the amount of 0.25 kg per day. The concentrate was made of maize meal, wheat bran with added sodium chloride and premix. Goats were slaughtered in an experimental slaughter house in the Institute for animal husbandry.

Analysis of quality parameters

Material used for the determination of chemical composition, fatty and amino acids, microelements content was *m. longissimus dorsi* from left side of halves. For tenderness, cooking loss, colour measurement and sensory analysis the same muscle from the right side of halves was used.

Moisture content [11], fat content [12], ash content [13], protein content [14] and pH value [15] were all determined according to ISO. Chemical parameters and pH were measured in meat 24 h after slaughter.

Modified Folch–Lees method [16] was applied for lipid extraction from 1 g homogenized tissue with chloroform–methanol mixture (2:1, V/V). The combined extracts were washed, filtered and evaporated to obtain purified lipid fraction. After the lipid hydrolysis with KOH in methanol, esterification of the fatty acids to methyl esters was performed, evaporated to dryness in a stream of nitrogen. Analysis of FAMES was performed by gas chromatography technique (GC6890N, Agilent Tech., USA) comparing with FAMES standard (Supelco, USA) [17].

The amino acids composition was determined by AOAC method 982.30 [18], for most amino acids by acid hydrolysis with 6 M HCl for 24 h at 110 °C, total sulfur amino acid after performic acid oxidation followed by acid hydrolysis and tryptophan after alkaline hydrolysis. Dabsyl amino acids were prepared from hydrolyzate [19] after reagent was added, dried under vacuum, redissolved and separated using a Waters Breeze HPLC System (Waters Corporation, Milford, MA) consisted of a binary pump (Waters 1525), UV/Vis detector (Waters 2487), reversed-phase column SUPELCOSIL LC-DABS (15 cm×4.6 mm ID, particle size 3 µm) equipped with a guard column Supelguard™ LC-18-T and a two-eluent mobile phase potassium dihydrogen phosphate as solvent A, and acetonitrile:2-propanol (75:25) as solvent B at a flow rate 2 mL/min at room temperature. The eluted DABS-AA and DABS-norleucine, as internal standards, were detected by UV/Vis detector at 436 nm wavelengths, respectively. A commercial amino acid mixture (Sigma, St. Louis, MO) was used as standard.

The microelements analysis was conducted by FAAS technique according to AOAC method 999.10 [20], using advanced microwave digestion system Ethos 1 (Milestone, Italy) and atomic absorption spectrophotometry AAnalyst 300 with HCL-lamps (Perkin-Elmer, USA). Dried samples (0.2–0.5 g) are digested with nitric acid and hydrogen peroxide in microwave oven. The microelements were determined at characteristic wavelengths separately for each element and calculated. Commercial individual standards (Merck, Germany) were used to prepare the standard calibration mixtures.

Principle of the method is to determine the mass loss due to heat treatment by measuring the weight before and after completing the heating and subsequent cooling of the sample. Goat meat is heat treated by boiling in a water bath at 90 °C for 60 min.

Tenderness was determined by Warner–Bratzler instrument. It was done by measurement of force, expressed in lb and converted into N, which was required to cut a cylindrical sample obtained by drill 0.5 inches in diameter in the direction of muscle fibers from heat-treated and cooled sample. The result was expressed as the mean value of 8 to 10 measurements [21].

The color was measured on the fresh meat cuts (*musculus longissimus dorsi*), from the right side of each carcass ($n = 20$, for each sample). CIE, CIEL*a*b* [22] were determined using Minolta chromameter CR 400 (Minolta Co. Ltd., Osaka, Japan) in D-65 lighting, with standard angle of 2 degrees of shelter and 8 mm aperture of the measuring head. These results were expressed in CIE system as the average: γ (reflectance or brilliance, %), λ (dominant wavelength, nm) and P (color purity, %) [23] and in CIEL*a*b* as: L^* (psy-

chometer light), a^* (psychometer tone) and b^* (psychometer chroma).

The sensory evaluation included appearance (color and surface), texture (structure and firmness) and aroma (odour) in each part of the meat (*musculus longissimus dorsi*). The same sensory evaluation was made on meat backed in Al folia at the temperature of 225 °C up to achieving of 75 °C in the inner part of meat, as well the textural characteristics – softness, chewiness and tenderness, and flavor (smell and taste). The sensory evaluation was made by ten trained assessors, according to relevant ISO [24]. Sensory analysis was made by according to the methodology described by the Ivanovic *et al.* [3].

Data obtained in this study were analyzed by descriptive and analytical statistical parameters: mean value (M), standard deviation (SD) by using MS Excel 2003 and analysis of variance ANOVA. The differences between the averages were compared by t-test at the level of significance of 95% [25].

RESULTS AND DISCUSSION

Live weight, chemical composition, pH value, tenderness, cooking loss and microelements

The populations of Serbian white goats had bigger live weight ($P < 0.05$) than Balkan goats. The average water means, total fats, proteins and ash expressed as percentage, showed that there were differences between compared groups ($P < 0.05$). The pH value of populations of Serbian White goats meat did not differ ($P > 0.05$) from Balkan goat. Regarding tenderness and cooking loss, there were significant differences ($P < 0.05$) between compared groups. There was a statistically significant difference ($P < 0.05$) in the content of copper and zinc between the samples, while in the content of iron and manganese was no statistically significant difference ($P > 0.05$) in these same samples of meat.

Results for moisture percentage and fat percentage which are shown in Table 1 and refer to the Balkan goat meat, are not in accordance with the results that we got from an earlier study for chemical and sensory

characteristics of Bunte Deutsche Edelziege and Balkan goat meat [3]. Results for protein, ash and pH, which refer to the Balkan goat meat (Table 1), are consistent with those in previous study [3].

Wattanachant *et al.* [26] examined the quality characteristics of raw goat meat obtained from different ages and breeds of goats: Anglonubia×Tai native aged one and three and race Saanan×Tai native in age of seven years, 24 h after slaughter. Comparing the results of these authors for the breed Anglonubia×Tai native, aged three years, for moisture %, fat %, protein %, ash %, pH value, cooking loss % and tenderness, g/cm^2 , it could be noted that they are not in line with the results shown in the Table 1. Sen *et al.* [27] examined the quality of the meat of one year old goats. Their results for moisture % and protein % are in agreement with our results concerning the Balkan goat meat, while fat %, pH and cooking loss % are not in line with our results, but tenderness comply. Our results, except pH, which are related to the Serbian white goat, are in agreement with the results of Paleari *et al.* [28], but the results obtained for the Balkan goat are inconsistent.

Results shown in Table 1 are not in agreement with the results of Webb *et al.* [29] who presented in their review paper the mineral concentrations in muscle for Cu, Mn, Fe and Zn.

Fatty acid analysis

The results of fatty acid composition in *m. longissimus dorsi* of Serbian White goat and Balkan goat, slaughtered at the age of four years, are presented in Table 2. Comparison between them showed that the lauric, myristic, pentadecanoic, pentadecenoic, palmitic, palmitoleic, margaric, stearic, oleic, linoleic, alfa linolenic and eicosenoic fatty acids statistically significantly differ ($P < 0.05$). There was no statistically significant difference ($P > 0.05$) between compared groups in content of cis – heptadecenoic, t – elaidic, t – linoleidic and eicosenoic fatty acids. The ratio of unsaturated/saturated fatty acids in meat of Serbian white goats was 0.96 and in Balkan goats was 0.92.

The results obtained in this study are not entirely consistent with the results we obtained in the previous

Table 1. Live weight, chemical composition, pH value, tenderness, cooking loss and microelements (mg/kg) of goat meat of Serbian white goat and Balkan goat; a, b – means within the same column with different superscripts differ significantly ($P < 0.05$)

Parameter, n = 20	M±SD		Parameter, n = 20	M±SD	
	Serbian white goat	Balkan goat		Serbian white goat	Balkan goat
Live weight, kg	50.90±3.29 ^b	44.70±1.13 ^a	Ash, %	1.06±0.01 ^b	1.04±0.01 ^a
Water, %	75.42±0.30 ^b	74.51±0.13 ^a	pH value	5.67±0.03	5.67±0.03
Fat, %	3.55±0.40 ^a	3.92±0.14 ^b	Tenderness, kg/cm ²	7.25±0.81 ^a	7.75±0.73 ^b
Proteins, %	19.95±0.48 ^a	20.55±0.05 ^b	Cooking loss, %	39.41±1.99 ^a	40.60±1.68 ^b
Copper	0.73±0.17 ^b	0.58±0.15 ^a	Manganese	0.06±0.02	0.07±0.02
Iron	7.25±1.22	6.51±1.18	Zinc	4.08±0.40 ^a	4.56±0.48 ^b

Table 2. Fatty acid composition of Serbian white and Balkan goat, mg/g of meat; a,b – means within the same column with different superscripts differ significantly ($P < 0.05$)

Parameter, n = 20	M±SD		Parameter, n = 20	M±SD	
	Serbian white goat	Balkan goat		Serbian white goat	Balkan goat
Lauric acid (C12:0)	0.34±0.03 ^b	0.29±0.01 ^a	t-Elaidic acid (C18:1)	0.13±0.05	0.11±0.03
Myristic acid (C14:0)	2.46±0.05 ^b	1.32±0.03 ^a	Oleic acid (C18:1)	13.96±0.23 ^a	15.23±0.19 ^b
Pentadecanoic acid (C15:0)	0.37±0.03 ^b	0.26±0.02 ^a	t-Linolelaidic acid (C18:2)	0.12±0.04	0.10±0.04
Pentadecenoic acid (C15:1)	0.15±0.01 ^b	0.06±0.01 ^a	Linoleic acid (C18:2)	0.86±0.04 ^a	1.32±0.02 ^b
Palmitic acid (C16:0)	9.12±0.16 ^a	11.91±0.31 ^b	AlfaLinolenic acid (C18:3)	0.20±0.01 ^a	0.47±0.01 ^b
Palmitoleic acid (C16:1)	1.77±0.08 ^b	1.23±0.03 ^a	Eicosenoic acid (C20:1)	0.07±0.01	0.08±0.01
Margaric acid (C17:0)	0.50±0.03 ^b	0.08±0.01 ^a	SFA	17.80	20.02
cis-Heptadecenoic acid (C17:1)	0.05±0.02	0.07±0.02	USFA	17.31	18.67
Stearic acid (C18:0)	5.00±0.10 ^a	6.16±0.19 ^b	USFA/SFA	0.96	0.92

study. During the year 2012 we investigated a fatty acid composition in Bunte Deutsche Edelziege race, of different age, six and three years old [30]. Paleari *et al.* [28] examined the fatty acids in fresh thigh 2–3-year-old goats, race Frisa×Frontalasca crosses. The findings of fatty acids: lauric acid, myristic acid, pentadecanoic acid, palmitic acid, margaric acid, stearic acid and linoleic acid, are not in agreement with our results shown in Table 2.

Webb *et al.* [29] in their paper show the values of fatty acids for Boer goats meat: tridecanoic acid, myristic acid, pentadecanoic acid, palmitic acid, palmitoleic acid, margaric acid, stearic acid, oleic acid, eicosenoic acid, saturated fatty acids and unsaturated fatty acids. These values do not comply with our results shown in Table 2.

Zervas and Tsiplakou [31] in their review paper showed the percentage of individual fatty acids in muscle tissue. The results that we obtained (Table 2) are consistent with the values presented by Zervas and Tsiplakou [31] for palmitic acid, palmitoleic acid, stearic acid and oleic acid, but did not agree with the values for myristic acid, linoleic acid and alpha linolenic acid.

Amino acid analysis

Table 3 shows the results of the amino acid composition (g/100 g) of protein in the *musculus longissimus dorsi* of Serbian white and Balkan goats. It could be noted that between the amino acid alanine, arginine, aspartic acid, cysteine, glutamic acid, glycine, histidine, isoleucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine and valine difference was not statistically significant ($P > 0.05$), while between the amino acid leucine there was a statistically significant difference ($P < 0.05$) between the analyzed samples.

Webb *et al.* [29] in their paper showed the presence of the amino acids in meat of one year old goats. The results of these authors agree with the results given in Table 3.

Ferreira [32] in his study gave the amino acids content present in carcass of Boer goats. These results are somewhat lower than the values presented in Table 3.

Brzostowski *et al.* [33] examined amino acid profile of protein in meat from male kids race French Alpine. The results listed there are in agreement with the results shown in Table 3.

Table 3. Amino acid composition (g/100 g) of Serbian white goat and Balkan goat protein; a,b – means within the same column with different superscripts differ significantly ($P < 0.05$)

Parameter, n = 20	M±SD		Parameter, n = 20	M±SD	
	Serbian white goat	Balkan goat		Serbian white goat	Balkan goat
Alanine	4.93±0.87	4.98±0.95	Lysine	8.36±1.55	8.11±1.60
Arginine	5.44±0.86	5.54±0.89	Methionine	3.20±0.57	3.51±0.60
Aspartic acid	8.66±0.95	8.74±0.90	Phenylalanine	4.22±0.76	4.55±0.75
Cysteine	1.02±0.21	1.04±0.22	Proline	3.45±0.80	3.37±0.84
Glutamic acid	14.41±1.70	13.95±1.59	Serine	3.92±0.82	3.89±0.87
Glycine	3.97±0.80	3.91±0.78	Threonine	4.84±0.94	4.97±0.90
Histidine	3.62±0.72	3.84±0.73	Tryptophan	1.19±0.27	1.27±0.33
Isoleucine	4.63±0.91	4.71±0.96	Tyrosine	4.17±0.78	4.44±0.75
Leucine	8.13±0.22 ^a	8.38±0.33 ^b	Valine	4.97±0.92	5.05±0.96

Instrumental determination of color

Table 4 shows the results of instrumental analyses of the *musculus longissimus dorsi* of the mentioned goat breeds in CIE and CIEL**a***b** system. According to the values of the parameters of this system it could be seen that there were no statistically significant differences ($P > 0.05$), *i.e.*, there was no difference in color between the samples.

Results obtained by instrumental determination of color in this study (Table 4) are in correlation with the results from our previous investigation regarding Balkan goat and Bunte Deutsche Edelziege goat [3].

Our results are not in agreement with the results of Wattanachant *et al.* [26] who investigated the quality characteristics of raw goat meat obtained from different ages and breeds. The values presented in Table 4 comply with the results by mentioned authors for the breed Anglonubian×Thai native goats aged 3 years. Results shown in Table 4 are compatible to the results of Teixeira *et al.* [34] who investigated ageing effect on fresh meat color.

Sensory analysis

Sensory evaluation of fresh meat (Serbian white goat ($n = 10$) and Balkan goat ($n = 10$)) is presented in the Table 5.

Table 4. Colour parameters of the *m. longissimus dorsi* of Serbian white and Balkan goats expressed in CIE and CIEL**a***b** system; reflectance – y , dominant wavelength – λ , P (color purity, %), lightness – L^* , redness – a^* , yellowness – b^*

Parameter, $n = 20$	$M \pm SD$		Parameter, $n = 20$	$M \pm SD$	
	Serbian white goat	Balkan goat		Serbian white goat	Balkan goat
$y / \%$	78.29±1.16	77.69±0.96	L^*	33.83±1.84	32.77±2.01
λ / nm	656.07±7.70	659.12±7.73	a^*	20.46±1.20	19.78±1.25
$P / \%$	21.24±1.50	20.24±1.89	b^*	4.94±0.50	4.63±0.50

Table 5. Sensory evaluation of fresh meat of Serbian white and Balkan goats ($M \pm SD$); a, b – means within the same column with different superscripts differ significantly ($P < 0.05$)

Attributes, $n = 10$	Appearance	Texture		Flavour	Percentage of maximal possible quality	Weighted average
	Colour surface	Visual evaluated structure	Palpatory evaluated firmness	Olfactory evaluated odour		
Coefficient of importance						
	4	3	3	10	100	100/20
Serbian white goat	19.50±0.43	12.50±0.38	12.00±0.40 ^a	48.00±0.49	92.00	4.60
Balkan goat	19.80±0.42	12.80±0.41	13.00±0.43 ^b	48.00±0.49	93.60	4.68

During the sensory evaluation of fresh meat of goats a statistically significant difference ($P < 0.05$) for the characteristic palpatory evaluated firmness between the groups was noted, while the surface color, visual evaluated structure, evaluated olfactory odor showed no statistically significant difference ($P > 0.05$).

Results of sensory evaluation are presented in Tables 5. Among the color of fresh meat, statistical

differences were not found ($P > 0.05$). The color of meat of Balkan goat obtained in the evaluation was 19.80 and of Serbian white goat meat was 19.50. Visual structure and firmness of fresh meat were also similar ($P > 0.05$). Structure was evaluated for meat of Balkan goat as 12.80 and for Serbian white goat meat 12.50.

During sensory evaluation of fresh goat meat samples, significant differences were found ($P < 0.05$) for the examined characteristic, palpatory evaluated firmness, between groups with 13.00 for meat of Balkan goat and 12.00 for Serbian white goat. Olfactory odor was evaluated for Balkan goat meat with 48.00 and for Serbian white goat meat with 48.00, which means that there was no statistically significant difference ($P > 0.05$). Sensory evaluation is very difficult to compare with the findings of other authors.

CONCLUSION

Comparing the results of analysed meat quality parameters of two goat races, Balkan goat and Serbian White goat, significant differences were noted in water means, total fats, proteins, ash, cooking loss, as well as for amino acid leucine content and in sensory evaluation of fresh meat for the palpatory evaluated firmness. Statistically significant difference ($P < 0.05$) for

copper and zinc content was also present, while the ration of unsaturated/saturated fatty acids in Serbian white was 0.96 and in Balkan goats 0.92.

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IZVOD

UTICAJ RASE KOZA NA KVALITET MESA

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Kozije meso ima otprilike istu hranljivu vrednost kao i ovčije (bliže rečeno više belančevina, a manje masti). Zbog niske zastupljenosti zasićenih masnih kiselina i holesterola, kozije meso u ishrani ljudi je zdravija alternativa u poređenju sa drugim vrstama crvenog mesa. Bez obzira na nutritivnu vrednost, ono je ipak manje cenjeno zbog specifičnog mirisa i ukusa koji su intenzivniji kod starijih životinja. U Srbiji se malo zna o kvalitetu kozijeg mesa u poređenju sa ostalim vrstama, a posebno je nedovoljno poznavanje kvaliteta mesa autohtonih rasa koza. Cilj ovog istraživanja bio je da se prikupe i uporede podaci hemijskog sastava, pH vrednosti, sastava masnih i amino kiselina, pojedinih mikroelemenata, boje i mekoće (instrumentalno), senzorne analize svežeg mesa i određivanje kala toplotne obrade srpske bele i balkanske koze iste starosti. Iz uzoraka *m. longissimus dorsi*, uzetih nakon klanja navedenih životinja, ispitivan je hemijski sastav i pH vrednost, primenom ISO metoda. Sastav masnih kiselina i određen je primenom gasne hromatografije (GC6890N, Agilent Tech., USA) i poređen je sa standardom masnih kiselina (standard mix of FAMES 37, Supelco, USA). Aminokiseline u navedenim uzorcima određene su nakon hidrolize tkiva primenom AOAC metode 982.30. Određivanje mikroelemenata u mesu koza vršeno je u metodom AOAC method 999.10. Princip metode za određivanje kala toplotne obrade sastoji se u određivanju gubitka mase usled toplotne obrade uzorka. Određivanje mekoće je obavljeno aparatom Warner–Bratzler. Boja svežeg mesa je takođe određivana u *m. longissimus dorsi* upotrebom Minolta chromameter CR-400. Senzornu analizu su radili obučeni ocenjivači u skladu sa ISO metodom. Dobijeni rezultati su statistički obrađeni primenom programa MS-Excel 2003, ANOVA, i utvrđene razlike srednjih vrednosti poređene *t*-testom na nivou značajnosti 99 i 95%. Na osnovu dobijenih rezultata može se zaključiti da je postojala statistički značajna razlika u kvalitetu mesa između ispitivanih uzoraka.

Ključne reči: Hemijski sastav • Koze • Meso • Kvalitet • Rase