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The impact of diet on the quality of fresh meat and smoked ham in goat

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ABSTRACT

Goat meat contains low amount of saturated fatty acids and cholesterol and it is a healthier alternative compared to other types of red meat. The aim of this study was to investigate the influence of different diets of goats on the basic chemical composition, fatty acids composition, volatile compounds, color and sensory evaluation of fresh meat and smoked ham (m. superficial gluteal). Meat was obtained from goats of Balkan breed, from three different regions (mountain, hilly and plain), 40 animals per region, about 4 years old at slaughter. Statistically significant difference ($P < 0.05$) was noted between values of live weight, protein, fat, moisture, ash, fatty acids, volatile compounds and color and sensory characteristics determined in fresh meat of goats from all regions. Two compounds from the group of aromatic hydrocarbons and compounds from the group of phenols were not determined in fresh meat, while they were present in smoked ham. Alfa-linolenic acid (n-3 FA) is found in higher percentage in goat meat from Mountain region, as well as Linolelaidic acid and Linoleic acid. In goat meat from Mountain region presence of volatile substances is lesser than from Hilly and Plain regions. The results suggest that diet has an impact on the quality of goat meat and goat meat products.

1. Introduction

In Serbia, the goats are bred especially in mountainous areas due to their ability to climb. The quality of goat products is affected by many factors such as: climate, terrain and soil characteristics, the primary abiotic and biotic factors and environmental conditions of milk and meat production (Zujovic et al., 2008). Goat has a less pronounced capacity for meat, but it is more fertile than the sheep, so the production of young goat meat is significant. On the basis of chemical composition, goat and kids meat regarding nutritional and biological value is not inferior to other types of meat (Todaro et al., 2004). Goat meat has a significant role in human nutrition because it contains essential amino acids such as lysine, threonine and tryptophan. Breeding of goats and goat meat consumption, despite mentioned excellent quality, is determined by religion, traditions and customs, as well as market and consumer habits. Although, indicated by Webb et al. (2005), its composition is constantly being redefined.

Animal feeding affects quality of the meat by muscle growth, muscle and fat ratio, fat accumulation, and the fatty acid composition (Casey and Webb, 2010). Goat meat presents an important source of proteins worldwide, especially in developing countries (Biswas et al., 2007). As goat meat contains low amount of saturated fatty acids and cholesterol, according to Anaeto et al. (2010) it present a healthier alternative compared to other types of red meat. According to the same author, polyunsaturated fatty acids are prevalent in meat of goats, and diet rich in unsaturated fatty acids is correlated with a reduced risk of stroke and coronary heart disease, which indicates important role of goat meat in human diet. The composition of fatty acids in the meat and milk of ruminants depends on their nutrition (Grubic et al., 2005). Lipids from diets get hydrolyzed in the rumen. Unsaturated fatty acids from feed go through the process of biohydrogenation by the activities of ruminal microorganisms. When biohydrogenation in the rumen is not complete, part of conjugated linoleic acid (CLA) manages to evade it so it gets absorbed in such form to supply animal tissues and products by isomers of CLA.

The fatty acids transformation forms substances which directly affect the smell and taste of goat meat. Slightly rancid odor is caused by hexanal which comes mainly from linoleic and arachi-

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donic acid (Martin et al., 2002). Other volatile aldehydes such as heptanal, octanal, nonanal, and decanal derive mainly from oleic acid (Machiels et al., 2004). Fatty acids have been specifically implicated in sheep and goat flavours. 4-ethylocatanoic fatty acid is mainly responsible for strong smell of goat. This acid was detected in goat meat, lamb and mutton, as well as in cheese made from milk of these species. In addition to fatty acids, taste and aroma are also affected with other compounds: hydrocarbons, aldehydes, ketones, alcohols, furans, thiophenes, pyrrols, pyrazines, oxazoles, thiazoles and sulfurous compounds (Todaro et al., 2004).

Bearing in mind the apparent trend of increasing production and consumption of goat meat in the world, the aim of this study was to investigate the influence of diet on the quality of goat meat and therefore the impact on the quality of meat products.

2. Materials and methods

Goats of Balkan breed, 40 animals per region, about 4 years old at slaughter, which was done in period August-September, were used in this 3 years long investigation. All goats were selected from private farms in three rural areas of Serbia: mountain region Stara planina (hight 1000–1500 m), hilly region of central Serbia (about 400 m altitude) and Vojvodina plain region. The goats were raised during the same period. Watering was ad libitum. Diets of goats during the winter were consisted of hay which was collected from natural pastures (3.5 kg/day per animal) and concentrate (0.25 kg/day per animal). In the summer months, the goats were pastured and fed with concentrate in the amount of 0.25 kg/day. The concentrate was made of maize meal, wheat bran with added sodium chloride and premix (consisted of vitamins: A, D3, E, K3, C, B1, B2, B12, Niacin, Ca-pantothenate and minerals: Fe, Cu, Mn, Zn, J, Se, Co and Mg).

The hay originated from natural meadows of selected regions, which composition is shown in Table 1.

Plants were determined and their names were harmonized with the nomenclature according to publications of Zlatkovic et al. (2005), Lakusic and Cetkovic (2007) and Stevanovic (2012).

Animals were slaughtered in slaughter house in the Institute for animal husbandry, after recorded preslaughter live weights with electrical stunning using captive bolt stunning followed by cutting carotid arteries and jugular veins. Carcasses were processed in the way common for industrial production, and cooled at 4 °C for 48 h. Processed goat hams with associated bones were dry salted with about 6% nitrite salt (99.5% sodium chloride and 0.5% sodium nitrite). Hams were kept in nitrite salt for 30 days at 5 °C. During the salting period they were rotated every second day. Desalting was carried out in cold water for 24 h while thereby the water was changed four times. Hams were cold-smoked for 45 days on moderate air circulation, humidity 70–78%. The smoke temperature did not exceed 20 °C. During the first 10 days smoking was carried out every day for 2 h, but between the tenth and forty fifth day it was done every second day for 2 h. After the smoking period, hams were air dried (18–20) °C for 45 days more.

The material used for the determination of chemical composition, fatty acids and volatile compounds was m. gluteus superficialis. Moisture content was determined by ISO 1442 (1997), fat content by ISO 1443 (1973) and ash content by ISO 936 (1998). The protein content was calculated from nitrogen content multiplied with 6.25 using ISO 937 (1978), sodium chloride content was determined by ISO 1841-1 (1996), pH value by ISO 2917 (1999) and nitrite content by ISO 2918 (1975).

AOAC 996.06 (1996, 2001) was applied and analysis of FAMEs was performed by an internal standard method using a gas chromatograph (GC6890N, Agilent Tech., USA) with column DB-23 (60 m × 0.25 mm ID, 0.15 μm) and comparing with standard mix of FAMEs 37 (Supelco, USA).

Volatile compounds analysis were conducted by Likens-Nickerson extraction procedure (Likens and Nickerson, 1964) and ISO 15303, 2001 using an GCMS-QP2010 Ultra (Shimadzu Corporation, Japan) (EIMS, electron energy = 70 eV, scan range = 30–350 amu, and scan rate = 3.99 scans/s) with SUPELCOWAX® 10Capillary GC Column (Supelco, Sigma-Aldrich Co. LLC) (30 m × 0.25 mm ID, particle size 0.25 μm). The carrier gas was helium with a flow rate of 1 mL/min, and the injection temperature was 200 °C. The oven temperature was programmed to initially hold for 10 min at 40 °C, and subsequently programmed from 40 °C to 120 °C at a rate of 3 °C/min and at a rate of 10 °C/min from 120 °C to 250 °C where it was held for another 5 min. Identification of the peaks was based on comparison of their mass spectra with the spectra of the WILEY library and in addition, in some cases, by comparison of their retention times with those of standard compounds.

The colour was measured on the fresh and smoked meat cuts (*musculus superficial gluteal*), from the right side of each carcass. CIE (CIE Colorimetry Committee, 1986) and CIE L*a*b* (CIE Colorimetry, 1986) color coordinates were determined using Minolta Chromameter CR 400 (Minolta Co. Ltd., Osaka, Japan) in D-65 lighting, with standard angle of 2° of shelter and 8 mm aperture of the measuring head. These results were expressed in CIE system as the average: y (reflectance or brilliance, %), λ (dominant wavelength, nm) and P (color purity, %) and in CIE L*a*b* were given as the mean values: L* (psychometer light), a* (psychometer tone) and b* (psychometer chroma). Sensory analysis were conducted according ISO 8586 (2012) and ISO 8587 (2006, 2013).

2.1. Statistical analysis

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

3. Results

3.1. Chemical composition in meat

In Table 2 are presented data of live weights, chemical composition, pH of fresh meat (m. gluteus superficialis) and chemical composition and pH value of ham, obtained from goats which were grown in Mountain region, Hilly region and Plain region.

3.2. Fatty acids in meat

Results of the fatty acid composition in *m. gluteus superficialis* of goat meat and smoked ham from these goats are presented in Table 3.

3.3. The volatile compounds

Table 4 shows the results obtained by analyzing the presence of specific volatile substances in fresh meat and smoked ham.

3.4. Color of fresh goat meat and smoked ham

Color parameters (L* a* b*) of fresh meat samples taken from a goat leg and samples of smoked ham, originated from the same leg, are presented in Table 5.