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DETERMINATION OF QUALITY PARAMETERS OF HERZEGOVINIAN DRY SMOKED GOAT MEAT

SUMMARY

Herzegovinian dry smoked goat meat is a traditional cured meat product made of the whole carcass of adult castrated bucks, dry salted and cold smoked. It has been traditionally produced in Herzegovina for centuries, especially in the wider area of the Stolac municipality. This study aimed to determine the quality parameters of Herzegovinian dry smoked goat meat. For the research, the samples were made into eight separate anatomical units (neck, sirloin, leg, loin, flank, breast, shoulder, hindshank), on which the tests were performed. Sensory, physical and chemical tests were performed on the examined samples. Also, to monitor changes in fats, its hydrolytic and oxidative changes (acid and peroxide number, TBARS value) were determined. The sensory evaluation determined that the examined samples were characterized by a "pleasant" aroma. Chemical tests revealed significant differences in the values of the examined parameters between samples from different anatomical regions. The least hydrolytic and oxidative changes were found in the breast samples which had the highest fat content. PCA analysis revealed a positive correlation between moisture content and pH value, as well as a negative correlation of these parameters with fat content. Furthermore, a significant positive correlation was found between NaCl content, ash, peroxide number, and TBARS values. Fat content was characteristic in the breast samples, moisture in the shoulder samples, protein in the hindshank samples, while NaCl and ash content were characteristic in the neck samples.

Keywords: quality, traditional product, sensory and physical attributes, Herzegovina, chemical parameters

INTRODUCTION

Dried meat products are highly valued products in the diet of the population and represent a good source of protein of great biological value.

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Traditional, preserved cured meat products that originate from a certain geographical area are characterized by specific sensory properties, and as a rule, top quality. The properties and quality of these products are significantly influenced, among other things, by the general characteristics of the climate, and especially by specific climatic conditions of a certain geographical area (Radovanović *et al.*, 2005; Dumić, 2008). Traditionally, meat processing is a means of extending shelf-life (preserving) and producing a convenient item for later use. Processing is aimed at reducing the enzyme activity in the meat, retarding oxidation of the fat, and preventing spoilage by microorganisms. These aims have been achieved through drying, curing with salt, or smoking meat. Either one or a combination of these procedures in various regions of the world has preserved goat's meat (Casey *et al.*, 2003).

Goat meat is an important source of proteins worldwide, especially in developing countries. It has about the same nutritional value as sheep meat (contains more proteins and less fat compared to sheep meat) (Ivanović *et al.*, 2014). The most important component of goat muscle tissue is, of course, proteins, whose nutritional value depends on the presence of certain essential amino acids. According to the presence of amino acids, goat meat fully meets the nutritional needs of an adult person (Ivanković *et al.*, 2013). Goat meat, due to its high protein content, low amount of intramuscular and subcutaneous fat, the richness of macro and microelements and water, and fat-soluble vitamins are of high nutritional value (Kegalj *et al.*, 2011). Also, the amount of fat, especially cholesterol, is low (Troskot & Pavičić, 2007). The chemical composition of goat meat, and more specifically intramuscular fat, is influenced by factors such as live weight, genotype, muscle, gender, and diet (Madruga & Bressan, 2011).

In Bosnia and Herzegovina, the processing of goat meat is symbolic and is mainly reduced to the thermal processing of goat meat (goat roasting) and the production of traditionally cured meat products (goat "stelja", "pastrma", "plaha" and dry smoked goat meat). One of them is the autochthonous "Herzegovinian dry smoked goat meat". The production of this traditional product is specific to the area of Eastern Herzegovina, and especially to the wider locality of the municipality of Stolac. The peculiarity of the Mediterranean climate and plant cover, the specificity of the smell and aroma of meat, as well as the production technology, gives this traditional meat product exceptional sensory properties (Ganić *et al.*, 2019; 2021). According to the Regulation of ground meat, meat preparations and meat products (Official Gazette of B&H No. 82/13), Herzegovinian dry smoked goat meat is classified as a preserved dried meat product where the moisture content must be less than 60%, water activity less than 0.93 and it must be stored at temperatures up to 15 °C. In Bosnia and Herzegovina, goat meat is most often consumed in the form of roast goat meat. Very small quantities are processed exclusively as dried meat products - goat "stelja". This way of meat technological processing is characteristic of certain areas such as Central Bosnia and Eastern Herzegovina. The production of goat "stelja" has an exclusively artisanal character, and a very small number of

artisanal meat processors are engaged in the production. In the last few years, based on the experience of producers, there has been a significant demand for cured meat products made from goat meat. This trend is probably a consequence of consumers being better informed about the nutritional characteristics of this type of meat. Also, meat processors point out that in the last two years (during the Covid 19 pandemic), there has been an enormous demand for goat "stelja" and tallow (goat fat).

"Herzegovinian dry smoked goat meat" is a traditional meat product, by which the area of Eastern Herzegovina, primarily the municipalities of Stolac and Berkovići, was recognizable in the past. Production was characteristic of the hill and mountain areas of these municipalities. Based on the oral traditions of the domicile population, in the middle of the 20th century, about 200 "plahas" of dried goat were sold per week at the local market in Stolac. Bearing in mind the fact that in the last 10 to 15 years, there is a strong trend of extinction and displacement, especially in hilly and mountainous rural areas, this production has been reduced to a minimum. Nowadays, in the wider locality of the municipality of Stolac, there is only one meat processor engaged in the production of "Herzegovinian dry smoked goat meat". Its annual production is around 150 "steljas", which are mainly placed on the Sarajevo market (market places). Based on the current circumstances, it is very likely that the production of this indigenous product will be shut down soon. On the other hand, the tradition, quality, popularity of the product, and the ubiquitous trend of consuming indigenous food, impose the need to preserve this product, i.e. its production. For this purpose, pioneering research on the technology and quality of "Herzegovinian dry smoked goat meat" was conducted. The obtained results will be used in the process of protection of this product with the label of authenticity on the national level. With the protection of "Herzegovinian dry smoked goat meat", the product would gain even more popularity. Preconditions would be created for its more significant production, and in the future, it could certainly have exceptional export potential. Local communities would certainly invest more in the infrastructure of rural areas, which would give the local population an incentive to stay on their properties and have a secure source of income. In addition to the above, the mentioned localities have exceptional potential for the development of rural tourism. In this regard, the production of Herzegovinian dry smoked goat meat would fit perfectly into such projects.

Available literature data indicate modest scientific work on the processing and quality of goat meat in Bosnia and Herzegovina. Ganić et al., (2013; 2019; 2020) and Forto (2020) cite significant scientific research on the technology and quality of cured meat products from goat meat. In contrast to the above mentioned, in other countries, the quality of various goat meat products is continuously tested, such as smoked goat ham (Ivanović et al., 2014; 2014a; 2016), goat mantas (Oliveira et al., 2014), goat bresaola (Paleari et al., 2003), salted and ripened goat thigh (Paleari et al., 2008), goat cured legs (Teixeira et al., 2017; Tolentino et al., 2016).

The research aims to record the production technology for the first time and to establish the basic quality parameters of "Herzegovinian dry smoked goat meat".

MATERIAL AND METHODS

Production technology of Herzegovinian dry smoked goat meat. To produce "Herzegovinian dry smoked goat meat", only castrated bucks over three years of age are used. The meat processor, which produces this meat product, owns its property on Hrgud mountain, where the animals stay all year round. Bucks intended for the production of "Herzegovinian dry smoked goat meat" are grazed exclusively on pasture, without the addition of a concentrated meal. The production of this traditional meat product is characteristic only for the period from December to February. For this research, five adult castrated bucks, older than three years, were selected.

Standard technology involves the following phases: bucks selection, slaughter, head and skin separation, evisceration, carcass cooling, deboning and processing of raw "stelja", salting, then drying and smoking. Bleeding of animals is done traditionally. The neck veins at the level of the atlanto-occipital joint are cut with a knife. After the bleeding is over, decapitation (separation) of the head and skin is performed. The boning and processing of the trunk begin by making an incision in the part of the sternum, towards the spinal column and the neck. The meat is then separated from the bones by dissecting the musculature and the pelvic symphysis (*Symphysis pelvis*). In the next phase, an incision is made on the cranial side of the hind limbs with separate musculature of the femoral (*Regio femoris*) and crural regions (*Regio cruris*). Eventually, the skeleton is completely separated from the musculature. The shoulders remain within the trunk, with the shoulder blade (*Scapula*) and the upper arm bone (*Humerus*) being deboned, while the forearm bone (*Radius*) remains within the muscle tissue. To remove the shoulder blade and the upper arm bone, an incision is made on the medial side and the capsule articularis is opened, whereby *cavitas glenoidalis* (cavity) and *caput humeri* (head) are observed.

The obtained raw "plaha" is additionally processed and shaped, whereby the salt is removed from the leg part so that the added salt penetrates better into the meat, and so that the smoking done is as complete as possible. When salting, only coarse crystalline sea salt is used, which is sprinkled on the meat (dry salting). Salting lasts only a few days (three to four days). After that, timber is introduced into the smokehouses for drying and smoking. Also, this part of the process varies according to weather conditions and lasts from a minimum of 15 to 20 days, depending on the temperature and airflow. It is desirable to smoke intermittently every two days for 24 hours. Apart from smoking and drying, all technological phases were performed in the slaughterhouse "Obradović" Stolac. Smoking and drying of meat are done in traditional stone smokehouses on the mountain Hrgud (above 1000 m).



Figure 1. Production technology of Herzegovinian dry smoked goat meat (a - deboning of thoracic part; b - deboning of axial skeleton without head, pelvis, and femur; c - salting; d - smoking)

Methods

Sampling. Research in this paper has been conducted in the period from January to June 2019.

For the research, five “steljas” were used (Fig. 2). Eight samples (neck, sirloin, leg, loin, flank, breast, shoulder, hindshank) from different anatomical parts were taken from each “stelja” (Fig. 3). The shoulder pattern in Fig. 3 is not visible because it is located on the lateral side of the “stelja”.



Figure 2. Herzegovinian dry smoked goat meat



Figure 3. Sampling of Herzegovinian dry smoked goat meat

Chemical analysis. Moisture content was determined by BAS ISO 1442:2007, protein content by BAS ISO 937:2007, fat content by BAS ISO 1443:2007, ash content by ISO 936:2007, pH was measured using pH meter (FiveGo™ F2, Mettler Toledo, Switzerland), and a_w value of the samples was measured using an a_w meter (LabSwift – a_w , Novasina, Switzerland). Determination of NaCl was performed by Mohr titration using 0.1 M AgNO_3 and 5% potassium chromate as an indicator (E. K. 8045, JUS., 1993).

Indicators of lipolysis and lipid oxidation. Acid value (AV) was used as an indicator of lipolysis. The acid value was determined according to BAS EN ISO 660:2010 method and expressed as mg KOH/g fat. The level of lipid oxidation was assessed by the determination of peroxide value (primary oxidation) and by the Thiobarbituric acid assay (secondary oxidation). Peroxide value (PV) was determined according to BAS EN ISO 3960:2018 method and expressed as mmol/kg. Thiobarbituric acid (TBA) assay was conducted according to Lemon (1975). The method is based on the spectrophotometric determination of the pink color that results from the reaction between Thiobarbituric acid (TBA) and malondialdehyde (MDA - ketoaldehyde, which is a secondary product of lipid oxidation of unsaturated fatty acids). Spectrophotometric absorbance readings were performed at 538 nm. A spectrophotometer (Perkin Elmer Lambda 25 UV/VIS, 190-1100 nm) was used to read the absorbances. The concentration of pigment formed was determined by reading from a standard curve where the TBARS values obtained were expressed as mg malondialdehyde/kg sample (mg MDA/kg sample). A calibration curve was developed using 0, 0.01, 0.02, 0.03, 0.04 and 0.05 μmol of malondialdehyde (MDA).

Sensory analysis. Sensory analysis was performed by a simple descriptive method (Radovanović & Popov-Raljić, 2000). When describing sensory properties of Herzegovinian dry smoked goat meat, the most frequent and appropriate descriptive terms were used (Stamenković & Dević, 2006). The sensory evaluation was performed by a three-member expert commission that performs evaluations for fairs and exhibitions. No standard scoring was applied in this study. This methodology of the sensory evaluation was used to identify for the first time the sensory and physical characteristics of individual segments of "Herzegovinian dry smoked goat meat". The facts will serve as a basis and corrective for future research on this product. Measurements of the dimensions of individual tissues were performed using a movable scale with an accuracy of 0.00 mm. Samples were cut into slices using a professional meat slicer (Meat Slicer AWT FS-190-15A) and served on plastic plates 30 minutes before the start of the sensory evaluation. For performing the sensory evaluation, the ambient temperature up to 20 °C and the presence of daylight is provided. About 50 mL of water and 15 g of unsalted bread were provided to assessors between successive samples.

Statistical analyses. All determinations (chemical parameters, indicators of lipolysis and lipid oxidation) were carried out in triplicate, and data were reported as mean \pm standard deviation. Influence of anatomical regions was tested using one-way ANOVA, and significant differences ($p < 0.05$) were calculated using Tukey test. For the correlation and presentation of the results multivariate data analysis was used - analysis of the basic components or PCA analysis. Statistical analyses were performed using Past software 3.15 (Hammer *et al.*, 2001).

RESULTS AND DISCUSSION

Chemical analysis. Results of the chemical analysis are shown in Table 1. Through statistical processing of the obtained results, it was established that the anatomical region had a statistically significant influence on all chemical parameters. Moisture content was in the range of 12,61-24,94%. The highest moisture content was in the hindshank samples (24,94%), while the lowest content was in the breast samples (12,61%). Higher moisture content compared to those determined in this paper are stated by Ganić *et al.*, (2013) in goat “stelja“, Ivanović *et al.*, (2014; 2014a; 2016) in smoked goat ham, Paleari *et al.*, (2003) in goat bresaola, Paleari *et al.*, (2008) in salted and ripened goat thigh, Oliveira *et al.*, (2014) in goat mantas, Teixeira *et al.*, (2017) in goat cured legs, Ganić *et al.*, (2009; 2013a) and Dumić (2008) in sheep ham, Gajić (2000) and Krvavica *et al.*, (2009) in sheep kastradina. All tested samples comply with the provisions of the Regulation of ground meat, meat preparations, and meat products (Official Gazette of B&H No. 82/13) in terms of moisture content because the recorded values were less than 60%.

Table 1. Chemical parameters of Herzegovinian dry smoked goat meat

| Part of carcass | Parameters (n=5) | | | | | | |
|-----------------|----------------------|----------------------|----------------------|---------------------|----------------------|-----------------------|------------------------|
| | Moisture (%) | Fat (%) | Protein (%) | NaCl (%) | Ash (%) | pH | a _w |
| Neck | 18,49 ^c ± | 33,71 ^f ± | 26,39 ^b ± | 9,99 ^f ± | 11,41 ^f ± | 6,14 ^d ± | 0,721 ^{abc} ± |
| | 0,16 | 0,30 | 0,66 | 0,14 | 0,23 | 0,04 | 0,00 |
| Sirloin | 17,32 ^b ± | 39,99 ^g ± | 25,79 ^b ± | 7,90 ^d ± | 9,00 ^d ± | 5,58 ^b ± | 0,716 ^a ± |
| | 0,56 | 0,21 | 0,79 | 0,15 | 0,17 | 0,04 | 0,00 |
| Leg | 24,02 ^e ± | 24,58 ^c ± | 38,94 ^d ± | 5,55 ^a ± | 6,91 ^a ± | 6,05 ^{cd} ± | 0,754 ^d ± |
| | 0,24 | 0,31 | 0,46 | 0,01 | 0,22 | 0,03 | 0,00 |
| Loin | 24,44 ^e ± | 26,16 ^d ± | 30,99 ^c ± | 8,50 ^e ± | 9,91 ^e ± | 6,00 ^{bcd} ± | 0,728 ^c ± |
| | 0,06 | 0,21 | 0,35 | 0,07 | 0,11 | 0,06 | 0,00 |
| Flank | 21,02 ^d ± | 30,14 ^e ± | 32,73 ^c ± | 7,38 ^c ± | 8,73 ^{cd} ± | 6,17 ^d ± | 0,720 ^{ab} ± |
| | 0,23 | 0,42 | 0,19 | 0,13 | 0,18 | 0,08 | 0,00 |
| Breast | 12,61 ^a ± | 50,35 ^h ± | 23,81 ^a ± | 5,79 ^a ± | 7,43 ^{ab} ± | 5,56 ^a ± | 0,722 ^{abc} ± |
| | 0,23 | 0,15 | 0,57 | 0,18 | 0,23 | 0,07 | 0,00 |
| Shoulder | 24,68 ^c ± | 23,10 ^b ± | 37,53 ^d ± | 6,52 ^b ± | 8,17 ^c ± | 5,89 ^{bc} ± | 0,725 ^{bc} ± |
| | 0,25 | 0,35 | 0,45 | 0,07 | 0,00 | 0,06 | 0,00 |
| Hindshank | 24,94 ^e ± | 14,40 ^a ± | 47,40 ^e ± | 5,69 ^a ± | 7,57 ^b ± | 6,06 ^{cd} ± | 0,727 ^{bc} ± |
| | 0,23 | 0,17 | 0,36 | 0,06 | 0,09 | 0,02 | 0,00 |

Different letters within the same column indicate statistically significant differences ($p < 0.05$)

The fat content was determined in the range of 14,40-50,35%. The hindshank samples had the lowest fat content (14,40%). In contrast, the breast samples had the highest fat content (50,35%) which had the lowest moisture content. These results are consistent with the results reported by Ganić *et al.*, (2013; 2009; 2013a), Gajić (2000), and Krvavica *et al.*, (2009). The fat content determined by Ivanović *et al.*, (2014; 2014a; 2016) in smoked goat ham is in the

range determined in this paper. In the examined samples, the protein content ranged from 23,81% (breast) to 47,40% (hindshank).

The protein content determined in the samples of Herzegovinian dry smoked goat meat is following the results recorded by Ivanović *et al.*, (2014; 2014a; 2016), Paleari *et al.*, (2003; 2008), and Oliveira *et al.*, (2014). The neck samples had the highest content of NaCl (9,99%) and ash (11,41%). On the other hand, the samples of the leg had the lowest content of the mentioned components (5,55%; 6,91%). The lower content of these components was determined by Ganić *et al.*, (2009; 2013), Ivanović *et al.*, (2014; 2014a; 2016), Paleari *et al.*, (2008) in their research.

Samples of Herzegovinian dry smoked goat meat had a pH value of 5,56-6,17. The stated values are under the established values for smoked goat ham (Ivanović *et al.*, 2014; 2016), goat cured legs (Teixeira *et al.*, 2017; Tolentino *et al.*, 2016), goat mantas (Oliveira *et al.*, 2014) and salted and ripened goat thigh (Paleari *et al.*, 2008). Samples of Herzegovinian dry smoked goat meat had an a_w value of 0.716-0.754 and showed the values typically associated with intermediate moisture foods, which include dry-cured meat products (Leistner, 1991). Higher values of the examined parameter were found for smoked goat ham (Ivanović *et al.*, 2014a), goat bresaola (Paleari *et al.*, 2008), goat mantas (Oliveira *et al.*, 2014), goat cured legs (Teixeira *et al.*, 2017; Tolentino *et al.*, 2016). All tested samples in terms of a_w values were under the Regulation of ground meat, meat preparations, and meat products (Official Gazette of B&H No. 82/13) because the values of this parameter did not exceed 0,93.

Indicators of lipolysis and lipid oxidation. The acid value, peroxide value, and TBARS value of Herzegovinian dry smoked goat meat are presented in Table 2. Through statistical processing of the obtained results, it was established that the anatomical region had a statistically significant influence on the stated parameters. The acid number of the tested samples ranged from 9,24 to 20,69 mg KOH/kg fat. The highest value of the acid number was found in the samples of the shoulder, which did not have the highest fat content. The activity of lipolytic enzymes increases with the increase of the moisture content, which is probably due to higher values of the acid number in the shoulder samples, which was characterized by higher moisture content. Also, the content of n-3 fatty acids increases the sensitivity to lipolytic changes, which may be another reason for these results. The lowest value of the acid number was found in the breast samples that had the highest fat content. The reason for these results is probably the higher content of more stable saturated fatty acids, which cannot be explained without a detailed analysis of the fatty acid composition. These results are in line with the results reported by Krvavica *et al.*, (2016) for kastradina, and Kurćubić and Vesković-Moračanin (2017) for beef prosciutto. Higher values of the acid number were found by Krvavica *et al.*, (2013; 2021) for Istrian ham, in their research.

The neck samples had the highest values of peroxide value (4,65 mmol/kg) compared to other tested samples.

Table 2. Indicators of lipolysis and lipid oxidation of Herzegovinian dry smoked goat meat

| Part of carcass | Parameters (n=5) | | |
|-----------------|-------------------------------|------------------------------|--------------------------|
| | Acid value (AV), mg KOH/g fat | Peroxide value (PV), mmol/kg | TBARS, mg MDA/kg sample |
| Neck | 9,60 ^a ± 0,13 | 4,65 ^f ± 0,28 | 1,02 ^f ± 0,01 |
| Sirloin | 17,74 ^d ± 0,22 | 2,35 ^{bcd} ± 0,18 | 0,57 ^d ± 0,00 |
| Leg | 19,51 ^e ± 0,18 | 1,87 ^{ab} ± 0,19 | 0,78 ^e ± 0,01 |
| Loin | 14,68 ^b ± 0,40 | 2,82 ^d ± 0,13 | 1,08 ^g ± 0,01 |
| Flank | 20,48 ^f ± 0,13 | 2,60 ^{cd} ± 0,18 | 1,17 ^h ± 0,00 |
| Breast | 9,24 ^a ± 0,15 | 1,53 ^a ± 0,04 | 0,47 ^b ± 0,00 |
| Shoulder | 20,69 ^f ± 0,26 | 3,78 ^e ± 0,15 | 0,50 ^c ± 0,00 |
| Hindshank | 16,50 ^c ± 0,20 | 2,03 ^{abc} ± 0,13 | 0,28 ^a ± 0,01 |

Different letters within the same column indicate statistically significant differences ($p < 0.05$)

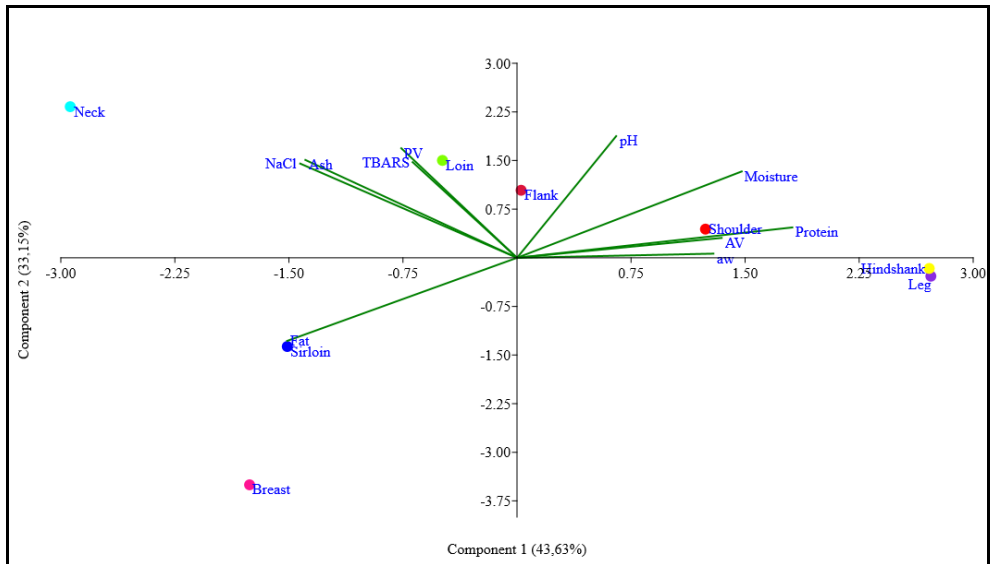


Figure 4. The plot of principal component analysis of the chemical parameters and indicators of lipolysis and lipid oxidation of Herzegovinian dry smoked goat meat

These samples had the highest NaCl content (9,99%) which is probably another promoter of lipolysis. Higher content of linoleic fatty acid and PUFA intensify oxidative changes, while higher content of SFA "protects" samples from oxidation. The breast samples had the lowest peroxide value (1,53 mmol/kg) although they had the highest fat content which is probably due to the higher

content of more stable SFA. Higher values of the peroxide number were found by Krvavica *et al.*, (2016) for kastradina and Krvavica *et al.*, (2013; 2021) for Istrian ham.

The TBARS value ranged from 0,28-1,17 mg MDA/kg sample in the tested samples. The hindshank samples had the lowest TBARS value, while the flank samples had the highest value. Higher TBARS values cite Oliveira *et al.*, (2014) for goat mantas. These results are by the values given for Istrian ham by Marušić *et al.*, (2011; 2014) and Krvavica *et al.*, (2021), for dalmatian dry-cured pork (Krvavica *et al.*, 2016a) and dalmatian ham (Marušić Radovčić *et al.*, 2016).

Sensory analysis. The results of the sensory evaluation of Herzegovinian dry smoked goat meat are shown in Table 3.

Table 3. Sensory and physical attributes of Herzegovinian dry smoked goat meat

| | |
|---------|---|
| Neck | <p>The external appearance of this anatomical part of the trunk indicates a dominant presence of muscle tissue, permeated with thin layers of golden-yellow adipose tissue. The presence of adipose tissue is especially noticeable on the inner (medial) part of the neck, where the muscle surface is almost completely covered in a thin layer of adipose tissue of lighter shades of yellow. The cross-section is dominated by muscle tissue.</p> <p>When chewing, the flesh of the neck is hard. The fragility in the mouth is very weak due to the presence of parts of the connective tissue (tendon). The smell of the meat is reminiscent of smoke, without the pronounced salinity and the characteristic pungent smell of goat meat. And due to the pronounced dryness, it is harder to cut into thin slices.</p> |
| Sirloin | <p>On the outer part of the sirloin are mutually differentiated surfaces of muscle and parts with predominantly adipose tissue. The muscular layer is dark brown (chocolate) shade, while the surface with the dominant adipose tissue is golden-yellow. In contrast, the inner sirloin region is divided into the central muscle part and the adipose tissue areas located at the periphery of the sirloin. The color of the muscle tissue is distinctly dark chocolate shade, while the adipose tissue with darker tones is yellow. In cross-section, the muscle tissue is dominant about adipose tissue in a ratio of 2:1.</p> <p>In the area of the sirloin, next to the back muscle, fat is more present, while in the part next to the abdomen, muscle tissue dominates. The structure is compact without the noticeable presence of cracks. Due to the dryness, it is difficult to cut into thin steaks. Muscle tissue is crumbly when chewed, and adipose tissue does not lag the palate when crushed in the mouth. The presence of salt is optimally expressed, and the smell and aroma are reminiscent of smoke and have a slightly pronounced aroma.</p> |

| | |
|----------|---|
| Leg | <p>Due to insufficient drying and smoking, the meat in the cross-section is distinctly red (the color of fresh meat). Marbling is present but to a much lesser extent than in loin samples. The layer of adipose tissue is thin and covers only the outer part of the leg (the part on which the skin rests). The flesh has a fine unique structure throughout the cross-section and no visible cracks. When minced in the mouth, the meat is juicy and soft. The crumbs in the mouth are very good and the fat does not lag on the palate. The smell is less pronounced and slightly reminiscent of smoke. The average “stelja“ thickness on the leg part was 40,60 mm (middle part of the area of <i>M. gastrocnemius</i>), 21,80 mm on the section of <i>M. glutaebiceps</i> and <i>M. semitendinosus</i>, and 35,00 mm of the area of <i>M. extensor digitorum longus</i> (Neil, 1964).</p> |
| Loin | <p>The color of the muscle tissue on the outer part of the loin is brown, while the adipose tissue is golden-yellow. It is dominated by muscle tissue. In the inner part (medial) of the loin, adipose tissue is more present, which has a significantly lighter tone compared to the lateral part. The cross-section is dark brown (chocolate) shades, with the dominant presence of muscle tissue. At the cross-section, a monolithic structure without cracks is noticeable, with a very small presence of adipose tissue. Compared to the neck and sirloin, it is much easier to cut into 2 mm thick slices. When chewing, adipose tissue sticks to the palate. It has no pronounced salinity. The smell is reminiscent of smoke, without the exaggerated aroma of dry goat meat.</p> |
| Flank | <p>This anatomical part of the trunk is made up of almost equally muscle and adipose tissue. The color of the muscle parts is a closed red shade, while the adipose tissue is yellow. It is relatively well cut into 2 mm thick slices. It has good crumbliness when chewed. The aroma has a present aroma of smoked goat meat, with a pungent taste and aroma.</p> |
| Breast | <p>Differentiated adipose and muscle layer, dominated by the adipose tissue part. The color of the muscle tissue on the inside is dark red with brown tones, while the color of the adipose tissue is white to light yellow. The meat is easily cut into 2 mm thick slices, it is crumbly in the mouth and the fat does not stick to the palate. The smell of the “stelja“ is characteristic and reminiscent of smoke. The taste of primarily adipose tissue is strong, astringent, and unpleasant. The thickness of the samples was 19,30 mm in the middle part, 19,10 mm towards <i>Linea alba</i> and the area of <i>regio xyphoide</i>, and in the part towards the ribs, the thickness was 17,70 mm.</p> |
| Shoulder | <p>The outer part of the muscle tissue is dark red to brown shades. The surfaces of adipose tissue are golden-yellow to brown. The smell is reminiscent of smoked meat, without the presence of overemphasized aroma of goat meat. It can be relatively easily cut into 2 mm thick slices. It has good crumbliness when chewed in the mouth. Muscle and, to a lesser extent, adipose tissue is present in this anatomical part of the trunk.</p> |

| | |
|-----------|---|
| Hindshank | The extremely dry muscle tissue of dark brown color. Very difficult to cut into 2 mm thick slices. Not overly pronounced smell of smoked goat meat. When chewed in the mouth, it shows exceptional hardness. At this anatomical position of the trunk, muscle tissue is dominant. |
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Relationship between chemical parameters and indicators of lipolysis and lipid oxidation. The analysis of the main components was performed based on a correlation matrix in which 10 parameters were included for eight samples of Herzegovinian dry smoked goat meat. For the analysis of the main components, a_w and pH value, moisture, fat, ash, protein, NaCl content, acid number, peroxide number, TBARS value were used as variables. The first two components that are the result of testing the above parameters of samples of Herzegovinian dry smoked goat meat contained 76,78% of the total variance, the first 43,63%, and the second 33,15%. The cumulative variance for the four main components was 93,53%.

From the results shown in Fig. 4, the moisture content and pH value achieved a significant positive correlation, while the stated parameters were in a significant negative correlation with the fat content. A positive correlation was found between the content of NaCl, ash, peroxide, and TBARS value. Also, a high positive correlation was found between protein content, a_w value, and acid number. From the presented graph the fat content was characteristic for the breast samples. The hindshank samples had a characteristic protein content, while the shoulder samples had characteristic moisture content. In contrast, the content of NaCl and ash was characteristic of the neck samples. TBARS value was characteristic of the flank samples, a_w value of the leg samples, peroxide value of the neck samples, and an acid value of the shoulder samples.

CONCLUSIONS

Herzegovina dried goat meat is a valuable food product thanks to its specific sensory properties and favorable chemical composition. From the aspect of sensory quality, this product is characterized by a pleasant aroma, smell of smoke, and slightly pronounced salinity, except for samples of the flank and breast. The samples of the flank had a pronounced smell of smoked goat meat, with a pungent taste and aroma, and this anatomical part of the carcass is characterized by almost equally muscular and fatty tissue. The breast samples had an adipose tissue taste that was strongly pronounced, astringent, and unpleasant due to the dominance of adipose tissue in this anatomical part, and which usually contained the compounds responsible for taste and aroma. The analysis of basic chemical indicators showed significant differences between individual anatomical parts. The most intense hydrolytic changes were found in the shoulder samples in which the acid value was 20,69 mg KOH/g fat. The highest value of the peroxide number was found in the neck samples (4,65 mmol/kg), and TBARS value in the flank samples (1,17 mg MDA/kg).

The results of the research will be used to standardize the production and quality of "Herzegovinian dry smoked goat meat". The determining technological and qualitative parameters will be used for the manufacturer's product specification in the process of its protection with the label of authenticity. With the protection of "Herzegovinian dry smoked goat meat" on the national level, the product will be officially branded and will gain even more in popularization and marketing. With certain technological additions (confectioning into smaller pieces, vacuum packaging, and labeling), it can represent an exceptional development opportunity for the rural areas where it is produced. Having in mind the above, there is an urgent need to protect this meat product, unique in Bosnia and Herzegovina and beyond.

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