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INFLUENCE OF THE RESEARCHED AREA AND PART OF THE CARCASS ON SOME QUALITY INDICATORS OF SHEEP DRY-CURED HAM

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Abstract

"Stelja" is an autochthonous dried meat product of sheep meat, and more rarely of goat meat, traditionally produced for centuries across Bosnia and Herzegovina. It is a very popular and respected product, especially for the Bosnians. The aim of the research was to determine whether the production technology of different localities and anatomical part of the carcass from which the sample was taken (*Musculus longissimus dorsi* and thigh with the leg), affected the overall quality of the sheep dry-cured ham samples. Besides that, one of the aims of the research was to collect certain qualitative parameters of the product in order to protect the product both at the national and the European Union level.

Tests were carried out in five different areas in Bosnia and Herzegovina. In total, 30 female animals of domestic sheep ("Pramenka") of different strains were used for the whole study. After selecting the animals, slaughter of animals and production of dry-cured sheep ham was carried out. For qualitative tests, sampling was performed after drying and cooling dry-cured sheep ham. Samples were taken from the three rib excerpt of the long back muscle and the thigh with the leg. In this research examined the slaughterhouse indicators and tests of sensory, chemical and microbiological quality of the finished product.

The results of chemical and sensory quality testing showed that there were significant differences ($P < 0.05$) linked to the influence of both the researched area and anatomical part of the carcass from which the sample was taken. By analysing the presence of heavy metals in the samples of long back muscle, it was found that the samples had been according to the EU legislation in force. Quantitative differences of the sensory properties were dependant on the researched area and the carcass part ($P < 0.05$).

On the basis of the sheep slaughter values, it can be concluded that the tested parameters were dependent on the researched area ($P < 0.05$). Sensory evaluation of the dry-cured sheep ham "Stelja" confirmed high level of acceptability and quality of the product.

Key words*: Slaughter traits, Technology, Sheep dry-cured ham, Chemical quality, Sensory properties.*

1. Introduction

Meat is the most important sheep product (Mioč *et al.*, [28]). Production of mutton involves mainly production of lamb, while smaller quantities of older categories of mutton are mostly obtained by slaughtering the animals culled from propagation (Krvavica, *et al.*, [26]). Taking into account the meat industry worldwide, the fact is that the sheep meat is least processed (Džinleski *et al.*, [14]). One of the important reasons for the minor use of sheep meat in the industry is its specific sensory properties - specific smell and taste (Džinleski [11]). Production of smoked sheep and goat meat is linked to the wider Mediterranean area. Furthermore, this production is still preserved in the southern parts of France and Corsica, Sardinia and southern Italy and Greece (Barbieri, cited by Krvavica [24]). Beriáin *et al.,* [5] by exploring the possibility of using mutton in production of dry sausages, concluded that there were no major differences in the technological properties whereas differences in texture, color and sensory properties highlight better cohesiveness, color and stability, and also worse flavor, smell and texture of the mutton sausages compared to the pork sausages. Džinleski *et al.,* [13] conducted certain experimental studies attempting to produce mutton dry sausages. According to the authors, such product would be a very interesting and attractive one for the areas inhabited by the Muslim population, since mutton is highly prevailing in their nutrition. In addition to a number of studies regarding the use of lamb and sheep meat, Džinleski *et al.*, [12] attempted to produce semi-dry and dry sausages cans. For that purpose, researchers used the combination of lamb and baby beef. Lamb (meat) used was from crossbreeds of the Šar-planina sheep and Wurttenberg race 2 - 3 months old with carcasses' weight of 8 - 10 kg. Frozen and defrosted lamb was used for the study. Ganić *et al.*, [19] produced sheep ham, from male animals of Sjenica's improved sheep, in accordance with the production technology of pork ham. The researchers pointed out the excellence of the product, with the remark that the quality would certainly have been better if fattening breeds of sheep could be used for the production. One way of additional rationalization of sheep production technology, especially for herds intended for meat production, is production of dry sheep meat - "Kaštradina" (Kostradina) - autochthonous dry-cured product of mutton which is now very rare to find at the market (Krvavica, *et al.*, [23]; Krvavica *et al.*, [24], and Krvavica *et al.*, [25]). Sheep "pastrma" is of Turkish origin and means salted, smoked and dried meat (Stamenković and Dević, [40]). In the region of Central and Eastern Bosnia, Krajina and Western Herzegovina "Stelja" (dry-cured sheep ham) is a product obtained by deboning whole sheep carcass which is then salted, dried and smoked. The synonym for the same product in the region of Eastern Herzegovina is sheep "plaha" (Ganić *et al.*, [17]). According to Milosavljević [27], sheep and goat pastrma are salted, cold smoked and air dried whole sheep or goat carcasses, halves or quarters, with bones or boneless. Pastrma is produced only by dry salting of specially processed whole sheep and goat carcasses, without the use of other methods of preservation (smoking, drying) or the addition of various additives (Džinleski, [10]).

2. Materials and Methods

2.1 Field tests

Tests were carried out in five different areas in Bosnia and Herzegovina (the Una-Sana Canton, the Zenica-Doboj Canton, the Herzegovina-Neretva Canton, the Canton 10 and the Tuzla Canton). At each location, six animals of approximate same age and size were selected. In total, 30 female animals of local sheep ("Pramenka") of different strains were used for the whole study. After selecting the animals, slaughter of animals and production of dry-cured sheep ham was carried out.

2.2 Methodology of preparation of dry-cured sheep ham

2.2.1 Slaughter of the animals

After the bleeding, skinning was conducted in a way to make the incision along the caudal side of the rear extremities of the tarsal joint (*Articulatio tarsi*) to the perineal region (*Regio perinea*). Then the ankle bones of metatarsals areas are separated. The carcass is hung with metal hooks on Achilles' tendon, placed in a vertical position and the skin is stripped towards the neck. Exenteration (opening of the carcass) is done by the knife in a way to open the abdominal cavity of the pubic region, and then cut right on the white line (*Linea alba*) from the *Regio pubis* to the *Regio xyphoidea*. All the internal organs, adipose tissue, except kidneys with the fatty capsule are removed. After the completed exenteration, the interior of the carcass is rinsed with water, drained and then cooled. Carcasses were weighed accurately to 0.01 kg after a 24 hour carcass cooling at a temperature of 2 to 4 ^{0}C, and dressing percentage was determined.

2.2.2 Carcass processing

Separating the meat from the bones is done by cutting the muscles and the pelvic symphysis (*Symphisis pelvis*). After that, the cut from the cranial side of hind limb with separate musculature of femoral (*Regio femoris*) and crural region (*Regio cruris*) is made.

Then separation of meat from the rest of the carcass is done by making the cut on the part of the breastbone (*Sternum*) to the spinal column (*Columna vertebralis*) and neck (*Pars cervicalis*), and in the end complete skeleton is separated. The front limbs are completely separated by cutting the muscle groups of *Synsarcosisa*; the shoulders are completely salted and smoked or forearm bone (*Radius*) can be deboned. For the purpose of faster penetration of salt, as well as of drying and smoking, crude "Stelja" is additionally processed by the thinning the thigh with the leg part (removing the topside). The meat is dry-salted exclusively with table salt (NaCl), and if desired, certain additives such as chopped garlic, pepper, etc., can be added. After salting, the meat is taken to the smokehouse for drying and smoking. Smoking and drying are done in traditional smokehouses in the households, and dry beech wood is most commonly used for the production of the smoke. This technological stage lasts 10 - 15 days, depending on the climate and temperature conditions. If the weather is cooler and airflow is optimal, smoking is shorter with reduced intensity (Figure 1).

2.2.3 Laboratory tests

For qualitative tests, sampling was performed after drying and cooling dry-cured sheep ham. Samples were taken from the three rib excerpt of the long back muscle (*M. longissimus dorsi* - Neil DS 1964 [31] - Figure 2) and the thigh with the leg (distal half of *Caudo-lateral* part of the thigh musculature with associated bones of *Crural* region and *Tarsal* joints).

The sample of the three rib excerpt of the long back muscle comprised the fifth, the sixth and the seventh ribs. Only a part of the muscle back musculature with the associated inter and intra-muscular fat tissue was used for the analyses. The connective tissue was removed from the back muscle and the back muscle was separated from rib (Figure 3). The sample of the thigh with the leg musculature was taken from proximal edge of the thigh with the leg with the dominant presence of the muscle tissue and associated muscles: *M. gluteus profundus, M. gluteus medius, M. gluteobiceps, M. semitendinisus, M. quadriceps femoris, M. sartorius, M. pectineus*, and *M. gastroenemius*. The sample from the part of the thigh with the leg was taken in the entire length of the cross-section visible on Figure 4. From each Stelja/dry-cured ham, one sample of the back muscle and one thigh with leg musculature each were taken. In total for the research 30 samples of the back muscle and 30 of the thigh with leg each were taken. The samples were comminuted and homogenized in homogenizer for the purposes of chemical tests.

2.3 Analytical methods

Moisture, fat (Soxhlet method), protein (micro-Kjeldhal method) and ash were determined as per AOAC method [1]. The sodium chloride was determined by the Mohr method as indicated in the AOAC [2] methods.

2.3.1 Detection of heavy metals

Detection of heavy metals (Fe, Zn, Cu, Cd and Pb) was performed on the atomic absorption spectrometer by using the calibration curve method. For the construction of calibration curve, solutions of known concentration were made and the absorbance of each solution was measured. By using the calibration curves, unknown concentrations of the tested solutions were determined by measuring their absorbance.

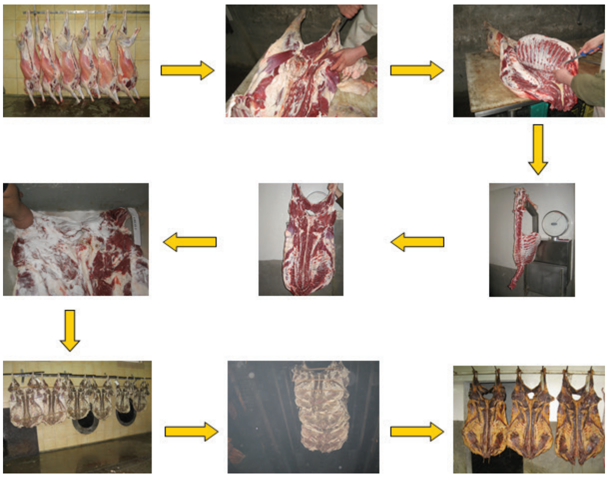

Figure 1. Production technology of "Stelja" - dry-cured sheep ham

Figure 3. Cross-section of the sample *Musculus longissimus dorsi*

Figure 2. Three rib excerpt (*Musculus longissimus dorsi*)

Figure 4. Sheep dry-cured with femoral area

2.3.2 Sensory analysis

For the sensory analysis and determination of sensory properties descriptive method was used (Radovanović and Popov-Raljić [34]). By this method it may be determined: external appearance, color, consistency, smell and taste. The maximum score is 20 points, which are distributed as follows: exterior appearance - 3 points, colour - 2 points, consistency - 3 points, cross-section appearance - 4 points, smell - 3 points and taste - 5 points. Sensory analysis was carried out in three replicates by a five-member expert committee responsible for the fair assessment of dry-cured meat products.

2.3.3 Statistical Analysis

Homogeneity of variance was confirmed and comparison between the means was made by two-way analysis of variance. Data are reported as mean values ± standard error (SE) of the mean. Significance was accepted at probabilities of 0.05 or less. All the statistical analyses were performed by SPSS 16.0 (SPSS Inc., Chicago, IL). To test the mean values, the Tukey test was used.

3. Results and Discussion

Results of the slaughter parameters' measuring (Table 1) indicate that head from the fifth researched area had the smallest (38.33 kg), and in the third one the largest average mass (71.33 kg). The differences in masses of the head prior to slaughtering are the result of exterior diversity of certain/individual strains of autochthonous Pramenka that are bred in particular areas. By analysing masses of cooled carcasses it is evident that they were in the same proportion to the masses prior to slaughtering. The largest average masses of carcasses were measured in the third (36.73 kg), and the smallest in the fifth locality (18.55 kg). The average values of the dressing percentage were in the range of 43.59% in the first, up to 51.49% in the fourth area. Thereby the lowest dressing percentage was established in the first one (41.60%), while the highest one was in the fourth locality (56.43%). The largest average mass of crude Stelja/dry-cured ham was measured in the third area and was in average 27.37 kg. On the other hand, the least of crude Stelja/dry-cured ham was gained per head in the fifth area, only 12.10 kg. The largest and the smallest average masses of salted and dried Stelja/dry-cured ham were following the same pattern as masses of crude Stelja/dry-cured ham. The proportion between the mass of foreskins being gained on the occasion of processing and mass of the carcass expressed in relative relation is actually the processing decay. This indicator varied in the range of 5.75% in the third area, up to 13.33% in the first researched area. At all the mentioned parameters, the influence of the researched area was statistically significant ($P < 0.05$). Čaušević *et al.*, [7] indicate that the head for the production of mutton Stelja/dry-cured ham had their pre-slaughtering mass of 42.53 ± 0.90 kg, varying from 36.00 to 49.00 kg. Mioč *et al.*, [29] established the average pre-slaughtering mass at the Travnik's Pramenka head of 65.94 kg.

Table 1. Slaughter indicators

Item	Researched areas					Influence of researched areas
	Area 1	Area 2	Area 3	Area 4	Area 5	
body weight at slaughter (kg)	62,67 ± 1,16^{ab}	58,00 ± 0,68^{b}	71,33 ± 1,08^{a}	63,17 ± 0,88^{ab}	38,33 ± 0,37^{c}	*
warm carcass weight (kg)	27,27 ± 0,47^{b}	28,18 ± 0,35^{b}	36,73 ± 0,60^{a}	32,43 ± 0,36^{ab}	18,55 ± 0,17^{c}	*
warm carcass dressing percentage (%)	43,59 ± 0,61^{b}	48,64 ± 1,12^{a}	51,47 ± 0,95^{a}	51,49 ± 0,97^{a}	48,45 ± 0,80^{a}	*
total separate bones (kg)	5,38 ± 0,20^{b}	5,67 ± 0,26^{ab}	6,37 ± 0,34^{ab}	6,53 ± 0,24^{a}	2,42 ± 0,16^{c}	*
meat trimmings (kg)	3,62 ± 0,18^{a}	2,87 ± 0,26^{ab}	2,13 ± 0,18^{bc}	2,70 ± 0,10^{b}	1,52 ± 0,11^{c}	*
crude sheep ham (kg)	15,27 ± 1,04^{cd}	16,08 ± 0,72^{c}	27,37 ± 1,20^{a}	21,88 ± 0,66^{b}	12,10 ± 0,38^{d}	*
salted sheep ham (kg)	14,97 ± 1,21^{c}	15,60 ± 0,78^{c}	28,12 ± 1,53^{a}	22,18 ± 0,57^{b}	13,42 ± 0,38^{c}	*
dry-cured sheep ham (kg)	10,87 ± 0,30^{b}	12,10 ± 0,25^{b}	20,23 ± 0,33^{a}	16,80 ± 0,14^{a}	9,67 ± 0,10^{b}	*
loss treatment (%)	13,33 ± 0,53^{a}	10,07 ± 0,66^{b}	5,75 ± 0,26^{c}	8,34 ± 0,17^{b}	8,14 ± 0,46^{b}	*
crude sheep ham/ body weight at slaughter (%)	24,30 ± 0,41^{d}	27,74 ± 0,84^{c}	38,46 ± 0,80^{a}	34,81 ± 0,87^{b}	31,58 ± 0,47^{b}	*
crude sheep ham/ warm carcass weight (%)	55,76 ± 0,72^{c}	56,98 ± 0,59^{c}	74,78 ± 1,53^{a}	67,58 ± 0,88^{b}	65,30 ± 1,49^{b}	*
dry-cured sheep ham/ body weight at slaughter (%)	17,20 ± 0,60^{c}	20,83 ± 1,11^{b}	28,40 ± 0,90^{a}	26,73 ± 0,61^{a}	25,23 ± 0,45^{a}	*
dry-cured sheep ham/ warm carcass weight (%)	39,46 ± 1,33^{b}	42,67 ± 1,46^{b}	55,12 ± 1,00^{a}	51,91 ± 0,60^{a}	52,10 ± 0,78^{a}	*
dry-cured sheep ham/ crude sheep ham (%)	70,68 ± 1,67^{b}	74,78 ± 1,95^{ab}	73,87 ± 1,79^{ab}	76,83 ± 0,54^{ab}	79,91 ± 1,18^{a}	*
dry-cured sheep ham/ salted sheep ham (%)	72,41 ± 0,91^{a}	77,16 ± 1,58^{a}	72,12 ± 1,71^{a}	75,74 ± 0,62^{a}	72,03 ± 1,10^{a}	*

Ivanković *et al.*, [20] established the average mass at the Kupres' Pramenka of 58.94 kg. Džinleski *et al.*, [15] indicate that the masses of cooled headless carcasses and without internal organs for local refined Pramenka were from 19.00 to 22.00 kg. Dumić [9], emphasises that the masses of cooled carcasses of the Sjenica sheep (with head, kidneys and kidney suet) intended for production of Stelja/dry-cured ham were of 19.98 kg (light), 23.99 kg (medium) and 28.17 kg (heavy weight group). Aničić *et al.*, [3] state that participation of bones in sheep carcass is 19.15%, and participation of meat foreskins in the carcass is 3.07%. Čaušević *et al.*, [7] in their researches state that the mass of foreskins on the occasion of processing and of crude Stelja/dry-cured ham was merely 0.30 kg or 1.69% in relation to the mass of carcass. Dumić [9] in his researches states that the average masses of crude Stelja/dry-cured ham at three different weight groups had the values as follows: 12.78 kg (the first group), 15.80 kg (the second group) and 19.02 kg (the third weight group). At these parameters as well, the influence of the researched area was statistically significant ($P < 0.05$) as well as differences of the mean values ($P < 0.05$). The influence of the researched area indeed had significance statistically ($P < 0.05$). The differences of the mean values, except the first locality, did not have statistical significance ($P > 0.05$). Considerably lower values of the dressing percentage were emphasised by Čaušević *et al.*, [7]. Thus at carcasses for production of mutton Stelja/dry-cured ham, the dressing percentage was 40.81%. Such low values the authors justify by weak fattening of head having been selected for production of Stelja/dry-cured ham. Mioč [28], determined the values of the dressing percentage as follows: for the Pag's sheep 59.79%, the Istra's one 52.56%, the Dalmatian Pramenka 56.03%, the Rab's sheep 52.21% and the Lika's Pramenka 54.10%. Dumić [9], established the three values of the dressing percentage at Sjenica's sheep, depending on their weight categories: 44.15% (light), 45.98% (medium) and at the heavy weight group it was 48.52%. Mitic [30], states that the dressing percentage with fattened sheep in the range 48 - 52%. Jovanović *et al.*, [22] state that the dressing percentage of adult head of Pramenka is about 45%, that is, depending on age, race, sex and degree of fattening, the value of the parameter ranges between 40 and 60%.

By analyzing the mean values, it was established that mutual differences were statistically significant ($P < 0.05$) in the first, the second and the third researched area.

3.1 Chemical quality

Results of chemical quality of dry-cured sheep ham samples are shown in Table 2. The lowest moisture content was observed in the samples of *M. longissimus dorsi* of the second researched area (33.43 ± 0.90%), and the highest in the thigh with leg samples from the fourth researched area (58.62 ± 0.52%). The differences found between the samples and researched areas were statistically significant ($P < 0.05$). In all the researched areas, significantly ($P < 0.05$) lower content of water was established in the samples of the back muscle than in the samples of the thigh with leg. The conclusion is justified by the fact that at the samples

Table 2. Chemical quality dry-cured sheep ham

The tested parameters	Anatomical part of the carcass	Researched areas					Influence of researched areas	Influence of anatomical part of the carcass	interaction
		Area 1	Area 2	Area 3	Area 4	Area 5			
Moisture (%)	LD n=30	33,53 ± 0,63^{d}	33,43 ± 0,90^{d}	35,04 ± 0,73^{d}	48,97 ± 1,43^{b}	43,40 ± 1,00^{c}	*	*	ns
	FA n=30	47,21 ± 0,55^{bc}	44,25 ± 0,51^{c}	46,07 ± 0,85^{bc}	58,62 ± 0,52^{a}	55,25 ± 0,77^{a}			
Protein (%)	LD n=30	20,59 ± 1,18^{c}	20,94 ± 1,14^{c}	22,37 ± 0,34^{c}	21,58 ± 0,64^{c}	25,15 ± 0,55^{bc}	*	*	*
	FA n=30	30,02 ± 1,09^{ab}	32,80 ± 0,64^{a}	24,81 ± 0,34^{bc}	21,89 ± 0,93^{c}	26,53 ± 0,43^{b}			
Fat (%)	LD n=30	34,76 ± 1,53^{a}	34,66 ± 0,67^{a}	36,50 ± 0,57^{a}	23,11 ± 1,41^{b}	26,21 ± 0,88^{b}	*	*	*
	FA n=30	13,69 ± 1,00^{c}	13,51 ± 0,44^{c}	23,90 ± 0,72^{b}	13,15 ± 0,34^{c}	13,07 ± 0,49^{c}			
NaCl (%)	LD n=30	9,48 ± 0,17^{a}	9,59 ± 0,35^{a}	4,02 ± 0,31^{b}	3,87 ± 0,50^{b}	4,63 ± 0,19^{b}	*	ns	ns
	FA n=30	9,53 ± 0,39^{a}	9,65 ± 0,36^{a}	4,31 ± 0,50^{b}	3,10 ± 0,27^{b}	3,82 ± 0,11^{b}			
Ash (%)	LD n=30	11,29 ± 0,32^{a}	10,52 ± 0,34^{a}	4,91 ± 0,30^{b}	5,11 ± 0,58^{b}	5,51 ± 0,21^{b}	*	ns	ns
	FA n=30	10,99 ± 0,47^{a}	10,95 ± 0,38^{a}	5,19 ± 0,52^{b}	5,33 ± 0,51^{b}	4,55 ± 0,11^{b}			

a, b,... Means with different superscripts in each row differ significantly ($P < 0.05$), n = 30 for each treatment
LD - *longissimus dorsi*
FA - thigh with the leg (femoral area).

of the thigh with leg, the muscle tissue that contains more water dominates in comparison to the samples of the back muscle that contains considerably more of fat tissue. Also, in the fourth and the fifth localities, a considerably ($P < 0.05$) higher content of water was established, both in the samples of the back muscle and in the samples of the thigh with leg. Such results are fruit of local population habits of preferring rawer (less dried) product. Also, a somewhat weaker fitness of the head from the locality 4 and 5 affected the higher content of water in the samples of Stelja/dry-cured ham. Approximately the same level of moisture in dry-cured sheep ham (45.75% samples from the industry and 40.93% of the handicraft sector) were determined by Ganić *et al.,* [17]. Džinleski [10], reported that the average moisture content in the thigh with leg part of the dry-cured sheep ham was 46.59%. Gajić [16], examined the moisture content in sheep Kaštradina and found significantly lower values (35.51%). Čausevic *et al.*, [7] in their research found that the moisture content of the dry-cured sheep ham, treated for 14 days, was 3.73%. In the samples of dry-cured sheep ham, treated for 21 days, Čaušević *et al.*, [7] found 3.90% of water. Such a low moisture content can be caused by a very high fat content, which was in range from 51.19% to 65.45%.

Dumić [9], in his research found that the presence of water in dry-cured sheep ham at a salt concentration of 3.50% was 46.20% (the first group), 48.07% (the second) and 49.67% (the third weight group). At the concentration of NaCl of 4.00%, the values were 45.56%, 46.91% and 48.18% respectively. Finally, at the quantity of salt of 4.50%, the water content in the first group of dry-cured sheep ham was 43.42%, 46.29% in the second and 47.20% in the third group. Krvavica, *et al.,* [23] reported water level of 31.23% in sheep Kaštradina. Džinleski *et al.*, [15] examined water content in cut dry mutton. The water content of individual pieces was as follows: thigh with leg 32.81%, shoulder 29.04%, short loin 28.30%, topside 31.59%, rose 32.21% and silverside 29.83%.

The protein content ranged from 20.59 ± 1.18% in the samples of *M. longissimus dorsi* from the first area, to 32.80 ± 0.64% in the thigh with leg samples from the second area. The differences found in the mean values as well as the impact of the researched area were statistically significant ($P < 0.05$). Approximate results regarding the presence of protein in dry-cured sheep ham (19.90%) were found by Ganić *et al.*, [17]. Džinleski [10], found in average 29.17% of protein in the samples of sheep pastrma (similar to dry-cured sheep ham). Čausevic *et al.,* [7] in the samples of dry-cured sheep ham, treated for 14 days, determined an average of 21.25% of protein, and in 21 day-treated samples, protein content was 34.94%. Dumić [9], in his study reports that the protein content in dry-cured sheep ham at salt concentration of 3.50% was 37.12% (the first group), 36.19% and 34.66% (the second and the third weight group). At the concentration of NaCl of 4.00%, from the first to the third group the values were 38.05%, 36.39% and 35.17% of protein respectively. In the end, at the used quantity of salt of 4.50%, protein content of dry-cured sheep ham in the first group was 39.46%, 36.50% in the second and 34.20% in the third group. Gajić [16], determined the following content of proteins in sheep Kaštradina: 20.22% (the first group), 17.51% (the second group) and 20.20% (the third group). Krvavica, *et al.*, [23] reported that in sheep Kaštradina they had found 25.67% of protein. The average fat content in the samples of MLD ranged from 23.11 ± 1.41% (the fourth area) to 36.50 ± 0.57% (the third area). On the other hand, the level of fat in dry-cured sheep ham samples from the thigh with leg ranged from 13.07 ± 0.49% (the fourth area), to 23.90 ± 0.72% (the third area).

It should be pointed out quite a high level of fat in the samples of the thigh with the leg from the third area that was significantly ($P < 0.05$) higher compared to other samples. This result may be justified by the fact that head from the third researched area had larger mass prior to their slaughtering because they had the highest degree of fattening. Also, high content of fat in the samples of the thigh with the leg may be a consequence of the race variety of sheep that have, with the intensive feeding more stronger deposition of, not only inter one but also intra-musculature fat. The level of the tested parameter was significantly ($P < 0.05$) influenced not only by the researched area but also part of the carcass. Similar results regarding fat content were reported by Krvavica *et al.*, [23], Gajić [16], Ganić *et al.*, [17], while significantly lower values (7.06%, 6.99% and 8.31%) were reported by Dumić [9]. On the other hand, Čausević *et al.,* [7] reported a significantly higher content of fat in the "Stelja" samples (65.45% and 51.19% respectively).

The average content of NaCl in both sample groups was significantly higher ($P < 0.05$) in the first two areas and was in the range from 9.48 ± 0.17% to 9.65 ± 0.36%. The differences found were not significant ($P > 0.05$). On the other hand, the lowest content of salt was found in the samples of dry-cured sheep ham from the fourth researched area (3.10 ± 0.27%). Differences found in the mean values of the NaCl presence between the first two and other three areas were significant ($P < 0.05$). On the contrary, differences within the same areas for both sample groups were not significant ($P > 0.05$). The established differences in total content of NaCl in the researched areas are primarily result of local population habits of preferring products with either smaller or larger salinity.

Similar results for the salt content (5.51%) were reported by Ganić *et al.*, [17]. Čausević *et al.,* [7] found the average NaCl content of 5.34% in the samples of dry-cured sheep ham (treated for 14 days). In the samples of dry-cured sheep ham, treated for 21 days, the researchers found a somewhat higher presence of NaCl

(6.30%). The authors examined the presence of salt in sheep pastrma treated for 14 and 21 days. On that occasion, they found that an average content of NaCl was 8.35% in the first group of samples, and 7.73% in the second group of samples. Vranić *et al.*, [42], who found the average content of NaCl from 5.09 ± 1.10% in dry-cured meat products, found similar results. Džinleski [15], reported the following values for NaCl in cut dry sheep meat: thigh with leg - 5.00%, shoulder - 5.15%, short loin - 4.78%, topside - 5.10%, rose. *M. pecteus* - 4.48% and silverside - 4.78%. Prgomet [33], reported salt content of 11.50% (shoulder) and 10.60% (the thigh with leg region) in the samples of sheep Kaštradina. Žlender [46], reported that the salt content in dry meat varied from 3.8% to 9.2%. Vuković [43], suggests adding table salt in quantity of 3-7% on the occasion of salting the dry-cured meat products. Čavoški [8], reported in his research that the content of table salt in dry-cured meat products is 4 - 7%, sometimes even more. Žlender and Gasperlin [45], reported that the presence of sodium-chloride in dry-cured meat products at the Slovenian market is 6%. Živković *et al.*, [44] reported that the too salty taste is a consequence of excessive salting or curing with more than 5% of NaCl in the product, while under-salted products contain less than 1.5% of NaCl. According to the study results of Radovanović *et al.*, [35] natrium chloride content in the samples of dry-cured beef ham was 4.3 to 4.5%, and during the sensory analysis the samples were rated as highly acceptable. The mentioned salt content of 4.3 - 4.5%, in addition to its sensory acceptability, meets the requirements in terms of shelf-life of products of this group (Radovanović and Stamenković, [36]).

The presence of total ash in the samples of dry-cured sheep ham was in range of 4.55 ± 0.11% (the fifth area) to 11.29 ± 0.32% (the first area). The level of ash in the samples was statistically-regarding significantly influenced by the researched area ($P < 0.05$). Džinleski [10], found 14.89% of ash in the samples of sheep pastrma. Considerably lower values of total ash were reported by Čaušević *et al.*, [7]. The researchers found 6.58% of ash in 14 days cured dry-cured sheep ham, while the content of total ash in the samples cured for 21 days was 7.87%. The researchers reported that the determined average ash content in 14 day-treated sheep pastrma was 10.65%, while in pastrma treated for 21 days ash content was 8.96%. Ganić *et al.*, [17] reported that the samples of dry-cured sheep ham produced in handicraft sector contained 5.15% of ash, while the ham produced in the industry contained 6.83% of ash. Dumić [9], in his study reported that the total ash content in dry-cured sheep ham at the salt concentration of 3.50% was 9.29%. At the concentration of NaCl of 4.00%, ash content was 9.24%. In the end, at the used quantity of salt of 4.50%, mineral matter content in the dry-cured sheep ham was 10.79%. Gajić [16] established ash content of 6.29% (the first manufacturer), 17.85% (the second manufacturer), and 9.97% (the third manufacturer) in sheep Kaštradina. Prgomet [33], also in the samples of sheep Kaštradina, found the average ash content of 14.30% in the shoulder, and 13.50% in the samples of the thigh with leg musculature.

Quantitative presence of heavy metals in dry-cured sheep ham was carried out only on the samples of *M. longissimus dorsi* (Table 3) for the following elements: iron (Fe), zinc (Zn), copper (Cu), cadmium (Cd) and lead (Pb).

If we compare the obtained values with the requirements stipulated by the Ordinance on the quantity of pesticides and other toxic substances, hormones, antibiotics and mycotoxins that may be present in food ("Official Gazette of SFRY", [32]), which was in force until the adoption of the present one in force in BiH, we would see that the values are in accordance with the provisions of the Ordinance. The European legislation (Regulation EC No 1881/2006, [6]) also sets maximum allowed levels for lead and cadmium only for meat and offal. Maximum permitted concentration of lead in meat is 0.10 mg/kg, while in offal it is 0.50 mg/kg. Maximum level of cadmium in meat (without offal) is 0.050 mg/kg. Gajić [16], also examined quantitative presence of heavy metals in dry mutton (sheep Kaštradina), and reported the following values for lead: 0.058 (producer 1), 0.131 (producer 2) and 0.146 mg/kg (producer 3), while the values for cadmium were: 0.003, 0.050 and 0.00 mg/kg respectively. Ganić *et al.*, [17] determined rather similar values for these elements in the samples of dry-cured sheep ham. Thus, the content of lead was < 1 mg / kg and of cadmium < 0.1 mg/kg. The same authors in their research found maximum values of 36 mg iron/kg, 38.7 mg zinc/kg and 2.5 mg copper/kg. Janković *et al.*, [21] reported that the cadmium content in meat and meat products was 0.015 µg/g.

Šuvalija [41], reported slightly higher values of heavy metals (lead and cadmium) in beef dry-cured meat products. In products from handicraft sector, Šuvalija [41], determined the average lead content of 0.132 mg/kg, while the content of cadmium was 0.038 mg/kg. On the contrary, the values in products from the industrial sector were lower and the value for lead was 0.106 mg/kg, while for cadmium it was 0.002 mg/kg. Bastić *et al.*, [4] also examined the presence of heavy metals in meat (arsenic, cadmium, mercury and lead), and especially in muscle tissue and certain internal organs of cattle and pigs. The authors in their study found that more than 90% of the tested samples of muscle tissue of animals had not contained lead and cadmium, but over 80% of mercury and over 45% of arsenic.

Table 3. The presence of heavy metals in samples of sheep dry-cured ham

Researched areas	Sample code	Fe (mg/kg)	Zn (mg/kg)	Cu (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
Area 1	S1	30.0	85.0	1.2	< 0.05	< 0.5
	S2	32.0	40.0	2.0	< 0.05	< 0.5
	S3	31.0	88.0	1.5	< 0.05	< 0.5
	S4	35.0	38.0	2.0	< 0.05	< 0.5
	S5	39.0	67.0	1.3	< 0.05	< 0.5
	S6	52.0	64.0	1.3	< 0.05	< 0.5
Area 2	S1	17.0	31.0	2.8	< 0.10	< 1.0
	S2	7.6	26.0	2.0	< 0.10	< 1.0
	S3	15.8	35.0	2.5	< 0.10	< 1.0
	S4	21.0	52.0	1.8	< 0.10	< 1.0
	S5	14.5	56.8	2.0	< 0.10	< 1.0
	S6	15.0	29.0	2.3	< 0.10	< 1.0
Area 3	S1	34.0	42.0	1.5	< 0.10	< 1.0
	S2	32.5	50.0	1.2	< 0.10	< 1.0
	S3	26.4	41.0	0.9	< 0.10	< 1.0
	S4	27.9	56.0	1.3	< 0.10	< 1.0
	S5	31.6	37.0	2.1	< 0.10	< 1.0
	S6	33.0	43.0	1.7	< 0.10	< 1.0
Area 4	S1	58.0	48.0	0.7	< 0.10	< 1.0
	S2	49.0	48.0	0.3	< 0.10	< 1.0
	S3	50.0	50.0	0.1	< 0.10	< 1.0
	S4	47.0	42.0	0.2	< 0.10	< 1.0
	S5	36.0	39.0	0.1	< 0.10	< 1.0
	S6	52.0	45.0	< 0.1	< 0.10	< 1.0
Area 5	S1	16.0	13.5	< 0.1	< 0.10	< 1.0
	S2	18.0	17.0	0.3	< 0.10	< 1.0
	S3	21.0	16.0	< 0.1	< 0.10	< 1.0
	S4	17.0	14.0	0.2	< 0.10	< 1.0
	S5	23.0	18.5	0.3	< 0.10	< 1.0
	S6	20.0	16.0	< 0.1	< 0.10	< 1.0

S1,... S6 - samples of sheep dry-cured ham

3.2 Sensory analysis

Results of sensory analysis of the samples of dry-cured sheep ham are shown in Table 4. Exterior appearance is best rated at the samples from the second area and the worst for the samples from the fifth researched area. The differences in mean values were significant, and were influenced by the researched area (P < 0.05). The colour was rather uniform in both groups of the samples from all five researched areas. Differences in mean values were not significant (P > 0.05) and were not affected either by the researched area or part of the carcass.

Consistency was best rated for the samples from the first area and the worst for the samples from the fourth area. The differences in mean values were significant (P < 0.05), and were affected both by the researched area and anatomical part of the carcass (P < 0.05). Cross-section appearance was also the best for the samples from the first researched area. The differences found in mean values were significant (P < 0.05) and were significantly (P < 0.05) influenced only by the research area. The samples from the first researched area had the best smell, and the worst one was found for the samples from the fourth researched area. The impact of the researched areas was statistically significant (P < 0.05). The taste of dry-cured sheep ham was best rated for the samples from the first area, and the lowest score was for the samples from the fifth area. The effect of the researched area on the taste was statistically significant (P < 0.05). Similar results of sensory analysis were reported by: Sinanović ([37, 38, and 39]), Stamenković and Dević, [40], Čaušević *et al.*, [7], Gajić [16], Ganić *et al.*, [17], Krvavica *et al.*, [23], and Ganić and Smajić, [18].

Table 4. Sensory quality of sheep dry-cured ham

The tested parameters	Anatomical part of the trunk	Researched areas					Influence of researched areas	Influence of anatomical part of the trunk	interaction
		Area 1	Area 2	Area 3	Area 4	Area 5			
Exterior appearance	LD n=30	$2,38 \pm 0,09^{abcd}$	$2,65 \pm 0,08^{a}$	$2,30 \pm 0,06^{bcde}$	$2,50 \pm 0,06^{abc}$	$2,02 \pm 0,08^{e}$	*	ns	ns
	FA n=30	$2,55 \pm 0,08^{ab}$	$2,68 \pm 0,06^{a}$	$2,20 \pm 0,08^{cde}$	$2,48 \pm 0,06^{abc}$	$2,07 \pm 0,07^{de}$			
Color	LD n=30	$1,82 \pm 0,07^{ab}$	$1,87 \pm 0,05^{ab}$	$1,70 \pm 0,04^{b}$	$1,83 \pm 0,04^{ab}$	$1,78 \pm 0,06^{ab}$	ns	ns	ns
	FA n=30	$1,97 \pm 0,02^{a}$	$1,83 \pm 0,05^{ab}$	$1,80 \pm 0,05^{ab}$	$1,85 \pm 0,04^{ab}$	$1,85 \pm 0,04^{ab}$			
Consistency	LD n=30	$2,83 \pm 0,05^{a}$	$2,47 \pm 0,07^{bcd}$	$2,58 \pm 0,06^{abc}$	$2,45 \pm 0,04^{bcd}$	$2,62 \pm 0,06^{ab}$	*	*	ns
	FA n=30	$2,82 \pm 0,05^{a}$	$2,33 \pm 0,07^{cd}$	$2,40 \pm 0,07^{bcd}$	$2,20 \pm 0,08^{d}$	$2,37 \pm 0,06^{bcd}$			
Cross-section appearance	LD n=30	$3,45 \pm 0,08^{a}$	$3,17 \pm 0,11^{abc}$	$2,93 \pm 0,07^{c}$	$3,05 \pm 0,09^{bc}$	$2,92 \pm 0,07^{c}$	*	ns	ns
	FA n=30	$3,40 \pm 0,08^{ab}$	$3,08 \pm 0,11^{bc}$	$2,95 \pm 0,06^{c}$	$3,00 \pm 0,06^{c}$	$3,07 \pm 0,06^{bc}$			
Smell	LD n=30	$2,85 \pm 0,06^{a}$	$2,73 \pm 0,06^{ab}$	$2,72 \pm 0,07^{ab}$	$2,30 \pm 0,06^{d}$	$2,62 \pm 0,06^{abc}$	*	ns	ns
	FA n=30	$2,83 \pm 0,06^{a}$	$2,68 \pm 0,08^{abc}$	$2,48 \pm 0,10^{bcd}$	$2,38 \pm 0,05^{cd}$	$2,45 \pm 0,07^{bcd}$			
Taste	LD n=30	$4,07 \pm 0,08^{ab}$	$4,15 \pm 0,08^{a}$	$3,83 \pm 0,08^{abc}$	$3,78 \pm 0,11^{abc}$	$3,70 \pm 0,07^{bc}$	*	ns	ns
	FA n=30	$4,15 \pm 0,09^{a}$	$3,95 \pm 0,08^{abc}$	$3,75 \pm 0,10^{bc}$	$4,02 \pm 0,07^{ab}$	$3,63 \pm 0,07^{c}$			

Legend:
a, b,... Means with different superscripts in each row differ significantly ($P < 0.05$),
n=30 for each treatment
LD – *longissimus dorsi*,
FA - femoral area (thigh with the leg).

4. Conclusions

- Statistical analyses of results of the slaughter values showed that the influence of the researched area was statistically significant ($P < 0.05$) as well as differences of the mean values ($P < 0.05$).

- Based on the chemical and sensory analysis having been carried out, it can be concluded that the chemical and sensory quality was statistically significant ($P < 0.05$) and affected by the researched area.

- On the other hand, the influence of the anatomical part of the carcass was significant ($P < 0.05$) only for chemical quality indicators, while the sensory evaluation was not significantly affected ($P > 0.05$) by this factor.

5. References

[1] Will Behington (Ed.). (1984). *Official methods of analysis* (16th Ed.). Association of Official Analytical Chemists, Rockville, Maryland, USA.

[2] Kenneth Helrich (Ed.). (1990). *Official Methods of Analysis* (15th Ed.). Association of Official Analytical Chemists, Arlington, VA, USA.

[3] Aničić V., Petrović N., Barać S. (1977). *Mutton delicatessen. Quality of meat and standardization*. Jugoinspekt Sarajevo, Bosnia & Herzegovina.

[4] Bastić Lj., Radović N., Saičić S., Mrđanov J., Hromiš A., Boldocki K., Medić O. (1988). *Heavy metals and arsenic-contaminated in meat and meat products*. Meat Technology, 11, pp. 306-310.

[5] Beriaín M. J., Iriarte J., Gorraiz C., Chasco J., Lizaso G. (1997). *Technological Suitability of Mutton for Meat Cured Products*. Meat science, 47, pp. 259-266.

[6] European Commission. (2006). *Commission Regulation (EC) No 1881/2006 on setting maximum levels for certain contaminants in foodstuffs*. OJ. L 364, pp. 5.

[7] Čaušević Z., Milanović A., Glogovac Ž., Lelek M., Rahim A A. (1984). *Technology of production of sheep prosciutto and pastrma with highlighted influence of curing their quality*. Faculty of Agriculture, University of Sarajevo, 32, (36), pp. 127-139.

[8] Čavoški D., Radovanović R., Perunović M. (1990). *Quality semi-dry meats and cooked sausages from the Belgrade market - in terms of the content of NaCl and nitrite*. Meat Technology, 3, pp. 105-109.

[9] Dumić S. (2008). *Exploring of more important characteristics of quality in Sjenica's sheep prosciutto as a basis for protection of origin*. Master's thesis, Faculty of Agriculture, University of Belgrade, Serbia.

[10] Džinleski B. (1969). *Sheep pastrma in feeding the population*. Meat Technology, 10, (6), pp. 175-179.

[11] Džinleski B. (1988). *The distinctive smell and taste of sheep meat*. Meat Technology, 29, (12), pp. 353-356.

[12] Džinleski B., Kocevski D., Mihailovski G., Kocarev P. (1992). *Lamb cans*. Macedonian Veterinary Review, 21, (2), pp. 21-30.

[13] Džinleski B., Kocevski D., Sokolov N. (1993). *Dried sausages with lamb*. Macedonian Veterinary Review, 22, (1-2), pp. 39-44.

[14] Džinleski B., Sokolov N., Kocarev P., Kocevski D. (1994). *Macedonian dry sausage*. Meat Technology, 6, pp. 252-254.

[15] Džinleski B., Sokolov N., Kocarev P., Kocevski D., Starova J. (1995). *Dried mutton in pieces*. Macedonian Veterinary Review, 24, (1-2), pp. 23-29.

[16] Gajić B. (2000). *Contamination of meat products' substances harmful to human health*. Master's thesis, Faculty of Agriculture, Sarajevo, Bosnia & Herzegovina.

[17] Ganić A., Smajić A., Bijeljac S., Brdarić N., Zahirović L., Jesenković L., Operta S., Omanović H. (2009). *Comparison of basic quality parameters of sheep prosciutto produced in handicraft and industrial conditions*. Proceedings of 20th Scientific-expert conference on agriculture and food industry, Neum, Bosnia and Herzegovina, pp. 117-123.

[18] Ganić A., Smajić A. (2013). *Influence of the researched area and anatomic position on the sensory quality of sheep prosciutto*. Faculty of Agricultural and Food Sciences, 58, (63/1), pp. 63-71.

[19] Ganić A., Čaušević A., Karahmet E., Stojković S., Ratković D., Krvavica M. (2013). *Contribution to technology and quality of sheep ham*. International 57th Meat Industry Conference Proceedings, Belgrade, Serbia, pp. 216-221.

[20] Ivanković S., Ćurković M., Batinić V., Mioč B., Ivanković A. (2009). *Exterior features of Kupres' Pramenka*. Livestock, 63, 3, pp. 163-173.

[21] Janković S., Nikolić D., Stefanović S., Radičević T., Spirić D., Petrović Z. (2013). *Estimation of dietary intake of cadmium food in Serbia*. Meat Technology, 54, (2), pp. 123-129.

[22] Jovanović S., Savić M., Petrujković T., Vučinić M. (2007). *Modern trends in breeding and health protection of sheep and goats*. Faculty of the Veterinary Medicine of Beograd and Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia.

[23] Krvavica M., Friganović E., Đugum J., Kegalj A. (2009). Dalmatian Kastradina (Kostradina). Meso, 11, (5), pp. 285-290.

[24] Krvavica M. (2010). *Indigenous meat products from sheep and goat meat*. Proceedngs of the Second Croatian Congress of Rural Tourism, Mali Lošinj, Croatia, pp. 387-393.

[25] Krvavica M., Mioč B., Konjačić M., Friganović E., Ganić A., Kegalj A. (2011). *Weight loss in the processing of dry-cured mutton: Effect of age, gender and processing technology*. Agriculturae Conspectus Scientificus, 76, (4), pp. 345-348.

[26] Krvavica M., Vrdoljak M., Kegalj A. (2012). *Number of sheep and production of sheep meat in the world and in Croatia*. Meso, 14, (6), pp. 491-495.

[27] Milosavljević Ž. (2004). *Production of dry-cure meat products*. Nolit AD, Beograd, Serbia.

[28] Mioč B., Pavić V., Sušić V. (2007). *Sheep-farming*. Croatian Dairy Association, Zagreb, Croatia.

[29] Mioč B., Marina Krvavica, I. Vnučec, V. Držaić, Z. Prpić, Andrijana Kegalj (2011): Slaughter indicators and features of carcasses of Travnik's Pramenka. Livestock 65 (3) 179-188

[30] Mitić N. (1987). *Sheep Breeding*. Institute for Textbooks and Teaching Aids, Beograd, Serbia.

[31] Neil D. S. M. (1964). *The anatomy of the sheep*. University of Queensland Press, St. Lucia Brisbane, Queensland, Australia.

[32] Ministry of Agriculture. (1987). *Regulation on quantities of pesticides and other toxic substances, hormones, antibiotics and mycotoxins that may be present in food*. Official Gazette of SFRY, No. 59/83 and 79/87.

[33] Prgomet A. (1979). *Contribution to the production and properties of Kastradina in Dalmatia*. Master's thesis, Faculty of Veterinary Medicine in Zagreb, Croatia.

[34] Radovanović R., Popov-Raljić J. (2001). *Sensory analysis of food products*. University of Begrade/University of Novi Sad, Serbia.

[35] Radovanović R., Stamenković T., Saičić S. (2003). *Sensory properties and chemical parameters of beef prosciutto*. Meat Technology, 44, (5-6), pp. 212-219.

[36] Radovanović R., Stamenković T. (2004). *Sensory quality evaluation of beef prosciutto*. Meat Technology, 45, (1-2), pp. 8-13.

[37] Sinanović N. (2005). *Estimation of dried meat products at the market of Sarajevo canton*. Master's thesis, Faculty of Agriculture, University of Sarajevo, Bosnia and Herzegovina.

[38] Sinanović N. (2005). *The attitude of consumers towards dried meat products at the market of the Sarajevo Canton area*. Faculty of Agriculture University of Sarajevo, 5, (55/2), pp. 163-175.

[39] Sinanović N., Smajić A., Ganić A. (2005). *Sensory estimation of quality dried meat products at the market of the Sarajevo Canton.* Faculty of Agriculture, University of Sarajevo, 5, (55/2), pp. 177-187.

[40] Stamenković T., Dević B. (2006). *Sensory properties of sheep prosciutto*. Meat Technology, 47, (3-4), pp. 115-122.

[41] Šuvalija B. (2002). *Production and quality of the Bosnian beef prosciutto*. Master's thesis, Faculty of Agriculture University of Sarajevo, Bosnia and Herzegovina.

[42] Vranić D., Saičić S., Lilić S., Trbović D., Janković S. (2009). *Study on the content of sodium chloride and sodium in some meat products from the Serbian market*. Meat Technology, 50, (3-4), pp. 249-255.

[43] Vuković I. (2012). *Basics of meat technology*. The Veterinary Chamber of Serbia.

[44] Živković J., Hađiosmanović M. (1996). *Cured meat products. Errors of meat products*. Medical publisher, Zagreb, Croatia.

[45] Žlender B., Gašperlin L. (2004). *Traditional methods in meat processing and possibility of their application in modern industrial technologies*. Meat Technology, (3-4), pp. 81-88.

[46] Žlender B. (2009). *Decreasing the salt concentration in meat products*. Meso, 11, (3), pp. 189-195.