THE INFLUENCE OF RAW MATERIALS AND DIFFERENT FERMENTATION INTERVALS ON QUALITY PARAMETERS OF THE TRADITIONALLY PRODUCED BOSNIAN SUDŽUK

ORIGINAL SCIENTIFIC PAPER

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ABSTRACT: Bosanski sudžuk (The "Bosnian sudžuk" – The Bosnian Smoked Sausage) prepared in a traditional way is fermented and dried product made from high-quality ground beef and beef tallow with the addition of salt and spices. The production of Bosnian sudžuk in a traditional way comes down to filling the natural sausage casings with ground, salted beef and fat with the addition of salt and spices which are subsequently smoked, i.e. dried. This study was aimed to determine how the composition of raw materials and the extended fermentation interval, applied after stuffing natural casings, affect physicochemical and sensory properties of traditionally produced Bosnian sudžuk. The following samples of Bosnian sudžuk were prepared in the traditional way: Sample I – Bosnian sudžuk made from a combination of beef and beef fat tissue with the addition of spices and Sample II – Bosnian sudžuk made from a combination of beef, lamb and beef fat tissue with the addition of spices. After preparation of stuffing and filling into casings, the samples underwent prolonged liquid squeezing (fermentation) that lasted three days. During the aforementioned squeezing, the samples of the stuffing were analyzed on their chemical composition as well as pH changes of the stuffing. After the completion of the liquid squeezing process, the samples of Bosnian sudžuk were dried and smoked in the classical drier. The research results showed that the weight loss of dried Bosnian sudžuk was higher in the Sample II than in the Sample I. The course of changes of pH was balanced for both samples tested, and the final pH of the dried product was higher in the Sample II than in the Sample I. Regarding the chemical parameters of quality, the Sample II had a lower content of water and a higher content of fat and proteins compared to the Sample I. Sensory evaluation showed that the Sample I had better overall grade compared to Sample II.

KEYWORDS: Bosnian sudžuk, fermented sausage, physicochemical properties, sensory properties

INTRODUCTION

Bosnian sudžuk produced in a traditional way is a dried meat product, traditionally made of beef and beef fat, salt, garlic and pepper. It has been produced without strict technological norms and it has a well known horseshoe shape and a characteristic taste. A similar product can be found in Turkey and it is assumed that origin of Bosnian sudžuk is exactly from Turkey. Owing to production norms of sliced meat, semi-products and products of meat [1] sudžuk is a product made of sliced beef, beef fat, salt or substitute for salt, sugar, additives, spices or spice extracts and starter cultures. The mixture for sudžuk is stuffed into thin beef natural or synthetic casings. Ingredients of recepie and production conditions are parameters responsible for specifications andadvantages in sensory properties of fermented sausages compared to ones produced in controlled conditions [2]. Content of meat proteins is not allowed to be less than 16%, and relative protein content of connective tissue in proteins (content of collagen) is not allowed to be grater that 20% [1]. Since there are no strict regulations regarding production of Bosnian sudžuk, products of different quality are available on the market as a result of diverse technological approaches in manufacture, but also as a result of different climate factors [3].

In traditional production of dried sausages, natural lactic-acid bacteria, during fermentation, are transmuting, already existing or additional sugars, in lactic acid [4]. Sudžuk production starts at the end of autumn and the begining of winter, and has a natural process of ripening. During fermentation, lactic acid is made and pH is decreased. Acidification helps in creating colour and coagulation of proteins affects firmness and cohesiveness of a product, as well activation of protein muscle [5].

Important factor for a taste and smell of fermented sausages is a proteolysis process, caused by an activity of endogenous and microbial proteinases and peptidases, which results in increased content of polypeptids, peptids and free amino acids [6]. Fermented sausages are products with a high fat percentage responsible for many properties of sausages. During the oxidation and lipolytic changes

in fat, important components of taste, smell and texture are created [7]. Spices used in production of fermented sausages, beside the taste, have the antioxidant impact and stimulatory impact on fermentation. Many spices have influence on microorganisms, and in specific conditions some spices can stimulate bacteria to create lactic acid [8].

MATERIAL AND METHODS

Experimental part of production was done in November 2015 by a local producer of dried meat products in Turija, a village in munipacility Bihać. Bosnian sudžuk has been mainly produced out of beef and sheep meat of I and II category.

Samples of sausages were produced in the following way: Sample I – a mixture for sudžuk production contained beef (92.59%) and beef tallow (7.41%); Sample II - a mixture for sudžuk production contained beef (74.07%), sheep meat (18.51%) and beef tallow (7.41%). All processes in production of Bosnian sudžuk were carried out in the same way for both mixtures. Meat and beef tallow were chopped manually, with a knife, in small pieces (4x4 cm); salt and black pepper were added, 3.1% and 0.07% respectively. After mixing meat and tallow together with spices, both samples (I and II) were left to ripen for 24 hours in a place at average temperature cca 10°C. Then garlic (1.9%) was added to the mixtures, mixed with meat and ground it in a meat grinder. The diameter of grid in the meat grinder was 4 mm. Sudžuk was stuffed in thin beef casings of 30-40 mm diameter. Before use, casings were salted and left in warm water to become elastic. A sausage stuffer was used to stuff the sausage mixture into casings. There is a hole with a thin tube on the bottom of the stuffer. A sausage casing was slid onto the funnel and pushed on the stuffer then, a casing was filled with the sausage mixture. Casings should be stuffed well, in order to become firm. After stuffing, the sudžuk was tied up in a shape of rings and settled on a stick to be equidistant; rings should not touch each other.

Prolonged liquid squeezing (fermentation) of the prepared samples lasted for 3 days. Room temperatures where samples were stored were in the range from 7°C up to 14°C. After prolonged liquid squeezing, the samples were settled on rounded sticks, separated from each other in order for every ring to be equally smoked and dried out. The samples were smoked and dried in a typical smokehouse with an open furnace, and it lasted for 12 days. Beech wood was used for fire. Distance between the sudžuk horseshoe and the furnace/fire bed was approximately three meters. Fire was made in the open furnace/fire bed without flame. Smoking and drying were done at room temperature between 0 °C and 10 °C. After the smoking process, the samples of sudžuk were left to ripen for 5 days in the same room at cca. 10 °C, while in the meantime sausages became of firmed consistency. During the whole process, mentioned above, the samples lost some of their initial weight which was determined by weighing the finished product and calculating lost weight (kalo). Afterwards, the samples of sausages were anylized in the Laboratory of Biotechnical Faculty, University of Bihać. Loss of weight during the liquid squeezing process (for 1st, 2nd and 3rd day) and at the end of process was determined using a scale (±0.01).

In the scope of physicochemical methods, the analyses of pH value were performed by pH metre according to the method ISO 2917:1999.

pH changes were recorded for samples I and II during the process of liquid squeezing (0, 1st, 2nd and 3rd day) and afterwards for the finished product. In the period of liquid squeezing process (for 0 and 3rd day) and for finished product, the following chemical analyses were performed: assessment of moisture content according to a method from drying to constant mass, BAS ISO 937; assessment of fat content according to a method by Soxhlet, BAS ISO 1443; assessment of protein content by Kjeldahl, determining nitrogen and multiplying by a factor (Nx6.25), BAS ISO 937; assessment of sodium chloride according to a volume method [9].

Sensory estimation of the finished product was done using quantitative-descriptive methods QDA [10]. The constant unstructured 10 cm long scale was used for the sensory estimation. Altogether 14 attributes of sudžuk were rated: view of cross section through four descriptors, connectivity of muscle and fat (adipose tissue), intensity in colour of muscle, intensity in colour of adipose tissue and presence of cortex; texture measuring in the mouth through four descriptors: softness, juiciness, toughness and fatness; taste through two descriptors: saltiness, sourness; aroma through four descriptors: flavour of garlic, flavour of black pepper, flavour of smoke and rustyness. A commission for evaluation of samples, consisted of 3 members, each of them having the following standards for tastes: saltiness (solution of 2% of salt) and sourness (solution of 0.1% of citric acid).

The obtained results were analyzed applying the statistical methods and significance of deviations was determined with an ANOVA test. When the main impact was significant, averages were split by Tukey's test of the smallest significant deviations at 5% level. Level of significance $p < 0.05$ was used for comparison and discussion of the obtained results.

The data were analyzed using statistical software SPSS (ver. 20).

RESULTS AND DISCUSSION

Table 1. Loss of weight (kalo) of Bosnian sudžuk after prolonged liquid squeezing (1st, 2nd and 3rd day) and of finished product

Liquid squeezing	Kalo %	
	Sample I	Sample II
1st day	5.50	6.25
2nd day	11.11	12.50
3rd day	18.88	18.75
Dried product	38.88	43.75

Loss of weight in the overall process (production) is due to process of drying, i.e. loss of moisture during the drying process. Loss of weight in fermented sausages is impacted by different factors: temperature, relative humidity, air circulation in a smokehouse, recipe of meat mixture, features of casings [11]. Operta et al. [10] stated that values for kalo ranged between 31.50% and 40.70% in Bosnian sudžuk production. Yildiz-Turp and Serdaroglu [12] determined kalo for Turkish fermented sausage of 35.10%. In Table 2, there are statistical parameters for pH of prolonged liquid squeezing (fermentation) (0 day, 1st day, 2nd day, 3rd day) and of dried product. On the 2nd day of liquid squeezing, Sample I had a quite low pH value compared to the 1st day. Sample II, which contained sheep meat, had a negligible increase in the pH value on the 2nd day, compared to the 1st day of liquid squeezing.

Table 2. Statistical-variation parameters for pH values of Bosnian sudžuk

Days	Sample I					Sample II				
	Parameters					Parameters				
	Σ	$\bar{x}$	SD	Stand. error	CV	Σ	$\bar{x}$	SD	Stand. error	CV
0 day	46.43	5.80^{A}	0.02	0.007	0.33	45.70	5.71^{B}	0.01	0.005	0.24
1st day	46.46	5.81^{A}	0.02	0.007	0.33	45.58	5.70^{B}	0.02	0.005	0.26
2nd day	45.76	5.72^{B}	0.02	0.008	0.41	45.91	5.74^{A}	0.01	0.004	0.21
3rd day	45.56	5.70^{B}	0.01	0.005	0.30	47.94	6.00^{A}	0.03	0.006	0.31
21st day –dried product	43.55	5.44^{B}	0.02	0.005	0.28	45.74	5.72^{A}	0.01	0.004	0.18

Σ – Summ, $\bar{x}$ – Average value of eight measurements, SD – Standard deviation, CV – Coefficient of variation; Average values in the same rows marked with supersricpts A,B are highly significantly different ($p<0.01$) (Tukey test)

Table 3. Statistical-variation parameters chemical analysis of samples during prolonged liquid squeezing (zero day and third day)

Chemical composition	Sample I –zero day					Sample II – zero day				
	Parameters					Parameters				
	Σ	$\bar{x}$	SD	Stand. error	CV	Σ	$\bar{x}$	SD	Stand. error	CV
Water %	513.12	64.14^{A}	0.80	0.281	1.45	490.84	61.35^{B}	1.08	0.383	1.77
Ash %	19.09	3.83^{B}	0.03	0.014	0.82	24.85	4.97^{A}	0.11	0.048	2.15
Fat %	52.04	10.41^{A}	0.08	0.035	0.75	42.49	8.50^{B}	0.05	0.022	0.58
Proteins %	97.43	19.49^{B}	0.03	0.014	0.16	114.02	22.80^{A}	0.08	0.038	0.37
NaCl %	15.00	3.00^{B}	0.05	0.023	1.72	19.69	3.94^{A}	0.03	0.016	0.89
	Sample I –third day					Sample II –third day				
	Parameters					Parameters				
	Σ	$\bar{x}$	SD	Stand. error	CV	Σ	$\bar{x}$	SD	Stand. error	CV
Water %	400.35	50.04^{b}	0.73	0.259	1.46	410.63	51.33^{a}	0.56	0.120	1.10
Ash %	27.81	5.56	0.06	0.026	1.06	27.62	5.52	0.25	0.115	4.66
Fat %	72.52	14.50^{A}	0.06	0.026	0.39	62.54	12.50^{B}	0.13	0.058	1.04
Proteins %	129.50	25.90^{b}	0.07	0.033	0.28	132.66	26.53^{a}	0.35	0.158	1.33
NaCl %	22.26	4.45^{b}	0.05	0.021	1.05	23.52	4.70^{a}	0.10	0.046	2.20

Σ – Summ, $\bar{x}$ – Average value of five measurements, SD – Standard deviation, CV – Coefficient of variation; Average values in the same rows marked with supersricpts A,B are highly significantly different ($p<0.01$); Average values in the same rows marked with supersricpts a,b are significantly different ($p<0.05$)

Table 4. Statistical-variation parameters chemical analysis of Bosnian sudžuk (dried product)

Chemical composition	Sample I					Sample II				
	Parameters					Parameters				
	Σ	$\bar{x}$	SD	Stand. error	CV	Σ	$\bar{x}$	SD	Stand. error	CV
Water %	348.64	43.58^{A}	0.03	0.012	0.08	330.08	41.26^{B}	0.03	0.010	0.07
Ash %	54.80	6.85	0.04	0.013	0.53	54.88	6.86	0.04	0.013	0.56
Fat %	85.49	17.10^{B}	0.05	0.021	0.28	90.00	18.00^{A}	0.04	0.017	0.21
Proteins %	157.34	31.47^{B}	0.03	0.012	0.08	164.39	32.88^{A}	0.03	0.012	0.08
NaCl %	31.20	6.24	0.03	0.013	0.47	31.04	6.21	0.03	0.015	0.54

Σ – Summ, $\bar{x}$ – Average value of five measurements, SD – Standard deviation, CV – Coefficient of variation; Average values in the same rows marked with supersricpts A,B are highly significantly different ($p<0.01$)

Table 5. Statistical-variation parameters sensory assesment of Bosnian sudžuk

Senzory properties	Sample I					Sample II				
	Parameters					Parameters				
	Σ	$\bar{x}$	SD	Stand. error	CV	Σ	$\bar{x}$	SD	Stand. error	CV
View of cross section										
Connectivity of muscle and fat	34.40	5.73	1.47	0.602	25.72	27.20	4.53	0.51	0.209	11.31
Colour of meat	28.60	4.77	1.14	0.466	23.94	32.50	5.42	2.50	1.020	46.12
Colour of fat	31.40	5.23^{A}	1.17	0.477	22.34	20.70	3.45^{B}	0.48	0.196	13.93
Presence of cortex	25.90	4.32	1.40	0.573	32.51	23.50	3.92	0.99	0.404	25.25
Texture in mouth										
Softness	23.40	3.90^{B}	0.45	0.183	11.47	34.00	5.67^{A}	1.13	0.461	19.92
Juiciness	29.10	4.85	0.97	0.395	19.94	23.90	3.98	0.65	0.266	16.38
Thougness	29.90	4.98	0.94	0.385	18.93	33.90	5.65	1.42	0.581	25.17
Fatness	29.00	4.83^{b}	0.75	0.307	15.57	38.40	6.40^{a}	1.04	0.426	16.30
Taste										
Saltiness	31.90	5.32	0.44	0.182	8.36	30.10	5.02	0.04	0.017	0.81
Sourness	25.80	4.30	0.55	0.225	12.82	28.90	4.82	1.36	0.554	28.17
Aroma										
Favour of garlic	33.10	5.52	1.23	0.504	22.36	20.60	3.43	2.29	0.937	66.82
Flavour of black pepper	23.30	3.88	1.85	0.756	47.72	16.00	2.67	1.96	0.802	73.62
Flavour of smoke	23.40	3.90	1.20	0.490	30.77	16.90	2.82	1.46	0.595	51.71
Rustyness	2.90	0.48	0.44	0.182	91.99	6.30	1.05	0.54	0.222	51.73
Overall grade	14.00	2.33	0.82	0.333	34.99	7.00	1.17	2.14	0.872	183.17

Σ – Summ, $\bar{x}$ – Average value of triplicate, SD – Standard deviation, CV – Coefficient of variation; Average values in the same rows marked with supersricpts A,B are highly significantly different ($p<0.01$); Average values in the same rows marked with supersricpts a,b are significantly different ($p<0.05$)

On the 3rd day, a further decrease in pH value in Sample I was recorded, while in Sample II pH value was increasing. Salgado et al. [13] state that the increase in pH value in later phases affects the decrease in a content of lactic acid in a sausage mixture. Turkish Food Codex [14] concluded that pH value in fermented sausage should not be greater than 5.4. Lactic acid that occurred during the activity of bacteria of lactic acid on carbohydrates is responsible for the decrease in pH value [15].

Standards for production of traditional Turkish sudžuk [16] recommend a pH value of dried sausages between 4.7 and 5.4. Erkmen and Bozkurt [17] concluded that traditionally produced samples had pH value greater than 5.4. Siriken et al. [18] determined the average pH value for Turkish sudžuk 5.49, while Bozkurt and Bayram [19] determined pH for Turkish sudzuk 5.1. Table 3 shows the chemical results of the sample analysis for day 0 and 3rd day. Sample I had a greater content of water compared to Sample II. Ercoskun et al. [20] found out that moisture content in Turkish sudžuk fluctuated between 57% and 58%. Sample II had a greater content of ash for day 0 compared to Sample I; 3rd day of liquid squeezing ash

content in the mixture was greater in Sample I than in Sample II. Ercoskun et al. [20] recorded ash content from 3.60% for day 0 to 5.11% for the fifth day. Sample I had a greater content of fat compared to Sample II. Ercoskun et al. [20] determined several values of fat content: from 25.66% of zero day to 36.57% of the fifth day. Sample II had a greater protein content compared to Sample I. Ercoskun at al. [20] determined lower values of proteins: from 13.26% for day zero 13.26% to 18.77% for the fifth day. Sodium chloride is responsible for the sensory properties and technological features in fermented sausage [21]. Sample II had a greater content of sodium chloride for day 0 compared to Sample I ($p<0.01$).

Third day Sample II had the increased content of sodium chloride compared to Sample I ($p<0,05$). Ercoskun et al. [20] determined a content of sodium chloride for day zero 2.56% to 3.66% for the fifth day. Table 4 shows the results of chemical analysis in the finished product. Sample I had greater water content compared to water content in Sample II ($p<0.01$). According to Operta et al. [22], a content of water in Bosnian sudžuk fluctuated between 28.65% and 33.45%. Siriken at al. [23] obtained variations in water content from 29.80% up to 47.60%. Sample II had greater fat content compared to fat content in Sample I ($p<0.01$). Operta et al. [10] determined high fat content for Bosnian sudžuk too, fluctuating from 27.33% up to 35.79%. Sample II had greater protein content compared to protein content in Sample I ($p<0.01$). Operta et al. [10] determined a content of proteins in samples of Bosnian sudžuk from 27.78% up to 33.40%.

Acording to Soyer et al. [24], a content of proteins in Turkish sudžuk fluctuated between 16.5% and 28.30%. NaCl (salt) is added to meat products because of its multiple impact on texture, aroma and sustainability, so that its decrease in meat products can have negative effects on water connectivity and emulsifying of fat, can damage the whole structure, increases losses in cooking, damages sensory quality, and especially affects taste [25]. In the survey by Operta et al. [26], a content of sodium chloride in Bosnian sudžuk was between 3.3% and 8.3%. Table 5 shows the results of sensory evaluation. Consistency of meat and fat in cross section was very good and uniform, also the colour of cross section was uniform. In both samples colour was dark red, except that colour tone in the sample with sheep meat was slightly darker. After ripening the cross section of product looked like mosaic, with small pieces of fat, which is characteristic for Bosnian sudžuk. There were no cracks inside the product, and the whole mixture had good consistency. Crust was standing out. According to the survey by Operta et al. [10], samples of sudžuk had good consistency in muscle and fat on cross section, while colour was dark red. The mark for softness (parameter of sensory feature texture in mouth) was greater for Sample II made with mixture of beef and sheep meat compared to Sample I, and Sample II had the greater mark for fatness than Sample I.

For sensory feature, saltiness in both of samples had a satisfactory salinity taste, without deviations in samples. Sourness was slightly stronger in Sample II compared to Sample I. Garlic aroma was stronger in Sample I compared to Sample II, which was the same for black pepper and smoke. The evaluators gave a greater grade for rustyness for Sample II. Toldra [27] suggested that rustyness and yellow colour of fat could be a consequence of oxidation unsaturated fat acids. The overall grade was better for Sample I compared to Sample II.

CONCLUSIONS

The results showed that loss of weight in Bosnian sudžuk (kalo) of a dried product was greater in Sample II in which recipe sheep meat was added. Fluctuation in changes of pH value in the stuffing mixture of sausage during the extended fermentation had a decreasing tendency in Sample I, while in Sample II the increase in pH was small. pH at the end of process (dried product) in both samples was lower than initial pH.

During the extended fermentation, the content of water decreased in both samples, and proportionally the content of other ingredients increased. After the sensory analysis, the overall result was better in case of Sample I compared to Sample II. Bosnian sudžuk produced from beef and from a mixture of beef and sheep meat in the prolonged liquid squeezing process (fermentation) is a high quality dried meat product.

Replacement in part of beef meat in the traditional recipe by sheep meat did not have a significant impact on quality and sensory acceptability, while the prolonged liquid squeezing process had a significant influence on the decrease in the pH value of mixture, that positively resulted in the quality of a finished product.

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