

# The influence of raw material on physical-chemical and sensory properties of Bosnian sujuka produced under controlled conditions

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## Summary

Sujuka, a dry fermented sausage in Bosnia and Herzegovina is traditionally produced from beef, beef tallow, salt, garlic and black pepper. This paper was focused on examining the influence of different raw materials (I, II and III, II, II and III category of beef and different quantities of added beef tallow) on some physical-chemical and sensory properties of Bosnian sujuka produced under controlled conditions. Four variants of Bosnian sujuka were produced (A, B, C and D) based on different quantities of certain categories of beef and different quantities of beef tallow. Variants A and B, at the end of the production process, had a significantly lower ( $p < 0.05$ ) pH value (5.1) relative to the variants C and D (5.2), which is the result of the lower initial pH value in these variants. In terms of Aw value, all the variants of sujuka were stable (0.89 – 0.90) and showed no significant differences ( $p > 0.05$ ). The loss of mass during the drying process ranged from 31% to 40%, where all the variants showed significant variations in mass ( $p < 0.05$ ). Chemical composition in all the variants was favorable in terms of moisture (28% - 33%) and proteins (27% - 33%). The content of fats showed the highest variation ranging from 27% to 35%. A significantly lower content of moisture was found in variant D relative to the variants B and C ( $p < 0.05$ ). A significantly higher fat content was found in variant A compared to C and B variants ( $p < 0.05$ ), but not to D ( $p > 0.05$ ) variant. There were some significant differences in protein content among all the variants, except for A and B ( $p > 0.05$ ). The content of hydroxyproline/collagen was significantly influenced by selected raw material, and all the sujuka variants showed significant differences in hydroxyproline and collagen contents. The content of ash in different variants of sujuka was uniform, showing no significant differences ( $p > 0.05$ ), and ranged from 5.2% to 6.2%. Variant C had a significantly higher content of NaCl, whereas variant A had a significantly higher ( $p < 0.05$ ) content of nitrites compared to other variants of sujuka. When it comes to the evaluation of cohesion of muscle and fat tissue, presence of crust at cross section, toughness, fattiness, sourness, garlic and black pepper aromas in sujuka variants, there were no statistically significant differences ( $p > 0.05$ ).

**Keywords:** categories of beef, beef tallow, Bosnian sujuka, physical-chemical properties, sensory properties

## Introduction

Sujuka – a Bosnian dry fermented sausage, is produced in large quantities in all parts of Bosnia and Herzegovina. Sujuka is produced in both traditional and commercial way. Bosnian sujuka is traditionally produced in winter time by filling the stuffing consisting of beef meat and tallow of older animals supplemented by salt, black pepper and garlic, into thin beef casings and then drying in traditional smoke chambers without any control of atmospheric conditions. But, commercial sujuka is produced from beef and beef tallow with addition of salt, spices and spice mixtures,

antioxidants, nitrites and starter cultures. Such sujuka is stuffed into artificial, usually collagen casings and subjected to controlled atmospheric conditions of drying and maturing. However, very few meat industries are in a possession of chambers for producing sujuka under controlled conditions, so that sujuka is usually dried in traditional smoke chambers, sometimes followed by a short thermal treatment. According to the Regulation on quality of meat products (RBIH Official Gazette, 02/92, and 13. and 14/94) sujuka is a dry sausage produced by producer's specification. The tradition of producing and

eating sujuka in Bosnia and Herzegovina and wider region is more than 500 years long, as it dates from the rule of the Ottoman Empire in the region (Gasparik-Reichardt et al., 2005). A similar fermented sausage called "soudjuk" or "sucuk" is produced in Turkey, which in the past used to be made from beef only, but today it is also made from mutton and buffalo meat.

Most of the meat industries in Bosnia and Herzegovina base their production of sujuka on traditional recipes which require beef meat and tallow, garlic and black pepper, but

Table 1 Composition of Bosnian sujuka (%)

Komponents	Variants of sujuka			
	A	B	C	D
I category beef	80	45		
II category beef		40	90	50
III category beef				50
Beef tallow	20	15	10	-
Nitrite salt	2.5	2.5	2.5	2.5
Garlic	0.4	0.4	0.4	0.4
Black pepper	0.25	0.25	0.25	0.25

Table 2. Process conditions of Bosnian sujuka

	Temperature (°C)				Humidity %	Air speed m/s	Time
	Meat	Beef	Mixture	Place			
Grinding	0	-18		to 10	to 75		-
Mixing			0	to 10	to 75	10 minutes	
Curing		2	0 - 4	to 10	to 85	24 hours	
Stuffing		4	to 10	to 10	to 75		
Conditioning				18 - 20	58 - 60		8 hours
Fermentation				22 - 24	92 - 94	0.5 - 0.8	2 days
Drying and smoking				20 - 22	88 - 92	0.2 - 0.5	2 dana
	Smoke was thrown into (4 days / 0.5 hours), Microclimate: 22°C and 80 - 85% RH				18 - 20		
Drying and ripening				16 - 18	80 - 86	0.1 - 0.2	7 days
Packaging				16 - 18	75 - 80	0.1 - 0.2	
Storage				10	do 75		
				4	do 75		

with the addition of nitrite salt and starter cultures. The quality of sujuka offered in BiH market is rather variable, which is also confirmed by previous research work (Čaušević et al., 1985; Smajić and Čorba, 1987; Smajić, 1988; Smajić et al., 1990; Tupajić, 1991; Gajić, 2000; Salihbegović, 2002; Operta, 2005; Sinanović et al., 2005; Gasparik-Reichardt et al., 2005; Kratina, 2005; Hadžiosmanović et al., 2005; Operta and Smajić, 2006; Operta et al., 2007; Operta et al., 2008; Operta, 2008; Čengić et al., 2008; Kozaciński et al., 2008). Previous researches state that oscillations in quality of sujuka are related to the following causes: the use of different raw materials (I, II, III categories of beef as well as their combination, with the supplement of different

percentage of beef tallow), different length of production process (from 3 to 30 days) and/or uncontrolled production conditions, especially smoking and drying of Bosnian sujuka in traditional smoke chambers. Čakolovica et al. (2005; 2006) researched antimicrobial effect of selected strains of lactic acid bacteria (1151, 1154 and 1155), and Alagić et al. (2009) researched lactoflora and sensory traits of Bosnian sujuka.

The purpose of this research is to determine the influence of different raw materials (I, I and II, II, II and III category of beef and different quantities of added beef tallow) on certain physical-chemical and sensory properties of sujuka produced under controlled conditions.

## Material and methods

In the production of Bosnian sujuka we used fresh cooled beef, frozen beef tallow, collagen casing of 55 mm in diameter, black pepper, fresh garlic and nitrite salt.

The categorization of beef was made as follows: I category beef (meat from leg, thoroughly cleaned from adipose and connective tissue, as well as from blood and lymphatic vessels and nerves), II category beef (meat from back, shoulder and loins, roughly cleaned from large pieces of adipose and connective tissue), III category beef (meat from chest, ribs and neck which is not thoroughly cleaned from other types of tissue). Beef and beef tallow were ground to the particles of 5 mm in diameter. Four variants of sujuka (A, B, C and D) were produced at Menprom meat industry in G. Tuzla. Collagen casings were soaked in water for half an hour before stuffing in order to achieve the desired elasticity. Fresh garlic was cleaned of veneers before weighing and it was chopped by an electric cutter. The composition of Bosnian sujuka and process conditions are presented in Tables 1 and 2.

The measurements of pH and Aw value of Bosnian sujuka, as well as loss of mass, were performed on 0, 3rd, 7th, 14th and 21st day of production. The measurements of water activity (Aw) were performed by Aw-meter (LabSwift - aw, Novasiva, Switzerland), and pH value by pH meter with puncture electrode (Eutech Instruments, Netherlands) by direct puncturing into the sample. Except for that, in Bosnian sujuka there were determined chemical indicators: moisture (BAS ISO 1444), protein (BAS ISO 937), fat (BAS ISO 1443), ash (BAS ISO 936), hydroxyproline (BAS ISO 3496), collagen content (hydroxyproline x 8), content of connective tissue (collagen/total protein x 10), NaCl (by Mohr) and content of nitrites (by R. Greau and

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A. Mirna). Three independent measurements were performed for each sample. Means and standard deviation were calculated.

Sensory evaluation was performed by a panel consisting of seven experienced evaluators. For the assessment of sensory traits of Bosnian sujuka there was used quantitative descriptive analysis (QDA) technique with a 10 cm long continuous unstructured scale. Evaluators rated intensity by placing vertical line on the point in line which best reflects their perception of relative intensity for a given attribute. A total of 14 attributes of sujuka were rated (Table 3). General acceptability was rated using a 9-grade hedonic scale of acceptability with the following ratings: 4 = extremely liked, 3 = very much liked, 2 = moderately liked, 1 = very little liked, 0 = neither liked nor disliked, -1 = very little disliked, -2 = moderately disliked, -3 = very much disliked, and -4 = extremely disliked. 15-20 slices of each sample were numbered by random three-digit codes during the evaluation and presented to evaluators on white plastic plates.

The obtained data were analyzed through variance analysis (ANOVA). In cases where major impact of raw material was significant, mean values were separated by using Fisher's test for smallest significant differences at the level of 5% ( $LSD_{0.05}$ ). The level of significance  $p < 0.05$  was used in all comparisons and will be used in the continuation of this discussion. Data analysis was performed by using the SPSS 16 (SPSS Inc., Chicago, IL, USA) statistic package.

### Results and discussion

Changes of pH value, Aw value, ullage and weight loss during the production of sujuka are presented in Figure 1. One of the stability/security factors in dry meat products is pH value. Initial average pH value

Table 3. Definition of descriptors for the quantitative-descriptive sensory analysis of Bosnian sujuka

Traits	Intensity	Definition
<b>CROSS SECTION APPEARANCE</b>		
Cohesion muscle/adipose tissue	0=poor 10= excellent	Visual estimation of cohesion of main ingredients
Muscle tissue color	0=light red, 10= dark red	Intensity of red color from light to dark red
Adipose tissue color	0=light (white) 10=dark (yellow or gray)	White color of adipose tissue is characteristic, whereas yellow
Presence of crust	0=unnoticeable 10=pronounced	Presence of darker external ring on a sausage slice due to an unnatural process
<b>TEXTURE (IN MOUTH)</b>		
Tenderness	0=extremely tender 10=extremely tough	Number of chews made in order to be able to swallow sausage (similar to young peas)
Juiciness	0=extremely dry 10=extremely moist	Describes perception of water content during the first bite at sausage /Opisuje percepciju količine vode pri prvom zagrizu kobasice
Toughness	0=extremely unnoticeable 10=extremely pronounced	Number of chews made in order to be able to swallow sausage (similar to tough beef)
Fattiness	0=extremely unnoticeable 10=extremely pronounced	Perception of fat content released by sausage during chewing
<b>TASTE</b>		
Salty	0=unnoticeable 10=pronounced	Describes basic taste of salt produced by dilution in aqueous solution of salt like NaCl and KCl
Sour	0=unnoticeable 10=pronounced	Describes basic acid taste produced by diluting many acid substances in water (like citric acid)
<b>Aroma</b>		
Garlic	0=unnoticeable 10=pronounced	Characteristic aroma of garlic
Black pepper	0=unnoticeable 10=pronounced	Characteristic aroma of black pepper
Smoke	0=unnoticeable 10=pronounced	Characteristic aroma of smoke
Rancidness	0=unnoticeable 10=pronounced	Aroma which reminds of rancid fat

of fresh cooled beef and beef tallow was  $< 5.8$ , which was consistent with statements by Vuković (1998), Fisher (1998) and Wirth et al. (1977) who recommend the use of beef with  $pH < 5.8$  for the production of fermented sausages. pH value of all the sujuka variants considerably decreases between the 0 and 3rd day of production ( $p < 0.05$ ). The decline of pH values is explained as a consequence of organic acids being produced by bacteria (Lücke, 1994). From

the 3rd to 21st day, pH value continues to decrease considerably, though with less intensity. At the end of production process, variants A and B had a significantly lower ( $p < 0.05$ ) pH value (5.1) compared to the variants C and D (5.2), which is the result of lower initial pH values in these variants. Considerably lower average pH values for traditional fermented sausages – sujuka, were stated in researches done by Kozaciński et al. (2008) and Gasparik-Reichardt et al. (2005),

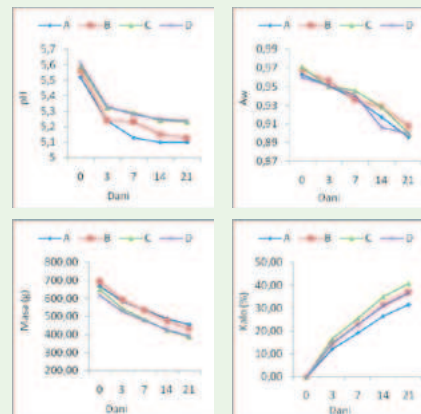


Figure 1. Changes of pH, Aw, mass and weight loss in Bosnian sujuka during ripening

whereas similar results were stated by Hadžiosmanović et al. (2005). Turkish Standard Institute (TS No: 1079, 1983) states that pH value for a good quality Turkish sujuka should range between 4.7 and 5.2. Siriken et al. (2009) state that pH of Turkish sujuka ranges from 4.84 to 6.50. Natural fermented sausages from Mediterranean countries are generally characterized by low acidity where final pH ranges between 5.2 and 6.4 in Italy (Comi et al., 2005; Rantsio et al., 2005), Greece (Fista et al., 2004), Spain (Ordoñez et al., 1999) and France (Chevallier et al., 2006); this range of pH values includes the results of sujukas examined in these researches. When it comes to Greek traditional sausages Papadima et al. (1999) state that their pH value widely ranges from 4.7 to 6.7. Water activity is one of the major factors that contribute to the stability of dried meat products; hence it is used in evaluating the quality of dried products, and along with pH value in evaluating

the quality of raw sausages. Aw value of fresh beef and beef tallow used in production of sujuka averaged 0.98. Aw value uniformly, yet considerably ( $p < 0.05$ ) decreases during the production process, from day 0 to day 21 in all the variants of sujuka (0 day - from 0.96 to 0.97; 21st day - from 0.896 to 0.90). However, these differences were not significant ( $p > 0.05$ ) between the 7th and 14th day in type B, that is, between the 14th and 21st day in type D. At the end of the production process all the variants of sujuka showed stable values of Aw with no significant differences ( $p > 0.05$ ). In general, meat products can be considered stable for storing if at the end of the process they have reached  $pH \leq 5.2$  and  $Aw \leq 0.95$ , or individually, either  $pH \leq 5.0$  or  $Aw \leq 0.91$  (Leister and Roedel, 1975). Results pertaining to Aw values of sujuka were similar to those obtained in a research carried out by Gasparik-Reichardt et al. (2005) and Kozaciński et al. (2008), who concluded that

Aw value in traditional fermented sausages from BiH, at the end of production process, averagely drops to 0.89 to 0.90. Researches of Turkish sujuka recorded a huge decrease of Aw values in all treatments - from 0.97 to 0.92 at the temperature of 20 - 22°C, and from 0.96 to 0.90 at the temperature of 24 - 26°C during the maturing (Soyer et al., 2005). Comi et al. (2005) in their research of natural fermented Italian sausages state that in three different fermentations, the final Aw value on the 28th day ranged from 0.91 to 0.92. Results of the analysis of sausage "Salchichon" (Rubio et al., 2007) showed significant differences among three types of sausage (0.862; 0.876; 0.869), though the values stayed within the range of other Spanish researchers (Hoz et al., 2004) as well as other European dry fermented sausages (Zanardi et al., 2002).

Sujuka's loss of mass during the production process occurs as an effect of drying, i.e. losing moisture. The loss of mass in fermented sausages depends on several factors such as: temperature, relative air humidity and air circulation in maturing chamber, size of particles in meat stuffing, recipe and casing material (Bloukas et al., 1997; Tömek and Serdaroğlu, 1990). After being filled into the casing, the initial average mass in variant A was 665 g, in variant B 691 g, in variant C 651 g and in variant D 617 g. LSD test showed that all the variants of sujuka had a significant loss of mass, i.e. that ullage increases considerably during the production process, from the 0 to the 21st day ( $p < 0.05$ ). Ullage is considerably more pronounced in the first fourteen days. At the end of the production process, the LSD test showed that there were some significant differences ( $p < 0.05$ ) in mass among all sujuka variants (A 456 g, B 434 g, C 386 g and D 392 g). The biggest ullage was recorded in vari-

ant C (40.70%), which had the lowest level of fat, whereas the smallest uillage was recorded in variant A (31.50%), which had the highest level of fat in finished product. Čaušević et al. (1985) stated much bigger uillage reaching 47.09% for sujuka after a 21 day drying period in traditional smoke chamber. Yıldız-Turp and Serdaroglu (2008) state that Turkish fermented sausage with 20% beef tallow loses 35.1% mass in 12 days, which is more compared to the loss of mass in sujuka in this research.

Results of chemical indicators are provided in Table 4. Level of moisture in any variants of sujuka was lower by 40% on average, i.e. it met the requirements of the Regulation (02/92, 13, and 14/94). A significantly lower level of moisture was identified in variant D relative to variants B and C ( $p < 0.05$ ). The level of moisture in this research ranged within the boundaries for moisture level (from 24% to 44%) that were recorded in previous researches of sujuka (Čaušević et al., 1985; Tupajić, 1991; Gajić, 2000; Operta et al., 2007; Operta, 2008; Operta et al., 2008; Kozaciński et al., 2008). Siriken et al. (2009), state similar variations in moisture level in Turkish sujuka, from 29.80% to 47.60%. The content of fat in sujuka varied the most. A significantly higher level of fat was identified in variant A in comparison to variants C and B ( $p < 0.05$ ), but not variant D ( $p > 0.05$ ). The results of fat content in sujuka were consistent with the results of previous researches (Čaušević et al., 1985; Tupajić, 1991; Gajić, 2000; Operta et al., 2007; Operta, 2008; Operta et al., 2008) which indicate that the level of fat in sujuka varies from 23% to 42%, as well as the results of Siriken et al. (2009), Papadima et al. (1999) and Comi et al. (2005) for Turkish, Greek and Italian traditional sausages.

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Table 4. Chemical properties in Bosnian sujuka at the end of ripening

Properties	Variants of Bosnian sujuka			
	A	B	C	D
Moisture content (%)	31.34±0.83 <sup>a</sup>	33.45±0.89 <sup>a</sup>	32.62±1.12 <sup>a</sup>	28.65±0.19 <sup>a</sup>
Fat content (%)	35.79±1.38 <sup>a</sup>	31.86±1.41 <sup>a</sup>	27.33±1.19 <sup>a</sup>	34.69±0.42 <sup>a</sup>
Protein content (%)	27.78±0.81 <sup>b</sup>	28.44±0.74 <sup>b</sup>	33.40±0.34 <sup>b</sup>	31.21±0.58 <sup>b</sup>
Hydroxyproline content (%)	0.24±0.00 <sup>d</sup>	0.36±0.02 <sup>d</sup>	0.44±0.00 <sup>d</sup>	0.56±0.01 <sup>d</sup>
Collagen content (%)	1.92±0.00 <sup>d</sup>	2.88±0.16 <sup>d</sup>	3.52±0.00 <sup>d</sup>	4.48±0.08 <sup>d</sup>
Collagen content/TP* x 100/	6.90±0.00 <sup>d</sup>	10.10±0.56 <sup>d</sup>	10.50±0.00 <sup>d</sup>	14.30±0.25 <sup>d</sup>
Ash content (%)	5.81±0.63	5.25±0.07	6.21±0.25	5.93±0.44
NaCl content (%)	4.08±0.09 <sup>b</sup>	4.43±0.06 <sup>b</sup>	5.23±0.26 <sup>b</sup>	4.16±0.02 <sup>b</sup>
Nitrite content (mg/kg)	8.31±0.03 <sup>a</sup>	7.37±0.04 <sup>a</sup>	7.10±0.22 <sup>a</sup>	6.91±0.17 <sup>a</sup>

Means within same rows with different letters (a-d) are significantly different ( $p < 0.05$ ). \*TP\* - Total proteins

Table 5. Sensory properties in Bosnian sujuka at the end of ripening

Properties	Variants of Bosnian sujuka			
	A	B	C	D
Fat/lean connection on the slice	6.06±0.42	5.02±0.45	5.41±0.35	5.54±0.22
Color of lean on the slice	5.91±0.13 <sup>a</sup>	7.12±0.04 <sup>b</sup>	7.60±0.27 <sup>b</sup>	7.80±0.24 <sup>b</sup>
Color of fat on the slice	3.70±0.33 <sup>a</sup>	4.49±0.34 <sup>a</sup>	3.11±0.24 <sup>a</sup>	3.20±0.30 <sup>a</sup>
Presence of crust	2.05±0.18	1.91±0.03	2.07±0.17	1.50±0.28
Softness	3.30±0.13 <sup>a</sup>	3.70±0.25 <sup>a</sup>	4.49±0.28 <sup>a</sup>	3.83±0.07 <sup>a</sup>
Juiciness	5.86±0.20 <sup>a</sup>	4.71±0.08 <sup>b</sup>	5.34±0.22 <sup>a</sup>	5.43±0.11 <sup>a</sup>
Toughness	2.42±0.21	2.94±0.10	2.52±0.28	2.51±0.14
Fatness	4.43±0.59	4.09±0.11	4.45±0.14	3.85±0.04
Salty taste	5.22±0.29 <sup>a</sup>	4.19±0.24 <sup>b</sup>	4.11±0.09 <sup>b</sup>	4.46±0.12 <sup>b</sup>
Acid taste	2.78±0.22	3.15±0.28	2.89±0.10	3.02±0.10
Aroma garlic	5.39±0.19	5.45±0.07	5.17±0.28	5.78±0.17
Aroma black pepper	5.00±0.15	5.10±0.25	4.90±0.06	4.15±0.04
Aroma smoke	2.97±0.16 <sup>a</sup>	3.11±0.08 <sup>a</sup>	2.24±0.04 <sup>b</sup>	2.30±0.09 <sup>b</sup>
Rancidness	1.39±0.16	1.39±0.06	1.48±0.06	0.89±0.05
Acceptability	2.67±0.13	2.33±0.17	2.43±0.08	2.67±0.19

Means within same rows with different letters (a-c) are significantly different ( $p < 0.05$ ).

se, proteins are the most valuable components of meat products. For this reason the level of proteins is used as an objective criterion based on which it is possible to evaluate quality of the products (Vuković, 2001). MPR ratio, that is, ratio between moisture and proteins in finished sausage is often used as an indicator of shelf-stability. According to the USDA ([http://origin-www.fsis.usda.gov/PDF/FSRE\\_SS\\_7Principles.pdf](http://origin-www.fsis.usda.gov/PDF/FSRE_SS_7Principles.pdf)), dry sausages must have a moisture:protein ratio (MPR) of 1.9:1 or smaller. Semi-dry sausages must have a MPR of 3.1:1 or smaller.

The level of proteins in sujuka was rather high and ranged from 27.78% to 33.40%, i.e. MPR ratio ranged between 0.91:1 and 1.17:1, which according to the moisture:protein ratio criterion categorizes it as a dry sausage. There were considerable differences in protein level among all variants, except between A and B ( $p > 0.05$ ). The researches by Tupajić (1991), Gajić (2000), Operta et al. (2007; 2008) and Operta (2008), average level of proteins ranged between 23.90% and 28.20%. The results of these researches, as well as of some previous ones, have shown

that Bosnian sujuka is a nutritionally valuable fermented sausage as it has a high level of proteins. Soyer et al. (2005) state a broader range reporting on the level of proteins in Turkish sujuka – 16.50% to 28.30%. It is a common knowledge that sausages containing more connective tissue have a smaller biological value and poorer sensory quality. This actually is one of the key reasons that the regulations on quality of meat products in many countries prescribe the limit for maximally allowed level of proteins from connective tissues. The level of hydroxyproline, that is, collagen in sujuka was favorable. The ANOVA has shown that the level of hydroxyproline/collagen is significantly influenced by selected raw material ( $p < 0.05$ ). The level of hydroxyproline /collagen reflected different levels of meat purification from connective tissue. The lowest level of hydroxyproline and collagen was found in variant A (0.24; 1.92), and the highest in variant D (0.56; 4.48). All the variants of sujuka showed significant differences in levels of hydroxyproline and collagen ( $p < 0.05$ ). The results of these researches are similar to those obtained by Siriken et al. (2009) for Turkish sujuka. Relative content of connective tissue in relation to the total protein content in Bosnian sujuka in variant A was 6.90%, variant B 10.10%, variant C 10.50% and variant D 14.30%. Significant differences were not established only between variants B and C ( $p > 0.05$ ). According to the Serbian Regulation (33/2004), fermented dry sausages produced mainly from meat of I and II category and more or less purified from connective tissue, may contain, depending on type, 15 or 20% proteins from connective tissue in total meat proteins. Given that relative level of connective tissue proteins was below 15% in all variants, it can be stated that it is a quality sujuka. The level of ash in different variants of sujuka was uniform, i.e. no significant differences

were found ( $p > 0.05$ ). Variant C had a significantly higher average level of NaCl-a, and variant A a significantly higher average level of nitrites in relation to other variants ( $p < 0.05$ ). Similar results for average level of ash were presented by Tupajić (1991). Results for the level of NaCl are consistent with the results of previous researches (Tupajić, 1991; Gasparik-Reichardt et al., 2005; Operta et al., 2007; Operta, 2008; Operta et al., 2008; Kozaciński et al., 2008) which indicate that level of NaCl ranges from 3.3% to 8.3%. Similar results were presented by Siriken et al. (2006) for Turkish sujuka, whereas results presented by Papadima et al. (1999) for Greek traditional sausages and Comi et al. (2005) for natural fermented Italian sausages show that they are considerably less salty and have less ash than sujuka. An average level of residual nitrites in all variants of Bosnian sujuka was in compliance with the Regulation's requirements; it was slightly higher than the level of nitrites identified by Tupajić (1991) and Gajić (2000) in their researches. However, it was in accordance with the results obtained by Üren and Babayigit (1997) for soudjuk and Comi et al. (2005) for naturally fermented Italian sausages. Variant A had a significantly ( $p < 0.05$ ) higher level of nitrites (8.31 g/kg) relative to other variants of sujuka.

Results of the sensory evaluation of Bosnian sujuka are shown in Table 5. Cohesion of muscular and adipose tissues at the cross section of sujuka is good to very good, rather uniform and with no significant differences between the variants ( $p > 0.05$ ). Sujuka has moderately to dark red color of the muscular tissue at cross section. Variant A had a significantly brighter color of the muscular tissue at cross section ( $p < 0.05$ ) relative to other variants. Significant difference in color of adipose particles at cross section were identified in variant B compared to variants C and D

( $p < 0.05$ ), but not variant A ( $p > 0.05$ ). Variant C had the most desirable white color of adipose tissue. Presence of crust at sujuka's cross section was slightly pronounced, with no significant differences among the variants ( $p > 0.05$ ). Sujuka has medium hard, that is, medium soft texture. Variant C appeared considerably harder (4.5) relative to variants A (3.3) and B (3.7) ( $p < 0.05$ ). However, there were no differences compared to variant D (3.8) ( $p > 0.05$ ). Sujuka is medium juicy, i.e. it is neither too dry nor too moist. Variants A (5.8), C (5.3) and D (5.4) had uniform juiciness. Results have shown that sujuka has low toughness and medium fattiness and that there are no significant differences in toughness and fattiness among the variants ( $p > 0.05$ ). Generally, sujuka from these researches was medium salty, i.e. it had desirable level of saltiness. Significantly saltier appeared variant A with 5.20 compared with other variants ( $p < 0.05$ ). Sujuka had little pronounced sourness, and there were significant differences in sourness among individual variants ( $p > 0.05$ ). The most pronounced aroma of sujuka in this research is garlic, whose level was slightly above medium pronounced intensity. Black pepper aroma was sensed less intensively and was moderately pronounced. No significant differences in garlic and black pepper aromas were found among the variants ( $p > 0.05$ ). Smoke aroma was poorly pronounced. Significantly more pronounced smoke aroma was found in variants A (3.0) and B (3.1) compared to variants C (2.2) and D (2.3) ( $p < 0.05$ ). Very little pronounced rancidness was found in variant D (0.9) and that was significantly less in relation to other variants ( $p < 0.05$ ). Results of these researches have shown that Bosnian sujuka, in general, is a product which is "moderately to very much liked" by the evaluators. Though there were no significant differences in acceptability among the variants ( $p < 0.05$ ),

it could be stated that variants A (2.6) and D (2.6) were slightly more acceptable than variants B (2.3) and C (2.4) of sujuka. Alagić et al. (2009) evaluate sujuka as a product with desirable sensory traits by using a rating scale from 1 to 10. They state that aroma (9.33) is the highest evaluated sensory trait of Bosnian sujuka, and cross section (7.70) was evaluated as the lowest. Total acceptability of sujuka (9.03) in researches of Alagić et al. (2009) satisfied over 90% of maximum score, which is a somewhat better evaluated acceptability related to Bosnian sujuka from this research where it satisfied 83% of maximum score on average.

### Conclusions

During the period of 21 days under controlled atmospheric conditions there was produced a stable dry, nutritionally valuable fermented Bosnian sujuka, regardless of the combination of beef and beef tallow used. Chemical properties of different variants of Bosnian sujuka did not vary much, which is the result of the previous categorization of beef and adequately added beef tallow depending of the used categories of beef. Still, the following combinations are recommended for the production of Bosnian sujuka: I category beef (80%) + beef tallow (20%) and I category beef (45%) + II category beef (40%) + beef tallow (15%) because that enables a faster drop of pH and Aw values, as well as a lower level of connective tissue. Different raw materials do not influence the intensity of most sensory traits of Bosnian sujuka. Variants of Bosnian sujuka which had a higher content of adipose tissue, lower content of NaCl and which appeared juicier were more acceptable for the evaluators. Bosnian sujuka is acceptable and recognizable by its garlic aroma, then black pepper aroma, whereas acidity and smoke aroma are weakly expressed.

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### Einfluss des Rohstoffes auf physikalisch-chemische und sensorische Eigenschaften von bosnischem Sudžuk hergestellt in kontrollierten Bedingungen

#### Zusammenfassung

Sudžuk, bosnische trockene fermentierte Wurst, wird in Bosnien und Herzegowina traditionell aus Rindfleisch, Rindtalg, Salz, Knoblauch und schwarzem Pfeffer hergestellt. In dieser Arbeit wurde der Einfluss verschiedener Rohstoffe (I, L und II, III, Rindfleischkategorie und unterschiedliche Menge des zugefügten Rindtalgs) auf physikalisch-chemische und sensorische Eigenschaften von bosnischem Sudžuk hergestellt in kontrollierten Bedingungen, untersucht. Es wurden vier Varianten (A, B, C und D) des bosnischen Sudžuk hergestellt, dies in Bezug auf unterschiedliche Mengen der einzelnen Rindfleischkategorien und unterschiedliche Mengen des Rindtalgs. Varianten A und B hatten am Ende des Herstellungsprozesses einen bedeutend niedrigeren ( $p < 0,05$ ) pH Wert (5,1) als Varianten C und D (5,2), was die Widerspiegelung eines niedrigeren initialen pH Wertes dieser Varianten ist. Alle Sudžuk-Varianten sind nach Aw Wert stabil (0,89 - 0,90) und zwischen ihnen sind keine bedeutenden Unterschiede festgestellt ( $p > 0,05$ ) worden. Der Verlust der Masse während des Trocknens bewegte sich von 31 % bis 40 % und zwischen allen Varianten bestanden bedeutende Unterschiede bei Massenverlust ( $p < 0,05$ ). Ein bedeutend niedrigerer Feuchtigkeitsgehalt wurde bei Variante D in Bezug auf Varianten B und C festgestellt ( $p < 0,05$ ). Ein bedeutend größerer Fettgehalt wurde bei Variante A in Bezug auf Varianten C und B festgestellt ( $p < 0,05$ ), jedoch nicht in Bezug auf Variante D ( $p > 0,05$ ). Es bestanden bedeutende Unterschiede bezüglich Proteingehalt bei allen Varianten, ausgenommen zwischen A und B ( $p > 0,05$ ). Der Inhalt von Hydroxyproline/Kollagen unterschied sich bedeutend in Varianten und war die Folge von unterschiedlicher Säuberung des Fleisches vom Bindegewebe. Der Ascheinhalt in unterschiedlichen Sudžuk-Varianten war gleichmäßig ohne große Unterschiede ( $p > 0,05$ ) und bewegte sich von 5,2 % bis 6,2 %. Variante C hatte einen bedeutend größeren NaCl-Inhalt und Variante A einen bedeutend größeren ( $p < 0,05$ ) Nitrit-Inhalt in Bezug auf andere Sudžuk-Varianten. Statistisch gesehen ( $p > 0,05$ ) gab es keine bedeutenden Unterschiede bei Sudžuk-Varianten in Bezug auf die Verbundenheit des Muskel- und Fettgewebes, Anwesenheit der Rinde beim Durchschnitt, Zähigkeit, Fettigkeit, Säure, Knoblauch- und Schwarzpfefferaroma. **Schlüsselwörter:** Rindfleischkategorien, Rindtalg, bosnischer Sudžuk, physikalisch-chemische Eigenschaften, sensorische Eigenschaften

### Influsso della materia prima sulle caratteristiche fisico-chimiche del sudžuk, salsiccia tradizionale di Bosnia, prodotto nelle condizioni controllate

#### Sommario

Sudžuk, la salsiccia secca fermentata di Bosnia, tradizionalmente viene prodotta in Bosnia ed Erzegovina della carne bovina, lardo bovino, sale, aglio e pepe nero. Quest'articolo esamina l'influsso di varie materie prime (Ia, la e IIa, IIIa, II e IIIa categoria della carne di manzo e diverse quantità del lardo bovino su alcune caratteristiche fisico-chimiche e sensoriche del sudžuk di Bosnia prodotto sotto le condizioni controllate. Sono prodotte quattro varianti del sudžuk di Bosnia (A, B, C e D) basate su varie quantità di certe categorie della carne bovina e su diverse quantità del lardo bovino. Le varianti A e B alla fine del processo di produzione avevano il valore pH (5,1) notevolmente più basso ( $p < 0,05$ ) delle varianti C e D (5,2), la cosa che riflette più basso valore pH iniziale di queste varianti. Tutte le varianti del sudžuk durante il valore Aw sono stabili (0,89-0,90) e tra di loro non sono state determinate differenze notevoli ( $p > 0,05$ ). La perdita del peso durante l'essiccazione variava tra il 31% e il 40%, e tra tutte le varianti esistevano le differenze notevoli nella perdita del peso ( $p < 0,05$ ). La percentuale notevolmente più piccola dell'umidità è stata determinata dalla variante D rispetto alle varianti B e C ( $p < 0,05$ ). La percentuale notevolmente più grande dei grassi è stata determinata dalla variante A rispetto alle varianti C e B ( $p < 0,05$ ), ma non rispetto alla variante D ( $p > 0,05$ ). Esistevano anche le differenze notevoli nel contenuto delle proteine tra tutte le varianti, salvo tra la A e la B ( $p > 0,05$ ). Il contenuto della idrossiprolina/del collagene era evidentemente differente nelle varianti e rifletteva la pulizia diversa della carne del tessuto connettivo. La percentuale delle ceneri nelle varianti differenti del sudžuk era equilibrata senza notevoli differenze ( $p > 0,05$ ) e variava dal 5,2% al 6,2%. La variante C aveva una percentuale notevolmente più grande del NaCl, e la variante A aveva una percentuale notevolmente ( $p < 0,05$ ) più grande dei nitrati rispetto alle altre varianti del sudžuk. Tra le varianti del sudžuk durante la valutazione del fatto di connessione del tessuto muscolare e il tessuto grasso, e la presenza della crosta sulla sezione trasversale, tenacità, grassezza, acidità, aroma d'aglio e aroma del pepe nero. **Parole chiave:** categorie della carne bovina, lardo di manzo, sudžuk di Bosnia, caratteristiche fisico-chimiche, caratteristiche sensoriche

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