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Chemical Characterization of Smoked beef Sausage – "Bosnian sudzuk"

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ABSTRACT

The aim of this paper is to analyze the quality of several commercially products such as smoked beef sausage – "Bosnian sudžuk" from different manufacturers that are available in the local market. The content of the analyzed metals in all samples is below the above acceptable intake. The analysis showed that cadmium and cobalt were not present in any of the samples. Other analyzed parameters are below the maximum allowable concentrations, from which we can conclude that the analyzed samples comply with applicable legislation and are safe for consumption.

Keywords : Chemical characterization, smoked beef sausage, Bosnian sudžuk

I. INTRODUCTION

Meat was traditionally considered essential for optimal growth and development because is source concentrated nutrients [2]. Meat is the flesh of certain animal species that is used as food by humans and includes many tissues and edible parts although the main tissue is the muscle [3]. Red meat is long established as an important dietary source of protein and essential nutrients including iron, zinc, vitamin B_{12} [4]. The approximate chemical composition of the meat and the proportions of the main components affect the quality of the end product [5]. In the production of meat products, meat is subjected to one or more processing processes, such as mincing, dehydration, fermentation, hardening or cooking, etc [6]. Today, there are meat products that are obtained by traditional process and industrial production around the world. Traditional meat production in Bosnia and Herzegovina has a special place.

One of the traditional Bosnian products is smoked beef sausage - Bosnian sudžuk which is producing on traditional way and industrial. It is produced from minced beef of I and II categories and spices such as garlic, red pepper, salt and has a characteristic horseshoe shape and has a light smoking aroma [7]. This sausage is in group of dry fermented sausages. These are products obtained from meat of the first and second category, solid adipose tissue and additives, which after filling into the wrappers are preserved by procedures fermentation, drying and ripening, with or without smoking [8].

According to the Guide for Producers of Traditional Food Products in Bosnia and Herzegovina, the approximate chemical composition of smoked beef sausage produced in the traditional way is as follows: % of moisture 36,18, % of fat is 23,86, % of protein 28,86, % of ash 1,60, % of NaCl 8,33 [9]. Over the last years, eating fermented sausages has been associated with potential health hazards due to their high contents of saturated fats, high NaCl content, presence of nitrite and its degradation products such as nitrosamines, and use of smoking which can lead to formation of toxic compounds such as polycyclic aromatic hydrocarbons [10].

In this research, the quality of smoked beef sausage (Bosnian sudžuk) as an traditional product industrially produced and present on the market was examined. Since this product is not yet standardized, there are differences in its chemical composition, which is why chemical characterization was done in this study.

II. METHODS AND MATERIAL

A. Materials

Reagents

$AgNO_3$, min. 99,8%, Alkaloid Skoplje; K_2CrO_4, p.a., Kemika Zagreb; NaOH, min. 99,6%, Lach:ner, Neratovice; Petroleum ether, p.a., Kemika Zageb; H_2SO_4 min. 95%, Fisher Chemical™, UK; HCl min. 37%, Fisher Chemical™, mUK; HNO_3, min. 65%, Lach:ner, Neratovice; Kjedahl tablets with selenium, Acros Organics B.V.B.A.; H_3BO_3, min. 99,5%, Acros Organics B.V.B.A.; $Na_2B_4O_7$ $10H_2O$, p.a. Zorka Šabac; $NaNO_2$, min. 98%, Semikem, Sarajevo; $C_6H8O_2N_2S$, min. 98%, Fisher Scientific, UK; N-(1-Naphthyl)ethylenediamine dihydrochloride, $C_{12}H_{14}N_2$, Fisher Scientific, UK; NH_4VCO_3, min. 99% Alkaloid, Skoplje; $[(NH_4)_6Mo_7O_{24}$ $4H_2O]$, 99% Alkaloid, Skoplje; KH_2PO_4, min. 99,5%, Semikem, Sarajevo.

Samples

Three (3) commercially available samples on the market of different producers from the territory of Bosnia and Herzegovina were obtained for this research. Prior to chemical characterization, the inedible coating was removed from the samples, then the samples were crushed and homogenized, and stored in polyethylene containers with a lid in the refrigerator at ± 4 °C.

Washing dishes

Special attention is paid to the cleanliness of laboratory utensils. The laboratory glassware was washed first with detergent, water and washed with distilled water. When determining the nitrite content, the dishes were additionally washed with hydrochloric acid, and when determining the phosphate content, the dishes were washed with sulfuric acid before use.

B. Methods

The study performed a quantitative analysis of three different products, commercially available products (water activity, pH value, moisture content by drying to constant masses, NaCl by Mohr, proteins by Kjedahl method, fat content by Soxhlet method, nitrite and phosphate content UV/VIS method as well as elementary analysis of selected metals by ICP method).

Precise determination of water activity in the samples was performed with a LabSwift-aw instrument with a resolution of ± 0.001 aw and an activity measurement range of 0.03-1 aw. Samples were stored in a refrigerator at ± 4 °C before measuring water activity.

Determination water content by drying to constant weight at 105 °C under normal pressure, exactly 3.0 g of the sample was weighed and the drying procedure lasted a total of 2 hours.

For each sample, 10 g were weighed and transferred to a 250 mL beaker and 100 mL of distilled water was added. After blending for 30 seconds, the pH value of the aqueous extracts was determined with a GLP 21 CRISON laboratory pH meter, with a resolution of 0.1, 0.01, 0.001.

The determination of the ash content is based on burning the samples at a temperature of 550 ^{0}C until all the organic matter is burned for 180 min. The Instrumentaria muffle furnace, Zagreb, was used.

Determination of NaCl content was performed by the Mohr method by titration with a standard 0.1 mol/L solution of $AgNO_3$ in a weakly basic or neutral medium (pH = 6.5-8) with 5% K_2CrO_4 as an indicator. The pH was adjusted with 0.1 mol/L NaOH solution.

Soxhlet extraction using petroleum ether as a standard method determined the fat content of the samples. The extraction lasted 4 hours, after which the fat flask was dried for 1 hour at 105 ºC, which is usually enough to achieve a constant mass.

Determination of protein content in the samples was performed by the standard Kjedahl method. Digestion of the sample was performed with concentrated H_2SO_4, distillation with 32% NaOH solution where the separated ammonia was collected in 2% H_2BO_3 solution. Titrations were performed with 0.1 mol/L HCl solution.

Determination of nitrite content in meat and meat products was performed by a standard method (ISO 2918:1975, IDT). The method is based on sample extraction with warm water, protein precipitation and filtration. If nitrites are present in the filtrate, a recognizable red color of the complex develops with the addition of sulfanamide and N-(1-Naphthyl) ethylenediamine dihydrochloride. The measurement was performed on a spectrophotometer at a wavelength of 538 nm. The spectrophotometer used for spectrophotometric determination of nitrite is UVmini - 1240 SHIMADZU.

Determination of phosphate content in meat and meat products was performed by the method according to ISO 13730:1996, and this method is based on the procedure of drying the test part or sample and dry incineration of the residue. After cooling, hydrolysis of the ash with nitric acid was performed, filtration and dilution followed by the appearance of a yellow color with a mixture of ammonium monovanadate and ammonium heptamolybdate. The measurement of the analytical signal of the sample thus prepared was performed on a spectrophotometer at a wavelength of 430 nm. The UVmini - 1240 SHIMADZU spectrophotometer was used for spectrophotometric determination of phosphate.

The concentration of metal content in the samples was determined by the ICP-OES method. ICP-OES analysis requires a sample in a liquid state, therefore different methods of decomposition or digestion of the sample are used. In this work, dry digestion of the sample was used to remove the present organic matter, before determining the mineral content. The ash content after dry digestion was then digested in a aqua regia. Samples prepared in this way were used to determine the metal content by the ICP-OES method using the Perkin Elmer ICP OPTIMA 2100 DV optical emission spectrophotometer.

III. RESULTS AND DISCUSSION

Table 1. shows the results of chemical characterization of the analysed Bosnian sudžuk samples. Samples were marked as Sample A, Sample B, Sample C. Each analysis result represents a mean of three determinations, and the confidence limits for the mean were calculated at a probability of 95%.

Table 1. Results of chemical characterization of Bosnian sudžuk samples.

Parameters	Unit	Sample A	Sample B	Sample C
aw	-	0,793 ± 0,00	0,794 ± 0,00	0,792 ± 0,00

pH	-	4,77 ± 0,12	4,63 ± 0,18	4,57 ± 0,14
Moisture	%	30,306 ± 1,55	31,291 ± 0,43	30,077 ± 1,44
Ash	%	4,703 ± 0,06	4,491 ± 0,26	4,850 ± 0,06
NaCl	%	4,010 ± 0,19	5,086 ± 0,23	4,923 ± 0,18
Fat	%	27,626 ± 0,96	22,045 ± 1,05	28,848 ± 0,58
Protein	%	25,462 ± 1,15	21,895 ± 2,59	26,308 ± 1,09
Nitrite	mg/kg	5,359 ± 0,14	7,935 ± 0,27	3,976 ± 0,19
P_2O_5	mg/kg	0,449 ± 0,013	0,454 ± 0,017	0,476 ± 0,020

95% confidence limit for mean (n = 3)

The pH value for Sample A was the highest and was 4,77 ± 0,12, while slightly lower values were for the other two samples and were 4,63 ± 0,18 for Sample B and 4,57 ± 0,14 for Sample C. Acidification helps in color formation and protein coagulation and affects the increase of strength and bonding, as well as the formation of product texture [11].

The value of aw for Sample B was the highest and was 0,794 ± 0,00, while slightly lower values were for the other two samples and were for Sample A 0,793 ± 0,00 and Sample C 0,792 ± 0,00. As stated by Operta et al. [12] if at the end of the drying process they reach pH 5.2 and aw ≤ 0.95 or individually pH ≤ 5.0 or aw ≤ 0.91 such products are considered stable for storage and these parameters are used to evaluate the quality of the dried and raw sausages.

The highest moisture content (%) was 31,291 ± 0,43 for Sample B, while slightly lower values were recorded for the other two samples. According to the Rulebook on minced meat, semi-finished products and meat products ("Official Gazette of BiH", number: 82/13), the maximum moisture content is up to 40% [13].

The ash content in the samples had no significant deviations, and the highest value of the ash content was found in Sample C and was 4,850% ± 0,06. Kurćubić et al. [14] established of the quality of industrially produced Bosnian sudžuk and the traditional household method, and found that the ash content in industrially produced Bosnian sudžuk was 5.16% and in the household 4.61%. According to other authors, the average ash content in sudžuk from the industrial sector was 4.92% [15].

Salt performs many functions, including microbial growth suppression, aw reduction, salt-soluble protein release and prooxidant effects [16]. The NaCl content had the lowest value for Sample A (4,010% ± 0,19), while the highest value of NaCl was for Sample B (5,086% ± 0,23). The obtained results are in accordance with the research conducted by Operta et al. where they established that the NaCl content varies from 3.3-8.3% [17].

The fat content in the analysed samples did not exceed 30%, so Sample C had the highest value (28.848% ± 0.58), while Sample A had a slightly lower value, and the lowest value of fat content was found for Sample B (22.045% ± 1, 05). Fat content for Bosnian sudžuk is fluctuating from 27.33% up to 35.79% [18]. Physical and chemical analyzes of sudžuk have been performed in numerous literature studies, and the results of these analyzes show deviations, so the fat content ranges from 23-41% [19].

The protein content results had a value of 26,308% ± 1,09 for Sample C, while a slightly lower value was for Sample A. The lowest value was 21,895% ± 2,59 and was found in Sample B. According to Ganić et al. [20] the protein content in "Visočka sudžuka" was 26.84%, which is slightly higher than Sample C.

The nitrite content (mg/kg) was 7,935 ± 0,27 for Sample B and was the highest value. Other samples had significantly lower nitrite values. According to the research of Kovačević et al. [21] the amount of $NaNO_2$ was for permanent sausages (7,000 ± 4 mg/kg), heat-treated sausages (24,000 ± 16 mg/kg), permanent cured meat products (37,000 ± 23 mg/kg) and semi-permanent cured meat products (42,00 ± 21 mg/kg). The total daily nitrites intake may be as high as 4% and 19% for fresh meat and cured meat, respectively [22]. In the EU, potassium and sodium nitrite are authorized for use in different meat products, and the maximum amount (150 mg/kg) is established for all products as well as maximum residual levels for some of Directives 95/2 /EC and 2006/52 / EC) [23].

The phosphate content expressed as P_2O_5 (mg/kg) had the highest value for Sample C 0.476 ± 0.020 mg/kg, while the lowest value was for Sample A and was 0.449 ± 0.013 mg/kg. Koricanac et al. [24] investigated the content of total phosphates expressed as P_2O_5 in 701 samples of different types of cooked sauces from the Serbian market. Their results show that 33.38% of the total number of tested samples have P_2O_5 values of 4.01-5.00 g/kg. Phosphate was added to meat products to improve their binding properties and water-holding capacity [25] however since this type of sudžuk was preserved by the addition of NaCl, smoking and drying there was no need to add larger amounts of P_2O_5. No impairment of renal function has been reported with daily doses of up to 2000 mg phosphorus (28.6 mg/kg per day), whereas doses of 4800 mg (68.6 mg/kg per day) elicited renal impairment [26].

Dry digestion was used to determine the content of essential and toxic elements in Bosnian sudžuk. The ash content after dry digestion was then decomposed in a gold smelter. Samples prepared in this way were used to determine the metal content by the ICP method using the Perkin Elmer ICP OPTIMA 2100 DV optical emission spectrophotometer. Three parallel measurements were performed for each sample.

Table 2. shows the values of essential and toxic elements in Bosnian sudžuk.

Table 2. Amounts (mg/kg) of essential and toxic trace elements in Bosnian sudžuk

Elements	Sample A	Sample B	Sample C
Ca	113,760 ± 22,390	103,600 ± 21,560	142,33 ± 23,081
Cd	0,00 ± 0,00	0,00 ± 0,00	0,00 ± 0,00
Co	0,00 ± 0,00	0,00 ± 0,00	0,00 ± 0,00
Cu	6,443 ± 1,40	6,720 ± 1,52	6,683 ± 0,57
Fe	43,073 ± 9,50	38,970 ± 7,10	33,966 ± 6,36
K	3268,667 ± 419,69	3102,667 ± 287,28	3336,333 ± 315,49
Mg	193,566 ± 9,81	185,566 ± 23,12	247,433 ± 30,063
P	1684,333 ± 220,18	1637,667±1 51,31	1724,667 ± 3,93
Zn	29,020 ± 6,56	26,760 ± 6,34	44,960 ± 1,33

95% confidence limit for mean (n = 3)

Table 3. shows the daily intake of essential in Bosnian sudžuk. Daily intake of essential and toxic elements in Bosnian sudžuk are calculated according to work of Koubova et al. [27]. It can be seen from Table 3. that the content of analyzed metals Bosnian sudžuk does not exceed RDA and AL* expressed mg/day for females and males.

Tabele 3. Daily intake estimations for essential in Bosnian sudžuk

Analyte	Range (mg/kg)	Daily Intake (mg/day)	RDA or AI* (F) (mg/day)	RDA or AI* (M) (mg/day)
Ca	103,600 - 142,33	10,360 – 14,233	1000	1000
Cu	6,443 - 6,720	0,644 – 0,672	0,9	0,9
Fe	33,966 - 43,073	3,396 – 4,307	18	8
K	3102,667 - 3336,333	310,266 – 333,633	4700*	4700*
Mg	185,566 - 247,433	18,556 - 24,743	320	420
P	1637,667 - 1724,667	163,766 - 172,466	700	700
Zn	26,760 - 44,960	2,676 - 4,496	8	11

AI *: Adequate intake is followed by an asterisk (*); RDA: Recommended Daily Allowance is written in ordinary type without an asterisk; M: male 31–50 years old; F: female 31–50 years old. A serving size of Bosnian sudžuk was set to 100 g.

Table 4. shows the daily intake for toxic trace elements in Bosnian sudžuk.

Tabele 4. Daily intake estimations for toxic trace elements in Bosnian sudžuk

Analyte	Range (mg/kg)	Daily Intake (µg/day)	RDA or AI* (F) (mg/day)	RDA or AI* (M) (mg/day)
Cd	0,00 - 0,00	0,111-0,383	-	-
Co	0,00 - 0,00	5,000-8,000	-	-

AI *: Adequate intake is followed by an asterisk (*); RDA: Recommended Daily Allowance is written in ordinary type without an asterisk; M: male 31–50 years old; F: female 31–50 years old. A serving size of Bosnian sudžuk was set to 100 g.

IV. CONCLUSION

All analyzed physico - chemical parameters correspond to the values prescribed by the Rulebook on minced meat, semi-finished products and meat products ("Official Gazette of BiH", number: 82/13). As this Bosnian traditional meat product is not yet standardized, it is hoped that this work will help in further research and standardization of the product.

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