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Proximate composition, water activity and sodium and potassium content in dry fermented sausages with reduced salt content

Slobodan Lilic[1], Ivana Brankovic Lazic[1], Danijela Vranic[1], Vladimir Koricanac[1], Dragica Nikolic[1], Branka Borovic[1], Branko Velebit[1]

A b s t r a c t: The aim of this study was to examine the influence of partially reducing sodium chloride in dry fermented sausages by adding potassium chloride and ammonium chloride in different amounts, on the proximate composition, water activity and sodium and potassium content in the final products. Control sausages were produced with 3% sodium chloride. In group 1 and 2 sausages, sodium chloride was partially replaced by potassium chloride, and in group 3 and 4 sausages, sodium chloride was partially replaced by ammonium chloride. The lowest moisture content and the highest fat content were determined in the sausages in which sodium chloride was partially substituted with 30% potassium chloride. Due to this, the water activity in these sausages was the lowest. The highest ash content was determined in the sausages in which sodium chloride was partially substituted with potassium chloride, in amounts of one third and one half, and in which the moisture content was the lowest as well. It could not be determined whether the protein and collagen contents were influenced by the partial replacement of sodium chloride with potassium chloride or ammonium chloride or whether the determined differences were the result of the raw material used. The highest potassium content and the lowest sodium content were determined in the sausages where sodium chloride was partially replaced with one half of potassium chloride. According to the added amount of potassium chloride, the sodium/potassium ratio in these sausages was favourable.

Keywords: *sodium chloride reduction, dry fermented sausages, proximate composition, water activity, collagen content, sodium, potassium.*

Introduction

From a health point of view, an excessive intake of meat products, because of their significant sodium and fat content, cannot be recommended for some population groups. Most of these products are manufactured with sodium chloride and are important sources of sodium in the diet (*Muguerza et al*., 2004). According to these authors, major difficulties occur when developing low-salt and low-fat dry fermented sausages, because salt and fat have important functions in the quality of these products. Sodium chloride has an important influence on the final taste of dry fermented sausages and also plays an important role in microbial stability. Fat is necessary for the development of sensory properties such as texture, juiciness and flavour.

Potassium chloride is the one of the main sodium chloride replacers in the production of dry fermented sausages. However, such replacement is limited because of the negative effects of potassium chloride on the sensory characteristics of dry fermented sausages. *Gou et al.* (1996) used potassium chloride, potassium lactate and glycine as sodium chloride substitutes in fermented sausages and found important flavour defects occurred when substitution with these salts was larger than 40% of the original salt weight. *Guàrdia et al.* (2006) found the overall acceptability of products decreased when potassium lactate, glycine and potassium chloride were used at levels higher than 30%, 20% and 40%, respectively. In contrast, *Askar et al.* (1993) concluded there was no difference in the overall acceptability of dry fermented sausages in which sodium chloride was replaced with 50% of potassium chloride or potassium lactate.

Ibañez et al. (1997) did not find statistical differences between sausages produced with 3% sodium chloride and sausages produced with 1.5% sodium chloride and 1% potassium chloride. *Gimeno et al.* (1998) used a mixture of 1% sodium chloride, 0.55% potassium chloride, 0.23%

[1]*Institute of Meat Hygiene and Technology, Kacanskog 13, 11000 Belgrade, Republic of Serbia.*

Corresponding author: Slobodan Lilic, slobodan.lilic@inmes.rs

magnesium chloride and 0.46% calcium chloride to replace the traditional amount of 2.6% sodium chloride in chorizo, and found out that sensorial acceptability was decreased mainly due to the lower salty taste.

In all of the investigations cited above, the authors did not establish any safety problems related to the growth of undesirable microorganisms, but rather, the taste of these dry fermented sausages was described as less salty and more bitter. According to *Ruusunen and Puolanne* (2005), the lowest sodium chloride content in dry fermented sausages is 2.5%, particularly in salamis. Sausages with less salt content are not firm enough and cannot be easily sliced.

The aim of this study was to examine the influence of partially substituting sodium chloride with potassium chloride and ammonium chloride in different amounts in dry fermented sausages on the proximate composition, water activity and sodium and potassium content of the final product.

Materials and Methods

Sausage production

Five groups of sausages were produced. Pork for production of control group sausages was cured only with nitrite curing salt, while sausages from groups 1 to 4 were cured with various salt mixtures, according to Table 1. Meat and fat were minced to a granulation of 6 mm, mixed with salt and salt mixtures and then filled into pig small intestine, 22–24 mm in diameter. Smoking, drying and fermentation lasted for 21 days in a smoking house.

Determination of proximate composition, collagen content and water activity

The proximate composition was carried out by determining the moisture (*SRPS ISO*, 1998a), total protein (*SRPS ISO*, 1992), total fat (*SRPS ISO*, 1998b) and total ash contents (*SRPS ISO*, 1999). Collagen[2] was determined by multiplying the hydroxyproline content by eight (*SRPS ISO*, 2002). Water activity (a_w) was measured according to ISO (2004).

Determination of sodium and potassium content

Sausage (approximately 0.3 g) was transferred into Teflon vessels and 5ml nitric acid (p.a. Sigma) and 1.5ml hydrogen peroxide (30%, p.a., Merck) were added. Digestion was conducted using a microwave program with three steps as follows: 5 min from room temperature to 180°C, 10 min hold 180°C, 20 min vent. After cooling at room temperature, the digested sausage samples were quantitatively transferred into disposable flasks and diluted to 100ml with deionised water (Elga).

Analysis was performed by inductively-coupled plasma mass spectrometry (ICP-MS). Measurements were performed using the instrument iCap Q (Thermo Scientific, Bremen, Germany), equipped with collision cell and operating in kinetic energy discrimination (KED) mode. The isotope detected was ^{23}Na.

Torch position, ion optics and detector settings were adjusted daily using tuning solution (Thermo Scientific Tune B), in order to optimise measurements and minimise possible interferences. For

Table 1. Composition of sausages, g

Group	Raw material	Sodium chloride	Potassium chloride	Ammonium chloride	Sodium nitrite
C	Pork shoulder, 2400 Fat, 600	90.00	–	–	0.4500
1	Pork shoulder, 2400 Fat, 600	60.00	30.00	–	0.4500
2	Pork shoulder, 2400 Fat, 600	45.00	45.00	–	0.4500
3	Pork shoulder, 2400 Fat, 600	45.00	–	30.00	0.3750
4	Pork shoulder, 2400 Fat, 600	60.00	–	7.50	0.3375

qualitative analysis of the samples, a five-point calibration curve (including zero) was constructed for each isotope in the concentration range of 0.1 to 2.0 mg L^{-1}. An additional line of the peristaltic pump was used for on-line introduction of multi-element internal standard (^{6}Li, ^{45}Sc – 10 ng mL^{-1}; ^{71}Ga, ^{89}Y, ^{209}Bi – 2 ng mL^{-1}), covering a wide mass range. Concentrations of each measured isotope were corrected for response factors of both higher and lower mass internal standards using the interpolation method.

The quality of the analytical process was controlled by analysis of a standard reference material (SRM 1577c, National Institute of Standards and Technology, Gaithersburg, MD, USA). Measured concentrations were within the range of the certified values for all isotopes.

Statistical evaluation

The results were statistically evaluated using Microsoft Excel 2010 and presented as mean ± SD. Differences between averages of examined parameters were determined at the level of 0.05 and 0.01 by Student's t-test.

Results and Discussion

Sausages from all groups were sensorially acceptable, and their overall acceptability was evaluated favourably despite statistical differences from the overall acceptability of control sausages (*Lilic et al.*, 2016).

Results of proximate composition, a_w and collagen content are shown in Table 2.

There was no difference in moisture content of control sausages and group 4 sausages (26.43±0.29 and 26.39±0.49%, respectively), but control sausages contained more moisture than group 1, 2 and 3 sausages ($p \le 0.01$; moisture content of 20.49±0.48, 22.95±0.21 and 24.59±0.23%, respectively). The moisture content of group 1 sausages was significantly lower than group 2 and 3 sausages ($p \le 0.05$). Consequently to the lowest moisture content, the a_w in group 1 sausages was the lowest (0.711±0.012), and was significantly lower ($p \le 0.01$) than the a_w determined in control and group 4 sausages (0.788±0.005 and 0.782±0.011, respectively). The a_w of group 1 sausages was significantly less than the a_w determined in group 2 and 3 sausages ($p \le 0.05$). According to these results, it is clear that adding potassium chloride as partial replacer of sodium chloride in amounts of one third and one half of the total amount of added salt significantly decreased a_w in dry sausages ($p \le 0.01$).

The fat content in control, group 3 and group 4 sausages (39.47±2.21%, 37.71±1.77% and 37.40±0.37%, respectively) was not significantly different, while it was higher ($p \le 0.05$) in group 1 and 2 sausages in comparison with sausages from other groups (42.43±0.39% and 41.92±0.35%, respectively). The highest fat content, determined in group 1 sausages, corresponded to the lowest moisture content in this group of sausages, which is expected because the content of these two components vary depending on each other in meat products (*Hui*, 2012). There was no statistical difference between protein content in control, group 1 and group 2 sausages (28.30±1.54, 29.93±0.38 and 28.75±0.84%, respectively), while group 3 and 4 sausages (33.58±2.03%

Table 2. Water activity, proximate composition and collagen content of sausages, mean±SD, n=6

Group	Water activity	Moisture, %	Fat, %	Protein, %	Ash, %	Collagen,%
C	$0.788 \pm 0.005^{b,x}$	26.43 ± 0.29^{x}	39.47 ± 2.21^{a}	28.30 ± 1.54^{a}	$5.48 \pm 0.52^{a,x}$	2.48 ± 0.40^{x}
1	$0.711 \pm 0.012^{a,y}$	$20.49 \pm 0.48^{a,y}$	42.43 ± 0.39^{b}	29.93 ± 0.38^{a}	6.71 ± 0.18^{y}	3.08 ± 0.07^{y}
2	$0.744 \pm 0.006^{b,y}$	$22.95 \pm 0.21^{b,y}$	41.92 ± 0.35^{b}	28.75 ± 0.84^{a}	6.39 ± 0.24^{y}	2.43 ± 0.22^{x}
3	$0.756 \pm 0.018^{b,y}$	$24.59 \pm 0.23^{b,y}$	37.71 ± 1.77^{a}	33.58 ± 2.03^{b}	$4.35 \pm 0.08^{b,x}$	2.71 ± 0.24^{x}
4	$0.782 \pm 0.011^{b,x}$	26.39 ± 0.48^{x}	37.40 ± 0.37^{a}	31.63 ± 1.05^{b}	$4.78 \pm 0.11^{b,x}$	2.46 ± 0.24^{x}

Legend: ^{a,b} Numbers with different superscript letters are significantly different ($p \le 0.05$); ^{x,y} Numbers with different superscript letters are significantly different ($p \le 0.01$)

Table 3. Sodium and potassium content and sodium/potassium ratio in sausages, mean±SD, n=6

Group	Sodium, mg/kg	Potassium, mg/kg	Sodium/Potassium ratio
C	16084.15 ± 1156.50^{x}	4947.17 ± 312.86^{x}	3.25
1	14620.78 ± 475.22^{y}	13945.21 ± 331.33^{y}	1.05
2	9847.71 ± 847.30^{z}	16587.90 ± 955.03^{z}	0.59
3	10706.42 ± 459.37^{z}	5191.01 ± 179.57^{x}	2.06
4	14197.06 ± 11.73^{y}	5066.77 ± 161.09^{x}	2.80

Legend: ^{x,y,z} Numbers with different superscript letters are significantly different ($p \leq 0.01$)

and 31.63±1.05%, respectively) contained more protein ($p \leq 0.05$) than sausages from other groups. The collagen content of group 1 sausages was significantly higher ($p \leq 0.01$) than that of sausages from other groups, probably due to differences in the raw meat used.

The sodium and potassium content and sodium/potassium ratio of the sausages are presented in Table 3. Sodium content was highest in control sausages as a consequence of the largest amount of added sodium chloride. Potassium content was highest in group 1 and 2 sausages, which corresponded to the added amount of potassium chloride. Excessive sodium intake in the human diet is one of the main causes of essential hypertension, and so it is very important to know the sodium/potassium ratio in foods (*Perez and Chang*, 2016). A diet high in sodium and low in potassium produces a biological interaction in the kidneys, resulting in excessive sodium and insufficient potassium concentrations in the human body. These biologic changes result in vascular smooth muscle cell contraction, followed by an increase in peripheral vascular resistance and higher blood pressure and finally hypertension (*Adrogué and Madias*, 2007). Some authors (*Drewnowski et al*., 2015) investigated the dietary intake of sodium and potassium as well as the sodium/potassium ratio and concluded that the main problem is not an insufficient intake of potassium, but rather, a poor sodium/potassium dietary ratio. According to new guidelines by WHO (2013), adults should consume less than 2000 mg of sodium and at least 3510 mg of potassium every day.

Conclusion

The lowest moisture content and the highest fat content were determined in the sausages in which sodium chloride was partially substituted with 30% potassium chloride. Due to this, the a_w in these sausages was the lowest.

The highest ash content was determined in the sausages where sodium chloride was partially substituted with potassium chloride in amounts of one third and one half, and in which the moisture content was the lowest as well.

The highest potassium content and the lowest sodium content were determined in the sausages where sodium chloride was partially replaced with one half of potassium chloride. According to the amount of potassium chloride added, the sodium/potassium ratio in these sausages was favourable.

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