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Effect of sodium chloride reduction in dry fermented sausages on sensory quality parameters and instrumentally measured colour

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A b s t r a c t : Modern trends in human nutrition require decreasing the sodium chloride content in food due to several negative health impacts of excessive sodium intake from food. The goal of this study was to investigate the possibility of reducing the amount of sodium chloride used in the production of dry fermented sausages by using different salt mixtures to partially replace the sodium chloride. Control sausages were produced only with sodium chloride (3%), while sausages from other groups were produced by partially replacing sodium chloride with other salts in different amounts. 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.

Moderate reductions of sodium chloride in the dry fermented sausages by partial replacement with potassium chloride (group 1) and with ammonium chloride (group 4) led to a slight reduction in saltiness, although this was still at an acceptable level. The overall acceptability of sausages from these groups was lower in relation to sausages from the control group, but despite that, their smell, colour and taste were at an acceptable level.

The most highly expressed bitterness was determined in group 2 and 3 sausages, and these were significantly more bitter than sausages from other groups. The use of different salt mixtures did not affect redness (a) or yellowness (b*) in sausages, but led to greater expressed lightness in the sodium-adjusted sausages in comparison to sausages from the control group.*

Keywords: *sodium chloride reduction, dry fermented sausages, sensory evaluation, colour.*

Introduction

Modern trends in human nutrition require the reduction of sodium chloride in food due to several negative health impacts of excessive sodium intake from food. Increased intake of sodium is one of the major causes of hypertension, which is the greatest risk factor for development of cardiovascular diseases. Excessive dietary sodium intake could be a cause of essential hypertension and also can lead to direct risk of heart attack (*Perry and Beevers*, 1992), hypertrophy of the left heart chamber (*Schmieder and Messerli*, 2000), sodium retention in extracellular fluid (*MacGregor and de Wardener*, 1997), greater possibility of infection by *Helicobacter pylori* and risk of gastric cancer (*Tsugane et al.,* 2004), increase of urinary excretion of calcium and risk of forming of kidney calculi (*Cappuccio et al.*, 2000), risk of reduced bone density (*Devine et al.*, 1995), exacerbations of asthmatic seizures (*Mickleborough et al.*, 2005) and increase of HOMA (homeostasis model assessment) insulin resistance in patients with essential hypertension (*Kuroda et al.,* 1999).

Sodium chloride (salt) content can be reduced in meat products in different ways but most common is partial replacement of sodium chloride with potassium chloride (*Terell,* 1983; *Guàrdia et al.,* 2006). According to some data (*Ruusunen and Puolanne*, 2005), the lowest sodium chloride content in dry fermented sausages is 2.5%, particularly in salamis. Sausages with lower salt content are not firm enough and cannot be easily sliced; thus, such low-salt sausages lack one of the main characteristics of dry fermented sausages. Besides potassium chloride, other chloride salts, mainly salts of magnesium and calcium and ascorbates can be used as replacers (Ruusunen and Puolanne, 2005). The main problem in this case is the occurrence of a bitter taste, because only sodium chloride has a clearly salty taste.

The aim of this study was to examine the effects of reducing sodium chloride in dry fermented sausages by replacing it with potassium chloride

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or ammonium chloride. To that end, sensory quality parameters and instrumental measured colour were determined in the sausages.

Material and Methods

Sausage production

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

Sensory evaluation

Surface colour, cut colour, intensity of saltiness and bitterness and overall acceptability were assessed by a sensory panel. Numeric-descriptive scales with 5 points were used. For evaluation of colour and overall acceptability, 5 points was the best attribute, while 1 point was the worst attribute. For evaluation of intensity of saltiness and bitterness, 5 points equated to product with the most highly expressed attribute (the most salty or the bitterest), while 1 point was the product with the least expressed attribute. Sensory evaluation was carried out by 10 trained assessors under the same conditions.

Instrumental colour determination

Colour of sausages was evaluated using colorimeter (Minolta Chroma Meter RC-400). The CIE system colour profile of lightness (L*), redness (a*) and yellowness (b*) was measured by a reflectance colorimeter using illuminant source D65, 8-mm aperture and 10° observation angle (*CIE*, 1976). The colorimeter was calibrated throughout the study using a standard white ceramic tile. Colour was measured on three cut surfaces of sausage and on each surface, three measurements were taken.

Determination of sodium content

Aliquots of approximately 0.3 g of sausage were transferred into Teflon vessels and 5mL nitric acid (p.a. Sigma) and 1.5mL hydrogen peroxide (30%, p.a., Merck) were added. The microwave digestion program consisted of 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 solutions were quantitatively transferred into disposable flasks and diluted to 100ml with deionized water (Elga).

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

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 qualitative analysis, a five-point calibration curve (including zero) was constructed for each isotope in the concentration range of 0.1 – 2.0 mg L^{-1}. An additional line of the peristaltic pump was used for online introduction of multi-element internal standard (^{6}Li, ^{45}Sc – 10 ng mL^{-1}; ^{71}Ga, ^{89}Y, ^{209}Bi – 2 ng mL^{-1})

Table 1. Composition of sausages, g

Group	Raw material	Sodium chloride	Potassium chloride	Ammonium chloride	Sodium nitrite
Control	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

covering a wide mass range. Concentrations of each measured isotope were corrected for response factors of both higher and lower mass internal standard by interpolation.

The quality of the analytical process was controlled by analysis of the standard reference material (NIST SRM 1577c). Measured concentrations were within the range of the certified values for all isotopes.

Statistical evaluation

The results are presented as mean±SD. Between averages statistical differences were significant at the levels P≤0.05 and P≤0.01 by Student's t-test. Significant differences in the tables are expressed as different superscript letters.

Results and discussion

Results of sensory evaluation are shown in Table 2. Sausages from all groups had high scores for surface and cut colour and there were no significant differences between the different groups of sausages (P≥0.05). The saltiest sausage was the control sausage (4.22±0.32), while sausages from other groups, although moderately salty, were significantly less salty than control sausages (P≤0.05). The most highly expressed bitterness was in group 2 and 3 sausages (3.94±1.07 and 3.56±0.86, respectively), and these sausages were significantly more bitter (P≤0.01) than the more moderate group 1 and 4 sausages (2.06±0.90 and 2.89±0.34, respectively). Control sausages were evaluated as the least bitter, which was expected, because only sodium chloride had been added to these products.

The best sensory scores for overall acceptability were obtained by control sausages (4.67±0.47), and this was significantly better than sausages from other groups (P≤0.01). Group 1 and 4 sausages were evaluated similarly (P≥0.05; 3.56±1.26 and 3.83±0.58, respectively), while group 2 and 3 sausages achieved the lowest evaluations (2.89±0.74 and 2.78±0.92, respectively). Despite worse scores for overall acceptability, sausages from groups 2 and 3 were still had acceptable colour, smell and taste. The only differences noted were a slightly bitter taste and less saltiness.

Gou et al. (1996) used potassium chloride, potassium lactate and glycine as sodium chloride replacers in fermented sausages and concluded that replacing 40% or more of the sodium chloride with these compounds or their mixtures lead to undesirable and irreversible changes in sensory quality of product. Also, product texture problems occured when 30% of the sodium chloride was replaced with potassium lactate or 50% of the sodium chloride with glycine. The same authors (1996) cited a fall in overall sensory acceptability when 30% of the sodium chloride was replaced with potassium lactate, 20% with glycine or 40% with potassium chloride.

Askar et al. (1993) did not find statistically important differences in odour or taste acceptability when the replacers, potassium lactate and potassium chloride, in total amounts of 50% of the sodium chloride, were used.

Ibañez et al. (1997) did not find differences in overall acceptability between dry fermented sausages produced with 3% sodium chloride (common amount) and sausages produced with 1.5% sodium chloride and 1% potassium chloride, whereby the sodium content was decreased by one half.

The results of the instrumental determination of cut surface colour of sausages are presented in Table 3. In this study, only the lightness of control sausages (32.57±1.43) was significantly

Table 2. Sensory evaluation of sausages

Group	Surface colour	Cut colour	Saltiness	Bitterness	Overall acceptability
Control	4.94±0.16	4.72±0.42	4.22±0.32^{a}	1.39±0.46^{x}	4.67±0.47^{x}
1	4.94±0.16	4.72±0.42	3.78±0.79^{b}	2.06±0.90^{y}	3.56±1.26^{y}
2	4.94±0.16	4.72±0.42	3.61±0.66^{b}	3.94±1.07^{z}	2.89±0.74^{z}
3	4.94±0.16	4.72±0.42	3.56±0.86^{b}	3.56±0.86^{z}	2.78±0.92^{z}
4	4.83±0.33	4.72±0.42	3.61±0.94^{b}	2.89±0.34^{q}	3.83±0.58^{y}

^{a,b} Numbers within one column with different superscript letters are significantly different (P≤0.05)

$^{x, y, z, q}$ Numbers within one column with different superscript letters are significantly different (P≤0.01)

Table 3. Results of the instrumental determination of cut surface colour of sausages, CIE Lab system

Group	L* – lightness	a* – redness	b* – yellowness
Control	32.57±1.43[a]	14.61±2.80	5.35±1.44
1	34.80±1.54[b]	15.72±1.98	6.91±1.04
2	36.11±2.20[b]	15.48±1.71	6.44±1.01
3	36.14±2.50[b]	14.78±1.94	6.40±1.52
4	35.25±1.53[b]	17.23±1.00	7.04±0.90

a,b Numbers within one column with different superscript letters are significantly different (P≤0.05)

lower (P≤0.05) compared to the lightness of group 1 sausages (34.80±1.54), group 2 sausages (36.11±2.20), group 3 sausages (36.14±2.50) and group 4 sausages (35.25±1.53), while there were no differences between lightness values of sausages from these four groups (P≥0.05). No significant differences (P≥0.05) were determined between redness or yellowness for all examined groups of sausages. The total colour difference (ΔE) between: control and group 1 sausages was 2.94; control and group 2 sausages was 3.80; control and group 3 sausages was 3.72 and; control and group 4 sausages was 4.11.

Gimeno et al. (1998) reduced the salt content in Chorizo sausage, using a mixture of 1% sodium chloride, 0.55% potassium chloride, 0.23% magnesium chloride and 0.46% calcium chloride, with the aim of replacing some of the 2.6% sodium chloride that is common for this sausage. They determined that sensory acceptability was reduced due to reduced saltiness intensity as well as decreased red colour intensity because of the reduction in the amounts of nitrosohaeme pigments. Instrumentally measured colour (CIE L*a*b*) showed there were no important difference in the colour between control and experimental group of sausages.

The sodium levels in the sausages are presented in Table 4. As would be expected, the highest sodium content was determined in control sausages (16084.15±1156.50) due to usage of only sodium chloride and this level was statistically higher than the sodium content determined in sausages from other groups (P≤0.01). Sodium levels were similar in sausages from group 1 and 4 sausages (14620.78±475.22 and 14197.06±11.73, respectively), and these were significantly higher than the sodium content determined in group 2 and 3 sausages (9847.71±847.30 and 10706.42±459.37, respectively). Moderate sodium reductions were seen in group 1 sausages of 9.09%, in group 2 of 38.77%, in group 3 of 33.43% and in group 4 of 11.73% in relation to control sausages.

Table 4. Sodium content in sausages

Group	Sodium, mg/kg
Control	16084.15±1156.50[x]
1	14620.78±475.22[y]
2	9847.71±847.30[z]
3	10706.42±459.37[z]
4	14197.06±11.73[y]

x,y,z Numbers within one column with different superscript letters are significantly different (P≤0.01)

Conclusion

Moderate reductions of sodium chloride in the production of dry fermented sausages by partial replacement of sodium chloride with potassium chloride (group 1) and with ammonium chloride (group 4) led to slightly reduced saltiness, although this was still at an acceptable level. Also, sausages from these two groups were acceptable and their overall acceptability was evaluated favourably, despite statistical differences from the overall acceptability of sausages from the control group.

The most highly expressed bitterness was determined in group 2 and 3 sausages, and these sausages

were significantly more bitter than the moderately bitter group 1 and 4 sausages, as well as the control sausages.

The use of different salt replacer mixtures did not affect redness (a*) or yellowness (b*) in sausages from all groups, but did lead to greater expressed lightness in all sausage groups compared to sausages from the control group.

Moderate sodium reductions were seen in group 1 sausages of 9.09%, in group 2 of 38.77%, in group 3 of 33.43% and in group 4 of 11.73% in relation to control sausages.

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