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# The Influence of Sodium Reduction on the Quality and Safety of Hot Dogs

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**Abstract:** The aim of this study was to evaluate the effects of replacing of sodium nitrite curing salt with the mixture of sodium and potassium chloride (Na-max 27 g/kg-min K 16 g/kg) at a rate of 25%, 50%, 75% and 100% on the quality, microbiological stability and colour of the cooked sausages - hot dog. Five production batches (PB) were manufactured. The first C (control) was prepared according to the manufacturer's original recipe. Experimental PB I was made by adding 50 g of mixed sodium-potassium salt (25%) and 150 g nitrite curing salt into 10 kg of stuffing, in PB II was replaced 50%, in PB III 75% nitrite salt. Hot-dogs of PB IV were made by adding 200 g (100%) of combined sodium-potassium salt into 10 kg of mass.

The results obtained clearly indicate a continuous decrease of sodium content in samples originating from the control group to the experimental samples PB IV, in which the nitrite salt was fully replaced with a mixture of potassium-sodium salt. Replacing of sodium nitrite salt with the mixture of sodium and potassium chloride did not significantly affect examined chemical parameters (content of moisture, proteins, fat, ash) of experimentally prepared hot-dogs. Replacing of sodium nitrite salt with the mixture of sodium and potassium chloride did not significantly affect examined colour (CIE L*, a*, b*) of experimentally prepared hot-dogs.

**Key words:** sodium content reduction, potassium chloride salt, hot dogs quality

## Introduction

Many of scientific reports have linked excessive sodium intake to the incidence of hypertension (Lilić *et al*., 2011; Xiaosong, 2007), and this is the main reason for reducing the sodium content of processed meats. Vandendriessche characterized (2008) today's meat processing as a period of improving the quality, food safety and nutrition/health. From the earliest period of human society development, salt has been used as a preservative for meat and it is one of the most common ingredients that used in meat processing in a wide range of products. Sodium and chlorides are essential for life and health, for stabilizing the internal fluids, electrolytes and blood pressure in the human body. They provide adequate function of muscles and nerves. Salt has a strong influence on the formation of desirable properties of meat products and their safety, through a different line of activities: it is essential for achieving an adequate taste; it has bacteriostatic effects (reduces the water activity); it activates proteins and improves water-binding capacity and hydration; it enables the solubilization of meat proteins that participates in the processing of meat and connective tissue, water and fat in the desirable structure of gel formation to improve texture; it increases the viscosity of the meat; it enables that protein myofibrils emulsify fat; and increasing the pH of meat or meat system in which participating (Vandendriessche, 2008).

Salt reduction in meat products thus has adverse effects on such technological functions as water and fat binding, impairing overall texture and increasing cooking loss, shelf life and also on sensory quality, especially taste (Ruusunen *et al*., 2005). Meat and meat products are one of the priority products (12 to 20% of the total intake of sodium with food) that need to contribute to the reduction of sodium content (Desmond, 2006).

Food manufacturers are faced with a dilemma: “How to reduce sodium content in foods without excessive modification of its flavor?”. Trends show that consumers are increasingly opting for “healthy” food, and the taste remains the most critical factor for the purchase. Manufacturers can choose to simply reduce the NaCl content without changing the taste. Toldrá and Barat (2009) published an overview of innovative patents to reduce salt in food.

Reducing the content of sodium in meat products can be achieved in the following manners: (1) by reducing the amount of sodium chloride added (Honikel, 2008); (2) by replacing part of NaCl with other salts (Lilić *et al*., 2008).; (3) by using flavor/aroma enhancers and masking agents (Desmond, 2006); (4) combination of mentioned procedures (Terell, 1983); (5) adding of spice herbs and spice extracts to meat products (Lilić *et al*, 2011); (6) optimization of the physical form of salt (Angus *et al*., 2005) and (7) alternative process techniques (Claus and Sørheim, 2006).

The aim of this study was to evaluate the effects of replacing of sodium nitrite curing salt with the mixture of sodium and potassium chloride (sodium-potassium salt) for human consumption (Na-max 27 g/kg; K min 16 g/kg) at a rate of 25%, 50%, 75% and 100% on the physico-chemical quality and colour of the cooked sausages - hot dogs.

## Material and methods

### *Sausage formulation and processing*

In this examination, five different production batches (PB), about 10 kg each were manufactured. The control (C) production batches were prepared according to the manufacturer’s original recipe (Table 1).

**Table 1.** Hot dog: Recipe of the control sample - control group (C)

| Ingredients | Content, % |
|---|---|
| Beef | 20 |
| Pork | 20 |
| Emulsion of pig skin | 15 |
| Firmly fat | 13 |
| Ice | 22 |
| Na nitrite curing salt | 2.0 |
| Adifos (E450, E451) | 0.5 |
| Miocolor VS | 0.4 |
| Corn Starch | 2.25 |
| Spice mixture for frankfurters | 0.4 |
| Soy protein isolates | 4.4 |

At the 10 kg mass of experimental PB I was added 50 g of mixed sodium-potassium salt (25%) and 150 g nitrite curing salt. In PB II to the 10 kg was added 100 g of combined sodium-potassium salt (50%) and 100 g nitrite curing salt. In PB III to the 10 kg of mass was added 150 g of combined sodium-potassium salt (75%) and 50 g nitrite curing salt. In hot-dogs of PB IV was added 200 g (100%) combined sodium-potassium salt on 10 kg of mass.

Beef, pork and firm fatty tissue was first grounded in the Wolf, on a grid of 3 mm, and then continued with the fragmentation in the cutter. After adding of soy protein and ice, the treatment was continued for 3 minutes. During the last minute of processing in the cutter was added grounded firmly fat tissue and after that emulsion was completely homogenized. Filled with stuffing envelopes are hand-paired, and sausages hanging on metal rods that are placed in the appropriate frame trolley, where they are transported to the conditioned chamber (athmos furnace) to heat treatment (drying, hot smoking, roasting and stewing). Temperature during the roasting and stewing in the chamber was 80 ºC and the process lasted until the achieving temperature 72 ºC in core of the product.

### *Determination of the hot dogs Chemical Composition*

The main chemical composition was evaluated by determining of the moisture content (SRPS ISO 1442), total protein content (SRPS ISO 937), total fat content (SRPS ISO 1443) and total ash content (SRPS ISO 936).

### *Determination of Na and K content*

After cooling, samples were transferred into a 50 mL volumetric flask with de-ionized water. Analyses were carried out on atomic absorption spectrometer "SpectrAA 220" according to Varian AAS Analytical methods (Flame Atomic Absorption Spectrometry Analytical Methods, 1989). All reagents used were of analytical grade and equipment which was pre-calibrated appropriately with standard solutions prior to measurement. Samples were prepared by microwave digestion according to manufacturer's recommendations (Tips and Techniques for ETHOS, 2003). 0.5 g of the sausage sample was treated with 8 mL of nitric acid ($HNO_3$) and 2 mL of hydrogen peroxide (30% $H_2O_2$); temperature program was as follows: 5 min from room temperature to 180 ºC then 10 min hold at 180 ºC.

### *Microbiological examination*

Three hot dogs per batch were used to evaluate the microbiological quality of the treatments. Coagulase-positive staphylococci, *Salmonella* spp., *Listeria monocytogenes*, sulphite-reducing bacteria, coliforms, total viable count and mesophilic lactic acid bacteria were quantified according to the standard methodology (SRPS ISO 6888-1 and 2:2009; SRPS ISO 6579:2008; SRPS ISO 11290-2:2010; SRPS ISO 15213:2011; SRPS ISO 16649-2:2008; SRPS EN ISO 4833:1:2014; ISO 15214:1998).

### *Instrumental measurement of colour*

Technological quality was evaluated by determinations of pH and colour. The pH value of the samples was measured by portable pH meter ULTRA, type UX 390, with reinforced Ingold combined electrode for direct determination of pH in meat. The colour measurements of cooked sausages were carried out using photo-colorimeter a Minolta CM2600d (Konica Minolta, Japan) and color characteristics were expressed by CIE $L^*a^*b^*$ system (lightness - $L^*$, redness and greenness - $a^*$; yellowness and blueness - $b^*$). Illuminant D65 and 10 standard observers were used. Color measuring of the samples of hot dogs from four production batches and one control batches were performed on the fresh cut of the sausage at room temperature in triplicate, where each parameter measurement carried out on six cross-sections of the same sausages.

All data are presented as mean values. Analysis of variance (Duncan test) was used to test the differences between obtained results. The software package STATISTICA 8.0 (2008) was used for analysis.

## Results and discussion

The chemical characteristics of hot dogs formulated according producer's recipe (control group C) and with replacement of 25% (PB I), 50% (PB II), 75% (PB III) and 100% (PB IV) nitrite curing salt by mixed sodium-potassium salt are presented in Table 2.

**Table 2.** Chemical composition and sodium and potassium content of the control (C) and experimental production batches (PB) of hot dogs

| Group | $\bar{X}$ | pH | Moisture, % | Protein, % | Fat, % | Ash, % | Na, mg/kg | K, mg/kg |
|---|---|---|---|---|---|---|---|---|
| C | | 5.89 | 55.10 | 11.13 | 28.14 | 2.85 | 4950.74 | 777.57 |
| | Sd | 0.01 | 0.26 | 0.12 | 0.73 | 0.06 | 257.16 | 20.34 |
| | $\bar{X}$ Cv | 0.10 | 0.47 | 1.08 | 2.59 | 2.10 | 5.19 | 2.62 |
| PB I | | 5.88 | 55.84 | 12.05 | 27.01 | 2.94 | 4871.96 | 950.00 |
| | Sd | 0.01 | 0.17 | 0.11 | 0.13 | 0.06 | 1.46 | 1.49 |
| | $\bar{X}$ Cv | 0.10 | 0.30 | 0.91 | 0.48 | 1.70 | 0.03 | 0.16 |
| PB II | | 5.90 | 55.44 | 11.81 | 27.44 | 2.86 | 4223.08 | 1741.26 |
| | Sd | 0.01 | 0.11 | 0.14 | 0.17 | 0.10 | 1.21 | 1.17 |
| | Cv | 0.17 | 0.20 | 1.18 | 0.62 | 3.50 | 0.03 | 0.07 |
| PB III | $\bar{X}$ | 5.86 | 53.69 | 12.35 | 28.63 | 2,99 | 3898.65 | 2379.38 |
| | Sd | 0.01 | 0.12 | 0.18 | 0.10 | 0.14 | 1.30 | 1.28 |
| | $\bar{X}$ Cv | 0.10 | 0.22 | 1.46 | 0.35 | 4.68 | 0.03 | 0.05 |
| PB IV | | 5.88 | 56.45 | 12.31 | 25.87 | 2.94 | 3422.44 | 2858.39 |
| | Sd | 0.01 | 0.11 | 0.26 | 0.20 | 0.07 | 0.49 | 0.56 |
| | Cv | 0.20 | 0.19 | 2,11 | 0.77 | 2.38 | 0.01 | 0.02 |

$\bar{X}$ – mean; Sd – standard deviation; Cv – coefficient of variation

Ash content was not significantly different between the samples of hot dog originating from the control and experimental groups. The treatments with the replacement of nitrite curing salt by mixed sodium-potassium salt presented a significant reduction in the content of sodium and a significant increase of potassium content. Ruusunen *et al.* (2002) examined the sodium reduction of cooked bologna-type sausage by replacing sodium phosphate with potassium phosphate. Sodium content in our investigation was 0.495 g/100 g, 0.487 g/100 g, 0.422 g/100g, 0.390 g/100 g and 0.342 g/100 g, respectively. The control formulation (C) presented a sodium content considered normal for cooked emulsion products. The replacement of 25%, 50%, 75% and 100% of nitrite curing salt with mixed sodium-potassium salt generated a reduction of approximately 1.59%, 14.70%, 21.25% and 30.87% in the sodium content in the relation to the control formulation, respectively. This reduction in the sodium content provides the modified products with a healthier appeal since the decrease of sodium intake in our diet is seen as a way to reduce risk factors for hypertension and, consequently, heart diseases (Antonios and Macgregor, 1997).

Handling and processing of meat create the conditions for more intense microbial contamination. The presence of aerobic bacteria in our samples (*Table 3.*) indicates possible contamination of hot dogs over the workers, work surfaces or equipment with which they come in contact, or through additives. In order to produce high-quality meat products, it is necessary that the raw material is high-quality and microbiologically safe, and that control is exercised during all stages of production and processing of the finished product.

According to the regulations of the general and special conditions of hygiene of food at any stage of production, processing and trade (Official Gazette of RS, 72/10), foods on the market must not contain: *Salmonella* species in 25 g (mL), coagulase-positive *Staphylococci* in 0.01 g (mL), sulfite-reducing *Clostridia* in 0.01 g (mL), *Proteus* species in 0.001 g (mL) and *Escherichia coli* in 0.001 g (mL). Tested samples originating from all experimental groups were microbiologically correct, according to the criteria set forth microbiological criteria prescribed in the Regulations, which is a by-law of the Food Safety.

**Table 3.** Results of microbiological examination of the control (C) and experimental production batches (PB) of hot dogs

| Group | Coagulase-positive Staphylococci | Salmonella spp. | Listeria monocytogenes | Sulphite-reducing bacteria | Coliforms | Total viable count | Mesophilic lactic acid bacteria |
|---|---|---|---|---|---|---|---|
| C | - | - | - | - | - | 350 | 300 |
| PB I | - | - | - | - | - | 1000 | - |
| PB II | - | - | - | - | - | 850 | - |
| PB III | - | - | - | - | - | 2000 | - |
| PB IV | - | - | - | - | - | 300 | - |

The colour characteristics of hot dogs formulated according producer's recipe (control group C) and with replacement of 25%, 50%, 75% and 100% nitrite curing salt by mixed sodium-potassium salt are presented in Table 4.

**Table 4.** Colour quality of the control (C) and experimental production batches (PB) of hot dogs

| Group | $\overline{X}$ | Light intensity CIE L* | Share of redness CIE a* | Share of yellowness CIE b* | Dominant Wave-length |
|---|---|---|---|---|---|
| C | | 65.63 | 14.16 | 10.47 | 595.26 |
| | Sd | 1.14 | 0.43 | 0.25 | 0.70 |
| | $\overline{X}$ Cv | 1.74 | 3.07 | 2.35 | 0.12 |
| PB I | | 66.15 | 12.82 | 11.45 | 592.37 |
| | Sd | 1.14 | 0.43 | 0.25 | 0.70 |
| | Cv | 1.73 | 3.39 | 2.15 | 0.12 |
| PB II | $\overline{X}$ | 67.36 | 13.19 | 10.72 | 593.68 |
| | Sd | 0.95 | 0.38 | 0.24 | 0.45 |
| | Cv | 1.42 | 2.90 | 2.21 | 0.08 |
| PB III | $\overline{X}$ | 68.34 | 11.96 | 11.10 | 591.71 |
| | Sd | 0.85 | 0.22 | 0.17 | 0.23 |
| | Cv | 1.25 | 1.83 | 1.56 | 0.04 |

| | | | | | |
|---|---|---|---|---|---|
| PB IV | $\overline{X}$ | 68.70 | 7.89 | 11.83 | 586.14 |
| | Sd | 0.41 | 0.24 | 0.34 | 0.52 |
| | Cv | 0.59 | 3.08 | 2.86 | 0.09 |

$\overline{X}$ – mean; Sd – standard deviation; Cv – coefficient of variation

Colour is one of the most important quality characteristic of cooked cured meat products.

In the present study, the average CIE *L** values (lightness) of sausages produced with reduced sodium were higher (66.15-68.70) in relation to hot dogs with sodium nitrite curing salt (65.63). The same relation was in the case of CIE *b** (yellowness) of sausages. The measured value was 10.47 at hot dog that were produced using sodium nitrite salt, while the share of yellowness (CIE *b**) in sausages produced with reduced sodium was higher and ranged from 11.45 in PB I to 11.83 in PB IV. Knowing the impact of $NaNO_2$ on developing pinkish-red color of meat products (Honikel, 2008; Horita et al., 2014), the result of the share of redness was expected (CIE *a**). Share of redness (CIE *a**) of sausage of control group (C) was the highest (14.16), while the measured values of CIE *a** sausages produced with reduced sodium content were lower and ranged from 12.82, in PB I to 7.89 in PB IV, sausage in which the sodium nitrite salt was completely replaced by with potassium chloride. Dominant wavelength measured in all sausages was in the red part of the spectrum. The highest value (595.26) is measured in the control group (C), while slightly lower values (586.14-593.86) were measured in the sausages of other experimental groups (PB). For the measured values of the characteristics of the color of produced sausages statistical differences were not significant.

## Conclusions

- The replacement in the amount of 25%, 50%, 75% and 100% nitrite curing salt with mixed sodium-potassium salt promotes better dietetic characteristics of hot dogs produced with low levels of sodium and high potassium level. Statistical differences were observed in pH values, sodium and potassium content among the treatment. Ash content was not significantly different between the samples of hot dog originating from the control and experimental groups.
- Microbiological safety of the hot dogs produced with replacement of nitrite curing salt by mixed sodium-potassium salt not altered by this substitution.
- The obtained results clearly indicate a continuous decrease of sodium content in samples originating from the control group to the experimental samples PB IV, in which the nitrite curing salt was fully replaced with a mixture of potassium-sodium salt.
- Replacing of sodium nitrite curing salt with the mixture of sodium and potassium chloride did not significantly affect the examined colour (CIE *L*, a*, b**) of experimentally prepared hot-dogs. Lightness (CIE *L**) of sausages produced with reduced sodium content were higher (66.15-68.70) in relation to hot dogs with sodium nitrite salt (65.63). Share of yellowness (CIE *b**) was 10.72-11.83 in the experimental production batches (PB) and 10.47 at hot dogs with sodium nitrite salt (C), while the proportion of redness (CIE *a**) was higher in the control group, C (14.16) than in the experimental groups, PB (7.89 to 13.19). Dominant wavelength measured in all the sausage was in the red part of the spectrum (586.14-595.26).

Further studies are necessary to assess the impact of this technological strategy on the shelf life of hot dogs regarding their sensory quality.

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