Sodium and potassium contents and ratios in pork stews produced with lower amounts of sodium chloride

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Abstract. The goal of this study was to investigate the influence on the sodium:potassium ratio of reducing sodium chloride content in pork stew by partial replacement with other two chloride salts. The trial consisted of five groups. In the control pork stew, only sodium chloride was added. In group 1, one third of the sodium chloride was replaced with potassium chloride; in group 2, one half of the sodium chloride was replaced with potassium chloride; in group 3, sodium chloride was reduced by half and one quarter of ammonium chloride (in relation to the control group) was added, and in group 4, sodium chloride was reduced by 62.5% and an equal amount of ammonium chloride was added. Moderate reduction of sodium content was achieved in group 1 (46.19%), while greater reductions of sodium content were achieved in groups 2, 3 and 4 (these had 64.69%, 61.54% and 67.91% less sodium than did the control, respectively). Potassium content increases were determined in groups 1 and 2 (potassium levels were 38.71% and 50.27% greater than in the control, respectively). The best sodium:potassium ratio was achieved in group 2 pork stew (0.47), in which half the sodium chloride was replaced with potassium chloride.

1. Introduction
Reducing sodium/sodium chloride in food, particularly in meat products, has become one of the main dietary aims nowadays, and will also be important in the future. Daily sodium intake often exceeds the level, as advised by the World Health Organization, that can cause several debilitative health effects, primarily linked to essential hypertension and consequent cardiovascular disorders. It has been estimated that 62% of stroke and 49% of coronary heart disease is caused by high blood pressure [1]. Sodium chloride is commonly used in all meat products and it has an important role as the prototypical stimulus for salty taste [2]. Saltiness perception is a very complex system and can be explained by the unique sodium-specific transduction mechanism involving epithelial sodium channels (ENaCs) on the taste receptor cells [3]. Beside saltiness, sodium chloride improves the sensory properties of food by decreasing bitterness and increasing sweetness [4]. Due to these desirable effects of sodium chloride, it is a great challenge to reduce its content in food. Use of other salts as partial replacers of sodium chloride could be a way to reduce the sodium content of meat products, but this is also linked to the
appearance of bitter and metallic tastes. The most common replacer is potassium chloride, followed by magnesium and calcium salts and ascorbates [5]. Ammonium chloride can also be used in combination with autolysed yeast [6]. Commercial use of sodium chloride replacers is still restricted, but presently, potassium chloride and ammonium chloride are both recognized as safe.

The topic of reducing sodium content in meat products pertains to many investigations on cooked sausages, fermented sausages and dry meat products, but there are few literature data about sodium reduction in prepared meat meals. Prepared and ready-to-eat meals have become an important choice for modern people with respect to their fast lifestyles, particularly in developed countries. Due to that, the goal of this study was to investigate the impact of reducing the sodium chloride content in pork stew by partial replacement of sodium chloride with potassium chloride or ammonium chloride with a target to achieve a better sodium to potassium ratio.

2. Materials and methods

2.1. Trial design
The trial consisted of five groups of pork stew with the compositions presented in Table 1. In the control, only sodium chloride was added. In group 1, one third of the control amount of sodium chloride was replaced with potassium chloride, while in group 2, one half of the sodium chloride was replaced with potassium chloride. In group 3, the control amount of sodium chloride was reduced by one half and one quarter of ammonium chloride (in relation to the sodium chloride in the control) was added. In group 4, sodium chloride was reduced by 62.5% of the amount added to the control and an equal amount of ammonium chloride (as sodium chloride) was added.

2.2. Meal preparation
Minced onion was fried in the sunflower oil for 20 minutes and after that, red pepper, salts and meat (pork shoulder) cut into pieces were added, as well as water. Stews were cooked for 80 minutes. After cooking, samples of stew were put into plastic containers and refrigerated until analysis.

| Group | Onion, g | Sunflower oil, mL | Meat, g | Red pepper, g | Water, mL | Sodium chloride, g | Potassium chloride, g | Ammonium chloride, g |
|-------|----------|-------------------|---------|--------------|-----------|-------------------|----------------------|----------------------|
| Control | 500 | 50 | 500 | 5.00 | 500 | 16.00 | - | - |
| 1 | 500 | 50 | 500 | 5.00 | 500 | 10.66 | 5.33 | - |
| 2 | 500 | 50 | 500 | 5.00 | 500 | 8.00 | 8.00 | - |
| 3 | 500 | 50 | 500 | 5.00 | 500 | 8.00 | - | 4.00 |
| 4 | 500 | 50 | 500 | 5.00 | 500 | 6.00 | - | 6.00 |

2.3. Determination of Na and K
To digest the stews, approximately 0.3 g amounts were transferred into Teflon vessels and 5 mL nitric acid (p.a. Sigma-Aldrich, St. Louis, MA, USA) and 1.5 mL hydrogen peroxide (30%, p.a., Merck & Co., Whitehouse Station, New Jersey, USA.) were added. The sample solutions were quantitatively transferred into disposable flasks and diluted, then digested using a microwave program that 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, digests were diluted to 100 mL with deionized water (ELGA). Analysis was performed by inductively-coupled plasma mass spectrometry (ICP-MS). Measurements were obtained using the instrument iCap Q (Thermo Scientific, Bremen, Germany), equipped with
collision cell and operating in kinetic energy discrimination (KED) mode. The following isotopes were measured: $^{39}$K and $^{23}$Na.

Torch position, ion optics and detector settings were adjusted daily using tuning solution (Thermo Scientific Tune B) in order to optimize measurements and minimize possible interferences. For the qualitative analysis of the samples, a five-point calibration curve (including zero) was constructed for each isotope in the concentration range of 0.1-2.0 mg/L. 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; $^{71}$Ga, $^{89}$Y, $^{209}$Bi – 2 ng/mL) covering a wide mass range. Concentrations of each measured isotope were corrected for response factors of both higher and lower mass internal standard using the interpolation method.

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

3. Results and discussion

All experimental samples of pork stew were sensorially acceptable [7]. Results of sodium and potassium content in pork stew are presented in Table 2. Sodium content was directly influenced by the amount of added sodium chloride, and the highest sodium content was determined in the control pork stew. Moderate reduction of sodium content was achieved in group 1 (46.19% less sodium than the control), in which the amount of sodium chloride was one third less than in the control. Greater reductions of sodium content were achieved in groups 2, 3 and 4 (64.69%, 61.54% and 67.91% less sodium than the control, respectively). In these stews, the amount of sodium chloride was half that of the control (groups 2 and 3), while in group 4, the sodium chloride content was 62.5% of that of the control.

Sodium content was directly influenced by adding potassium chloride to the experimental pork stews. Potassium content increased in groups 1 and 2 (38.71% and 50.27% more potassium than the control, respectively). In groups 3 and 4, potassium contents were lower than in the control, by 21.86% and 17.97%, respectively, due to potassium chloride not being added to these products. The highest sodium:potassium ratio was in the control pork stew (1.99). However, the best sodium:potassium ratio was achieved in group 2 pork stew (0.47), in which half the sodium chloride was replaced with potassium chloride, bringing the ratio into accord with level of 0.43 that is recommended by the World Health Organization [8]. The sodium:potassium ratios in groups 1 and 4 were similar (0.77 and 0.78, respectively), while that of group 3 was 0.98.

Table 2. Sodium and potassium content in pork stew, mg/kg

| Group | Sodium  | Potassium | Sodium:Potassium ratio |
|-------|---------|-----------|------------------------|
| Control | 11591.27 | 5838.61   | 1.99                   |
| 1     | 6237.78  | 8099.01   | 0.77                   |
| 2     | 4092.86  | 8773.81   | 0.47                   |
| 3     | 4458.14  | 4562.02   | 0.98                   |
| 4     | 3719.92  | 4789.25   | 0.78                   |

4. Conclusion

The highest sodium content was determined in the control pork stew, due to this having the highest amount of added sodium chloride. Moderate sodium reduction was achieved in experimental pork stews in which sodium chloride was partially replaced with potassium chloride or ammonium chloride and in which, at the same time, the amount of added sodium chloride was reduced.

The highest potassium contents were determined in the groups 1 and 2 pork stews, produced with added potassium chloride.
In all stews from experimental groups, the sodium:potassium ratio was better than in the control pork stew, and without particular impact on sensory attributes of the products.

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