Ways of reducing the sodium content in meat products

Markéta Adamcová, Tereza Škorpilová, Adam Skřivánek, Petr Pipek

Department of Food Preservation
Faculty of Food and Biochemical Technology
University of Chemistry and Technology Prague
Prague, Czech Republic

Abstract

Excessive intake of sodium has been criticised due to its negative influence on human health, and for that reason ways are being sought to reduce its content or replace it in foods. The objective of this study was to investigate the partial replacement of sodium chloride in meat products with potassium chloride and potassium lactate. Sensory evaluation was first performed on various combinations of sodium and potassium salt solutions in water (chlorides, lactates) and specimen meat products prepared on the laboratory scale. Suitable recipes which were used for the production of meat products under operational conditions were then selected on the basis of the results of the sensory analysis. The effect of the composition of the salting mix on texture, colour and organoleptic properties was then tested. It was shown that sodium chloride may be partially replaced in meat products by potassium salts without negatively affecting quality.

Meat products, reducing the sodium content, technological and organoleptic properties

Introduction

Sodium chloride is one of the oldest preservative additives used in the production of meat products. It has a positive influence on technological and organoleptic properties. However, many studies point to its negative effect on human health, as excessive sodium intake contributes towards high blood pressure and thereby to the development of cardiovascular diseases and other illnesses (e.g. Alzheimer's disease, kidney stones, etc.) (Puolanne and Ruusunen 2005).

Sodium chloride has an important function in meat products. In particular, it contributes to the formation of structure, the assurance of shelf life and to highlight the typical taste of meat products (Bidlas and Lambert 2008 and Desmond 2006).

Sodium chloride assures the structure of meat products by dissolving myofibrillar proteins and allowing them to swell, so that the firm jell of the meat product can be formed after thermal processing (Bush et al. 2013). It increases the ability of meat to bind water, reduces water losses and increases juiciness (Desmond 2006). However, water binding capacity in meat products depends on a number of additional factors, in particular pH, the presence of polar groups of side chains of amino acids, the number of cross-bridges, the content of polyvalent ions, the progression of post-mortem changes in the meat, etc. (Puolanne and Ruusunen 2005). Therefore, reducing the salt content may have a negative effect on the solubility of proteins and the structure of the meat product which must then be supported by other substances, for example by the addition of polyphosphates, etc. (Ruusunen et al. 2005).

The shelf life of meat products is not assured only by sodium chloride, but by a combination of effects acting negatively on microbial contamination (the hurdle technology). There is more than one mechanism by which salt contributes to shelf life, and all of these mechanisms act together (Brewer 1999). The most significant of these effects is the reduction of water activity, thereby creating an unfavourable environment for microorganisms, particularly bacteria (Puolanne and Ruusunen 2005). Reducing the solubility of oxygen in the product batter has an indirect effect on microorganisms, particularly aerobic microorganisms. Furthermore, sodium chloride does, have a direct impact on the microflora present: salt increases the osmotic pressure which leads to the

Address for correspondence:
Ing. Markéta Adamcová
Department of Food Preservation
Faculty of Food and Biochemical Technology
University of Chemistry and Technology Prague
Technická 3, 166 28 Prague 6 – Dejvice, Czech Republic
Phone: +420 220 443 003
E-mail: adamcovamarketa@email.cz
www.maso-international.cz

dehydration of microbial cells (Ockerman and Basu 2004). Thus, reducing the sodium chloride content without the use of other preservatives or procedures may have a negative effect on the shelf life. According to Desmond (2006), reducing the salt content beneath 1.5% by weight may result in significantly more rapid growth of the microflora.

Sodium chloride also has a significant influence on the taste of meat products: it highlights the taste of the meat and has its own pronounced salty taste. Saltiness of sodium chloride is primarily caused by sodium cations and chloride anions then accentuate it (Puolanne and Ruusunen 2005). Typical taste of sodium chloride can be accompanied by a sweet, bitter or metallic taste. The intensity of tastes depends on the content of potassium, magnesium, calcium, iron and other elements (Opletal et al. 2011).

According to the literature, there are a number of ways of reducing the sodium content in meat products. The easiest way is the managed reduction of the salt content in meat products down to a level that does not affect the technological or organoleptic properties of the product (Kloss et al. 2015; Phelps et al. 2006 and Puolanne and Ruusunen 2005). Further reduction of the sodium content is possible by means of the partial or complete replacement of sodium chloride by substances that do not have a negative effect on the technological or organoleptic properties of the product. These substances may be other chlorides (potassium, calcium or magnesium) or lactates (sodium, potassium) (Desmond 2006). These methods have already been tried in certain products with varying results.

Another solution of reducing the sodium presents itself from the viewpoint of taste (without considering the technological aspects). This involves the use of natural non-toxic substances that highlight the salty taste of sodium chloride (Kloss et al. 2015 and Opletal et al. 2011). It is done by influencing the size and shape of sodium chloride crystals to make them dissolve in the mouth more quickly so that the impression of saltiness is perceived more rapidly (Desmond 2006; Phelps et al. 2006), or influencing the structure of the food in such a way that the receptors for salty taste are stimulated as fast as possible (Kloss et al. 2015). However, this does not relate to meat products, as sodium chloride is present here in the form of a solution.

The above indicates that every change in used salting mix must be preceded by experimental tests that make it evident what effect the salting mix used has on the technological and organoleptic properties.

Materials and Methods

In this experimental work, we studied whether it is possible to reduce the sodium content by replacing it with other elements or salts without negatively affecting technological and organoleptic properties. Shelf life, colour and texture were monitored, in addition to sensory analysis.

Methods

Sensory analysis: all samples were presented to a panel of 30 evaluators who evaluated a number of descriptors of taste with the use of 10 cm scales. The limit values for intensity were: 0 – not intense, 10 – extremely intense. The acceptability of the individual tastes was assessed as follows: 0 – unacceptable, 10 – acceptable; a value of 5 represented the optimum for the acceptability of salty taste.

Texture was measured with an Instron texture analyser (model 5544) and the results evaluated using the program Merlin. The value of the force required to compress the sample (cylindrical shape, height 25 mm, diameter 25 mm) to 80% of its original size was recorded (Fig. 1).

Colour was evaluated on the basis of the values $L*$ (lightness), $a*$ (redness) and $b*$ (yellowness) as measured by a Minolta CM-5 reflectance spectrophotometer.

Samples used

First, the taste of pure salts in solutions in water was investigated. The concentrations of sodium chloride (7.5 $g \cdot l^{-1}$, which is 0.1283 $mol \cdot l^{-1}$) were replaced on an equimolar basis, i.e. without the interfering effect of different relative molecular weight, with other chlorides and/or salts. An overview of the solutions assessed is given in Table 1.

Table 1. An overview of solutions for sensory evaluation; equimolar replacement of sodium chloride [%]

Sample	Sodium chloride	Potassium chloride	Potassium lactate
R1	100	-	-
R2	-	50	50
R3	-	75	25
R4	-	25	75

Specimen meat products were then prepared under laboratory conditions during which the original addition of sodium chloride (20 $g \cdot kg^{-1}$, i.e. 0.3608 $mol \cdot kg^{-1}$) was partially or entirely replaced on an equimolar basis with potassium chloride, potassium lactate and/or a combination of the two. The composition of the salting mixes and the proportion of equimolar replacement of sodium chloride are given in Table 2. The sensory intensity of sodium chloride replacement was assessed in these samples.

Table 2. An overview of salting mixes for meat products prepared in the laboratory; equimolar replacement of sodium chloride [%]

Sample	Sodium chloride	Potassium chloride	Potassium lactate	Sodium lactate
L1	100	-	-	-
L2	75	25	-	-
L3	50	-	50	-
L4	-	50	-	50

After the laboratory tests, the same combinations of salting mixes were used for samples of homogenous Lyoner type sausage under industrial conditions. A common basic mix of meat, seasonings and ice (200 kg) was pre-cut and pre-mixed on a cutter and divided into four equal batches, and the mixing of individual batches completed with the addition of the pertinent salting mix in the cutter. The samples of batter were filled in polyamide casings (calibre 75 mm) and heat-treated in the usual way. An overview of combinations of salting mixes and equimolar replacement of sodium chloride is given in Table 3.

Table 3. An overview of salting mixes for industrially produced meat products; equimolar replacement of sodium chloride [%]

Sample	Sodium chloride	Potassium chloride	Potassium lactate	Sodium lactate
J1	100	-	-	-
J2	75	25	-	-
J3	50	-	50	-
J4	-	50	-	50

Results and Discussion

The solutions of salting mixes were the first to be subjected to sensory analysis. First, the threshold concentrations of the individual substances were determined to ensure that their intensity was neither too high nor too low for the evaluators. The greatest differences were recorded for salty taste, with the sample with sodium chloride (R1) showing greater saltiness for the evaluators than the other samples. Differences were also observed for bitter taste, though the evaluators did not state any of the samples to be completely unacceptable to them. Metallic and sweet taste received an extremely similar assessment in all the samples (Fig. 1).

Specimen meat products were prepared under the laboratory conditions with the same salts used in the solutions on the basis of the results of the sensory analysis. It was expected that the effect of the matrix would lessen the differences between the individual tastes.

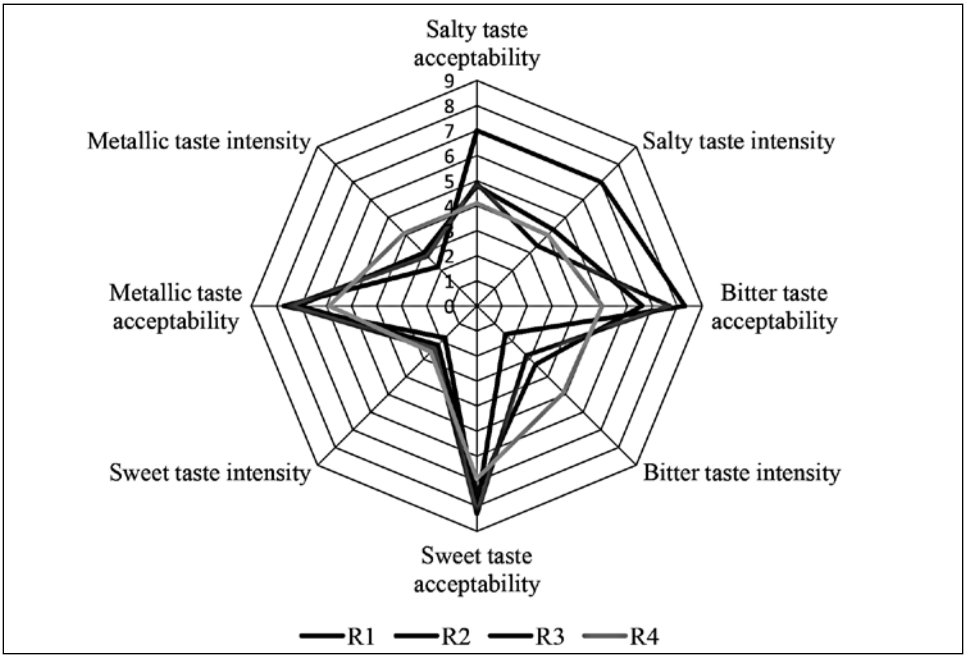

Fig. 1. Sensory analysis of salt solutions

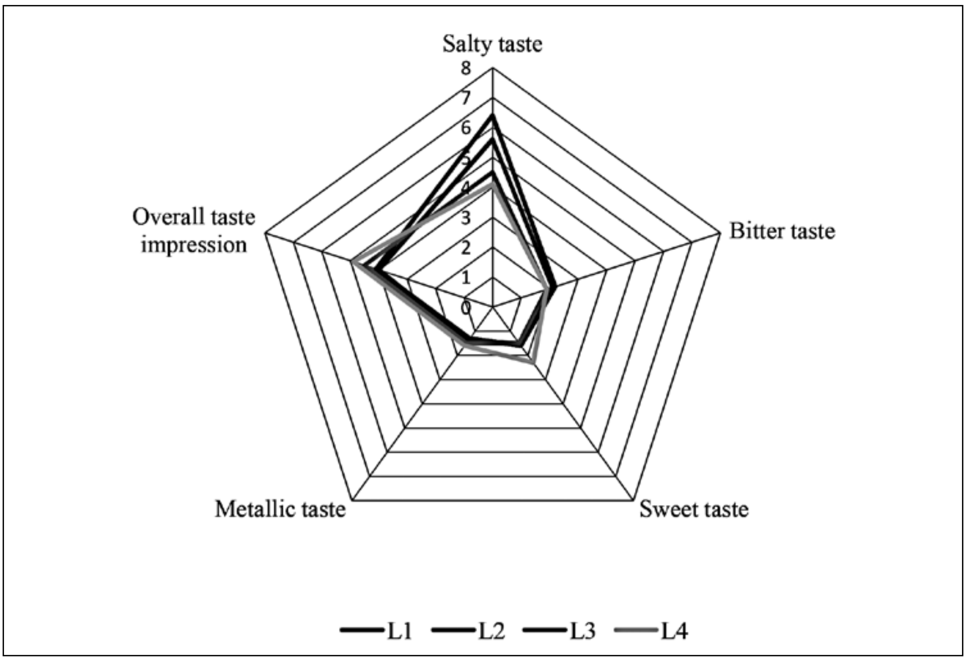

Fig. 2. Sensory analysis of samples prepared in the laboratory

Flavourings were not added to the samples to make it easier to monitor the effect of the salts on sensory properties. From the results obtained (Fig. 2) it is clear that the evaluators perceived a slight difference only for salty taste, as they did in the case of the solutions. They assessed samples L1 (standard) and L2 (25% KCl substitution) as slightly saltier than samples L3 (50% potassium lactate substitution) and L4 (50% KCl substitution and 50% potassium lactate substitution). The other tastes (bitter, sweet and metallic) were evaluated almost identically.

Sensory analysis of industrially produced soft sausage (Fig. 3) confirmed the results obtained by sensory analysis of samples prepared in the laboratory. All of the studied tastes and properties were evaluated almost identically. The only difference to be observed was, as in the case of the solutions and samples prepared in the laboratory, for the salty taste. Certain small differences may have been concealed by the intense seasoning, for which reason we anticipate reducing or completely eliminating the addition of seasoning in further measurements for the purposes of the experiment.

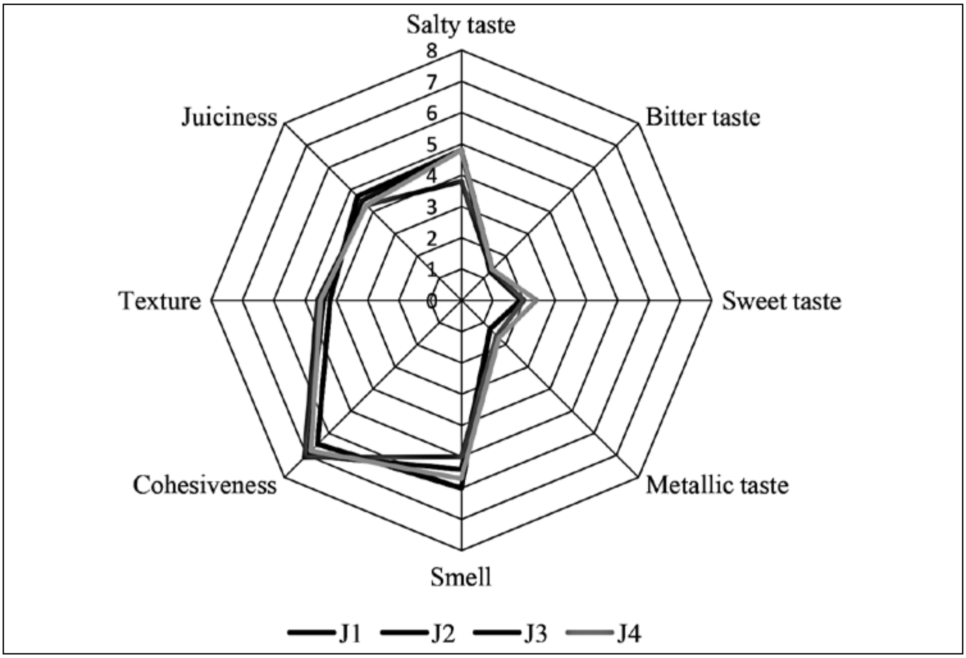

Fig. 3. Sensory analysis of Lyoner type sausage

Other properties that can be expected to be influenced by a change of ions were also objectively evaluated in addition to sensory evaluation. Although sodium or chloride ions were substituted on an equimolar basis and the ion strength should be similar, the solubility and size of the molecules in the substitute salts used vary.

Product texture depends, first and foremost, on the release of muscle proteins as a result of the action of added salt. The replacement of sodium ions with potassium ions did not have a statistically significant influence on texture (force during compression), as is evident from Table 4. A slight firming of structure occurred in products in which a half of the salt was replaced with lactate, this being more pronounced when a combination of potassium chloride and sodium lactate was used. An explanation can perhaps be found in the effect on the pH of the batter (a lactate is a salt of a weak acid).

The effect of potassium chloride on product texture is also described by Lorenzo et al. (2015), Horita et al. (2014), Aliño et al. (2010) and Aliño et al. (2009) who found a firming of the texture of the products they studied (frankfurters and all-muscle dried products made from pork) when potassium chloride was used to replace sodium chloride to an amount of 50% or more. This fact correlates with the results obtained in this work, as a visible firming of texture was seen in sample J4 (50% KCl and 50% sodium lactate).

Table 4. The effect of the salts used on the texture of sausages

Sample	Force [N]	Substitution
J1	68.67 ± 6.04	-
J2	68.31 ± 5.46	25% KCl
J3	72.57 ± 2.63	50% K-lactate
J4	77.70 ± 4.77	50% KCl and 50% Na-lactate

Colour was, as expected, not significantly influenced by a change in the composition of salts, as is evident from Table 5. The same results were also obtained by Horita et al. (2014) who studied the effect of salting mixes with a reduced content of sodium ions on the colour of frankfurters. Lorenzo et al. (2015) also studied reduction of the sodium content by means of potassium chloride and tested the use of various salting mixes on all-muscle dried products.

Table 5. The effect of the salts used on the colour of sausage

Sample	Measured values		
	*L**	*a**	*b**
J1	57.6	26.1	28.1
J2	56.6	27.6	29.7
J3	58.2	26.1	27.2
J4	56.5	27.6	29.6

Conclusions

It was demonstrated that sodium chloride can be partially replaced in meat products by potassium chloride and potassium lactate without any negative effect on the quality. Their use had merely an insignificant effect on technological and organoleptic properties.

References

Aliño M, Grau R, Toldrá F, Blesa E, Pagán MJ, Barat JM 2009: Influence of sodium replacement on physicochemical properties of dry-cured loin. Meat Sci **83**: 523-430

Aliño M, Grau R, Toldrá F, Blesa E, Pagán MJ, Barat JM 2010: Physicochemical properties and microbiology of dry-cured loins obtained by partial sodium replacement with potassium, calcium and magnesium. Meat Sci **85**: 580-588

Bidlas E, Lambert RJW 2008: Comparing the antimicrobial effectiveness of NaCl and KCl with a view to salt/sodium replacement. Int J Food Microb **124**: 98-102

Brewer MS 1999: Traditional Preservatives – Sodium Chloride. Encyclopaedia of Food Microbiology. 1st Ed., Cambridge, Academic Press: 1723-1727, 2372 p

Busch JLHC, Yong FYS, Goh SM 2013: Sodium reduction: Optimizing product composition and structure towards increasing saltiness perception. Trends Food Sci Tech **29**: 21-34

Desmond E 2006: Reducing salt: A challenge for the meat industry. Meat Sci **74**: 188-196

Horita CN, Messias VC, Morgano MA, Hayakawa FM, Pollonio MAR 2014: Textural, microstructural and sensory properties of reduced sodium frankfurter sausages containing mechanically deboned poultry meat and blends of chloride salts. Food Res Int **66**: 29-35

Kloss L, Meyer JD, Graeve L, Vetter W 2015: Sodium intake and its reduction by food reformulation in the European Union – A review. NFS J **1**: 9-19

Lorenzo JM, Bermúdez R, Domínguez R, Guiotto A, Franco D, Purriños L 2015: Physicochemical and microbial changes during the manufacturing process of dry-cured lacón salted with potassium, calcium and magnesium chloride as a partial replacement for sodium chloride. Food Cont **50**: 763-769

Ockerman HW, Basu L 2004: Chemistry and physics of comminuted products. Other ingredients. Encyclopaedia of Meat Sciences. 1st Ed., Cambridge, Academic Press: 283-286, 1523 p

Opletal L, Wimmer Z, Čopíková J, Lapčík O, Moravcová J, Cahlíková L, Drašar P 2011: Salty taste of natural substances and their derivatives. Chemické listy **105**: 761-765 (In Czech)

Phelps T, Angus F, Clegg S, Kilcast D, Narain C, Den Ridder C 2006: Sensory issues in salt reduction. Food Qual Pref **17**: 663-634

Puolanne E, Ruusunen M 2005: Reducing sodium intake from meat products. Meat Sci **70**: 531-541

Ruusunen M, Vainionpää J, Lyly M, Lähteenmäki L, Niemistö M, Ahvenainen R, Puolanne E 2005: Reducing the sodium content in meat products: The effect of the formulation in low-sodium ground meat patties. Meat Sci **69**: 53-60