The effect of reducing the sodium content on the quality of meat products

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Abstract

Sodium chloride is a traditional food additive that contributes to microbial stability, has a positive effect on the structure of meat products and is responsible for their salty taste. A number of negative effects on human health are, however, linked to excessive intake of sodium, for which reason various possibilities for reducing its intake are being investigated. This study evaluates the possibility of partial replacement of sodium chloride by potassium chloride and potassium lactate in soft salami. The paper also examines the influence of the sodium replacements on shelf life and the key technological and organoleptic properties. The effect on shelf life was assessed by means of microbiological analyses conducted every three or four days for a period of three weeks. The following properties were monitored in the samples: colour (reflectance spectrophotometry), lipid oxidation (TBARS) and texture (compression method). The samples of salami sausage were also subjected to sensory analysis. Our results suggest that sodium chloride can be partially replaced by potassium chloride and potassium lactate without significant negative effects on the quality of the final product.

Meat products, sodium content reduction, shelf life, technological and organoleptic properties

Introduction

Sodium chloride is one of the oldest additives used in meat products. Table salt plays a significant role in extending the shelf life of meat and attaining the desired technological properties and taste. A number of studies, however, point to the negative effect of excessive sodium intake on human health and to the need for reducing its content in foods (Škorpilová et al. 2016; Kloss et al. 2015; Desmond 2006; Puolanne and Ruusunen 2005).

Sodium chloride is required in meat products to assure the microbial stability of the meat. It has a positive effect on microbial stability by reducing the water activity (Puolanne and Ruusunen 2005), reducing the solubility of oxygen, increasing the osmotic pressure (Ockerman and Basu 2004) and damaging microbial enzymes (Brewer 1999). Table salt is also important in forming the texture of meat products as it dissolves myofibrillar proteins to form a firm gel after heat treatment that retains water in the product (Desmond 2006; Puolanne and Ruusunen 2005). Another important role played by sodium chloride is enhancing the flavour of meat products. Pure sodium chloride has a markedly salty taste for which the sodium cation is responsible, with the chloride anion then intensifying this saltiness (Opletal et al. 2011; Puolanne and Ruusunen 2005). The effects of table salt on the quality of meat products have been described in detail in the previous study by Škorpilová et al. (2016).

The negative effects that sodium chloride has on the human organism are currently the subject of frequent discussion. It is, however, often forgotten that the sodium cation along with the chloride anion are important blood plasma ions and have a role to play in a number of vitally important processes. They are required, first and foremost, to maintain the osmotic pressure of liquids in the body. Sodium is also crucial for maintaining the membrane potential of cells (Kloss et al. 2015; Higdon et al. 2016) and is the primary determinant of the extracellular volume of liquids, including the volume of blood. This

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is why a number of processes determining the volume of blood and blood pressure are regulated by means of its retention or excretion (Kloss et al. 2015). The recommended daily intake of sodium chloride is around 3.8 – 6 g. The average intake of the European population is, however, significantly higher (9 – 12 g per day) which may lead to a number of medical complications. The human organism is not programmed for long-term excessive intake of sodium and the regulatory systems for this element are considerably limited. People taking in high doses of sodium chloride are at greater risk of high blood pressure and the subsequent development of cardiovascular diseases (Higdon et al. 2016).

One of the most common ways of reducing the sodium content in meat products is to replace it with other substances, usually with a salty taste (Kloss et al. 2015; Opletal et al. 2011; Puolanne and Ruusunen 2005). Sodium chloride is often replaced in meat products on an equimolar basis over a wide range from 5 to 75%, with the amount replaced generally depending on the type of meat product and its recipe (Santos et al. 2014; Puolanne and Ruusunen 2005). The most widely used substitutes for sodium chloride undoubtedly include potassium chloride (Puolanne and Ruusunen 2005) and potassium lactate (Phelps et al. 2006).

The use of potassium chloride is advantageous for a number of reasons. It has the same inhibitory effect as sodium chloride on the growth of microorganisms (Bidlas and Lambert 2008) and just a minimal effect on the technological properties of meat products (Lorenzo et al. 2015; Campagnol et al. 2011). The addition of increasing amounts of potassium chloride is, however, associated with an increasing intensity of undesirable bitter, sweet and metallic tastes, for which reason it generally substitutes for no more than 50 % of the sodium chloride in meat products (Armenteros et al. 2012).

There may also be advantages to replacing sodium chloride with potassium lactate as lactates retard the growth of microorganisms (Carpenter and Broadbent 2009), can retard lipid oxidation (Tan and Shelef 2002) and do not affect product colour (Jensen et al. 2003). Their use as additives can, however, have a negative influence on texture and lead to a product that appears softer and less cohesive (Armenteros et al. 2012; Puolanne and Ruusunen 2005). The salty taste of potassium lactate is markedly less intense that the saltiness of sodium chloride, and the addition of a large amount may give the product a bitter and metallic taste (Jensen et al. 2003), for which reason substitution of sodium chloride with potassium lactate generally amounts to 30 – 50% (Phelps et al. 2006).

Although there is no known substance that would completely substitute for the technological and organoleptic properties of sodium chloride, an appropriately selected combination of salting mixes and the possible modification of the recipe can be used to obtain meat products of high quality corresponding to the demands of customers (Kloss et al. 2015).

Materials and Methods

The aim of this work was to find combinations of salting mixtures that would make it possible to reduce the sodium content with no negative effect on the quality of meat products. The growth of microorganisms during storage, colour and lipid oxidation were monitored in the samples. The products were also subjected to sensory evaluation.

Samples used

Soft heat treated salamis were produced under operational conditions. Sodium chloride was replaced in these products on an equimolar basis by potassium chloride or potassium lactate (the commercial products Purasal Hi Pure P Plus and PuraQ® Arome NA4). The composition of salting mixes (Table 1) was drawn up on the basis of our previous study (Škorpilová et al. 2016). The samples were stored for 23 days at 5 °C.

Methods

The PCA pour plate method was used for the microbiological analysis of samples. Incubation took place at 30 °C for a period of 72 hours. The samples were inoculated with a known number of microorganisms – one

Table 1. Composition of salting mixes for individual samples

Samples	NaCl		KCl		Purasal Hi Pure P Plus		PuraQ® Arome NA4	
	n [mol]	Weight [%]	n [mol]	Weight [%]	n [mol]	Weight [%]	n [mol]	Weight [%]
A	17.11	2.00	0	0	0	0	0	0
B	12.83	1.50	4.28	0.64	0	0	0	0
C	8.56	1.00	8.56	1.28	0	0	0	0
D	8.56	1.00	0	0	8.56	2.81	0	0
E	8.56	1.00	0	0	0	0	8.56	3.99
F	4.28	0.50	4.28	0.64	8.56	2.81	0	0

group with a mixed mesophilic culture of bacteria commonly occurring on meat products, the second group with bacteria of the family *Enterobacteriaceae*.

The colour of meat products was measured with a reflectance spectrophotometer Minolta CM 5 and recorded by the computer program Spectra Magic. Measurement of the values of lightness (L^*) and coordinates for red (a^*) and yellow (b^*) colour in the CIELab colour system was performed over the full range of the visible spectrum from 360 to 740 nm.

The level of lipid oxidation was assessed with the use of the thiobarbituric number (TBARS) and expressed as the concentration of malondialdehyde in $mg \cdot kg^{-1}$.

Texture was measured with an Instron 5544 device on the basis of the force required to compress the sample (a cylinder of a height of 25 mm and diameter of 25 mm) to 20% of its original height. The values of force obtained were recorded by the program Series IX and processed in the statistical program STATISTICA 10.

The sensory panel evaluating the meat products was comprised of 33 evaluators who assessed a number of descriptors (salty, bitter, metallic, sweet and meaty taste) using a 10 cm scale. The limit values of intensity were 0 – little intensity and 10 – extremely intense. The centre of the scale was considered the optimal saltiness.

Results and Discussion

The total numbers of microorganisms in samples inoculated with a mixed culture of microorganisms commonly occurring on meat products (Plate I, Fig. 1) increased significantly more quickly than the numbers of microorganisms in samples inoculated with bacteria of the family *Enterobacteriaceae* (Plate I, Fig. 2). Samples with added lactates retarded the growth of bacteria in both cases. This effect was less marked in the case of the mixed culture of bacteria. This was probably the result of the presence of lactobacilli, which are more resistant to the antimicrobial activity of lactates. The inhibitory effect of lactates was, however, extremely pronounced in samples with *Enterobacteriaceae*.

The colour of meat products (the values of lightness L^* and the values for red a^* and yellow b^* colour) was not affected by the salting mixes used (Table 2). This is in agreement with the studies by Santos et al. (2014), Campagnol et al. (2011) and Cheng et al. (2007) who state that, although the colour of meat products depends on a number of factors (the concentration of haem pigments, the addition of nitrites and colourings, pH, lipid oxidation, etc.), the replacement of sodium chloride with potassium chloride and potassium lactate does not have a significant influence on colour.

The thiobarbituric number (Plate II, Fig. 3) increased in all samples throughout the storage period. Samples with potassium chloride and sodium chloride were more strongly oxidised throughout this period than samples with added lactates. This agrees with the work by Tan and Shelef (2002). The threshold concentration of the secondary oxidation product malondialdehyde (0.3 – 1 $mg \cdot kg^{-1}$) given by Fernandéz et al. (1997) was exceeded at the end of storage, which made the sensory detection of lipid oxidation probable.

Table 2. Dependence of lightness (*L**) and coordinates for red (*a**) and yellow (*b**) colour on the salting mixes used (PHP+ – Purasal HI Pure P Plus; PA – PuraQ® Arome NA4)

Samples	*L**	*a**	*b**
2 % NaCl	71.03	14.61	7.79
1.5 % NaCl + 0.64 % KCl	71.09	14.61	8.00
1 % NaCl + 1.28 % KCl	71.16	14.25	8.08
1 % NaCl + 2.81 % PHP+	71.47	14.18	7.81
1 % NaCl + 3.99 % PA	70.82	13.83	8.52
0.5 % NaCl + 0.64 % KCl + 2.81 % PHP+	70.69	14.07	7.82

PHP+ – Purasal HI Pure P Plus; PA – PuraQ® Arome NA4

An evident difference between the sample with added sodium chloride and the samples with lactates, which are as much as 15% softer, can be seen from the results of the measurement of texture (Plate II, Fig. 4). These differences were assessed as being statistically significant ($\alpha = 0.001$). In contrast, the force required to compress the samples with added potassium chloride was comparable to the sample with sodium chloride. Similar results have previously been published in the studies by Armenteros et al. (2012) and Puolanne and Ruusunen (2005).

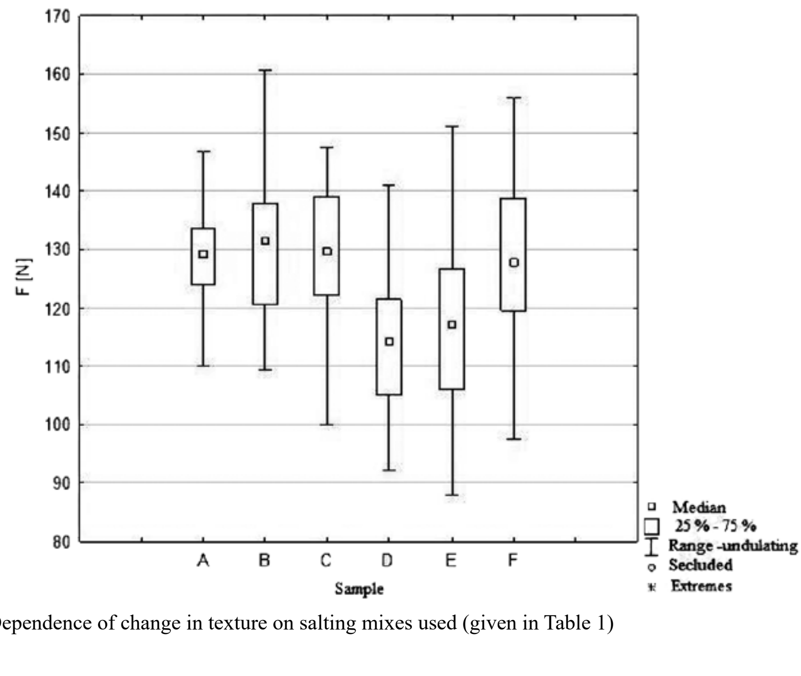

Fig. 4. Dependence of change in texture on salting mixes used (given in Table 1)

Sensory analysis (Plate II, Fig. 5) showed that the samples with potassium chloride display a slightly higher intensity of salty taste than the standard sample. The samples with added lactates, on the other hand, were considered slightly undersalted. The addition of substitutes for sodium chloride led to a slight increase in the intensity of undesirable tastes. The results agree with the studies by Kilcast (2007) and Lawless et al. (2003).

Conclusions

This study suggests that none of the substitutes for sodium chloride used had a pronounced negative effect on the quality of soft heat treated salami. The addition of lactates may, in contrast, have a positive effect on retarding lipid oxidation and extending the shelf life of meat products. Similarly, the taste of products with potassium salts was comparable with the standard product with sodium chloride. Therefore, potassium chloride and potassium lactate seem to be a suitable partial substitutes for sodium chloride.

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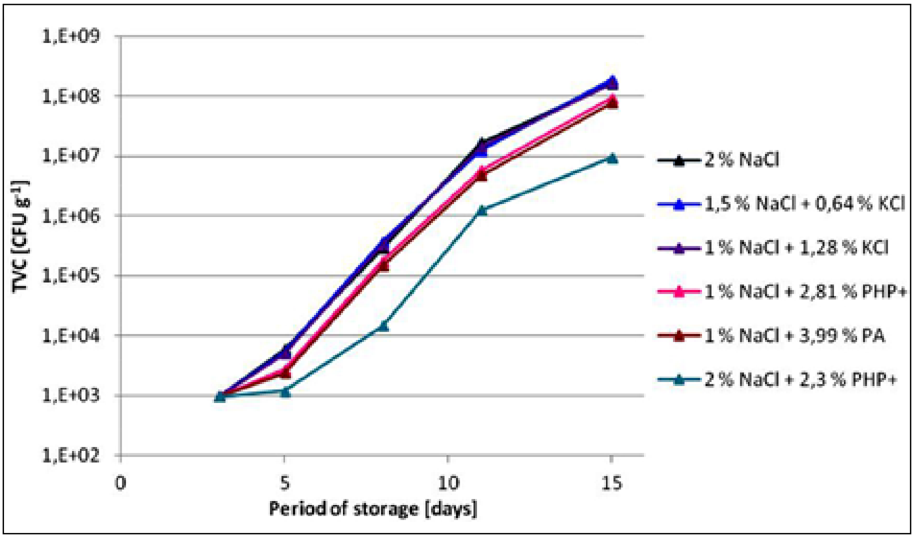

Fig. 1. Total number of microorganisms in soft salami inoculated with a mixed culture of bacteria (PHP+ – Purasal HI Pure P Plus; PA – PuraQ® Arome NA4)

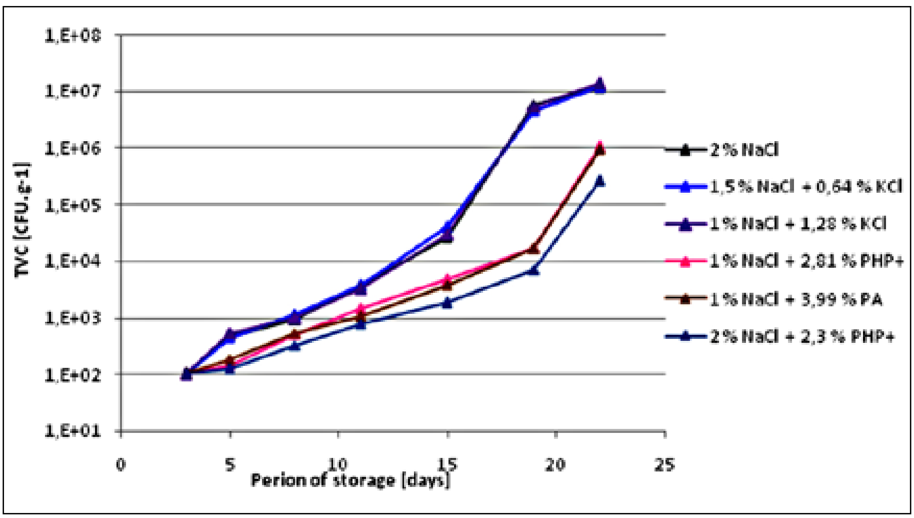

Fig. 2. Total number of microorganisms in soft salami inoculated with a mixed culture of bacteria of the family *Enterobacteriaceae* (PHP+ – Purasal HI Pure P Plus; PA – PuraQ® Arome NA4)

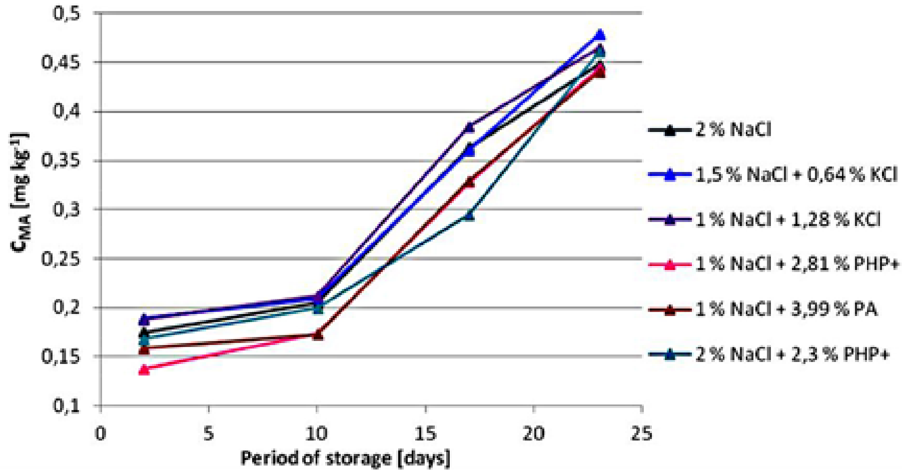

Fig. 3. Dependence of the thiobarbituric number on the salting mixes used and the period of storage (PHP+ – Purasal HI Pure P Plus; PA – PuraQ® Arome NA4)

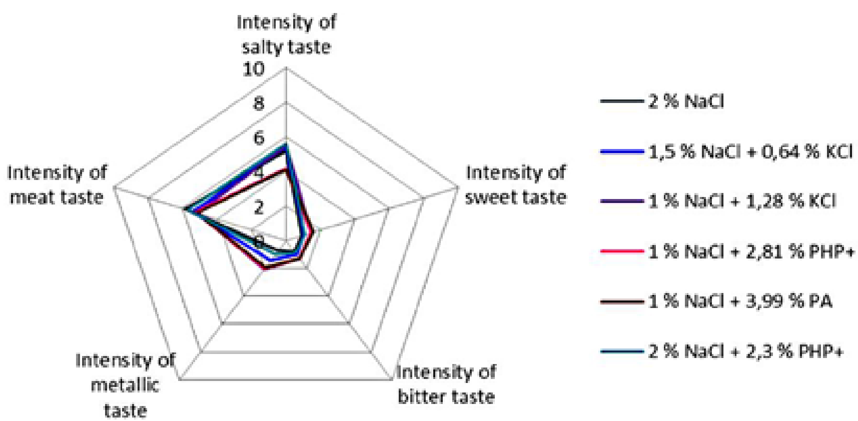

Fig. 5. The results of sensory evaluation of soft salami (PHP+ – Purasal HI Pure P Plus; PA – PuraQ® Arome NA4)