Reducing the sodium content of meat products

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Abstract— **In order to minimize the sodium content of heated meat products, meat extracts were treated with salt solutions in which sodium chloride was fully or partially replaced by other chloride salts or phosphates. The salt incubated samples were heated to form a gel. The gel strength of several heat gelled samples was measured. In addition the cooking loss was determined. The cooking loss of samples in which sodium chloride was fully replaced by calcium, magnesium or ammonium chloride decreased strongly, indicating that these salts perform better than sodium chloride. Interestingly magnesium and calcium chloride caused a strong decrease in pH during incubation with the meat extract and even more during heating. This pH lowering has to be compensated to minimize the cooking loss. Unfortunately mixtures of ammonium, calcium and sodium chloride had more cooking loss than sodium chloride or the other salts on there own. The lowest amount of cooking loss together with the strongest gel formation was obtained by a mixture of sodium chloride with addition of diphosphate. Unfortunately, magnesium and calcium chlorides can not be used in combination with phosphate due to strong complexation.**

Keywords—**sodium, reduction, gelation.**

I. INTRODUCTION

The role of salt (normally NaCl) in meat products is related to taste, microbiological safety and texture. In order to reduce especially the sodium content in meat products, it is of great importance to understand the role of salt. The role of salt strongly depends on the type of meat product. In products where water or fat binding is essential (minced meat products, cooked sausages or hams), the major role of salt is the solubilisation of myofibrillar proteins. This solubilisation is required because the myofibrillar proteins are responsible for the largest part of gelling and emulsifying capacity in meat products. It seems that especially the chloride is responsible for the expansion of the myofibrils by penetrating into the myofibril and causing a repulsion between the negative charges (1, 2). Sodium seems to be located more on the outside of the fibrils (3). Simply minimization of the salt concentration will lower the protein solubility and therefore reduce the gel strength and water holding capacity of the meat product. To lower the amount of sodium chloride, phosphates can be used. Phosphates and sodium chloride salts seem to work synergistically which enables a reduction of the amount of sodium chloride.

In dry fermented meat products (e.g. Coburger, Salami), the role of the salt is not related to the solubilisation of the myofibrillar protein, but instead it is required to prevent microbial spoilage. The addition of salt to these meat products minimizes the amount of free water in the product which prevents or slows down the growth of micro-organisms.

Apart from the role of salt in solubilisation of the myofibrillar proteins and in preventing microbial spoilage, taste is another essential factor. Besides the direct effect of salt perception on the tongue, salt also has an additional effect in enhancing other flavors. The salty taste we experience when we add sodium chloride to a food product comes from the sodium ion and not the chloride ion. This effect is caused by receptors on the tongue that can detect sodium ions and not chloride ions. The reason that salt enhances other flavors is more difficult to understand, but seems to be mostly related to a reduction of the taste of bitter substances and enhancement of the taste of sweetened substances (4).

This research is set up to lower the concentration of sodium in meat products with a focus on meat products that from a gel upon heating. The effect of heating of meat extracts was investigated with varying types and mixtures of salt.

II. MATERIALS AND METHODS

A Preparation of a meat extract

Pork meat (topside muscle) was grinded using a 3 mm Wolf performed at 0ºC with defrosted meat at 0 ºC and a pre-cooled Wolf of 0 ºC. The grinded meat was put on ice before extra grinding using a Grindomix GM200 (3 times 10 sec at 7000 rpm). After grinding the meat was put on ice.

B Gelation of meat extracts

Meat extracts were prepared at ratio meat/water of 10/4, 1/1 and 1/2. All steps were performed at 0ºC with pre-cooled salt solutions. Various concentrations of different chloride and phosphate salts were tested. All samples were stirred (300 rpm) for 2 hours at 0 ºC. The samples were put inside 50 ml centrifugation tubes. The tubes were centrifuged (10 min 4000 g) to remove air bubbles. The centrifuged samples were heated for 30 min at 80 ºC. After cooling overnight (4 ºC) the samples were cut in to coupes and the gel strength was measured.

C Gel strength measurement

Method 1 Uniaxial compression

Large deformation properties of the heated protein gels (sausages) were determined using a Texture Analyser (TA Instruments) with a stainless steel plate (diameter 30 mm) which is large than the sample. The probe was moved with a speed of 1 mm/s into the gel until a penetration of 90% was reached. From the measured force-distance (F-d) curve, the maximum force F_{max} (N) at fracture, the F-d gradient (N/mm) and area beneath the curve were determined.

Method 2 Stress relaxation

Stress relaxation gives information on visco-elastic properties related to energy storage and dissipation. Therefore the compression of sample is done similar to the uniaxial compression test by only to a certain deformation before fracture occurs. Subsequently. relaxation of force as a function of time is measured. In this research the samples was deformation to 40%.

D Cooking loss

The Cooking loss during heating was determined by simply decanting the tubes and weighing the supernatant. The cooking loss was determined as the amount of supernatant divided by the weight of the total sample

III RESULTS

Effect of magnesium and calcium chloride on pH

Addition of calcium or magnesium chloride induces a decrease in pH of the meat extracts (Fig 1). The starting pH of the meat was 5.6. The ratio in figure 1 corresponds to the ratio meat/water. Fig. 2 shows for 0.8M $CaCl_2$ that the decrease in pH is even more pronounced after heating of the extract. This is for all dilutions tested. Dilutions are calculated as the weight of the water used divide by weight meat the used.

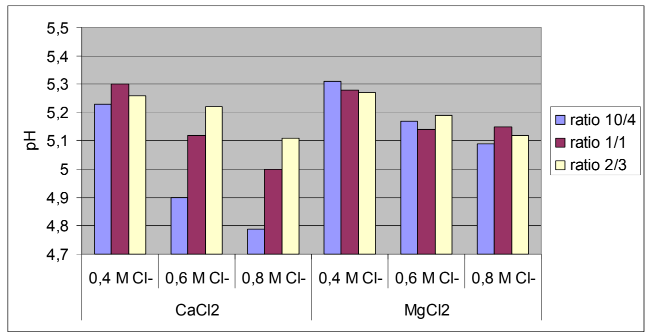

Fig. 1 pH of meat extract after incubation with various amounts of calcium and magnesium chloride

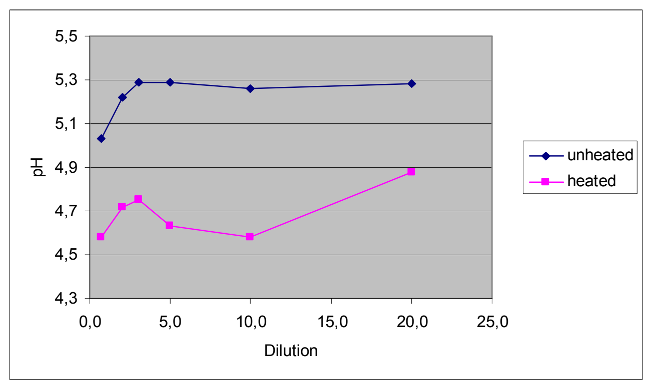

Fig. 2 Comparison of the obtained pH's before and after heating meat extracts prepared at 0.8M calcium chloride

Cooking loss

The cooking loss of heated meat extracts prepared with various concentrations of calcium chloride was very dependent on the pH and on the calcium concentration (Fig. 3). The cooking loss decreased at higher pH and higher calcium chloride concentration. This demonstrates that the pH of meat with added calcium chloride has to be set at a higher pH. When meat extracts were prepared with different salt formulations at a ratio meat/water of 10/4, the cooking loss was determined after heating (Fig. 4). It shows that sodium chloride has a high amount of cooking loss, which can be eliminated by addition of 0.25% tetra potassium diphosphate (TKPI). The cooking loss of samples prepared with calcium chloride (compensated for pH drop) and with ammonium chloride was very low. Unfortunately the all mixes of sodium, ammonium and calcium chloride showed cooking loss higher than the individual salts.

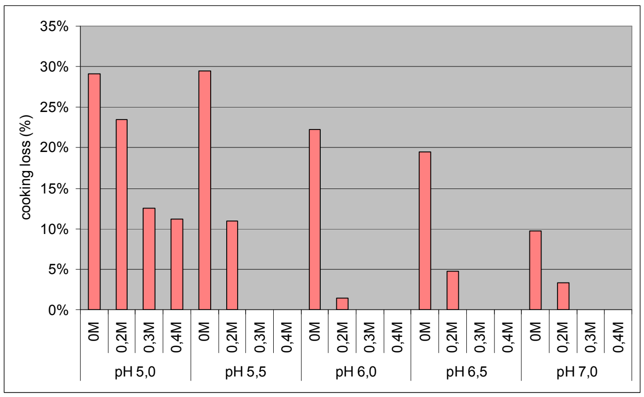

Fig 3. Percentages cooking loss liquid after heating as a function of pH and $CaCl_2$ concentration

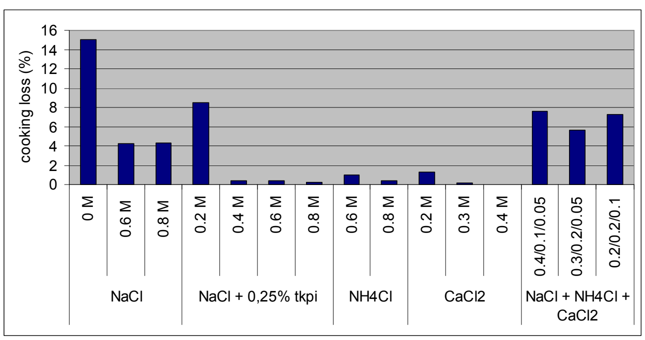

Fig 4. Percentages cooking loss liquid after heating as a function of different salts

Gel strength measurement

Uniaxial compression

The fraction force was measured of all samples (fig 5) of which the cooking loss was determined (fig 4). The fraction force of samples prepared by the addition of tetra potassium diphosphate, were clearly the strongest. All others seem to be in the same range but is has to be mentioned that some of these samples (NaCl and the mix of NaCl, HN_4Cl and $CaCl_2$) have high cooking loss, so they have a higher protein percentage in the gel.

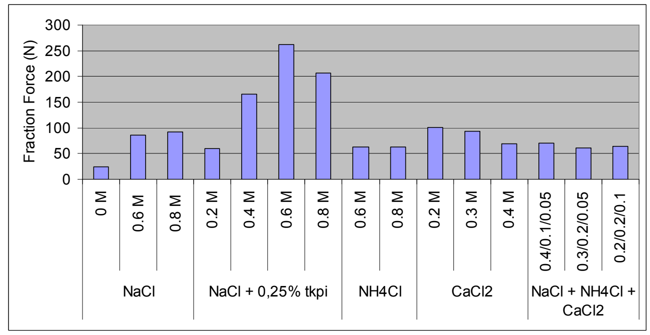

Fig 5. Gel strength of samples after heating using fraction force measurement as a function of different salt concentrations

Stress relaxation measurement

The F_{max} was measured of all samples (fig 6) with a deformation of 40%. Here is seems that the strength is almost similar with the exception of the sample without salt. A comparison between fig 5 and 6 shows that the gels that are stronger in fig 5 in fact brake at a later stage thereby showing a higher fraction force.

The time that is used to reach half of the starting gel strength is the $T_{1/2}$ (Fig 7). If a gel is very elastic, the $T_{1/2}$ is large. The samples of 0.4, 0.6 and 0.8M NaCl + 0.25% TKPI show the highest elasticity. Apart from the low elasticity of the sample without salt and the sample of 0.2M NaCl + 0.25% TKPI, the mixed salt samples showed also a low elasticity.

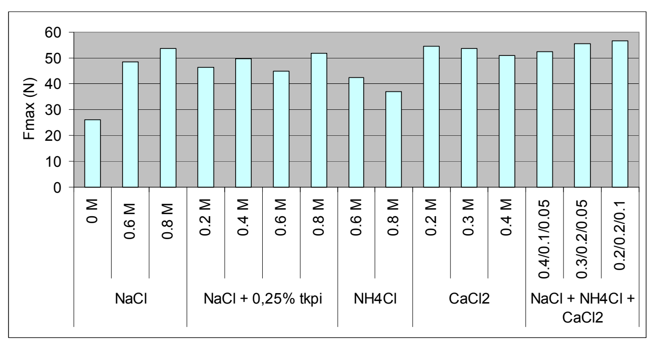

Fig 6. Gel strength of samples after heating using the stress relaxation experiment as a function of different salt concentrations

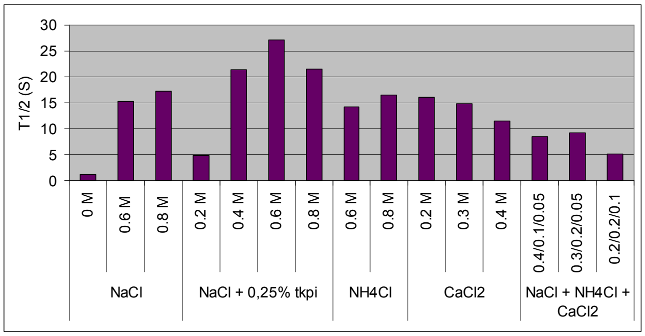

Fig 7 $T_{1/2}$ of samples after heating using the stress relaxation experiment as a function of different salt concentrations

IV CONCLUSIONS

The replacement of sodium chloride by other sodium salts seems to have a positive effect on the reduction of the cooking loss of heat gelled meat products, except when a mixture of sodium, ammonium and calcium chloride is used. The reduction of the sodium chloride content and cooking loss can also be easily achieve by addition of 0.25% tetra potassium diphosphate. Calcium and magnesium chloride seem to lower the pH of the meat extracts. This could be related to the precipitation of calcium and magnesium phosphate form naturally occurring phosphates in meat. This is in line with the fact that the pH drops even further after heating, as the solubility of these phosphate salts is lower at high temperature.

Because of the cooking loss, heat gelled meat products (without additional ingredients) containing only sodium chloride are not suitable even not at high concentrations of sodium chloride. Using full replacement of sodium chloride by ammonium or calcium chloride can lower the cooking loss; however these samples will definitely have taste issues. The simplest way of reducing the sodium content of heat gelled meat products is by addition of traditionally used diphosphate. This lowers the cooking loss and strengthens the gel through a synergistically solubilisation effect of chloride and phosphate on myofibrillair proteins. Despite the fact that calcium chloride performs better than sodium chloride it can not be used in combination with phosphate as a result of precipitation of calcium phosphate.

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