REDUCING THE SODIUM LEVEL OF MEAT PRODUCTS SHOULDN'T BE DIFFICULT

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***Abstract*—There is a clear understanding that the dietary intake of sodium is too high and related to this, the sodium content in meat products has to be lowered. According to the amount of effort, which is put into this subject, shows that it seems to be difficult to decrease the sodium content without changing the sensory and quality aspects of the meat products. The role of salt (normally NaCl) in meat products is related to taste, microbiological safety and texture. A high salt content of especially heat treated meat products shows that a critical amount of sodium chloride is necessary to solubilise myofibrillar proteins. This is necessary to obtain a good structure after heating. It is therefore surprising that sodium chloride is not a very good salt in respect to solubilisation of myofibrillar proteins or water binding. Some other chloride salts (Calcium, Magnesium, Lithium and Ammonium) seem to perform much better that sodium chloride or potassium chloride. In addition iodide salts tend to work much better than chloride salts in water binding and solubilisation of myofibrillar protein. Combined with the fact that several organic sodium salts (acetate, lactate, formate) do not have any effect on myofibrillar protein solubilisation and a small effect on water binding, does show that the role of sodium in respect to texturisation of heat treated meat products is very limited. Therefore texture should not be a problem when replacing sodium. It seems that the greatest barrier for sodium replacement is in fact taste. Many of the salt alternatives have a severe taste problem and this problem has to be overcome to produce sodium light meat products.**

Index terms: Myofibrillar protein, replacement, sodium chloride, solubilisation

1: INTRODUCTION

In order to lower the dietary amount of sodium in meat products, experiments were carried out to investigate the role of different types of salts on the extractability of myofibrillar protein and on water binding. The role of salt strongly depends on the type of meat product. In products were 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; 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.

II: MATERIALS AND METHODS

Materials used are pig meat (topside muscle), several salts (Sigma).

Preparation of soluble protein fraction and insoluble protein fraction was carried out in accordance with scheme in fig. 1.

Stirring or grinding was carried out with a grinder mixer, overhead or magnetic stirrer.

Methods to analyse the protein content are Coomassie (Bradford) Protein Assay Kit (obtained from Pierce), SDS-PAGE was performed using a BioRad Mini Protean II system. The water holding capacity was defined as the weight of the pellet divided by the total weight of the extract after centrifugation.

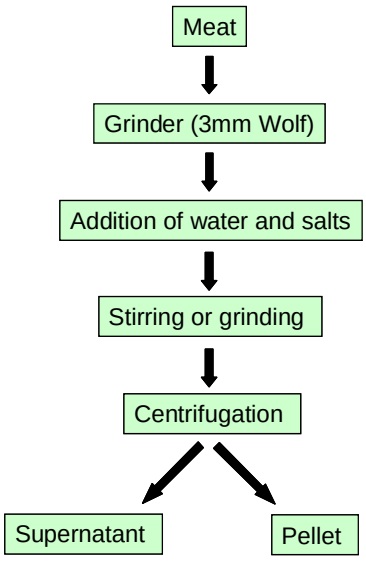

Fig. 1, Scheme of preparation meat

III: RESULTS AND DISCUSSION

Effect of replacement of sodium

A dilution of a 1 to 1 ratio meat/water was necessary to obtain a liquid phase after centrifugation which could be used for the analysis of solubilised protein. This ratio was also used to test the efficacy of chloride or iodide salts on solubilisation of proteins and on water holding capacity. Figure 1 shows the water holding capacity of the meat extracts. NaCl and KCl behave similar with a maximum water holding capacity of around 80% at 1M salt. The iodide salts show a completely different pattern, already at 0.4M NaI or KI, the water holding capacity is 100%, indicating that the water is strongly bound by the pellet.

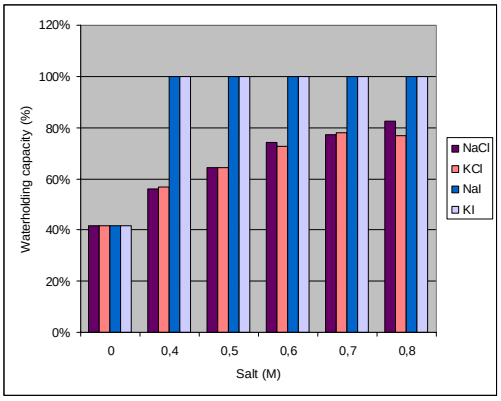

Fig.1 Water holding capacity of meat extracts at varying concentrations of NaCl, KCl, NaI and KI after centrifugation at 25000 g

Figure 2 shows the solubilised protein after extraction with different concentrations of NaCl and KCl. It is clear that the concentration of solubilised protein is higher with increasing salt concentrations. The difference between solubilised protein at 0 M and 1M NaCl is limited indicating that the amount of myofibrillar protein solubilised is not complete. Without any salt 30 mg/ml of protein is solubilised, with salt, the level is less than 60 mg/ml. This suggests that the amount of extracted myofibrillar protein is the same as the amount of extracted sarcoplasmatic protein. The amount of myofibrillar protein in meat is however much larger than the amount of sarcoplasmatic protein.

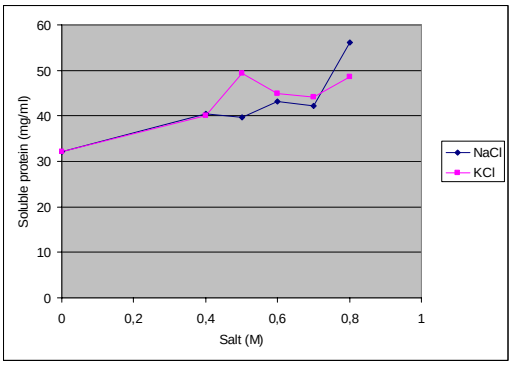

Fig 2: Solubilised proteins of meat extracts at varying concentrations of NaCl and KCl after centrifugation at 25000 g

Figure 3 shows the protein concentration of the solubilised protein in the presence of KI and NaI. Note that the samples are diluted compared to figure 3.6. If one compensates for the dilution it becomes clear that more protein is solubilised in the presence of the iodide ions. Both iodine salts show an optimum protein extraction at 0.4M and a graduate drop in solubility at higher salt concentrations.

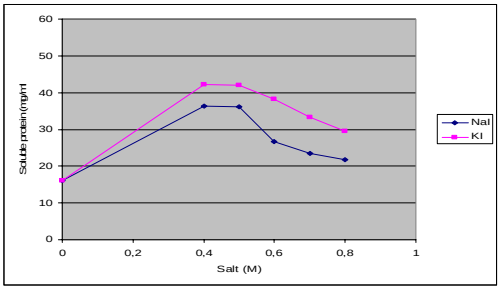

Fig 3: Solubilised proteins of meat extracts at varying concentrations of NaI and KI after centrifugation at 25000 g

Addition of tripolyphosphate results in a strongly enhanced water holding capacity (Figure 4). At 0.8 M NaCl, the water holding capacity of the sample with 0.014 M sodium tripolyphosphate is more than 80% and without polyphosphate it is just above 40%. Two important items have to be discussed here:

- The tripolyphosphate added contains 5 sodium ions per molecule, addition of polyphosphate will also enhance the sodium content. (This is shown in figure 5)
- The addition of tripolyphosphate will also lead to a chance in pH (This is also shown in figure 5)

Figure 5 shows that the increase of sodium through addition sodium tripolyphosphate is rather limited. The figure shows that addition of sodium tripolyphosphate has a strong increase in pH.

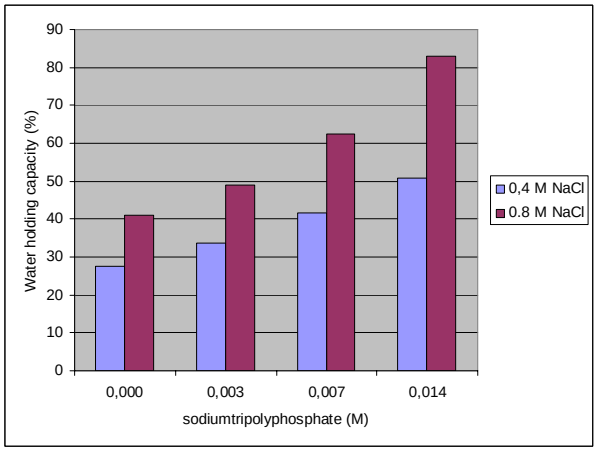

Figure 4 Water holding capacity of surimi extracts at varying concentrations of polyphosphate after centrifugation at 25000 g

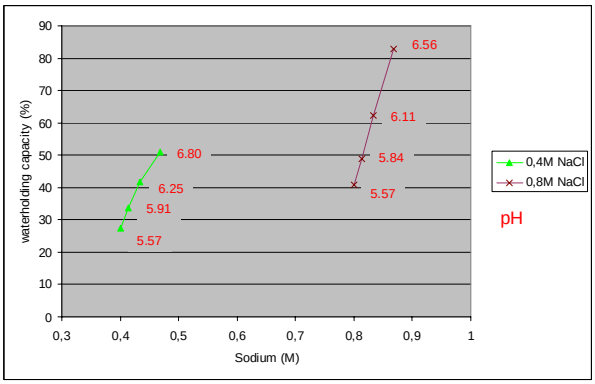

Figure 5 Water holding capacity of surimi extracts at varying concentrations of polyphosphate after centrifugation at 25000 g, corrected for sodium addition

Comparison between chloride salts

The amount of extracted protein using different concentrations NaCl, KCl, LiCl, NH_4Cl, $MgCl_2$ and $CaCl_2$ and KI are shown in figure 6. In this graph the amount of extracted protein per gram of extracted meat is shown. The x-axis shows the concentration of the chloride ion, this means that for $MgCl_2$ and $CaCl_2$ the molarity is half that of the other salts. Clearly $MgCl_2$ and $CaCl_2$ show the highest protein extractability. Already at 0.4 M chloride both salts can solubilize around 140 mg of protein per gram of meat. In order to solubilise the same amount of protein, 1 M NaCl is necessary. LiCl and NH_4Cl seem to perform somewhat better than NaCl and KCl.

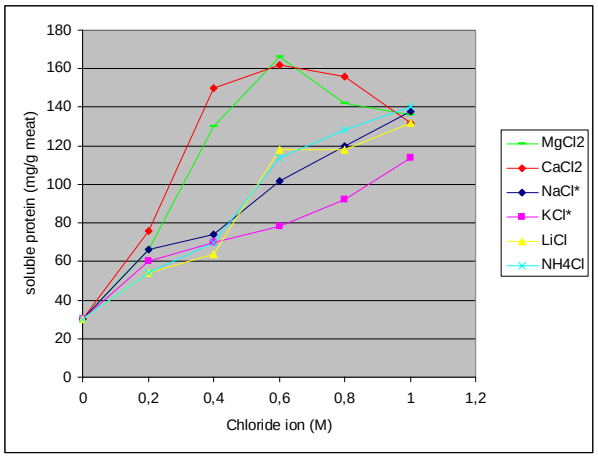

Figure 6 Solubilised protein of meat extracts at varying concentrations of salt (concentrations NaCl, KCl, LiCl, NH_4Cl, $MgCl_2$ and $CaCl_2$) after centrifugation at 4200 g

The electrophoresis of the samples with NaCl and KCl showed a common picture with very limited solubilisation of myofibrillar protein at 0.6M and some better solubilisation at 0.8 M. The electrophoresis of the samples with LiCl and NH_4Cl showed a difference compared to NaCl and KCl. Already at 0.6 M there is good solubilisation of myofibrillar proteins (myosin heavy chain and actin) which seems to be similar at 0.8 and 1.0M. The NH_4Cl showed a strange feature as the myosin heavy chains seems to appear as a very large aggregate at the top of the gel. There is no evidence that this is indeed myosin, but the pattern of all the proteins seems to be the same, expect for myosin. The electrophoresis of the samples with $MgCl_2$ and $CaCl_2$ showed a very strange outcome. Despite the high protein content, the gels, especially with $CaCl_2$ show a low amount of protein. Further analysis of the electrophoresis samples showed that during the incubation of the samples with denaturation buffer a clear gel was obtained at the bottom of the tube. It is not clear what caused the gelation, but clearly Ca^{2+} and Mg^{2+} were responsible for the gelation. When the pellets were washed with normal denaturation buffer which causes the concentration of Ca^{2+} and Mg^{2+} to become much lower, the gels dissolved. These dissolved gels were analysed and it became clear that the gels contained a large amount of myofibrillar protein, therefore $MgCl_2$ and $CaCl_2$ are very good capable of solubilising myofibrillar proteins from meat.

IV CONCLUSION

Solubility of myofibrillar proteins

- Cl^- has a strong effect on myofibrillar protein solubility,
- I- performs however better in solubilise myofibrillar protein than Cl^-
- Cl^- salts work in the order of $CaCl_2$, $MgCl_2$> LiCl, NH_4Cl > NaCl, KCl
- Polyphosphates strongly enhance myofibrillar protein solubility at at 0.8M NaCl

Waterbinding

- NaCl and KCl strongly increase the water binding of the meat protein extracts
- NaI and KI increase the water binding of the meat protein extract better than the corresponding chlorides
- Polyphosphates strongly increase water binding
- The water holding capacity of the chloride salts seems to be in the same order as the extraction of myofibrillar protein: $CaCl_2$, $MgCl_2$> LiCl, NH_4Cl > NaCl, KCl. This however depends on the method used. When a centrifugation step was performed at extreme high speeds (50000g), the MgCl2, CaCl2 and LiCl pellets seemed smaller compared to NH_4Cl, NaCl and KCl pellets which might be related that the highly swollen myofibrils partly collapse at this high centrifugation forces.

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