PROPERTIES OF FREEZE-TEXTURED WET CONCENTRATE OF MYOFIBRILLAR PROTEINS AS AFFECTED BY SODIUM CHLORIDE ADDITION

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SUMMARY : The purpose of this work was to investigate the effect of sodium chloride addition (0 - 2%) on texture and structure of freeze-textured wet concentrate of myofibrillar proteins (WCMP) obtained from mechanically deboned pork by washing and screening. Results showed that salt at the level usually accepted in meat products strongly affected structure and deteriorated rheological parameters of freeze-textured WCMP. These changes were connected with increased amount of unfreezable water (determined using DSC) and decreased heating loss of WCMP. Decreased activation energy of ice melting in WCMP in the presence of salt was determined from the DSC thermograms. This suggests modified structure of ice crystals due to incorporation of Cl^- ions into the ice.

INTRODUCTION : In recent years some attempts have been made at obtaining surimi-like material (which can be also called a wet concentrate of myofibrillar proteins - WCMP) from mechanically deboned meat - MDM (Knight et al., 1991). Our previous studies showed that WCMP obtained from pork MDM has poor gelling properties. However, rheological parameters of this WCMP after heat treatment can be improved by applying freeze texturization process (Tyburcy and Mroczek, 1991). Composition of the frozen material is one of the crucial factors influencing properties of a freeze-textured product. Sodium chloride is used as an ingredient imparting desired salty taste into a freeze-textured product (Lillford, 1985), but its impact on other aspects of the freeze texturization process is not emphasized.

The objective of this study was to investigate the effect of sodium chloride on structure and texture of a wet concentrate of myofibrillar proteins subjected to freeze texturization.

MATERIALS AND METHODS : Mechanically deboned pork from backbones purchased from a local meat processing plant was bagged, frozen and stored no longer than 3 months before processing. The wet concentrate of myofibrillar proteins (WCMP) was obtained by two-step washing treatments (with distilled water and a solution of 0.2% NaCl) and screening. WCMP containing on the average 88.0% water, 1.0% fat and 10.7% crude protein was thoroughly mixed with 1 and 2% NaCl addition.

DSC measurements of WCMP were performed using a DuPoint 910 DSC + 1090B TA + 1091 DM instrument equipped with a cooling head containing acetone-solid CO_2 mixture. Each sample was scanned from temp. of 15°C to the temp. of -30°C and back to temp. of 15°C at cooling and heating rates of 2°C/min. Amount of unfreezable water was calculated as the difference between total water content (determined by drying at the temp. of 105°C) and the amount of water detected by the melting peaks. Temperature dependence of kinetic constant for melting and activation energy were evaluated according to the method described by Koga and Yoshizumi (1979).

For freeze texturization metal tubes (27mm diam x 110mm l) were filled with WCMP and air frozen at the temp. -20°C. After removing from tubes frozen WCMP was deep fried in rapeseed oil (10 min, 130°C). The heating loss was determined after cooling to room temperature. The profile texture analysis was performed using an Instron Universal Testing Machine 1140. Cylindrical samples (12 mm diam x 15 mm l) cut from the center of fried cylinders were compressed twice to 50% of their original height at crosshead speed of 50 mm/min. Springiness, hardness and cohesiveness were evaluated from force-deformation curves according to the method described by Chang-Lee et al. (1990).

For histological preparations slices of fried samples (0.5 - 0.6 cm thick) were fixed in formalin and embedded in paraffin. After dewaxing sections (5 μm thick) were stained with haematoxylin and with eosin (Burck, 1975).

For statistical calculations analysis of variance, Tukey test and regression analysis were used.

RESULTS AND DISCUSSION : Increasing level of salt increased the amount of unfreezable water (tab. 1). The amount of unfrozen water for WCMP without salt (0.58 g H_2O/g solids) agrees well with results of Wang and Kolbe (1991) who obtained 0.48 g H_2O/g solids for fish surimi. The influence of NaCl on increasing amount of water bound to isolated myofibrills was also reported by Lioutas et al. (1988). Based on sorption isotherms these authors showed that upon addition of 4% salt the total amount of bound water increased from 0.22 to 0.27g of H_2O/g of solids. These data are markedly lower than values obtained from our calorimetric studies.

Significantly linear correlation between lnk and 1/T (where: k - kinetic constant for ice melting, T - temperature) was found for all samples. This confirmed earlier assumption that process of ice melting was of the first order. The activation energy of melting process for the sample without salt was significantly higher than in the case of the samples with salt (tab. 1). These results can be explained by the selective incorporation of ions (mainly Cl anions) into the ice. This phenomenon was demonstrated during freezing of dilute salt solutions (Taborsky, 1971).

The differences between freeze-textured samples with and without NaCl are also clearly visible in the micrographs. Parallel proteinaceous fibers are thicker and empty voids remained after ice crystals melting are smaller in the micrograph of the sample containing 2% NaCl (Fig. 1B) if compared with the sample without salt (Fig. 1A). Differences between structure of freeze-textured samples seem to be closely connected with different amount of unfreezable water. The limited amount of water available for ice crystals formation diminishes their size. On the other hand water retained within proteinaceous fibers causes their swelling. Offer et al. (1979) also observed swelling of separated myofibrills in NaCl solutions. In the opinion of these authors most of the water in meat is held within narrow channels between the filaments. All changes in water holding are due to changes in the volume of myofibrills.

The increasing addition of NaCl significantly decreased heating loss of fried WCMP (tab. 2). All rheological parameters (hardness, cohesiveness and springiness) were significantly lower for the samples with NaCl addition (tab. 2). Salt at the level of 1% caused sharp drop of the parameters if compared with the sample without NaCl. However, increase in NaCl addition to 2% did not cause further significant changes. Decreased heating loss means increased retention of water within proteinaceous material which results in softening of the freeze-textured product.

Disappearance of the positive effect of freeze texturization upon salt addition have to be considered as disadvantage. Sharp decrease in the rheological parameters already at the amount of 1% NaCl implies that salt can not be added at the level usually accepted in meat products (2-3%).

CONCLUSIONS :

1. Sodium chloride at the level usually accepted in meat products strongly modifies structure and deteriorates rheological properties of freeze-textured wet concentrates of myofibrillar proteins (WCMP).
2. Changes in structure and texture are connected with the changes in unfreezable (bound) water content of WCMP.
3. The presence of salt changes the kinetics of ice melting in WCMP.

REFERENCES

BURCK H.C., (1975). "Histologische Technik". GTV, Stuttgart.

CHANG-LEE M.V., LAMPILA L.E., CRAWFORD D.L., (1990). Yield and composition of surimi from Pacific whiting (Merluccius productus) and the effect of various protein additives on gel strength. J. Food Sci. 69, 83-86.

KNIGHT H.K., CHOO B.K., WOOD J.M. (1991). Applying the surimi process to red meats and poultry. Food Technol. Int. Europe, 147-149.

KOGA K., YOSHIZUMI H., (1979). Differential scanning calorimetry (DSC) studies on the freezing processes of water ethanol mixtures and distilled spirits. J. Food Sci., 44, 1386-1389.

LIOUTAS T.S., BAIANU I.C., BECHTEL P.J., STEINBERG H.P.,(1988). Oxygen-17 and sodium -23 nuclear magnetic resonance studies of myofibrillar protein interactions with water and electrolytes in relation to sorption isotherms. J. Agric. Food Chem., 36, 437-444.

LILLFORD P.J., (1985). Freeze-texturing and other aspects of the effects of freezing on food quality. In "Properties of water in foods" (D. Simatos, J.L. Multon, eds). Martinus Nijhof Publ., Dodrecht, The Netherlands, 543-553pp.

OFFER G., RESTALL P., TRINICK J., (1984). Water-holding in meat. In "Recent advances in the chemistry of meat" (A.J. Bailey, ed). Special Publication no 47, Royal Soc. Chem., 71-86pp.

TABORSKY G., (1979). Protein alternations at low temperatures: an overview. In "Proteins at low temperature (O. Fennema, ed). ACS Sym. Ser. 180. Am. Chem. Soc., Washington, 1-25pp.

TYBURCY A., MROCZEK J., (1991). Wpływ sposobu frakcjonowania mięsa odzyskanego mechanicznie na właściwości uzyskanego półproduktu. In "Procesy technologiczne a wartość odżywcza żywności", Proc. 22nd Scientific Session of Polish Academy of Sciences, Olsztyn, 123p.

WANG D.Q., KOLBE E., (1991). Thermal properties of surimi analyzed using DSC. J. Food Sci., 56, 302-308.

Tables :

Table 1. Effect of salt addition on amount of unfreezable water and activation energy of melting in WCMP (means from three replicates, means in the same column with different superscripts are significantly different, α=0.05).

Salt level (%)	Amount of unfreezable water (g/g solids)	Amount of unfreezable water (% of total water content)	Activation energy (kJ/mol)
0	0.58^a	7.9^a	329^a
1	0.93^b	12.7^b	198^b
2	1.52^c	22.8^c	186^b

Table 2. Effect of salt on heating loss and rheological parameters of freeze textured WCMP (means from four replicates, a-c means in the same column with different superscripts are significantly different α=0.05).

Salt level (%)	Heating loss (%)	Hardness (N)	Springiness	Cohesiveness
0	53.2^a	12.1^a	0.85^a	0.57^a
1	41.8^b	1.9^b	0.65^b	0.40^b
2	23.8^c	1.1^c	0.59^b	0.38^b

Figure 1. Effect of salt on structure of freeze-textured WCMP (A - sample without salt, B - sample with 2% salt).