Protein-protein interactions in myofibrillar protein gelation

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Introduction

It is clear that the final network formed after processing governs meat product texture. Muscle proteins play a key role in end-product quality as these proteins have a broad range of functionalities: emulsification, water holding, texture and heat induced gelation. Especially heat induced gelation is a property that is related to protein-protein interactions. When the balance between the various protein interactions is generally positive, then a network with gel-strength can be formed. These interactions are:

- Hydrophobic interactions
- Hydrophilic interactions
- H-bonds
- Covalent bonds
- van der Waals forces

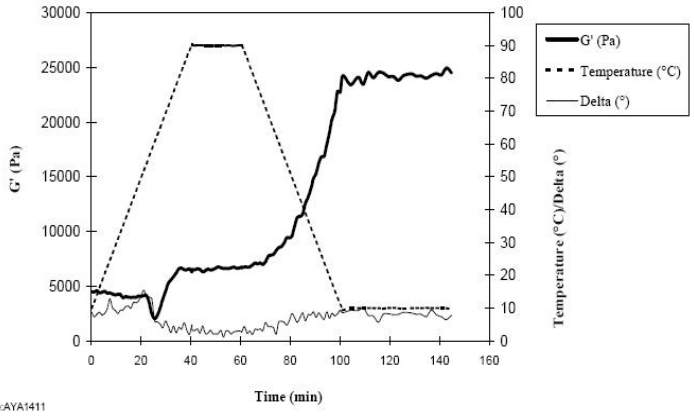
The importance of hydrophobic interactions during heat-induced gel formation of muscle protein has been pointed out by Xiong & Brekke[1]. The presence of H-bonds has been shown by immersing gels of muscle protein into concentrated urea. The chaotropic effect of urea dissolves the heat induced protein network, hence indicating a network stabilization by non-covalent interactions[2]. For so-called single phase protein gels our understanding has increased considerably over the years. However, for systems where two different proteins are mixed together it is less clear how these affect the pattern of interaction. Therefore we set out to investigate the effects on gelation of blending/mixing the myofibrillair fraction of chicken meat with: 1) wheat gluten and 2) maize gluten. Both proteins are of cereal origin, but are quite different in protein composition, structure and functionality. Wheat gluten is of high molecular weight and conveys visco-elastic properties in protein-starch systems like dough. Maize gluten has lower molecular weight, is poorly soluble and does not convey visco-elastic properties in protein-starch systems. In order to better understand the factors affecting protein-protein interaction, the effect of these gluten proteins on heat-induced gelation of muscle proteins were investigated.

Materials and Methods

Myofibrillar proteins were separated from chicken meat. For the purification procedure the lean chicken meat was minced in a kitchen blender. The minced meat was washed with 0.6% NaCl aqueous solution buffered at pH 7 with phosphate buffer. The water-soluble sarcoplasmatic proteins were separated from the myofibrillair proteins by centrifugation in a Jouan CR 312 lab-centrifuge. The residue obtained is a meat paste that mainly consists of myofibrillar proteins. The purified chicken paste is used as reference for studying the gelation properties of myofibrillar protein. Wheat gluten and maize gluten were obtained from industry (Cerestar-Cargill). Protein content of the wheat gluten was 78%, protein content of the maize gluten was 73%. The protein content of the myofibrillar protein paste was adjusted to 10%, containing 2% NaCl as in most applications salt is added to the meat product. Preparation of protein blends was done as follows: based on protein 10% protein containing blends were prepared in various ratios: 10% myofibrillar protein (mf), 8% mf + 2% gluten. 6% mf + 4% gluten, 4% mf + 6% gluten, 2% mf + 8% gluten and 10% gluten. All preparations contain 2% NaCl, pH 7. This way a series of blends was prepared and mixed. The material was then transferred to the cup and bob geometry of the Bohlin rheometer. Thermal treatment of protein was performed in the rheometer by: heating the sample from 10 º C to 90º C at 2º C/minute rate, 90º C was maintained for 20 minutes followed by, a cooling step at 2º C/minute back to 10 º C. The storage modulus (G') and the phase angle (delta) were followed during thermal treatment using a target strain of 0.2 mm at a frequency of 1Hz. *G'* was determined, after described thermal treatment at 10°C. Then an amplitude sweep was performed to obtain information on the protein network's resistance to increased deformations. Sealing the measuring cell prevented water evaporation during experimentation.

Results and Discussion

In figure 1 the result is plotted for the myofibrillar proteins separated from lean chicken meat. The heat induced gelation pattern shows the phenomena during protein network formation. During the first stages the meat paste has a G' of about 4500 Pa. Between 20ºC - 40ºC there is a significant decrease in G', suggesting heat induced denaturation of the myofibrillar proteins. As temperature increases, heat induced fortification is noticed, pointing at a heat induced increase of hydrophobic interactions. After the heating process, cooling starts after 20 minutes, and then the finalization of the network formation occurs.



During the cooling step it has become clear from this experiment that G' increases from 7000 Pa towards 25000 Pa, a 3.5 times increase of the stiffness. During cooling the strength and number of H-bonds are thought to increase, resulting in a stiffer network. In order to investigate the effect of gluten proteins on network formation, the same type of experiments were done. Figure 2 shows the results for the final gel stiffness of the protein-protein blends.

Figure 1 *The heat induced gelation pattern of purified myfobrillar protein from chicken meat. G' signifies gel stiffness (bold line), dotted line is the temperature profile / cooking profile, Delta signifies the viscous to elastic ratio of the gel network.*

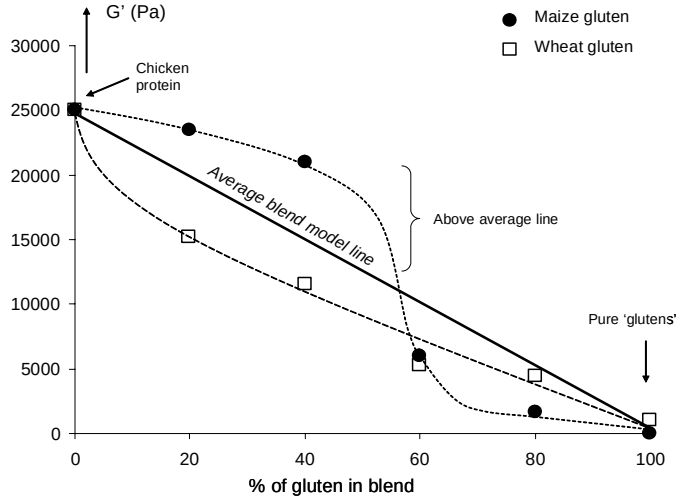


Figure 2 depicts how adding gluten protein affects the gel stiffness after heat induced gelation. The filled dots show the effect of maize gluten blended into the myofibrillar protein. The open squares show the effect of wheat gluten. Clear differences are revealed, the maize gluten shows an above average interaction with the myofibrillar protein, for 0-50%; the wheat gluten has a below average interaction with the myofibrillar protein. Both gluten proteins have poor gelation capacity and as their concentration increases > 50% protein the gel network strength decreases rapidly.

Figure 2 *The effect of gluten proteins from maize and wheat on gelation of myofibrillar protein*

Analyzing the data demonstrated, it becomes clear that proteins can interact quite differently with other proteins. How to explain this phenomenon? Both gluten proteins are poorly soluble and wheat gluten is known to have elastic properties. However in these experiments maize gluten appears to be advantageous in interaction with myofibrillar proteins. One difference stands out between these proteins. When adding the amino-acids: Val+Pro+Leu+Ile+Phe+Trp content to estimate hydrophobicity[3] , it becomes apparent that wheat gluten has 42% hydrophobic amino-acids, in contrast maize gluten has almost 60% hydrophobic amino-acids. This difference may be key to understand their different behavior in the protein blends studied in this paper. Furthermore when more is learned about multiple protein phases[4] and factors affecting their interaction, protein ingredient selection can be rationalized by using model predictions instead of trial & error approaches.

Conclusions

So far the experiments show that protein-protein interactions can vary considerably. Hydrophobicity may be an important aspect in fortifying myofibrillar-maize gluten interaction. However it is also required to look further into the protein phases, their structure and factors governing their interaction.

References

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