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***Abstract* - During development stages of new meat products and during production stages, the innovative product developer is faced with several challenges. The main challenge is to develop a new meat product, but keep, or even improve the product to meet consumer desires on: texture, taste and health benefits. This is a difficult task because pork meat products are a complex mix of proteins (myosin, acto-myosin, collagens), fats, water, salt and other functional ingredients. In order to have a framework to better understand the interactions in meat and meat products, the key protein fractions have been researched. The results obtained by a stepwise unravelling of the techno-functional role of each fraction, suggests that meat is a multiple protein phases material.**

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I. INTRODUCTION

Meat and meat products are a complex mix of proteins like: myosin, acto-myosin, collagens etc.. At a certain stage in the production chain, so-called "living" muscle turns into meat. Most enzymatic / biochemical processes act on certain proteins or a protein chain when muscle becomes meat. In simple physics these reactions take place on a molecular level, moreover it often involves the modification of certain biochemical bonds [1]. It is also clear we can measure for instance pH drop and conclude that this is a result of lactic acid production. As pH is –with some effort- a measurable parameter it is often seen as an important predictor of quality. However, still we are faced with varying meat protein functionality or more generic: a large variation in meat protein quality. Mostly expressed as perceived quality when eating the meat product: tender, dry, juicy, tough, rubbery, heterogeneous (particles of fat and protein). Or expressed as "poor functionality" for further processing into sausages, dried or cooked hams, diced pork meat, minces and patties. In the practicality of the real world we observe macro level differences and label/rank them, for instance in pork we have PSE and DFD. These are clearly "textbook" extremes and the majority is in middle of these extremes, but meat and meat protein sources are applied in large quantities in industrial processing. By definition, meat is nothing less than an industrial protein, a commodity. Industrial proteins have one or more specific functional property, their market value is largely determined by functionality [2]. Protein functionality is of a physical or physico-chemical nature. Especially for the large meat proteins the key interactions take place at the meso-scopic level, sometimes also called protein aggregate level. In food physics there are certain classes of functionality:

- Solubility / dispersability
- Gel formation
- Texturisation (heat or acid-induced)
- Adhesiveness
- Stabilising emulsions and suspensions
- Foam formation

Ideally a valuable industrial protein has 2 or more of the functionalities mentioned. Predicting protein functionality / meat protein quality for end-use purposes is important. This warrants the set-up of systematic functionality testing of the most important protein classes and a framework that helps to better understand interactions.

II. MATERIALS AND METHODS

Porcine MDM

Mechanically deboned pork meat (MDM) was used as an explorative model system for lightly to heavier processed pork meat and pork meat products. Lean pork MDM was used to obtain three fractions: 1) myofibrillar fraction, 2) collagen-rich fraction and 3) sarcoplasmatic fraction.

Washing and separation procedure step 1

Cold water (5°C) with 0.6% NaCl and buffered at pH 7 was used to wash the MDM. By mechanical stirring ~1kg MDM was dispersed into 2L of aqueous solution. Pork fat creamed up to the surface, the fat was skimmed and collected. With the first washing followed by centrifugation using a MSE centrifuge equipped with four max. 1L buckets (3000 rpm). Liquid with soluble sarcoplasmatic proteins was carefully poured from the protein sediment.

Washing and separation procedure step 2

The collected sediment from step 1 was dispersed in 2L of washing solution. Now a simple kitchen sieve was used to separate crude collagen material from the soft/pasty myofibrillar material. By pouring the dispersed proteins over the sieve, the myfobrillar

protein fraction passed through the sieve, the collagen material remained behind. Further rinsing of the collagen material resulted in the collection of whitish fibrous collagen material. In order to collect the myofibrillar fraction a 2nd centrifugation was required. This resulted in a sediment containing (light) pink coloured myofibrillar protein.

Functionality testing and functional mapping/indexing
Solublity was assessed at pH 6, 2% protein and 2% NaCl. After solubilisation in a 50mL tube (Greiner) the solution was centrifuged. The indexation was 100 – wt% insoluble, ranking 0 – 100 for non-soluble to completely soluble.

Emulsion quality was assessed by stepwise addition of pork fat and blending on a kitchen blender (Moulinex). As a crude estimation the maximal wt% of fat that could be emulsified, (visual inspection) was noted as the emulsion functionality index

Gelforming/aggregation was assessed by blending to ~10% protein content and 2% salt "brine". Transferring the protein mass into a tube and cooking for 30 minutes at 90°C. After cooling the gels / aggregates were studied. Strength was determined by a penetration test (cone) of 2 cm high slices. For the index strength: (10 – penetration in mm) times 10.
Elasticity index by measuring the G' / G" of the gels on a Bohlin rheometer and manually.

Cook loss was determined after the heat gelation by weighing the % of liquid lost: index the wt % of liquid collected.

Texture and colour were assessed by sensorial testing: texture/bite by taking a "first bite", colour by comparing with a white tile (L=100, Hunter) and scoring the gel.

Most of the functionality tests used here, are modifications of some of the basic tests that are also described in ref. [3].

III. RESULTS AND DISCUSSION

The 3 fractions obtained from pork MDM were tested for functionality. Functionalities were ranked in a functional mapping a schematic. Figs 1 - 3 respectively show the functionality map of the: 1) myofibrillar fraction, 2) collagen fraction and 3) sarcoplasmatic fraction. It is clear from figure 1 that the muscle proteins have a broad scope of functionalities, however there is some tendency to high elasticity/rubberiness. Typically the myofibrillar fraction forms lightly coloured aggregate/particle gels.

The collagen fraction (fig 2) shrinks with cooking, hence a lot of moisture is squeezed out (cook loss). Contrary to the collagen derived product gelatin, this crude collagen is not a good hydrogel. Interesting of collagen is the strength and effect on bite. Perhaps a bit tough on first bite, but the collagen material appeared to have a texture feature that is not found in the myofibrillar gel systems.

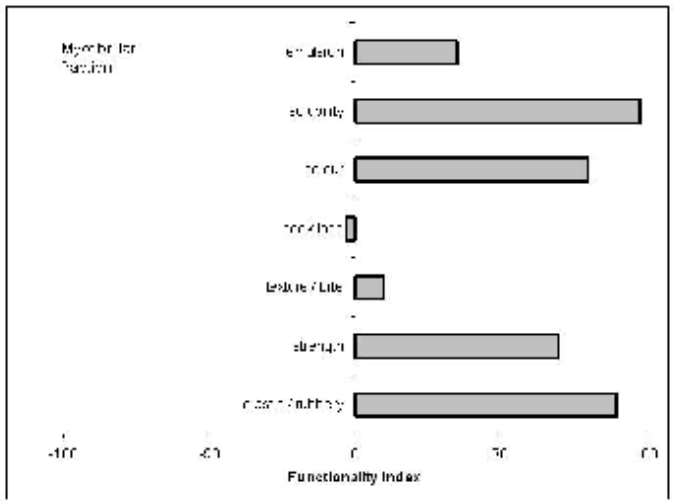

Figure 1 Functionality of the myofibrillar fraction

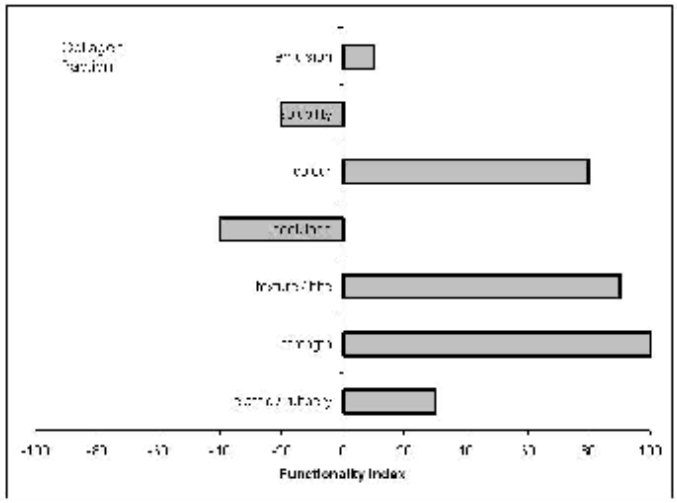

Figure 2 Functionality of the collagen fraction

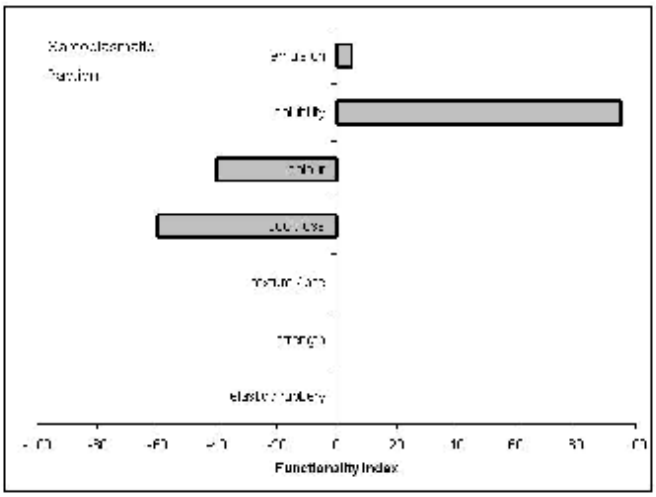

Figure 3 Functionality of the sarcoplasmatic fraction

With further thermo-mechanical processing and in a more acidic environment collagens swell, soften, and interact forming networks. Under these conditions collagens may form a more opaque to semi-transparent gel. In contrast with earlier opinion on collagens, further processing and swelling could convey interesting texture/functional properties that used to be ascribed to muscle protein functionality. The sarcoplasmatic proteins show hardly any functionality, only small precipitating aggregates are formed when these salt (0.6% NaCl) soluble proteins are heated. Clearly, with the conditions used, the sarcoplasmatic protein fractions seem to have poor functionality as compared to myofibrillar proteins. Although when combined it may appear that the properties of small sarcoplasmatic protein aggregates add to the total picture. For an example by forming loose particle networks in the liquid phase of cooked meat/meat products. Perhaps aiding resistance to cook loss and adding to the overall texture (e.g. juiciness). Although sometimes suggested, our functionality tests did not reveal an important role of SH – S-S chemistry in texture/aggregate formation of the three protein fractions studied here. This points to only physical interactions like H-bonds, hydrophobic stabilisations, v/d Waals forces, ionic bonds as being responsible for the macro-properties of meat and meat products [4]. This is in agreement with the earlier proposed approach of the multiple protein phases model [5].

Highly schematic, the direction of perceived macroscopic product differences is suggested in figure 4.

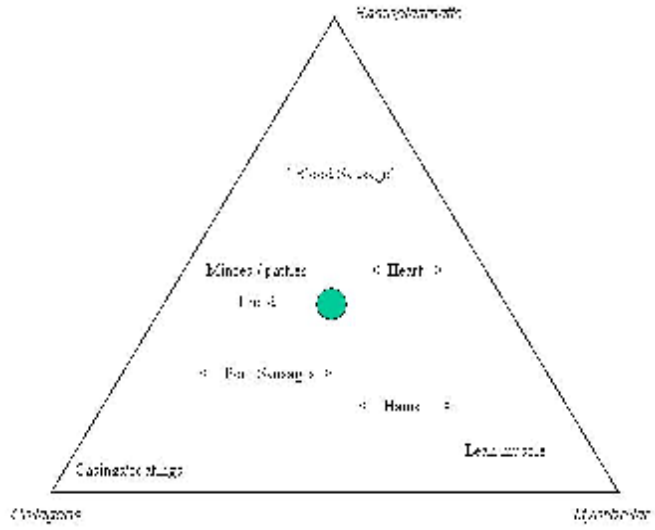

Figure 4 Schematic of a multiple phase approach

Using a ternary diagram a functional mapping technique can be developed including the three protein phases. Here contrary to theories that focus on a single protein class, the three protein phases have been taken into account. The schematic can be used as a framework for new product development or help to unravel the pork meat protein functionality puzzle.

IV. Conclusion

Contrary to common practice, it was shown that the three main protein fractions in pork meat, each have a distinct functionality profile. Interactions of the sacroplasmatic proteins, collagens and myofibrillar proteins are the key to meat protein functionality and meat product quality. This is in agreement with approaches that consider (pork) meat as a multiple protein phases system. By unravelling the full scope of interactions between the multiple protein phases, our understanding of factors affecting meat quality can be improved.

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