STRUCTURAL CHANGES IN BEEF MUSCLE PROTEINS DURING HEATING

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Conformational changes in the muscle proteins of uncured beef having pH 6.6 and 5.4 were studied with the protein intrinsic fluorescence method in the process of meat ageing for 3 to 96 hours.

It was found that during heating

- conformational changes in beef muscle proteins occur in several steps characterised with structural transitions of denaturation or coagulation type;
- the basic differences in the pattern and temperature ranges of structural rearrangements of beef myofibrillar proteins are observed at 50-9°C, the ageing time and meat pH being of great importance;
- irrespective of pH, within the first hours post slaughter beef is characterised with the development of coagulation at quite low temperatures (60-70°C) in the structure of its muscle proteins;
- the denaturation loosening of the structure of meat myofibrillar proteins post rigor (pH 6.6) occurs at the temperatures up to about 70°C, whereas in PSE beef (pH 5.4) denaturation takes place only up to about 60°C.

The quality and yields of the finished products are known to be greatly related to the state of the structure of meat myofibrillar proteins. Technological processing, heating, for example, effects considerably the pattern and extent of the conformational changes in meat proteins. The knowledge available is insufficient, especially with account for large variations in the raw meat materials delivered for processing (Solovyov, 1966; Sokolov, 1970; Acton and Dick, 1984; Honikel & Kim, 1986).

During meat ageing post slaughter considerable biochemical and structural changes occur in muscles, which determine the water-hold capacity (WHC), tenderness and juiciness of both raw and heated meat, the ageing time being a very important factor (Davey & Graafuis, 1976; Hamm, 1982; Lee and Schön, 1985; Hecht, 1987).

Meat pH after slaughter and the course of its changing during ageing have a marked influence upon meat quality (Monin & Selklier, 1985; Honikel & Kim, 1986; Hofmann, 1987).

Knowing how the structure of muscle proteins changes in the process of heating due to these factors, one can regulate the heat treatment of different raw meats in such a way as to ensure stable manufacture of high-quality products.

The purpose of the present work was to study changes in the conformation of beef myofibrillar proteins during heating, meat having different pH-values and being taken at different intervals post animals slaughter.

Studies were carried out on beef l. dorsi muscles with pH 6.6 and 5.4. Samples were assessed at 3, 24, 48, 72 and 96 h post mortem. The 24-96 hour samples were polyethylene-packed and stored at 4±1.5°C.

Structural changes of muscle proteins were studied with the protein intrinsic fluorescence method in the process of heating, as described by Oreshkin et al. (1985). The experiment was repeated four times, muscles of similar type and pH were chosen for parallel tests. Data spread was ±1 nm and ±2°C.

Fig. 1 shows the relationships of the main fluorescence parameters of the actomyosin proteins (Permyakov et al. 1986), viz., those of the maximum location ($\bar{\lambda}$) and fluorescence yield (S) to beef temperature (pH 6.6) during 3-96 h ageing post mortem. Curves are of a quite complicated and ambiguous nature depending on ageing time. Thus, 3 h post slaughter two pronounced shifts of the maximum of the fluorescence spectrum toward the long-wave region are obvious in the meat: at 50-62°C and at 67-75°C. It indicates that within these temperature ranges there occur the denaturation twisting of protein chains and their structure loosening. At 62-67°C and at above 75°C the fluorescence spectrum maximum shifts towards the short-wave region, it evidencing the occurrence of an opposite process at these temperatures, viz., that of inordinate approaching and coalescence of protein chains, i.e. coagulation. Considerable changes in the fluorescence yield within the above temperature ranges show that such conformational alterations are of a general character, not localised at certain spot of the structural arrangement of the proteins of the actomyosin complex.

24 h post mortem changes in the conformation of the muscle proteins of such beef during heating occur in a different way. Now denaturation loosening lasts up to 68-70°C and at 75-83°C, coagulation taking place at 68(70)-75°C. From the 48th hour post mortem and through the 96th hour considerable changes in proteins conformation during heating are taking place as two rearrangements: denaturation at 55-70°C and coagulation at 70-80°C.

The behaviour of muscle proteins during heating of beef having a lower pH-value (5.4) (it is considered as PSE-beef) differs greatly from the one described above. Thus, in case of ageing for 3, 24, 72 and 96 h denaturation transitions in beef proteins at 50-62°C and 68-78°C are evident, while at 60-70 and above 75°C coagulation transitions are observed. And it is only 48 h post mortem that one denaturation transition at 50-68°C and one coagulation transition at above 75°C occur in such meat. A comparison of changes in the muscle protein structure during heating of normal and PSE beef demonstrates that in both cases within the early post mortem period these changes are similar, their important feature being coagulation at sufficiently low temperatures (60-70°C). However, the similarity disappears one day post slaughter. Denaturation is developing up to 70°C in the protein structure of normal meat and only up to 58-60°C in PSE beef, coagulation following denaturation at 60-70°C being extensive and, obviously, covering a greater part of the structure of myofibrillar proteins and filaments if judged by an abrupt fall of the fluorescence yield. Though, at higher temperatures (68-75°C) denaturation loosening of the protein structure in PSE beef re-appears; the development of extensive coagulation compacting of the structure at comparatively low temperatures (60-70°C) is however extremely undesirable during meat heat treatment.

CONCLUSIONS

In the process of uncured beef heating the following changes in its myofibrillar proteins take place:

- within the first hours post mortem at 50-90°C two rearrangements in protein conformation occur which are accompanied with the denaturation loosening of protein structure: at 50-62°C and at 68-75°C; as well as two rearrangements of the opposite, coagulation character: at 62-68 (70°C) and at above 75°C. These changes are observed both in normal (pH 6.6) and PSE beef (pH 5.4). It is necessary to emphasise that at such ageing time coagulation proceeds at comparatively low temperatures (60-70°C), this determining, probably, toughness of the finished products prepared from beef treated within the first hours after slaughter (Hamm, 1982);

- at 48-96 hours post mortem the denaturation process in the proteins of normal beef 9pH 6.6) occurs up to 70°C, further heating causes coagulation rearrangements in the protein structure;

- in PSE beef (pH 5.4) low temperature coagulation at 60-70°C proceeds practically through the 4th day of ageing.

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