Protein Changes on Heating and Their Influence on Water-Binding Capacity of Meat

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SUMMARY

Various heating regimes of meat result in different cooking losses. The purpose of the study was to learn about the causes of the variations in water-binding capacity of meat subjected to various thermal treatment. The experiments were carried out on normal, PSE and DFD meat of porcine and bovine origin. Solely M. longissimus dorsi was used. Denaturation processes in muscle proteins were measured by solubility changes, calorimetric studies and PAGE-SDS.

Weight losses of cooked meat depend on protein changes, protein solubility, and protein release from meat.

INTRODUCTION

Weight losses of lean meat during cooking are primarily due to water losses. These changes occur in several phases and are affected by meat quality, final temperature of cooking and also by the method of heating.

One of the most controversial problems is the interpretation of results connected with the evaluation of the effect of the cooking temperature and the rate of cooking on weight losses. Some authors report higher meat losses at slow cooking rates (ABUGROUN et al. 1985; BRADY and PENFIELD, 1981; DINARDO et al. 1984; SEUSS et al., 1986), while others publish the opposite opinion (APPEL and LÖFQVIST, 1978; CHOUN et al., 1986). Finally, there are also reports stating that the cooking rate does not affect water binding capacity of meat tissue at all (TYSZKIEWICZ and TYSKIEWICZ, 1966).

The objective of this paper is an attempt to explain causes of different water binding capacities of muscles subjected to the various thermal treatment.

MATERIALS and METHODS

M. longissimus dorsi samples from pig and cattle carcasses were analyzed. Pork muscles were divided into two groups, i.e. muscles of normal quality ($pH_1 > 6.0$ and $pH_{24} < 5.8$) and PSE ($pH_1 < 5.8$ and $pH_{24} < 5.8$). In the case of beef normal muscles ($pH_1 > 5.8$, $pH_{24} < 5.6$) were compared with DFD ($pH_{24} > 6.4$). Pork was used 4 to 5 days post mortem, beef was at least 8 days, in some experiments up to 20 days old.

The meat was cut into 4 x 2 x 0.3 cm thick slices (equal to about 3 g) and put into polyethylene bags. Samples were then heated to one of the five endpoint temperatures 55, 65, 75, 85 and 95°C. Two cooking rates were used: A slow heating rate of 2.5°C/min and a rapid heating rate of about 80°C/min. After reaching the required temperature the muscles were cooled by placing the bags in tap water and analyzed. The small samples were used in order to have a rapid and uniform heat transfer to the meat.

The analysis included: Determination of weight losses (% loss of original weight); denaturation changes using differential scanning calorimetry (DSC) were applied after heating as well as determination of protein solubility and protein content in cooking loss. The extraction for solubility measurements was conducted with 0.03M phosphate buffer of pH 7.4 (HELANDER, 1957). This treatment yielded two fractions of muscle, the fraction of crude myofibrillar proteins and sarcoplasmic proteins. Individual protein fractions as well as the cooking fluid together with its sediment were subjected to electrophoretic analysis on polyacrylamide gel with SDS (PGAE-SDS).

RESULTS and DISCUSSION

The experiments showed that the highest weight losses occured in muscles cooked slowly while the lowest ones occured in the DFD muscles heated rapidly (fig. 1). Heating to higher temperatures led to higher cooking losses. PSE-pork had similar cooking losses as normal pork.

Comparison of samples cooked to the endpoint temperature of 75°C and lower using different rates of heating showed that higher values of remaining denaturation enthalpy (SEUSS et al. 1986) were observed in samples cooked rapidly (fig. 2). In order

Fig. 1a

Influence of quality and temperature
in pork and beef
slowly heated (2.5 C/min)

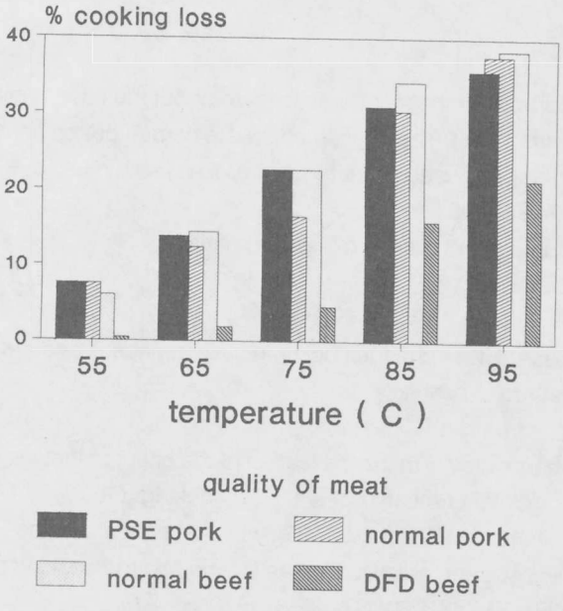


Fig. 1b

Influence of quality and temperature
in pork and beef
rapidly heated (ca.80 C/min)

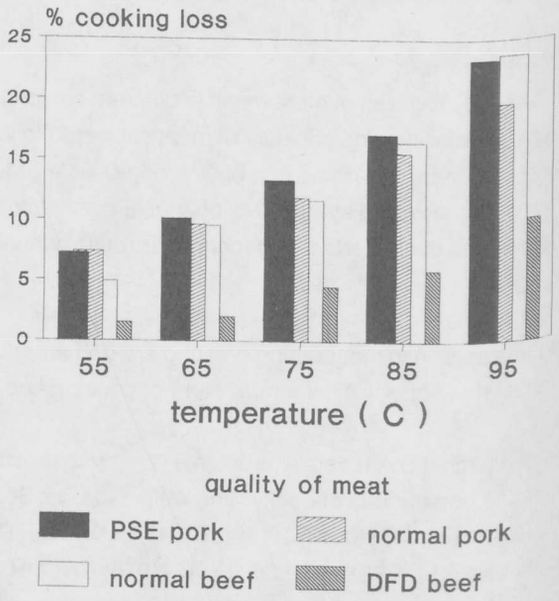


Fig. 2a

Rest enthalpy of preheated meat
in pork and beef
slowly heated (2.5 C/min)

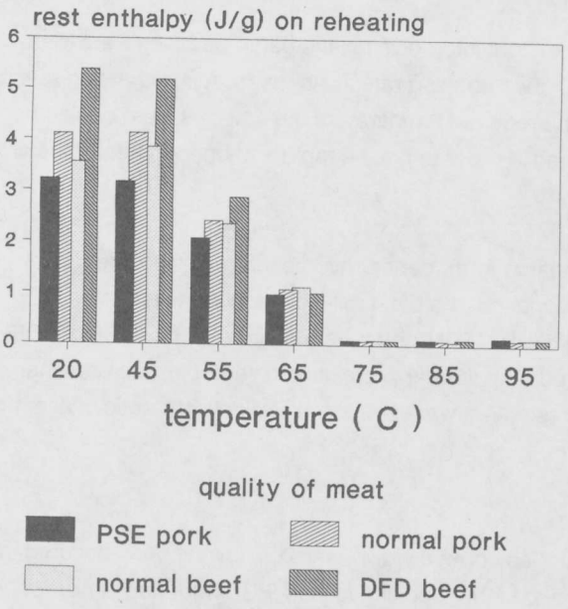
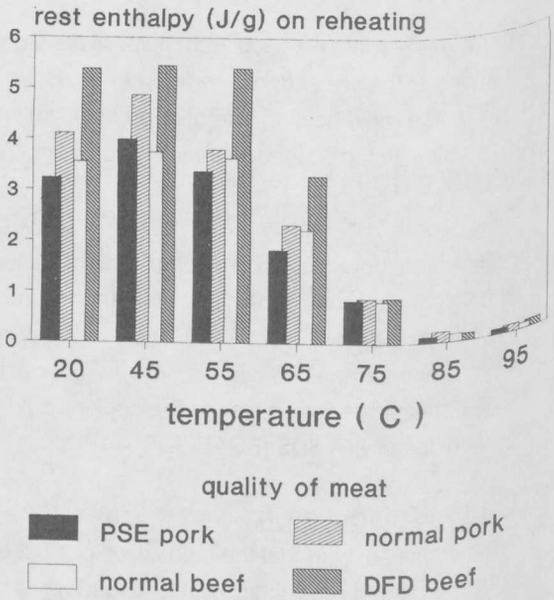


Fig. 2b

Rest enthalpy of preheated meat
in pork and beef
rapidly heated (ca.80 C/min)



to avoid misinterpretations: The meat was cooked in bags in the waterbath, cooled and samples of about 0.4 g were reheated to 100° C in the DSC. The remaining enthalpies are reported in fig. 2. High values mean less denaturation in the bags.

It can be noted in fig. 2 that in samples cooked slowly to 75°C and quickly to 85°C denaturation processes which use energy (endothermic) come to an end. After the above mentioned temperatures were reached also only slight changes were observed in the amount of total nitrogen both in the cookout and in the extract obtained from the tissue treated with 0.03 M phosphate buffer. Weak protein bands were observed on SDS electropherograms of the extract and the cooking juice from meat heated above these temperatures. Only one "protein" was found in the cooking juice in the temperature range of 85°C and 95°C, when high molecular weight material was precipitated using TCA. This was attributed to collagen (gelatine).

Electrophoretic analysis showed furthermore that the amount of myosin heavy chains (MHC) in the crude myofibrillar fraction of cooking juice decreased with heating. This decrease was more intensive in rapidly heated muscles than that in slowly heated ones, particularly in the initial stages of the treatment up to 65°C with the exception of PSE meat. But we found that the amount of myosin in the cookout **sediment** was markedly higher in fast heated samples than in slowly heated ones (fig. 3). The highest amounts of myosin in the sediment we found in DFD beef rapidly heated.

PSE-meat (slowly heated) and especially DFD-meat (rapidly heated) increase myosin concentration in sediment with heating temperatures. PSE-pork (rapidly heated) enhances from 0.7 to 1.9 mg Myosin/100 g cookout between 55 and 95°C, PSE-pork (slowly heated) from 0.4 to 5.2 mg/100 g.

Slowly heated beef-DFD-meat from about 0 to 4.4 mg/100 g and DFD-beef rapid heated from 8 to 20 mg/100 g. The reasons for these observations are different. In PSE meat the membranes are disintegrated and high-molecular weight proteins are released into the cooking juice. In beef DFD-meat the high pH-value of the meat increases the solubility of proteins releasing them in the cooking juice after the cellular membranes are disintegrated by heat.

It was also found that thermal treatment reduced the amount of cytoskeletal proteins as evidenced on electrophoreto-

Fig. 3a

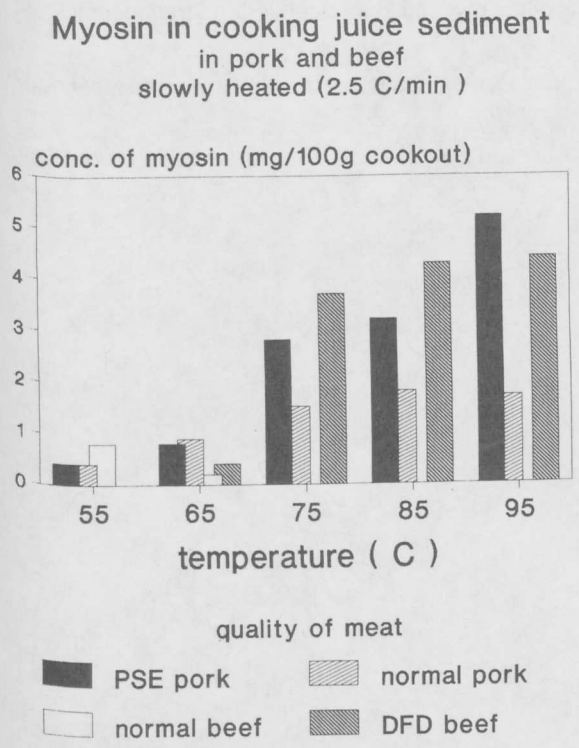
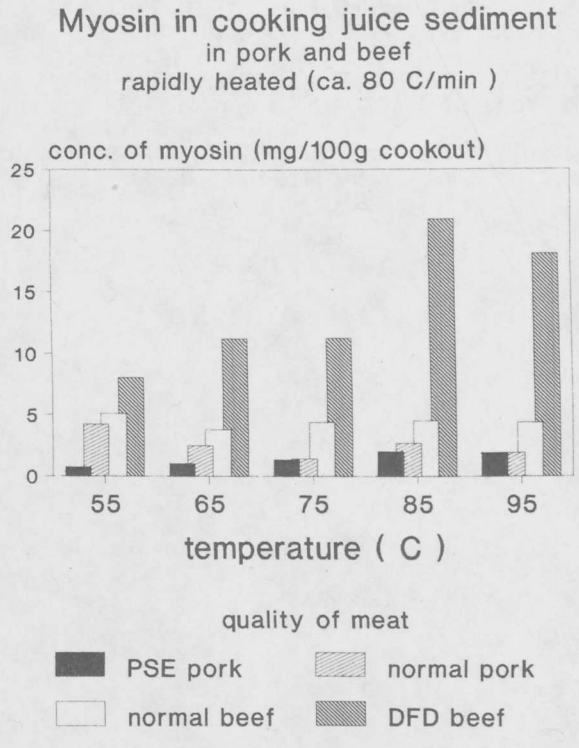


Fig. 3b



grams of crude myofibrillar fraction. They were denoted as the band of proteins of molecular weight above 200 kD (LOCKER and WILD, 1984).

In the cooking juice sediment of beef muscles heated rapidly (80°C/min) the amount of cytoskeletal proteins was usually twice as high as was found in slowly cooked meat. This was not observed in pork.

CONCLUSIONS

Rapid heating of meat which could be done with the small pieces in this experimental setup resulted in less cookout (often about 50 %) of slow heating. Rapid heating causes less "denaturation" of proteins measured with DSC as the rest enthalpy which is believed to be an indicator or protein denaturation was higher in rapidly heated meat. Thus weight losses of cooked meat depend on denaturation and by denaturation caused shrinkage of proteins; the release of proteins from the structure of muscle may be an indication for the degree of protein changes and membrane disintegration. Losses of myosin/actomyosin in the cooking juice were smaller increased in the cookout sediment. A simple relationship to water holding capacity does not exist, even if there is most probable a relationship.

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