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MEAT RAW MATERIALS IN COMMINUTED MEAT PRODUCTS

A.-M. HERMANSSON

SIK - The Swedish Food Institute
P.O. Box 5401, S-402 29 Gothenburg, Sweden

SUMMARY

The meat raw materials can give rise to considerable differences in the functional properties of coarsely and finely comminuted meat products. Some muscle material cannot emulsify fat and the fat is predominantly found in fat cells and larger fat pools, whereas other muscle materials give rise to a large proportion of small fat droplets during similar processing conditions. The size distribution of fat particles can be quantitatively determined by light microscopy and image analysis. Fat raw materials can also behave in different ways as a result of comminution and subsequent heat treatment. Considerable differences in water holding capacity were also found and some examples from studies of fresh and freeze-stored meat raw materials from beef and pork are presented. The comminuted systems differed with regard to the structural state of the collagen and the degree of muscle fibres decomposition as a result of comminution and heat treatment.

INTRODUCTION

The meat raw materials can give rise to considerable differences in texture and cooking losses when used in coarsely and finely comminuted meat products (Hermansson, 1984). Despite their importance for both product quality and economy, the relationships between the microstructure and functional properties of comminuted meat products have been far too little studied. The significance of the state of swelling of myofibrils for the water holding properties of intact muscle and coarse comminutes prior to heat treatment has been reported by Offer and Trinick (1983) and recently by Wilding et al. (1986). However, further decomposition of the muscle fibres by mechanical treatment and/or heat treatment can alter the structure drastically and give the meat constituents quite different roles than in the intact muscle. The relative roles of the myofibrillar proteins myosin, actin and titin depend strongly on their structural state, and the degree of decomposition of the muscle tissue during comminution and heat treatment may play a more important role for the continuous structure and functional properties than hitherto acknowledged. Not only comminution and heat treatment but also frozen storage can significantly affect the functional properties of comminuted meat products. The aim of this paper is to give some examples from a study of fresh and freeze-stored muscles and trimmings from pork and beef of differences between meat raw materials .

MATERIALS AND METHODS

Meat raw materials

The following types of muscle and meat trimmings were used: m. biceps femoris, m. longissimus dorsi and m. abdominus rectus from beef, m. infraspinatus and m. biceps femoris from pork, foreleg and ribbon loin trimmings from beef, shoulder, foreleg and head meat trimmings from pork. The composition of the meat raw materials is shown in Table 1. If nothing else is stated, the meat was freeze stored at -40°C for approximately 2 months before use.

Preparation of model systems and sausages

The coarsely comminuted meat systems were minced through a 2 mm sieve. Water and salt were added and the mixing was made by hand.

The finely comminuted meat systems were minced through a 2 mm sieve, water and salt were added and the system was further comminuted in a Moulinex mixer for 30 sec.

Sausage batters were made in a 25 l bowl chopper, as previously described (Hermansson, 1984). The recipes were adjusted to the following composition: protein 8.7%, fat 23.4%, water 65,3%, and salt 2.0%.

Functional properties

Fat and water loss, frying loss and texture parameters were determined according to the previously described procedures (Hermansson, 1984).

Light microscopy and image analysis

Small samples were frozen in liquid nitrogen and cryosectioned. The 7-8 µm sections were stained for fat with Sudan B Black and for collagen with a aniline orange G solution. Image analysis was made with a KONTRON-SEM-IPS system and a TV camera placed directly on the light microscope.

RESULTS AND DISCUSSION

Distribution of fat in the protein matrix

There is some controversy in the literature about the mechanisms of fat dispersion i.e. whether the fat is emulsified or not. (Schut, 1976; Evans and Ranken, 1975; Hermansson, 1986). Our results show that both the muscle raw material and the type of fat used determine the performance of the fat during chopping and heat treatment. If pork back fat is used, a common observation is an optimum in fat holding properties at higher temperatures, due to overprocessing and phase separation (Hermansson, 1986). Figure 1 shows that this is not always the case and the result depends on the type of muscle raw

Table 1. Composition of muscle samples and meat trimmings

Muscles and trimmings		Fat %	Water %	Total protein %	Collagen %
Beef	m. biceps femoris (beef)	4.3	74.0	20.7	1.3
	m. longissimus dorsi (beef)	4.4	72.7	22.0	1.5
	m. abdominus rectus (beef)	3.1	75.4	20.0	1.5
	m. biceps femoris (pork)	3.2	75.4	20.7	0.9
	m. infraspinatus (pork)	8.7	71.6	19.1	2.0
Pork	foreleg	9.0	71.5	19.0	2.9
	shoulder trimmings	13.2	68.5	17.8	1.4
	head trimmings	28.0	56.7	14.6	3.2
Beef	foreleg	4.0	72.6	22.3	4.8
	ribbon loin trimmings	22.8	68.9	17.2	2.1

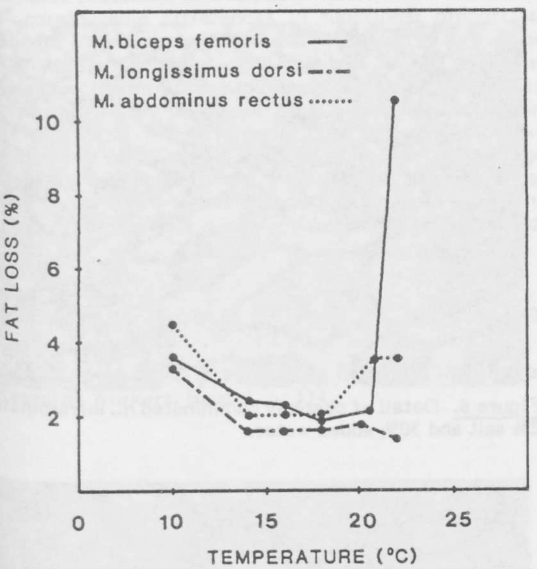


Figure 1. Fat loss as a function of chopping temperature.

material used. For m. biceps femoris the fat loss increased sharply at 21°C, as expected. For the other two types of muscle it was not possible to achieve phase separation and increase in fat loss, even after chopping for 15 min. at 22°C. Microstructure evaluation revealed a continuous decrease in particle size with increasing processing time. All three types of muscle used in the chopping experiment had the ability to emulsify or disperse the fat into droplets which were considerably smaller than the original fat cells. There are other muscle raw materials, in which most of the fat from mechanically damaged fat cells separates directly into bigger fat pools without being emulsified. In a study of meat trimmings it was found that meat from beef ribbon loin trimmings had poor emulsifying ability whereas beef foreleg trimmings had good emulsifying ability. The number of small fat droplets

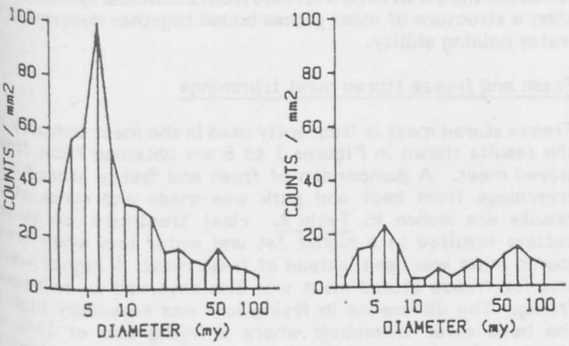


Figure 2. Particle size distribution in batters with beef foreleg meat (left) and beef ribbon loin trimmings (right).

formed during chopping can be evaluated by image analysis. Figure 2 shows that the number of small fat droplets was considerably larger in the meat batter with foreleg meat than in that with ribbon loin trimmings. The latter contained more fat pools bigger than the original fat cells (Ø 80 - 100 µm), but this cannot be seen from figure 2. The reasons for the difference in emulsifying properties are not fully understood and further studies are needed.

The behaviour of different types of fats during comminution and heat treatment has been investigated by several scientists (Schut, 1968; Townsend et al., 1968; Swift et al., 1968; Schut and Brouver, 1975; Evans and Ranken, 1975). Most studies have been made with pork back fat, which can be dispersed or emulsified into fine fat droplets. Under conditions allowing phase separation, the droplets fuse together and bigger fat pools are formed, which results in increased cooking loss (Hermansson, 1986). A comparative study of pork back fat and

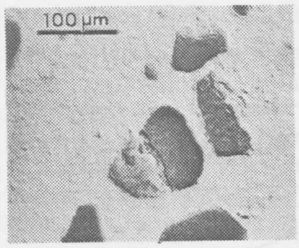


Figure 3. Beef tallow fat cells fractured during chopping

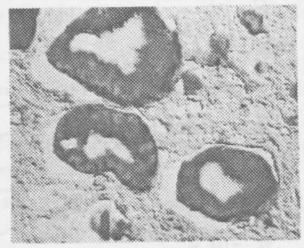


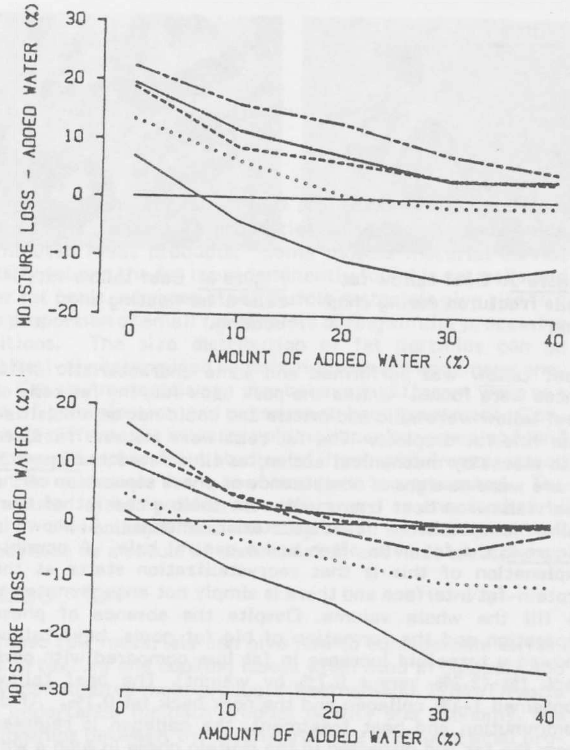
Figure 4. Beef tallow fat cells after heating and cooling.

beef tallow was performed and some characteristic differences were found. Unlike the pork back fat, the fat cells of beef tallow were solid and brittle and could not be emulsified into fine fat droplets. The fat cells were instead fractured into pieces by mechanical action, as illustrated in Figure 3. There were no signs of coalescence or phase separation of the beef tallow on heat treatment. On cooling the fat of beef tallow recrystallized in a characteristic manner. As shown in Figure 4, the fat cells often had a central hole. A possible explanation of this is that recrystallization starts at the protein-fat interface and there is simply not enough material to fill the whole volume. Despite the absence of phase separation and the formation of big fat pools, beef tallow showed a threefold increase in fat loss compared with pork back fat (2.2% versus 0.7% by weight). The beef tallow contained 1-4% collagen and the pork back fat 0.7%. After comminution and heat treatment, the collagen is released from the fat and dispersed in the protein phase in such a way that it may have a negative effect on the continuous matrix which is reflected in both the water and fat holding properties. The microstructure evaluation thus indicates that the greater cooking loss observed with beef tallow is due to changes in the continuous network structure rather than to coalescence of fat into big fat pools.

Water holding capacity

Considerable difference can be found in the water holding capacity of different meat raw materials, regardless of their chemical composition. These differences are influenced by the degree of decomposition of the muscle tissue and the structural state of the meat constituents. The upper part of Figure 5 shows the effect of added water on the moisture loss infive coarsely comminuted meat systems with 2% NaCl. The Y axis shows the total moisture loss subtracted by the amount of added water and the zero line means that the total moisture loss corresponds to the amount of added water. At values below zero the meat systems bind part of the added water and at values above zero all the added water and part of the original water is lost. Figure 5 shows results from two well-defined muscles and three trimmings from pork. The best result was obtained with m. infraspinatus and there was a maximum difference in moisture loss of appr. 20% by weight, regardless of the amount of water added. Second best was meat from the foreleg. An interesting observation is that m. biceps femoris with the highest protein content showed relatively great moisture loss.

Figure 5 also shows the moisture loss as a function of the amount of added water at a higher degree of comminution. The ability to bind added water increased with increasing comminution in all the meat systems. The m. infraspinatus and foreleg systems had the best water holding capacity and also at the higher degree of comminution it was found that collagen/gelatin formed a continuous network structure in these two systems. At the higher degree of comminution even the head meat trimmings had better water holding ability than m. biceps femoris. However, the structural state of the fat in a meat batch can affect the water holding ability of the meat raw materials in different ways due to reinforcement by small fat particles of the gel network. The water holding capacity of m. biceps femoris is thus considerably improved by fat dispersion due to its emulsifying properties. When sausages were made from the five pork meat raw materials, only m. infraspinatus was found to give better water holding ability than m.



Figures 5. Moisture loss as a function of the amount of water added for coarsely comminuted (top) and finely comminuted (bottom) model systems.

m. infraspinatus — head trimmings
m. biceps femoris — shoulder trimmings
foreleg meat

biceps femoris.

The microstructure evalution revealed a difference between the meat systems in the structural state of the collagen/gelatin and the meat fibres. In the m. infraspinatus and foreleg systems a substantial amount of collagen was released during heating and a continuous network structure which enhanced the water holding capacity of these systems, was formed. Figure 6 shows a micrograph of the minced m. infraspinatus system with 30% added water, and Figure 7 the corresponding microstructure of the pork shoulder system. The dark network structure in Figure 6 is dominated by collagen/gelatin but contains also myofibrillar proteins. A comparison between Figures 6 and 7 also shows a pronounced difference in fibre structure. Part of the meat fibres of m. infraspinatus have been emptied, which has not happened to the pork shoulder fibres. Figure 6 shows an emptied "fibre ghost" and cross-sections of partly extracted fibres. The observed difference in fibre structure is not correlated with protein solubility since the solubility of the myofibrillar proteins was the same for the meat systems studied. This implies that the myofibrillar proteins are released from the fibres as myofibrils, filaments or some other aggregated state rather than as solubilized protein.

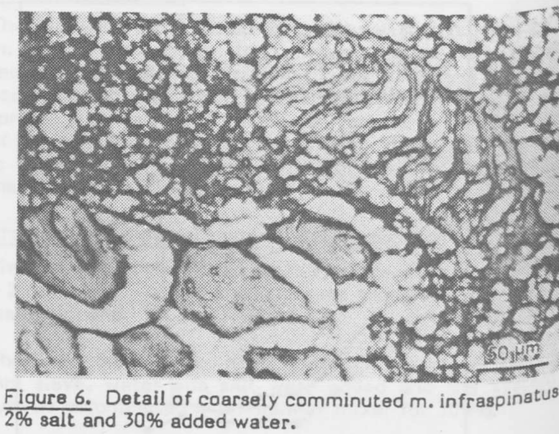


Figure 6. Detail of coarsely comminuted m. infraspinatus with 2% salt and 30% added water.

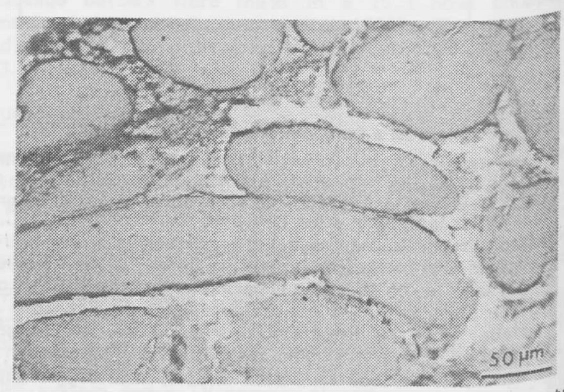


Figure 7. Detail of coarsely comminuted pork shoulder trimmings with 2% salt and 30% added water.

At a higher degree of comminution most of the fibre structure is lost and the gel structure formed from a colloidal system rather than a structure of meat pieces bound together determine the water holding ability.

Fresh and freeze stored meat trimmings

Freeze stored meat is frequently used in the meat industry and the results shown in Figures 1 to 8 are obtained from freeze stored meat. A comparison of fresh and freeze stored meat trimmings from beef and pork was made and some of the results are shown in Table 2. Heat treatment of sausage batters resulted in a higher fat and water loss when freeze stored meat was used instead of fresh meat. A higher weight loss for freeze stored meat was also observed on subsequent frying. The difference in frying loss was especially high for the head meat trimmings where a frying loss of 14% was observed for fresh meat and as much as 26% by weight for freeze stored meat. As can be seen from Table 2 freeze storage gave rise to a less firm product for all trimmings tested.

Table 2. The use of fresh and freeze stored trimmings in sausages

Meat trimmings		Functional properties of sausage systems: Water loss %	Fat loss %	Frying loss %	Rupture force (N)
Beef foreleg	fresh	25	1.4	13	35
	freeze-stored	28	1.8	17	21
Beef ribbon loin	fresh	22	2.4	15	31
	freeze-stored	25	2.8	21	23
Pork foreleg	fresh	21	0.9	11	31
	freeze-stored	23	1.5	20	17
Pork head meat	fresh	25	0.7	14	31
	freeze-stored	28	3.5	28	20

CONCLUSIONS

The examples presented in this paper clearly show the existence of considerable differences in functional properties, depending on the source of the meat raw material as well as on the handling of the meat. Since approx. 50% of the meat from a carcass is used in comminuted meat products, it may be questioned whether this meat is classified and handled in the optimum way. The differences observed cannot be explained in terms of chemical composition. More knowledge about the relationships between the structure and functional properties of meat raw materials at various degrees of comminution and muscle tissue decomposition is therefore needed.

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