POST MORTEM PROCESSES AND MEAT QUALITY
PROSPECTS OF RESEARCH NEEDS

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INTRODUCTION AND DEFINITION OF QUALITY

Slaughter animals are raised, slaughtered and the meat is processed in order to be consumed by human beings. Consumers expect meat and meat products of best quality.

Discussing meat quality presupposes a definition of the term "meat quality". By quality I understand an objective description of all characteristics of meat. Subjective preference of attributes of meat cannot be the basis of a scientific discussion. Meat quality can be divided in four groups of quality factors:
I) Nutritional factors; these are different for different species of animals but also change during processing of meat.
II) Hygienic factors; contamination with microorganisms and viruses are one aspect. The content of unwanted or health hazardous substances may be the second aspect. During processing contamination with microorganisms and the addition of additives may take place.
III) Sensorical factors; post mortem processes and meat processing influence the sensorical properties of meat considerably besides animal feeding, raising, species and breed.
IV) Technological factors; post mortem processes like chilling regimes, ageing but also animal treatment before and during slaughter changes the physical and chemical properties of meat.

Thus, meat quality is influenced in many aspects by postmortem processes, handling und processing of meat. In the framework of this paper nutritional, sensorical and technological factors influenced by meat processing will be discussed. As required by the organizers of the congress research needs will be the subject and not the present state of art.

BIOCHEMICAL CHANGES IN MUSCLES POST MORTEM

As the muscular tissue is the most valuable and most expensive part of the carcass, extensive research has been carried out with this tissue and its changes post mortem since decades. From the innumerable books and papers on this subject three books as examples should be cited: Bendall (1969), Needham (1971), Ziegler (1958). With respect to normal post mortem biochemical processes we know comprehensively the sequence of events and the metabolism of substances in various species of animals. Furthermore it became obvious in recent years what causes cold shortening and how to avoid it, we are familiar why DFD pork and dark cutting beef is observed and know also a lot about PSE pork. But especially in PSE pork we still lack a full explanation of the sequence of events which results in pale, soft and exudative pork. Without doubt hormones

initiate or take part initiating the process intramortem, leading to a rapid breakdown of glycogen and finally due to low pH and prevailing high temperatures to denaturation of proteins and early desintegration of membranes. But what does cause the rapid pH fall? Contrary to our human made machinery which may waste energy for no necessary purpose, a muscle does not turn over energy just for the sake of producing heat. As Scopes (1974) could show in an excellent experimental set up, the glycolysis and its speed depends on the ATP-turnover in the interacting enzyme system of the muscle cell.

What ATPases in the cell do use up the ATP? We know, that it is not a general muscle contraction in PSE muscles like in the cold or rigor shortening process. Also the early lack of oxigen and anaerobic glycogen breakdown to lactate cannot be the cause. Transport of matter through intracellular membranes or futile cycling between the glycogen breakdown catalyzing enzymes and glyconeogenic ones may be reason for an accelerated ATP turnover.

Another open question is how is it possible to accelerate the glycogen breakdown in PSE muscles by a factor of about 10? Around a dozen of glycolytic enzymes must be able to increase their turnover rate rapidly over the pH range of 7.0 to 5.5. There exists the principle of convoy. The "slowest" turnover rate determines the velocity of glycogen breakdown. Thus enzymes must be able to increase their turnover rate. Do higher concentrations enzymes exist in PSE muscles, or have muscles different isoenzyme patterns? we could show (table 1) pyruvate kinase normal (pH_1 > 6.1) pork muscles exist two isozymes, at pH_1 5.9 three or four isozymes are present with different activ patterns.
With respect to PSE and its causes we urgent research needs and I call upon international cooperative efforts to solve problem.

In this context other research projects should start. After we know what does happen on the level of enzymes and other proteins in PSE muscles we should begin identify the genomes of normal and PSE prone pork muscles in cooperation of m scientists and molecular biologists.

CHANGES IN PHYSICAL PROPERTIES

1) Water holding capacity

It is rather easy to provide a general description of water holding capacity (WHC): It is the ability of meat to hold its own and in some cases added water du handling and processing. But meat is treated in many ways. It is chilled and st as intact meat in cuts, it is minced, it is heated and for many meat products it is salted and/or comminuted with fat. The

Table 1

Relative intensity of the isoenzymes of pyruvate kinase after isoelectric focussing

pH_1 in muscle	6.6		6.4		5.9		5.4		5.5	
	relative intensity of isoenzymes bands (left) and their ratios (right)									
isoenzyme No 1	32,3	1	43,7	1	23,8	1	44,8	1	26,0	1
isoenzyme No 2	59,7	1,84	41,5	0,95	36,8	1,54	38,0	0,75	48,4	1,86
isoenzyme No 3	-	-	-		26,3	1,10	14,6	0,33	22,1	0,85
isoenzyme No 4	-	-	-	-	11,4	0,48	-	-	-	-

WHC of fresh intact meat has little or no relationship to the WHC of a sausage made from this meat (Honikel, Hamm, 1984). Furthermore the WHC of fresh meat does not allow to draw conclusions on the WHC of cooked meat (Honikel, 1987). The reason is that with different treatments different forces are applied. Thus there is a research need to evaluate which components of the muscle or meat hold or bind water, which changes occur in the meat during handling and processing and by which methods the WHC should be measured. International cooperation should try to standardize procedures and recommend finally the procedures. That this is possible, numerous agreements in analytical methods (e.g. ISO) have shown.

2) Toughness of meat

The most important attribute of the eating quality of meat is its tenderness. In thousands of papers sensorical tests are reported and instrumental measurements are used. I don't want to compare sensorically evaluated toughness with its instrumental measurement even if I believe that there is also a research need. I want to emphazise that we don't know yet satisfactoryly what happens in the ageing process and in fresh or aged meat during preparation. What role do play the different connective tissue sheets in meat? Which changes in myofibrillar protein and connective tissue do happen on heating? Why do Warner-Bratzler peak shear force values increase and show a maximum on heating to 50-55°C (Bouton et al., 1981 and fig. 1) whereas meat shrinks only above 55°C (fig. 1)?

CHANGES IN MEAT AFTER THE ADDITION OF SALT AND ADDITIVES

It is a well known fact in the practise of meat products manufacturing, that comminuted and cooked (frankfuter type) sausages need a minimum salt concentration to hold the added water and fat. Depending on the meat protein concentration 1.3 to 1.6% NaCl are the minimum requirements. This applies

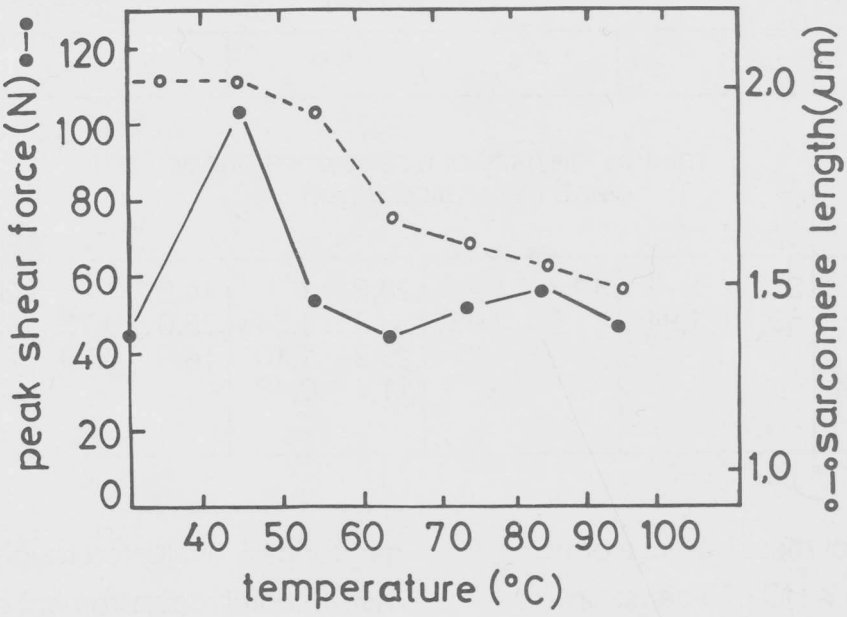

fig. 1
Influence of heating temperature on peak shear force measurements and shortening of sarcomeres

5 days post mortem slices of M. long. dorsi of young bulls (20 months old) were heated to the temperatures indicated with a rate of 2,5°C/min. In the meat after cooling to ambient temperatures peak shear force and sarcomere length were determined.

to rigor or postrigor meat comminuted with pork fat older than one day post mortem. It is also known since decades, even centuries that prerigor salted meat requires less salt (1.2 - 1.5%) for a similar effect on water and fat binding (Hamm 1986 and own unpublished results). Offer and Trinick (1983) explained what happens with the myofibrillar proteins.

The use of slaughterfresh fat used within about 10 hours after slaughter also improves water and fat binding in cooked sausages (own observations and reports from practise). What is the reason for this? What post mortem changes do we have in animal fat?

Other unsolved questions and thus research needs we encounter whith additives. Of some additives we know their mode of action e.g. diphosphate as an ATP analog (Bendall 1954, Yasui et al. 1964, Fischer et al. 1984). Citrates act as heavy metal ion scavengers (Denk, Honikel 1987). In some countries mono- and diglycerides are allowed as additives to stabilize water and fat binding in cooked sausages. As we could show (Honikel, Hamm 1983) only

monoglycerides with saturated fatty acids of 16 or more C-atoms improve the WHC of cooked sausages. Unsaturated fatty acids in the monoglycerides have a pronounced negative effect. There is a research need to solve this problem as the solution of this problem would help us to understand what happens in meat products and why the fat is dispersed and hold on cooking in these products.

CHANGES IN FAT IN MEAT AND MEAT PRODUCTS

The predominant problem of meat spoilage is the development of rancidity in meat in modern meat industry. In many countries the rancid flavour of meat and meat products surpasses the spoilage by microorganisms. Especially with the rise and paramount availability of the microwave ovens and the increasing demand for convenient ready-to-eat preprepared meals the warmed-over flavour becomes a problem. Antioxidative substances may help but the consumer demands more and more meat and meat products without or at least a minimum of additives. There is an urgent research need how to prevent or at least slow down rancidity in meat and meat products. In this respect it is not very helpful to use leaner meat as this develops rancidity even faster than fatty tissue. Apparently iron ions oxidize the phospholipids in muscular tissue membranes very rapidly. We need to know urgently how to treat meat in the best way, which non hazardous additives may be used and how to manufacture meat products without initiating the rancidity process. Basicly we need to know at first how and which compounds are involved and what reactions products are formed.

CONCLUDING REMARKS

At least in the surplus societies of our world the consumers become more and more health conscious but they demand meat products which are convenient to handle and nevertheless of best quality. The two latter requirements will be difficult to fulfill as with few exceptions (raw sausage and ham) the consumers' organoleptic anticipations of meat emanate from the fresh meat or fresh meat product. The natural occuring changes in meat and fat with time of storage the consumer has experienced rarely. In the last century several days to two/three weeks were and are the time span for fresh meat. And the meat was prepared and consumed at once. In earlier times before the time of refrigeration the period of storage was even shorter - one to several days. Our ancestors were able to cope with the problem and learned to accept meat after some storage period. I hope that again our skilled industry together with researchers solve the problems of our post-modern time and learn how to handle preheated meat. But I think researchers should start now and construct a wall against a decrease in meat consumption which in many countries gains momentum. Meat is healthy and it should remain a valuable and tasting part of our diet.

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