Post-slaughter handling and meat quality

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Introduction

Since we are ultimately aiming at satisfying the consumer who is purchasing the meat, this paper will mainly concentrate on some post-slaughter handling aspects which are of direct eminence for the sensory perception of meat by the consumer. Microbiological quality aspects and their association with these handling procedures (e.g. carcass decontamination) are not covered in my presentation.

I have decided not to restrict myself in my paper to subjects such as chilling, electrical stimulation and hot boning, but to cover also some aspects of carcass classification. After all, in most instances, this is the first post-slaughter handling. If we want to assure quality throughout the chain, the first thing is to evaluate the results of the preceeding phases before a decision is made about the further processing and destination of the carcass, sides or parts.

Carcass classification

In many European countries pig carcass classification systems based on backfat measurements and visual evaluation of shape, are likely to be replaced in the forthcoming years by instrumental classification methods such as the Danish Fat-O-Meater or the New Zealand Hennessy Grading Probe. Through probe measurement of (side)fat and muscle thickness, the meat percentage of the carcass is automatically assessed through a prediction equation.

The question is to what extent carcass type (muscularity) will still be used in addition to these objective grading systems. A lower emphasis on carcass type may certainly help to alleviate the PSE problem in some countries, due to the negative relationship which usually does exist between muscularity and meat quality.

Until recently practical and reliable methods to determine (potential) PSE carcasses at the time of classification, were lacking. However, the development of fibre optics, with determination of the scatter in the near-infrared region, appears to offer new potentials. Using the Fibre Optic Probe developed at MRI (MacDougall and Jones, 1975) at the end of the slaughterline, we found values over 130 indicative for PSE. Good results have also been obtained with the Danish Meat Quality Probe (Andersen, 1983), which is however not commercially available. With the newest generation of classification equipment, it is also possible to determine the presence of PSE, through measurements based on the same principle. Acceptable relationships were found between probe values and protein solubility of the meat the day after slaughter (Barton-Gade & Olsen, 1984). These systems are certainly of help to the meat industry in their attempts to achieve better control of the PSE problem.

In Europe visual assessment of fatness and shape are still essential elements in beef classification. The current EEC classification scheme represents a major step in standardizing carcass description. The future challenge is to make the system receptive to innovation (e.g. probe measurements, video image analysis) and special needs of individual countries, because of the market requirements of their cattle (Kempster et al., 1984).

Chilling

The current EEC meat directives require not to ship meat before an internal temperature of 7 °C has been reached in the deep round. Since there are no limits set in the directive to the chilling rate, most meat industries try to achieve this temperature within a 24 hrs cycle. Although in smaller species this may possibly also be obtained with conventional chilling methods, economic reasons (further increase of factory troughput, reduction of weight loss) have also led to the introduction of more intensive chilling regimes. In these systems carcasses are immediately after slaughter conveyed, through various compartements of chillers set at low freezing temperatures and high air velocity, before they are moved to the "holding".

A fast rate of carcass chilling is a major cause of inferior eating quality in beef, because of the induction of cold shortening. As a result there is a decrease in tenderness, which is a major determinant in the overall acceptability of meat by the consumer. The significance of this condition in various countries in Europe was nicely illustrated in the research conducted by Dransfield et al. (1982). In their survey loin steaks of 10 animals (representing two types suited for local consumption) of each of eight European countries, were assessed for eating quality at five different meat laboratories. The authors conclude in their paper that "breed, sex and age or carcass fatness were not major factors contributing to quality, which was influenced mainly by post slaughter handling... Ageing for 16 days produced the most tender meat ... The degree of toughness in 12 out of 80 steaks suggested that cold shortening had occurred".

It is generally believed that cold shortening sets in during the chilling of lamb and beef, if the conditions are such that the temperature in the muscle has fallen below 11 °C before the pH has fallen below 6.2 (Bendall, 1972). This has resulted in the rule of thumb, the socalled "ten-and-ten-rule", which recommends that lamb or beef carcasses should not be chilled below 10 °C until at least 10 hrs post mortem. Lochner et al. (1980) question the supposition that the extent of cold shortening is a major determinent of beef tenderness, since they found in their experiments tenderness not closely linked with sarcomere length. Lean slowly cooled cattle showed longer sarcomeres than fat cattle, cooled either fast or slow. Yet, the meat of the lean, slowly cooled beef was tougher. The authors suggest that slow cooling, whether achieved by fat cover or ambient manipulations, only improves tenderness if near fysiological temperatures are maintained in the musculature during the first few hours post slaughter; the so-called Very Early Post Mortem Period (VEP). It has been hypothesized (Marsh et al., 1981) that hydrolysis of protein-bonds through (neutral) proteases, when pH and temperature are at near fysiological range, may possibly explain these results. A slowly falling pH also improves tenderness, while electrical stimulation would counteract this protein hydrolysis, because of the induction of a rapid pH-fall. It seems as if there are indeed two separate mechanisms, both of which are pH and temperature dependent, although at quite different conditions and times post mortem. A good understanding of post mortem muscle fysiology is essential, if we want to avoid cold-induced toughening by the introduction of new and advanced technology.

Unlike beef and lamb, pork is in general thought not te be prone to cold shortening because of its relatively rapid pH-fall and onset of rigor mortis. In fact, an abnormally rapid pH-fall, while muscle temperature is still high, results in denaturation of soluble and structural proteins. The ultimate result is the condition known as pale, soft, exudative (PSE) pork, which is still the major quality problem in pork.

There is no doubt that the genetics of the animal, as determined by halothane phenotype (Eikelenboom and Minkema, 1974), as well as preslaughter handling, are major factors which determine the occurrence of PSE. Thus, efforts to improve meat quality should primarily be directed to the breeding of stress resistant animals and to adequate loading, transport, lairage and stunning procedures.

However, I think that in general we may also improve meat quality in swine if we lower carcass temperature more rapidly. In an experiment (Eikelenboom et al., data to be published) we kept muscle specimens, excised after debleeding, at temperatures varying from 25 - 42.5 °C for the first 2 hrs post mortem. Total driploss during the first 3 days p.m. in these samples ranged from 4.7 to 14.2 %. Samples kept at higher temperatures showed characteristics similar to PSE. Lowering carcass temperature more rapidly, would mean in practice shorter slaugherlines, in which the carcasses are opened as soon as possible and rapidly conveyed to the chillers, with preferably a high initial chilling rate.

James et al. (1983) studied the effect of ultra rapid chilling of pork. Carcasses and sides were chilled for 4 hrs at -30 °C and 1 m/sec air velocity, in comparison with chilling in air at 0 °C and 0.5 m/sec. Rapidly chilled loins were slightly darker and less saturated in colour with lower FOP-values, than conventional chilled loins. They found that there were no important differences in carcass appearance and the pork could be cut and packed immediately after ultra rapid chilling. It was demonstrated that freezing should be indeed avoided, since it produced a considerable increase in drip. However, a toughening effect of ultra rapid chilling was also observed in this study, which was probably due to cold shortening. The authors stated that the commercial significance of this finding was not clear.

Electrical stimulation

In the early seventies New Zealand research has looked into the effect of electrical stimulation (ES) on meat quality, as a means to overcome cold-shortening in lamb carcasses that were chilled or frozen in the prerigor state (Chrystall and Hagyard, 1976; Davey et al., 1976). The ES process has been implemented fairly quick in New Zealand. Research on electrical stimulation in beef (Savell et al., 1978) resulted in the installment of the first commercial equipment in 1978 in Texas. It seems that the improvement of carcass quality grade and the avoidance of the so-called heat ring, rather than the improvement of tenderness is responsible for the early adoptation of ES in commercial practice in the US. Why is the application of ES in Europe, with the exception of Norway and Sweden, still very limited? Is it because our meat industry does not get complaints about the tenderness of their meat, which they attribute to the occurrence of cold toughening? Is it because there is no benefit from ES with grading, because carcasses are nog graded here on cross-section of the longissimus at 24 hrs post mortem, as they are in the US?

As reviewed by Savell (1982) there is a considerable amount of literature on the beneficial effects of electrical stimulation: the improvement of colour, tenderness and even palatibility aspects (s.a. flavour).

The prevention of cold shortening through electrical stimulation is well accepted. But do we still have an effect on tenderness, if cold shortening conditions are supposed to be absent, either by ambient conditions or anatomical location of the muscle? In other words, does a tenderizing effect per se exist? Several authors respond positive to this question and a number of mechanisms has been suggested to be responsible for this effect, such as fysical disruption of muscle fibres (Savell et al., 1978). lysosomal damage resulting in release of proteolytic enzymes (Dutson et al., 1978) and an accelerated ageing process. Whatever the case, an improvement of tenderness can be achieved through electrical stimulation.

Once the decision is made to install ES equipment, there is a variety of stimulation systems available (West, 1982). We do have high voltage systems, in which ES is usually performed after evisceration or splitting of the carcass, and low voltage systems, which are usually used in the bleeding area. High voltage (automatic) systems allow a high volume throughput, but require also extensive safety measures. With low voltage systems, the electrodes are usually fixed to the nostrils and earth (rail). In Holland, we obtain quite satisfactory results with the automatic stimulation system we designed for use immediately after debleeding in veal.

With low voltage and particularly with extra low voltage systems, which are used in Australia (Powell et al., 1983), there is the danger of understimulation if the shackle, hook or rail are not well cleaned. There exists in my opinion also the danger of overstimulation. Beef is usually rarely affected by conditions resembling PSE in pork, because of its relatively low pH-drop. Yet, there is evidence that also in unstimulated beef, part of the variation in colour and WHC is associated with post mortem pH and temperature profiles in the muscle (Hunt and Hedrick, 1977). If a very rapid pH-decline is induced through electrical stimulation, this association might become more strict. In fact, in some of our experiments on electrostimulation we found evidence for a decreased protein solubility (Eikelenboom and Smulders, 1982) in stimulated meat, together with an increased drip loss during vacuum storage. In general, however, literature is rather conflicting as to the effect of ES on water retention (Hönikel, 1983).

In practice how do we monitor the effectiveness of the electrical stimulation process? If we use (in spite of their limitations) pH-measurements, what rate of pH-fall should we aim at? Or should we use tenderness measurements, according to the method developed by Powell et al.(1983)?

A conditioning period prior to chilling was the previous treatment for avoiding cold shortening. Although this has been replaced by electrical stimulation, the New Zealand work has demonstrated that even in electrical stimulated lamb tenderness is improved by delayed chilling or (accelerated) conditioning (Chrystall and Devine, 1982). In Europe today the technique of conditioning meat is particularly used for pre-rigor excised muscle, to avoid excessive muscle contraction and a corresponding negative effect on meat tenderness. Allowing rigor to develop at temperatures around 15 °C, both heat and cold shortening are avoided.

Hot boning

There is an increasing interest in hot boning (HB) or hot processing. The potential economic advantages of HB and immediately vacuum packaging of primal cuts are strong: a higher yield, more saleble meat, lower refrigeration costs, lower labor costs etc.

An improvement of meat quality because of less drip in the vacuum package after longer storage periods and a more uniform colour as a result of a more even cooling of the HB joints, has been shown (Cuthbertson, 1982; Taylor, 1983). With regard to the effect of tenderness, cold shortening may occur if the ambient temperature for the vacuum packed meat is not carefully controlled. Although a preceeding electrical stimulation of the intact carcass will considerably diminish this risk, we found that it is certainly not fully disappeared (Smulders et al., 1984). There is also some evidence that electrical stimulation may minimize the beneficial effects of HB on colour (Taylor et al., 1980). There are, clearly, certain potential disadvantages of the HB technique s.a. the requirement of a more strict hygiene control, the desirability of on rail boning, the unconventional shape of cuts, the synchronisation of slaughter and boning lines, trade resistance at retail level, etc. (Cuthbertson, 1982). Such factors make it difficult to introduce the technique in existing plants, which are now gradually moving to the vacuum packaging of cold boned cuts.

Closing remarks

In many beef plants in Europe, there is a great variety as to breed, sex and age in the beef presented for slaughter and, as a result, the further processing is also variable. Specialisation is probably a requirement for a succesful introduction of new technology. Fortunately, we do have some good examples here in Europe.

By hot processing of the lower valued carcasses and carcass parts and the subsequent manufacturing of comminuted meat products, the eating quality of such products might be largely controlled. However, if we want to control and improve also the quality of fresh meat with new post-slaughter technology s.a. electrical stimulation, hot boning and vacuum packaging, we need to put sufficient emphasis to their interactions with the animal production system. Only with an integrated approach throughout the chain we may achieve optimum results and products with a good and uniform quality, to the ultimate benefit of the consumer.

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