1 - 1 Developments in the pre-slaughter treatment of slaughter animals

by

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Summary

The subject of this review is developments in the pre-slaughter treatment of slaughter animals. The review concentrates mainly on pigs but cattle also receive a mention. Definitions of the term "quality" are given and the present state of our knowledge on the effect of pre-slaughter handling on relevant parameters is described. The practical utilisation of this knowledge is discussed together with future developments in the field.

Several developments are underway which must be expected to radically change the pre-slaughter treatment of animals - at least for pigs. Markets are becoming increasingly demanding with respect to meat quality, factories are beginning to optimise production processes and are becoming more aware of variations caused by meat quality differences and finally, on-line systems are being developed for the measurement of meat quality in factories. These developments will ultimately lead to producer payment according to meat quality.

The introduction of producer payments for meat quality will be the impetus necessary for improvements in pre-slaughter handling all the way from the producer up to the stunning itself, improvements that will fulfil animal welfare requirements, give factories raw material of good quality and form the best possible basis for consumer satisfaction.

For cattle, it is much easier to minimise the DFD-incidence in young bulls (via a controlled transport and lairage) than is the case with PSE- and DFD-meat in pigs. Routine measurements of pH will ultimately lead to the introduction of improvements in the pre-slaughter treatment and thus in the welfare of the animals during this time.

Introduction

The subject of this review is the pre-slaughter treatment of slaughter animals and its effect on the quality of the meat produced. The present state of our knowledge will be described as well as the developments which can be expected in the near future. My talk will concentrate mainly on pigs, as this is my own field of work, but I will also touch on cattle. For the latter my colleagues Lis Buchter and Torben Himmelstrup are responsible for the work carried out at the Institute.

First of all we must define what we mean by the word "quality". Different consumer groups - and I use the word in its most general sense - may have quite different requirements as regards quality. The ordinary consumer, for example, is primarily interested in good sensory characteristics. Appearance must be attractive or the consumer may not buy in the first place. Wide variations in colour over a muscle or cut, whether these are due to differences in water holding capacity, pH or the chemical state of the pigment present are not acceptable as is the presence of excessive bruising or blood splashing. Cuts must present a lean appearance and excessive amounts of fat will be discriminated against, even when these may actually improve palatability. After cooking all consumers require that the meat should be tasty and tender. Some consumers are beginning to make other demands regarding the meat they buy i.e. that the meat is produced under conditions which they consider to be morally and aesthetically acceptable. These consumers, who are willing to pay a premium for such meat, have mainly concentrated on the rearing aspects up till now but there is no doubt that pre-slaughter treatment will come under increasing scrutiny from this quarter.

Meat plants selling carcasses for fresh consumption require meat to have a normal quality, i.e. not PSE or DFD, to have little skin damage and no bruising or blood splashing. The emphasis which they put on these factors varies enormously and depends mainly on the requirements of their customers. If these are uncritical then meat plants may not have to consider these factors at all; if they are critical then plants may have to reject certain carcasses for particular customers. Retail chains - at least in Western Europe - are becoming more and more critical of the meat they buy for fresh consumption and increasing demands regarding quality must be expected in the future.

Pork processers require meat with good processing characteristics for the product concerned. PSE-meat leads to lower yields and poorer appearance in the finished product for both bacon and cooked, cured pigmeat products. DFD-meat leads to a poorer colour formation and shelf-life for bacon products but can be used to advantage in cooked, cured products. Processers often have sorters on cutting lines to reject PSE-meat for certain products and in Western Germany for example, DFD-meat is rejected for certain raw, cured products. Values as low as 5.8 can be used as an indicator of DFD-meat in this situation (Hilse, 1983).

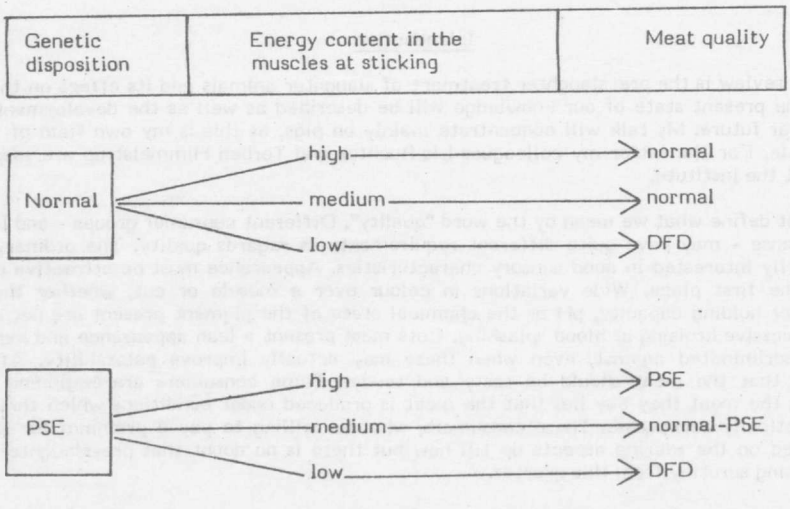
Apart from these factors the protein content i.e. the nitrogen content of the raw material is of extreme importance for the yield in e.g., cooked, cured hams for the US market. The import control uses the % PFF (protein on fat free basis) in the finished product as a measure of processing yield and product category, and failure to keep within the proscribed limits for the category concerned can have dire economic consequences for the factory. The protein content of the raw material does not have to vary very much before yields are effected. Our work has shown that a fall of 0.25% protein is approximately equal to 1% less yield in the finished product. The precentage of intramuscular fat is also of importance for the quality of cured products. Apart from its indirect influence on protein content, high levels of intramuscular fat have a detrimental effect on the appearance of the finished product. Products such as canned hams are expected to be lean and ham slices with extensive marbling will have reduced consumer appeal.

Pre-slaughter treatment does not, of course, affect all the quality factors I have mentioned but certainly for pigs the frequency of PSE- and DFD-meat, skin damage, bruising and blood splashing, and for beef the latter three, are affected as is animal welfare. I will therefore confine my attention to these factors for the remainder of my talk.

Effect of pre-slaughter treatment on meat quality - pigs

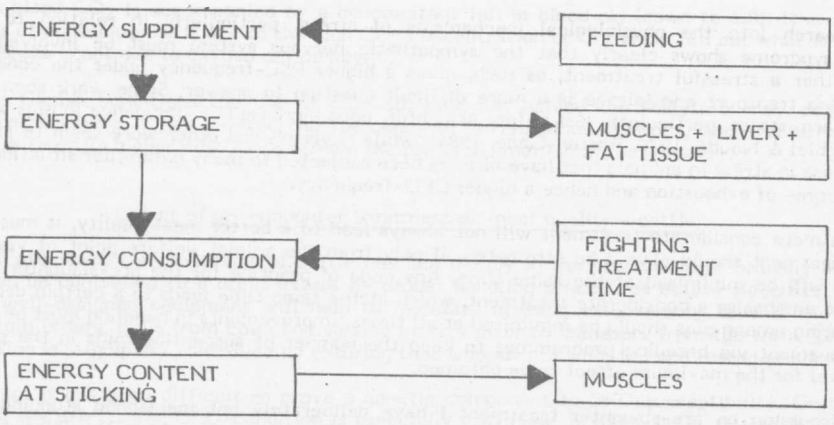
A great deal of work has been carried out over the years on the effect of transport and handling procedures before slaughter on meat quality. This has shown clearly that the PSE/DFD-status of a pig will mainly be an interaction between its genotype and the pre-slaughter environment. The effect of any pre-slaughter treatment will be dependent on the genetic predisposition of the pigs concerned, and thus identical experiments carried out in different countries will not necessarily give the same results in practice. The different aspects of pre-slaughter treatment must never be considered separately but as a whole chain of interacting events. Improvements in one sector will not lead to a positive effect on meat quality if other sectors are neglected.

The Danish Meat Research Institute has worked extensively in the field of transport and handling of pigs in the practical situation and I will use our results to illustrate the important factors influencing meat quality. Our experiments have shown that for all practical purposes only those factors which affect energy reserves in the muscle at the point of slaughter are important. Nielsen (1981) proposed the following scheme for the relationship between genotype, energy reserves and meat quality:



The scheme is, of course, simplified as pigs do not have genetic disposition for PSE or not - they have a more or less disposition for PSE, but the scheme does point to the factors which must be changed, to get the required meat quality.

The genotype of any group of pigs is fixed, so that it is only by regulating the energy reserves in muscles that meat quality can be influenced in the practical situation. Various conditions are important for the energy content of muscles:



Through the daily feeding pigs are supplied with among other things energy for their growth and maintenance. Surplus energy is stored in the liver, muscles and fat tissue. The longer the time between feeding and collection, the less is the available energy for withstanding the rigours of transport and lairage.

During transport and lairage the energy consumption of pigs will be dependent on the treatment they receive. Energy consumption will be quite different from pig to pig. Some pigs will consume large amounts of energy - especially if they fight, others will have a low consumption. Pigs genetically pre-disposed to the PSE-condition have a more rapid energy turnover than pigs not so disposed. The duration of the transport and holding period also affects energy consumption, the longer the time, the higher the energy consumption. However, with very long transport/holding periods pigs will begin to mobilise energy from depots in the fat and liver, thus rebuilding energy reserves in muscles again. Weather conditions during transport also have an effect - hot weather leading to a greater PSE-frequency, while extremely cold weather leads to a greater energy consumption, and hence a higher DFD-frequency.

Using the above information we would expect that the PSE-frequency of any group of pigs to increase with feeding on the day of slaughter, short transport and lairage times and hot weather, while DFD-frequency will increase with no feeding for prolonged periods before slaughter, long transport and lairage times, fighting and/or an inconsiderate treatment and finally very cold weather conditions. This is indeed what we find - see Table 1, which illustrates the effects of lairage time and feeding for pigs with a constant transport.

Table 1

Frequency of PSE and DFD meat in relation to feeding time and holding period

PSE: Subjective evaluation on cutting 1-2 days after slaughter

DFD: pH-value in at least one muscle > 6.5 or pH-value in two or three muscles > 6.1 1-2 days after slaughter.

Feeding condition	Holding period hours	No. of pigs	% PSE Gluteus medius and Semimembranosus	% DFD Semispinalis capitis Longissimus dorsi and Semimembranosus
Unfed	0	204	7.8	2.9
	2	206	5.8	17.0
	4	205	2.9	12.2
	24	104	1.9	20.2
Fed	0	175	13.1	3.4
	2	174	7.5	10.3
	4	177	4.0	6.2
	24	81	2.5	7.4

Source: Nielsen, 1981.

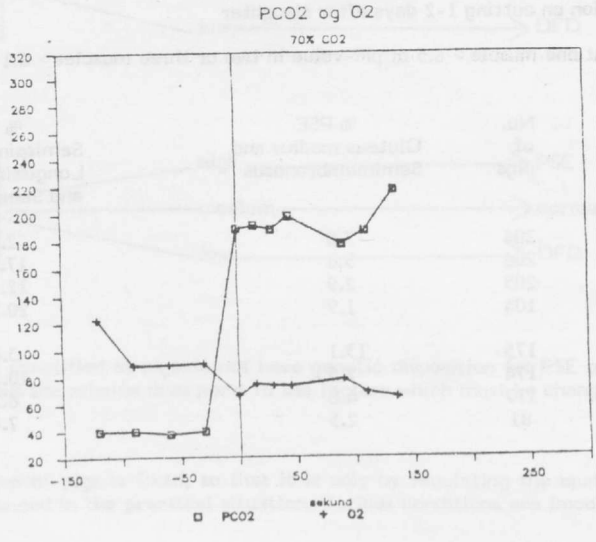
Extensive research into the physiological mechanisms of stress, particularly in relation to the malignant hyperthermia syndrome shows clearly that the sympathetic nervous system must be involved (Lister 1982). However, whether a stressful treatment, as such, gives a higher PSE-frequency under the conditions normally prevailing during transport and lairage is a more difficult question to answer. Some work seems to show that severe short-term stress, particularly just before slaughter, does increase PSE-incidence in pigs with high energy reserves (Klingbiel & Naudé, 1976, Barton-Gade, 1984), while Nielsen's and other work seem to point to the fact that any increase in stress in animals that have already been subjected to many unfamiliar situations will only lead to a greater degree of exhaustion and hence a higher DFD-frequency.

Even though a more considerate treatment will not always lead to a better meat quality, it must be emphasised that such a treatment should always be attempted, if only from the animal welfare point of view. Bruising and other damage will be minimised at the same time. Any code of practice for the pre-slaughter handling of pigs must therefore emphasise a considerate treatment, which at the same time leads to a certain decrease in energy reserves. Fighting among pigs should be minimised at all times. Improvements in handling must be accompanied by genetic improvement via breeding programmes to keep the number of susceptible pigs in the population at an acceptable level for the maximum effect to be obtained.

In all this discussion on pre-slaughter treatment I have deliberately not mentioned stunning method or the treatment immediately prior to stunning. Automatic systems for getting pigs from the lairage to the point of stunning can be very stressful, as a certain amount of force must often be used to ensure a constant stream of pigs. The most critical point in the system is at the entrance to the race, where the group must separate and go single file. This is probably the only point in the whole of the pre-slaughter treatment where the use of an electric goad is really necessary. Grandin (1980a) has reviewed many different layouts and designs but it is probably fair to say that the ideal system has not yet been found. Education of abattoir personnel will help to reduce stress at this point but will never eliminate it entirely and one of the future challenges must be the development of systems to transport pigs to the point of stunning with a minimum of force being necessary.

Regarding stunning itself there has been a great deal of debate. Dutch workers (Hoenderken 1978, Hoenderken et al. 1979, Wal 1978) maintain that high voltage electrical stunning causes instant unconsciousness and must be preferred to CO_2-stunning which first causes a loss of consciousness about 20 sec. or so after exposure to CO_2-gas. They state that pigs experience pain during this initial period, that they are suffocated and not stunned, and for this reason CO_2-stunning is no longer used in Holland.

Others - mainly Danish medical specialists - have contested these statements. They say that CO_2-anaesthesia is like anaesthesia with any other kind of anaesthetic gas. There are three phases, a phase of induction, a phase of excitation and a phase of anaesthesia. On the basis of experience gained from the CO_2-anaesthesia of pigs in an experimental chamber they maintain that pigs do not seem to experience any sensation of pain during the initial exposure to CO_2 and that they are not conscious when the phase of excitation sets in. A Committee was set up in Denmark to investigate CO_2-stunning in pigs in the light of the Dutch accusations. The results of their work, soon to be published, show that although the blood concentration of CO_2 is high within seconds of the application of a 70% CO_2-air mixture, the O_2-concentration falls only slightly with shorter stunning times i.e.less than 2 minutes:



Source: Barfod et al. (1985)

The increase in blood CO_2 is accompanied by a concomitant fall in blood pH (down to 6.8). It is difficult to say whether the loss of consciousness is due to the high CO_2 concentration or to the pH fall but what is certain is that loss of consciousness is not due to oxygen deficiency.

Certainly under Danish conditions the use of CO_2-stunning has halved the PSE-frequency compared to high voltage electrical stunning; it has lowered the frequency of severe blood splashing and fractures, and for this reason - and in spite of its higher cost - will remain the preferred method in that country.

Effect of pre-slaughter treatment on meat quality - cattle

The emphasis in pre-slaughter treatment of cattle has lain mainly in the prevention of bruising and DFD-meat. Both defects can be controlled to a great extent by proper handling procedures before slaughter. A considerate treatment and well-designed equipment will help to minimise bruising considerably as will the separation of horned cattle from others, bulls from cows and sorting by size prior to transport from the farm (Grandin, 1980b). The DFD-condition is principally controlled by ensuring that animals are well-fed and rested at slaughter.

In contrast to pigs it has been difficult to prove a genetic component to DFD-susceptibility. On the other hand there is a strong sex effect. The DFD-condition is especially prevalent in young bulls, is less frequent in heifers and steers and only seldom seen in cows (Tarrant, 1981). Feeding cattle after arrival at the slaughter plant is not feasible as a method of preventing DFD-meat, as it takes more than 2-3 days for glycogen levels to return to normal (McVeigh, 1982). Thus, the emphasis must lie in reducing energy consumption during transport and lairage.

Direct delivery from farm to slaughter plant is important. As long ago as the late 1960's Buchter showed that calves delivered via markets or kept in overnight lairage had more than 3 times the DFD-incidence of calves delivered directly and slaughtered on the day of arrival and therefore the industry was advised to transport animals directly (Buchter, 1975).

Mixing strange cattle is an important factor leading to the DFD-condition in young bulls. Strange cattle should therefore - where at all possible - be kept separate from one another during transport and lairage.

Short lairage times at the slaughter plant are another important component for reducing DFD-incidence especially when dealing with loose cattle. Himmelstrup (1985) recently described recent Danish developments in handling facilities for slaughter cattle and he recommends that sensitive categories such as young bulls should be slaughtered as soon as possible after arrival at the abattoir, and moreover that they should be penned separately during lairage.

Utilisation of knowledge in practice

From the foregoing it can be seen that we have a considerable amount of knowledge regarding the treatment of slaughter animals but is it being utilised by the industry? The answer is - unfortunately - to a limited degree only. Some results have been incorporated into national legislation. In some countries research is carried out by industry itself and thus has the best possible basis for the utilisation of relevant results. However, the co-ordination necessary - a co-ordination which must reach all the way from the producer up till the point of stunning - is often not possible, as producers, hauliers and factories are essentially independent of one another.

Producer economy is to a large extent independent of meat quality or carcass damage. Payment is at best based on slaughter weight and some form of carcass classification. This is true even in countries with co-operatives, where factory economy does have consequences for producers, because the consequences are indirect and not readily apparent. Transport is mainly carried out by independent hauliers whose task is to transport animals from the producer to the factory as cheaply as possible and whose vehicles will only fulfil the necessary requirements of national legislation. They receive no premium for a good transport and are even covered by insurance for losses during transport. Finally, abattoirs are often entirely independent of both hauliers and producers and must buy animals where they can get them. Factories making demands on the treatment of the animals they buy may not get the animals they need. We can say that the whole system is built up in such a way that co-ordinated efforts to improve pre-slaughter treatment will meet with difficulties all the way through the journey from the producer to the factory.

However, there are now developments on the scene which in my opinion will revolutionise the pre-slaughter treatment of animals - at any rate for pigs. Firstly, markets are increasingly making demands regarding meat quality, blood splashing etc. and are willing to pay a premium for meat of guaranteed quality. The Japanese market comes to mind as an example here. Secondly, systems are being developed for the on-line measurement of meat quality in factories - at present mainly in Western Europe. Finally, factories are beginning to optimise production processes and are becoming more and more aware of the variations caused by differences in meat quality.

The development of on-line systems is particularly significant and many Western European countries are at present actively investigating the application of various probes for this purpose. We are also developing equipment in Denmark based on continuous probe measurements using the so-called MQM-meter (Meat Quality Marbling). This equipment, which registers internal reflectance to a depth of about 10 cm, gives a good indication of water holding capacity (Barton-Gade & Olsen 1984) and to a certain extent also of marbling.

With an experienced worker probe measurements can be carried out at the rate of about 200 pigs per hour with 2 measurements per pig and the results are given immediately on a printer and can be stored at the same time on a floppy disc. The equipment, which at present is only used the day after slaughter is now under extensive testing on

Danish factories. It has been found to be highly advantageous in sorting meat quality and optimising production processes.

Routine measurements of meat quality on factories immediately expose both producer differences and variations due to pre-slaughter treatment e.g. lairage times. We have measured wide differences between producers whose pigs have received essentially the same pre-slaughter treatment, i.e. from 2-30% PSE. Danish factories have estimated that a PSE-carcass is on average 20% less value to them than a carcass of good meat quality - due to higher drip, lower yields, canalisation to special productions etc. and they will increasingly focus on producer differences. Other factors, of course, affect the ultimate meat quality of pigs, and the first that will happen will be that factories will put their own house in order. Lairage times will become standardised as will lairage conditions. The factories will make recommendations to producers and hauliers regarding delivery systems at the farm and transport to the factory - and moreover, they will be willing to pay a premium for the fulfilment of these recommendations. When this has occurred - and the knowledge to do this is available, then producers will also be paid according to meat quality.

This scenario may seem somewhat farfetched to some and certainly the developments will come in some countries before others. However, I am in no doubt that they are on the way for pigs as well as for cattle. In truth, future delivery systems as I have described here will fulfil animal welfare requirements; they will result in a good quality raw material for factories and will form the best possible basis for consumer satisfaction.

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