DEVELOPMENT OF A STANDARDIZED PROCEDURE FOR THE SLAUGHTER OF EXPERIMENTAL BEEF ANIMALS FROM THE DANISH PROGENY STATION "EGTVED"

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Lis Buchter

Danish Meat Research Institute, Roskilde

Introduction

Since 1967, progeny testing for meat production in cattle has been centralized at the experimental station "Egtved". Every year 30 sire progeny groups are tested. Each sire is represented by 18 sons of which 10 are slaughtered as 250 kg calves and 8 as 450 kg young bulls. The Danish Meat Research Institute is responsible for the determination of carcass composition and meat quality in these animals.

With the publication of Locker & Hagyards (1963) findings on how the state of contraction in the muscle fibers could be influenced during the development of the rigor processes, it became evident that it was necessary to investigate the significance of these findings under practical conditions. The main part of the investigations was directed towards the chilling conditions but at the same time smaller experiments dealing with transportation, splitting, cutting up, and ageing had to be undertaken. These latter experiments were by no means exhaustive, but were carried out to form a base of information from which a standardized procedure for the treatment of animals from the experimental station could be established with a reasonable degree of reliability.

The standard procedure was chosen so that it would not only give reproducible results in the evaluation of the meat quality in the experimental animals, but that it would also be recommendable as a procedure which could give good meat quality in commercial animals.

General Methods. The experimental material from which the described results are obtained consisted of 250 kg commercial calves and 450 kg young bulls from the progeny testing station. Only results from animals with a normal final pH in the longissimus dorsi muscle are included. Chilling and storage of carcasses and sampling and ageing of samples has, when nothing else is indicated, followed the procedure described for the experimental animals from the progeny testing station.

Determination of tenderness. Sheraforce values were obtained on a 6 cm thick steak of longissimus dorsi (1. lumbar vertebrae). The sample was cooked in boiling water to an internal temperature of 72°C with thermocouples. Six 10 x 20 mm strips were cut from the centre of the sample parallel to the fibres. The shearforce value indicates the average force in kg which was required to bite through one of the strips with the 20 mm wide rounded wedges of the Volodkewich apparatus (Grünewald, 1957). Taste testing evaluations were performed by a trained panel of 9 housewives. 22 mm wide steaks were sawed from frozen samples. After thawing the steaks were prepared on a 170°C griddle plate without addition of any fat, to an internal temperature of approx. 70°C by cooking for a set number of minutes. The samples were evaluated for colour, taste, tenderness, juiciness, and overall impression on a hedonic scale from -5 to +5, where 0 is neither good nor bad.

Transportation. Very little information is available on how the meat quality in young beef animals can be influenced by the conditions of transportation and by a period of rest in the lairages of the slaughter-house. Even less is known about the effects of excitement immediately prior to slaughter. Transportation and stay in strange environments are stressors which can lead to a depletion of the muscle glycogen and thus result in a high value for the final pH in the meat.

This was confirmed in a preliminary survey of the incidence of meat with high final pH among commercial calves slaughtered at a major Danish slaughter-house. The pH_{∞} was measured in the lumbar part of the longissimus dorsi with a transportable pH-meter and spear electrodes. The figures presented in table 1 summarize a total of 3 series each covering one week in the months of November, February, and May, respectively.

The results showed that among animals transported directly from the farm to the slaughter house and slaughtered on the day of arrival only very few had meat with high pH_{∞}, while the incidence was almost one out of ten in the calves which had been sold via a market or which had spent a night in the slaughter-house lairage.

It is doubtful whether a stay in the lairage after arrival at the slaughter-house is restful, and the procedure chosen for the experimental animals is, therefore, the following:

The animals are collected at 5 o'clock in the morning and transported according to the regulations for transportation of live animals. The distance is 120 km on good roads. The live animals are weighed on arrival. The slaughtering starts at 8:30 and the animals have seldom spent more than 1/4 - 1/2 hour in the lairage.

Since 1967 a total of 1500 animals have been slaughtered. Only 0.5-1.0 % of these animals have been omitted from the meat quality evaluation because they had a pH of 5.8 or higher in the longissimus dorsi. Bruises and bleedings in the meat are, however, found with some frequency.

Slaughtering. Animals from the experimental station are slaughtered according to the methods used at the slaughter-house. All changes in these methods are registered and the animals are always slaughtered quickly so that they can hang in the chilling room within 45 min. post mortem.

The final meat quality might be influenced during the slaughtering especially by the processes of stunning, dehiding, splitting, and washing. Of these factors only the time and method of splitting have been investigated. The results are shown in table 2. In the first experiment the muscles, due to circumstances, had to be cut from the carcasses already one day after slaughter and the results became completely dominated by the increase in toughness found to be induced by this procedure. In the second experiment the influence of the chilling temperature was minimized by chilling at 10°C. No significant differences due to time or method of splitting could be found in any of the two experiments.

Calves from the experimental station are split 2 days after slaughter while the young bulls are split by saw on the slaughter line.

Chilling. The cold shortening effect was first investigated by Locker & Hagyard (1963). They found that excised prerigor muscle shortened quickly and progressively when cooled towards 0°C. Marsh & Leet (1966) showed the relation between % shortening and toughness. In the same paper the authors also suggested how cold shortening could take place in muscles suspended on a skeleton by stretching in some zones and contracting in others.

The influence of the conditions of chilling on the meat quality has been investigated in several series of experiments. The results, which are to be published in detail, are summarized in table 3. Chilling temperatures of 10°C, 8°C, 6°C, 4°C, 2°C, 0°C, and rapid chilling in tunnels were investigated. Right and left sides of the carcasses were chilled at different temperatures for 24 hours post mortem whereafter both sides were transferred to 4°C for final chilling.

From table 3 it can be seen that with a decreasing temperature in the chilling room an increasing number of the animals had meat which was tougher, i.e. as the temperature fell the figures for the average shear-force and standard deviation for the shearforce values increased while the average tenderness score decreased. The results suggested that young bulls which have a larger muscle mass than calves could be chilled at slightly lower temperatures before the increase in toughness was extensive.

For hygienic reasons the temperature in the chilling room should not be higher than 7 °C. It was therefore chosen to chill the experimental animals at 6 °C during the first day after slaughter. This means that the effect of the chilling temperature is small, but not negligible. It is therefore important that not only the temperature, but also the chilling rate is kept as constant as possible for all animals.

Chilling room. The slaughter-house provides a 7.5 x 8 m room with five rails of 6 m. When experimental animals are slaughtered the room is filled within 1 hour with either 9 calves or 10 half beef carcasses on each rail. The carcasses are hung with the breastbone facing the direction of the airflow and the position of the carcasses is marked with coloured bands on the rails to ensure an even distribution. The guiding vanes are adjusted so that the air velocity over rump, back and neck of all carcasses is close to 1 m/sec. The temperature is regulated with a thermostat and can be kept constant at 6 °C ± 1/4 °C already shortly after the filling of the room is completed.

Cooling storage. The influence of the chilling temperature on the toughness of the meat is not as critical during the later part of the rigor processes as during the first part. Early in the morning the day after slaughter (21 hrs post mortem) the experimental animals are weighed and transferred to 4 °C for further chilling and storage. Fluctuations in the temperature over short periods of time are tolerated but the average temperature in the room should be held within 4 °C ± ½ °C.

Cutting up. Although temperature changes during the second day post mortem only have little influence on the toughness of the meat, it is absolutely detrimental for the meat quality to cut muscles from the skeleton already 24 hrs post mortem (see table 3). An explanation of this finding could be that sufficient energy is available at this point to effectuate some of the contraction for which the tension is built up by the low temperatures. As long as the muscles are suspended on the skeleton this contraction is to some degree restricted, but when the muscles are cut loose the contraction can take place. For practi-

cal reasons it is desirable to be able to cut up the carcasses as early as possible after slaughter.

Table 4 shows the results from an experiment with 20 calves where the longissimus dorsi was cut from left or right sides either 1, 2, 3, 4, or 6 days post mortem. The cut muscles were aged in the same room as the carcasses. Sampling and calculations were done according to a balanced incomplete block design (5 treatments, 20 blocks, 2 units per block, 8 replications). The figures shown are adjusted for block differences. The results showed that the carcasses should be left intact at least until the second day after slaughter. No differences in toughness could be found among samples cut 2 to 6 days post mortem.

All muscles for evaluation of meat quality from experimental animals are removed from the carcasses ca. 46 hrs post mortem. The actual cutting up of the carcass into meat, fat and bone is performed 2 or 3 days after slaughter according to the number of animals to be treated.

Samples. Traditionally the longissimus dorsi muscle is used for evaluation of meat quality. The loin of the right side is divided between the 1. and 2. lumbar vertebrae, while the half side is still hanging. A photo is taken to record the area of the muscle. The sample for the taste panel consists of the part of longissimus dorsi corresponding to the 5. to the 2. lumbar vertebrae. The sample for laboratory determinations corresponds to the 12., 13. thoracic- and the 1. lumbar vertebrae. The samples are cut directly from the hanging carcass and packed in plastic bags. They are shipped 300 km by rail in 30 l containers. The addition of 1 liter ice in cans ensures that the temperature in the samples can be kept under 5 °C during the transportation.

Ageing. It was chosen to age the samples at 4 °C. This temperature which is a continuation of the cooling storage, provides a reasonably fast rate of ageing without giving excessive bacterial growth.

Table 5 shows the results from experiments where longissimus dorsi muscles from calves and young bulls were aged for different periods of time at 4 °C. The design of the experiment was a balanced incomplete block design, where the number of samples from each muscle equated the number of treatments (periods of ageing). From development of the shearforce results it can be seen that no significant increase in the tenderness of the longissimus dorsi muscle can be found after ageing for 4 to 5 days after slaughter for calves and after ageing for 8 to 10 days for young bulls.

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Table 1

Frequency of $pH_{\infty} \geq 6.2$ in the longissimus dorsi muscle in 250 kg commercial calves as related to trade route and holding time in the slaughter-house lairage.

Time of holding on slaughter-house	Trade route	Number of calves examined	% $pH_{\infty} \geq 6.2$
Slaughtered on the day of arrival	Farm - slaughter-house	296	2%
	Farm - market - slaughter-house	187	9%
Overnight stay	Farm - slaughter-house	34	(9%)
	Farm - market - slaughter-house	353	9%

Table 2

Method of splitting and time when it was performed in relation to tenderness in aged longissimus dorsi muscle from calves.

Experimental conditions different from standard procedure	Method and time post mortem of splitting		No.	Shearforce value		Tenderness score	
				$\bar{x}$	s	$\bar{x}$	s
Experiment 1:							
Chilling temperature 4 °C	Axe	½ hr	6	30.1	9.8	-1.9	2.1
Muscles were cut from skeleton 24 hrs post mortem	Saw	½ hr	5	28.9	6.0	-2.3	0.6
	Ax	4 hrs	5	29.3	11.1	-2.2	0.9
	Axe	26 hrs	7	25.4	6.3	-2.3	0.5
Experiment 2:							
Chilling temperature 10 °C	Axe	½ hr	8	8.4	3.3	+1.4	1.8
	Axe	25 hrs	8	7.7	2.0	+1.5	0.8

Table 3

Temperature in chilling room as related to tenderness in aged longissimus dorsi muscle from calves and young bulls.

Temperature in chilling room	Calves [x]				Young bulls [xx]			
	Number of animals	Shearforce value $\bar{x}$	s	Tenderness score $\bar{x}$	s	Number of animals	Shearforce value $\bar{x}$	s	Tenderness score $\bar{x}$
10 °C	45	8.6	2.3	1.3	1.1	-	-		-
8 °C	6	10.0	2.0	0.9	0.7	-	-		-
6 °C	44	10.5	4.0	1.2	1.4	32	8.1	2.2	2.7
4 °C	21	13.7	5.6	0.3	1.2	8	10.2	5.3	1.7
2 °C	-	-		-		12	9.6	4.0	1.8
0 °C	-	-		-		12	12.2	4.7	1.4
Tunnel then + 1°C	7	24.5	3.7	-1.3	0.8	-	-		-
Least significant difference between two treatments at 5% level (approx.)		2.3		0.8			2.8		1.1

x) Summarized from several different experiments.

xx) All right sides were chilled at 6 °C.

Table 4

Time post mortem when muscle was cut from skeleton in relation to tenderness in aged longissimus dorsi from calves.

Time of cutting muscles from the skeleton	Shearforce value	Tenderness score
24 hrs post mortem (1 day)	21.5	-0.44
48 hrs post mortem (2 days)	10.6	+0.82
72 hrs post mortem (3 days)	11.0	+1.01
96 hrs post mortem (4 days)	10.0	+1.63
144 hrs post mortem (6 days)	11.1	+0.77
Significant difference between two treatments at 5% levels	4.9	0.98

Table 5

Ageing time at 4 °C related to tenderness in longissimus dorsi muscle from calves and young bulls.

Type	Calves						Young bull			
Number of animals	6 x)		12 x)		12		4		6	
Samples aged until:	Shearforce values									
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
2 days post mortem	18.2	8.5	11.8	5.1	-		-		-	
3 days post mortem	-		10.6	5.0	-		19.1	4.8	16.7	4.
4 days post mortem	10.2	2.8	8.5	3.1	-		14.3	4.6	-	
5 days post mortem	-		-		-		12.6	4.0	11.6	2.
6 days post mortem	8.1	2.3	8.2	3.0	10.8	3.3	-		-	
7 days post mortem	-		-		10.9	3.9	11.3	2.5	11.4	2.
8 days post mortem	8.3	2.1	7.7	3.5	10.7	3.2	-		-	
9 days post mortem	-		-		-		9.9	2.1	-	
10 days post mortem	7.4	1.7	-		-		-		8.4	2.
14 days post mortem	-		-		-		-		8.8	2.

x) Chilled at 10 °C.