FIBRE OPTIC PROBE MEASUREMENTS IN LANDRACE PIGS OF DIFFERENT HALOTHAN PHENOTYPES

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INTRODUCTION

The assessment of pork quality through measurement of muscle reflection or scatter via fibre optics has become of increasing interest in recent years. This is in particular so, since in principle these methods potentially allow a non-destructive on-line measurement of pork quality. For these purposes special equipment has been developed such as the British Fibre Optic Probe (FOP; McDougall and Jones, 1981) and the Danish Meat Quality Probe (Barton-Gade and Olsen, 1984). Also some of the presently in EEC countries introduced equipment for instrumental classification, s.a. the Hennessy Grading Probe (HGP_2) and the Fat-O-Meat'er (FOM) offer this option.

In various studies the relationship between slaughterline measurements with the FOP or HGP_2 and ultimate meat quality attributes, appeared to be of a low to moderate nature (Lundström et al., 1987; Tarrant and Long, 1986; Van der Wal, 1987).

On the other hand in German studies (Sack et al., 1984), using the FOM, much better relationships were found between slaughterline measurements and ultimate meat quality. It seems reasonable to assume that apart from possible differences in technical performance of the equipment used, difference in the post mortem rate of development of abnormal colour between the pig populations used, might be responsible for these varying results.

Previous studies from our laboratory have shown distinct differences in stress-susceptibility, post mortem glycolytic rate and ultimate meat quality between halothane-negative (HN) and halothane-positive (HP) Dutch Landrace pigs (Eikelenboom and Minkeman, 1974; Eikelenboom et al., 1976, 1078). The indication of a recessive inheritance of the halothane gene (Minkema et al., 1976), has lead to an exploitation of the halothane test in many pig breeding programs (Kallweit, 1985) in order to control the frequency of the gene. Yet, the frequency of the gene in the Landrace still varies considerably between European countries (Webb, et al., 1987).

The aim of the present study was to determine in HP and HN pigs the potential of FOP measurements, taken at various times post mortem, to predict ultimate meat quality.

MATERIAL AND METHODS

The animal material consisted of purebred slaughterpigs, which were derived from one of the synthetic Landrace breeding lines of a commercial hybrid breeding company. Al pigs were halothane-tested (Eikelenboom en Minkema, 1974) at 7 - 9 weeks of age. A total of 70 halothane-positive and 70 halothane-negative pigs were used. The animals were slaughtered in four batches, spread over 4 difference days distributed over a 6 weeks period. Two out of the 4 batches were exactly balanced for halothane-phenotype, the other two almost.

After a transport period of 1 h, the pigs were subjected to a 2 h resting period in lairage. All batches were slaughtered in the same commercial abattoir.

After weighing at 45 min post mortem (p.m.) measurements were made of the pH (Schött, model CG 818; Ingold pH-electrode, model LOT 406) of the M. glutaeus medius (GM) and M. semimembranosus (SM), temperature (GM) and rigor (SM). In addition, Fibre Optic Probe (FOP; TBL Fibres Ltd., Leeds, England)

Table 1. Results of Carcass and Meat Quality (longissimus) Measurements in Pigs of Different Halothane-phenotype.

Item	LSM ± s.e.		Level of significance	
	Halothane negative	Halothane positive	Phenotype	Day of slaughter
n	70	70		
pH_1 (SM)	6.28 ± 0.03	5.74 ± 0.03	***	*
pH_1 (GM)	6.29 ± 0.03	5.79 ± 0.03	***	**
pH_3 (GM)	5.89 ± 0.03	5.70 ± 0.03	***	ns
T_1 (°C) (GM)	40.7 ± 0.1	41.7 ± 0.1	***	***
Rigor value	6.7 ± 0.3	10.6 ± 0.3	***	ns
FOP_1 (LD)	108 ± 2	148 ± 2	***	ns
FOP_3 (LD)	125 ± 2	148 ± 2	***	***
FOP_{17} (LD)	130 ± 2	153 ± 2	***	***
pH_u	5.48 ± 0.02	5.49 ± 0.02	ns	***
Drip loss (%)	5.3 ± 0.3	6.7 ± 0.3	***	***
Heating loss (%)	27.4 ± 0.2	27.3 ± 0.3	ns	***
L*-value	55.2 ± 0.5	61.6 ± 0.5	***	ns
a*-value	5.3 ± 0.1	5.5 ± 0.1	ns	**
b*-value	15.4 ± 0.1	16.5 ± 0.1	***	ns
Colour score (Jap.)	2.7 ± 0.6	1.8 ± 0.7	**	ns
Overall score (1-4)	1.9 ± 0.8	2.8 ± 0.8	**	ns
Transmission (%)	27 ± 3	56 ± 3	***	***
Sarcomere length (µm)	1.60 ± 0.01	1.67 ± 0.01	***	ns
Fat content (%)	3.0 ± 0.3	2.6 ± 0.3	ns	*

ns: not significant; P ≤ 0.05; ** P ≤ 0.01; *** P ≤ 0.001

Table 2. The relationships between certain meat quality traits in halothane positive/ halothane negative pigs.

	pH_1 (GM)	pH_1 (SM)	FOP1 (LD)	FOP3 (LD)	FOP17 (LD)	Drip loss	L*-value	Overall score	Trans-mission
pH_1 (GM)	--								
pH_1 (SM)	$^{+.27}/_{+.62}$	--							
FOP1 (LD)	$^{-.60}/_{-.56}$	$^{-.48}/_{-.50}$	--						
FOP3 (LD)	$^{-.45}/_{-.60}$	$^{-.53}/_{-.53}$	$^{+.65}/_{+.64}$	--					
FOP17 (LD)	$^{-.51}/_{-.49}$	$^{-.32}/_{-.56}$	$^{+.77}/_{+.57}$	$^{+.72}/_{+.84}$	--				
Drip loss (%)	$^{-.44}/_{-.57}$	$^{-.26}/_{-.55}$	$^{+.48}/_{+.60}$	$^{+.47}/_{+.68}$	$^{+.64}/_{+.75}$	--			
L*-value	$^{-.50}/_{-.37}$	$^{-.43}/_{-.36}$	$^{+.60}/_{+.48}$	$^{+.62}/_{+.62}$	$^{+.75}/_{+.71}$	$^{+.62}/_{+.62}$	--		
Overall score	$^{-.44}/_{-.56}$	$^{-.28}/_{-.56}$	$^{+.62}/_{+.67}$	$^{+.67}/_{+.75}$	$^{+.74}/_{+.74}$	$^{+.57}/_{+.78}$	$^{+.76}/_{+.71}$	--	
Transmission (%)	$^{-.54}/_{-.62}$	$^{-.26}/_{-.51}$	$^{+.60}/_{+.74}$	$^{+.64}/_{+.81}$	$^{+.74}/_{+.78}$	$^{+.51}/_{+.77}$	$^{+.68}/_{+.60}$	$^{+.61}/_{+.73}$	--
pH_u	$^{+.34}/_{+.28}$	$^{+.28}/_{+.30}$	$^{-.46}/_{-.35}$	$^{-.57}/_{-.50}$	$^{-.60}/_{-.67}$	$^{-.59}/_{-.72}$	$^{-.55}/_{-.62}$	$^{-.60}/_{-.57}$	$^{-.40}/_{-.59}$

$r = .24 : P \leq 0.05$; $r = .31 : P \leq 0.01$

measurements were made of the M. longissimus (LD) between 3rd -4th from last rib. After the initial chill, at 3 h p.m., measurement of pH (GM) and FOP (LD) were repeated, while FOP measurements were also made the next day, at 17 h post mortem.

After cutting at 18 h p.m., the LD was removed at the 2 - 4 lumbar vertebrae. A slice of 2 cm thickness was removed from this sample and weighed as the starting point for the determination of drip loss. All samples were subsequently packed and transported (0 - 2°C) to the laboratory for further assessment of meat quality.

In the laboratory meat quality was scored visually by an experienced panel for colour, exudate and texture on a O(DFD) - 4 (extreme PSE) scale, while in addition the colour was visually judged using the Japanese colour scale (1 = extreme PSE; 6 = extreme DFD; Nakai et al., 1975) Further, meat colour was objectively determined by measuring (CIELAB) L*-, a*- and b*-values with a Hunter Labscan (lightsource D65, 10 standard observer, 30 mm aperture).

Drip loss was assessed by using the method described by Hönikel (1987). Slices were, after mopping dry, reweighed after 40 h storage at 1 - 3°C and drip loss was expressed as a percentage of the initial weight. Thereafter, the same samples were vacuumised (under low pressure) and heated in a waterbath for 1 h at 70°C. After cooling for 0.5 h in running tap water, the percentage heating loss was determined and expressed as to a percentage of the initial weight.

Protein solubility (perc. transmission) was determined using the procedure of Hart (1964) and fat content by the Soxhlet procedure (ISO 1444). From five randomly distributed locations on the crossection of the LD, samples were collected for replicate measurements of sarcomerelength, using the laser diffraction technique described by Voyle (1971).

The data from the instrumental measurements were analysed with an analysis of variance model including the fixed effects 'halothane phenotype' and 'day of slaughter'. For the statistical analysis of visual meat quality scores, a modified Wilcoxon test was used and, furthermore, simple correlations coefficients of all traits were computed for each halothane phenotype separately HP and HN pigs were classified as PSE (score 3 and 4) and normal (score 1 and 2) and the differences between phenotypes within each quality category was tested by t-test.

RESULTS AND DISCUSSIONS

In Table 1 the results from the carcass measurements, taken at 45 min (1), and 3 and 17 h p.m., are reported and for HP and HN pigs separately, together with the levels of significance for the model used.

A significant effect was found for day of slaughter in pH and temperature measurements taken in the slaughterline. Also such an effect existed for the FOP-measurements taken at 3 and 17 h, but not at 45 min post mortem. These effects are often observed in meat quality studies for various traits (see Table 1) and frequently there is no obvious explanation, other than to recognise that they do exist.

As found previously, HP pigs showed a more rapid post mortem pH-fall and onset of rigor mortis, as well as a higher muscle temperature than HN pigs (Eikelenboom and Minkema, 1974; Eikelenboom et al., 1976, 1978).

At all three measuring moments a significant difference in FOP-readings was found between HP and HN pigs, the largest difference being at 45 min post mortem. The results here suggest that FOP measurements taken at 45 min are largely affected by the halothane phenotype. This is of importance for situations where, based on slaughterline measurements with equipment using a similar measuring principle, payment for meat quality to the producer is considered.

Table 1 also presents the results of meat quality measurements in the LD sample. Based on the visual evaluation (overall score) meat quality 49% of the HP

and 10% of the HN pigs showed slight PSE (score 3), and 20% and 4% serious PSE (score 4) respectively. Thus, the total incidence of PSE was 5 times higher in HP than in HN pigs. Also the differences found in meat colour and protein solubility (perc. transmission) between HP and HN pigs are in agreement with our studies mentioned before. The lower intramuscular fat percentage found in HP pigs might be explained from the leaner carcasses of HP pigs found in various studies. A significant difference between both halothane-phenotypes was also found in driploss during 48 h, although the difference was not as large as expected. Sarcomere length, but not ultimate pH and per cent heating loss differed between HP and HN pigs.

In Table 2 the simple correlation coefficients between certain carcass measurements and traits of ultimate meat quality, are shown separately for each halothane phenotype. The results indicate that the relationship between slaughterline measurements and ultimate meat colour (L*-value) is higher in HP pigs than in HN pigs, while for the relationship with percentage drip loss the reverse is true. The latter might be explained from the following observation. Within the total of 58 pigs that showed PSE (score 3 and 4), the HP pigs had a significant (P.01) lower driploss (7.5 vs 10.2%) than the HN pigs, which was associated with a higher ultimate pH (5.44 vs 5.25; $P < 0.01$). Furthermore, although between PSE pigs of the HP and HN phenotype, FOP_1 (157 vs 127; $P < 0.01$) and pH1 (SM; 5.69 vs 5.93; $P < .01$) were significantly different, this was not so for pH (GM), rigor, FOP_3, FOP_{17}, L*-, a*-, b*-values, per cent transmission and heating loss. Apparently, the HN/PSE pigs also exhibit a fast post mortem pH decline. Therefore, it is unlikely that a similar phenomenon is present here as in the Hampshire breed, where the post mortem pH fall is normal, but a low ultimate pH causes poor waterbinding properties (Monin and Sellier, 1985). Yet, ultimate pH played here also an important role in the HN pigs, since drip loss was higher correlated with pHu (-.72) than pH1 (GM; $r = -.57$) in these pigs (Table 2).

Also in the HP and HN pigs with normal quality (score 1 and 2), there was a higher ultimate pH for HP than for HN pigs (5.62 vs 5.51; $P < 0.05$), although drip losses were not significantly different (4.90 vs 4.58%). It should be pointed out that the HN pigs consist of pigs of the homozygote (NN) and heterozygote (Nn) genotype (Minkema et al., 1976), the latter being the majority in this material.

The results presented here suggest, at first, that although selection for HN pigs in the Landrace will drastically decrease the PSE frequency, the remaining PSE problem might be more serious, particularly with regard to waterbinding.

Secondly, the relationships between slaughterline measurements of muscle reflection and ultimate meat quality (e.g. colour and waterbinding) is influenced by the halothane phenotype. This may partially explain the varying results obtained by different authors (see introduction).

Thirdly, the non-destructive measurement of reflection in the slaughterline clearly offers new opportunities for identifying potential PSE carcasses. There is a large genetic influence of halothane-phenotype on this parameter, which may eventually justify a payment for meat quality to the producer to be based on it.

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