PALE PIG MEAT - RELATIVE INFLUENCE OF PSE AND LOW PIGMENT CONTENT

K. Lundström[1], P. Barton Gade[2], J. Rud Andersen[2] and I. Hansson[1], [1]Swedish University of Agricultural Sciences, Dept. of Animal Breeding and Genetics, Division of Meat Science, S-750 07 Uppsala, Sweden; 2Danish Meat Research Institute, P.O. Box 57, DK-4000 Roskilde, Denmark

SUMMARY

The relative influence of pigment content and structure (PSE) on the reflectance of pig meat was evaluated. Two materials were used, one with a low incidence of PSE (n = 162) and one with a high incidence (n = 82). The reflectance values were recorded with EEL, MQM and GP2-Q instruments. Drip loss, soluble sarcoplasmic and myofibrillar proteins and pigment content were analysed. The soluble sarcoplasmic and myofibrillar proteins explained most of the variation in reflectance values in all instruments for both materials. The pigment influence was appreciable for the EEL recordings (r = -0.47), whereas the instruments using internal reflectance values showed only low relationships with pigment.

INTRODUCTION

The colour of pig meat can be used to help select for improved meat quality in pigs, both for breeding purposes and in marketing. Pale meat colour is, however, not invariably associated with poor meat quality in the same way as low water holding capacity, but may be due to a low pigment content.

Meat colour is widely used as an indirect measure of meat quality. Due to changes in the absorbance of light in PSE musculature, when the muscle proteins partly denaturate after slaughter, a relationship exists between reflectance and structure. The colour of musculature per se is mainly due to the concentration of the haem-containing protein myoglobin together with residual haemoglobin, which both have absorption maxima in the region 400 to 630 nm. As the human eye is sensitive in the same region (400 to 700 nm), we have a good ability to judge the meat colour as based on pigment content.

When assessing the structure of meat, i.e. if the muscle is PSE or not, no influence of pigment is desirable. The instruments available to measure either surface reflectance or internal reflectance utilize a variation of wavelengths, thus also giving a varying degree of pigment influence.

The purpose of the present investigation was to study the relative influence of pigment content and structure (PSE) on the reflectance of pig meat evaluated in various ways.

MATERIALS AND METHODS

To be able to better evaluate the relative influence of pigment and structure two materials were used, one with a low level of PSE, and one with a high level.

The animals used in the sample with a low level of PSE were from the pig progeny testing scheme (n = 162). They were either purebred Swedish Landrace or Swedish Yorkshire pigs. The sample with the high level of PSE were commercial pigs (n = 82), either crossbred Swedish Landrace/Swedish Yorkshire or a threeway cross with the above crossbred sow bred to a Hampshire boar. In order to get a high proportion of PSE, a selection was made, based on the internal reflectance values of the warm carcass. The animals in the two materials were slaughtered in different slaughterhouses.

The following instruments and analyses were made to evaluate the meat quality of M. longissimus dorsi the day after slaughter.

1. Surface reflectance value was measured with an EEL reflectance spectrophotometer (Evans Electroselenium Ltd., Halstead, UK). The Y-filter was used giving a measure of visual brightness. The mean value of three separate recordings was used.

2. Internal reflectance was recorded using two different instruments.

   a) the MQM-instrument (Meat Quality Marbling; Danish Meat Research Institute, Roskilde, DK), utilizing a wavelength near the infrared region, i.e. 940 nm.

   b) the GP2-Q instrument (GP2-Q, Hennessy-Philips Grading Systems, NZ). The wavelength used for the GP2-Q is 570 nm.

Both instruments were equipped with a profile function, thus giving an integrated measure of the internal reflectance values in the muscle.

3. pH-value was recorded the day after slaughter (pH_2).

4. Soluble proteins were determined according to a method developed by Danish Meat Research Institute, Roskilde, DK. Minced muscle was homogenized and extracted in phosphate buffer of either a high (soluble sarcoplasmic and myofibrillar proteins, i.e. total proteins) or a low ionic strength (sarcoplasmic proteins). After one night in the refrigerator the extract was filtered and the protein content was determined at 550 nm using biuret reagent.

Table 1. Meat quality measurements in the two materials studied, means and standard deviations (SD)

	Low incidence of PSE (n=162)		High incidence of PSE (n=82)	
	Mean	SD	Mean	SD
EEL	23.9	3.1	--	-
MQM	51.7	10.9	66.5	21.6
GP2-Q	104.9	14.9	111.8	29.7
pH_2	5.54	0.14	5.47	0.18
Soluble proteins, absorbance units				
total	0.176	0.019	0.151	0.036
sarcoplasmic	0.067	0.004	0.058	0.009
Pigment, ppm haematin	21.9	3.3	24.0	3.6
Drip, %	5.8	2.0	-	-

Table 2. Relationships between the traits studied. Values below the diagonal are from the material with the low level of PSE and values above are from the high level material

	EEL	MQM	GP2-Q	pH_2	Soluble proteins Total	Soluble proteins Sarcoplasmic	Pigment
MQM	0.41 ***	-	0.86 ***	-0.11 n.s.	-0.81 ***	-0.57 ***	0.05 n.s.
GP2-Q	0.60 ***	0.60 ***	-	-0.12 n.s.	-0.79 ***	-0.55 ***	0.02 n.s.
pH_2	-0.40 ***	-0.32 ***	-0.48 ***	-	0.17 n.s.	0.36 ***	0.19 n.s.
Soluble proteins total	-0.54 ***	-0.66 ***	-0.58 ***	0.40 ***	-	0.67 ***	0.04 n.s.
Soluble proteins sarco-plasmic	-0.28 ***	-0.55 ***	-0.43 ***	0.29 ***	0.46 ***	-	0.08 n.s.
Pigment	-0.47 ***	-0.12 n.s.	-0.28 ***	0.24 **	0.20 **	0.16 *	-
Drip	0.28 ***	0.24 ***	-0.10 n.s.	-0.36 ***	-0.27 ***	-0.25 ***	-0.12 n.s.

Level of significance: n.s. = not significant (P>0.05); * = P≤0.05; ** = P≤0.01; *** = P≤0.001.

5. Pigment content was determined according to a modified Hornsey (1956) method and was expressed as ppm haematin.

6. Drip loss was determined as the percentage loss of a 2.5 cm thick slice of M. longissimus dorsi cut at the last rib. The slice hung in a plastic bag for four days in 2°C.

EEL and drip measurements were only made in the material with the low incidence of PSE. Based on the total soluble proteins, four meat quality classes were obtained, ranging from PSE (low solubility) to normal (high solubility). The normal class was further divided into normal or DFD muscle based on pH_2-values (muscle was considered DFD when the pH-value was equal to or exceeded 5.8, e.g. overall mean + 2 S.D.).

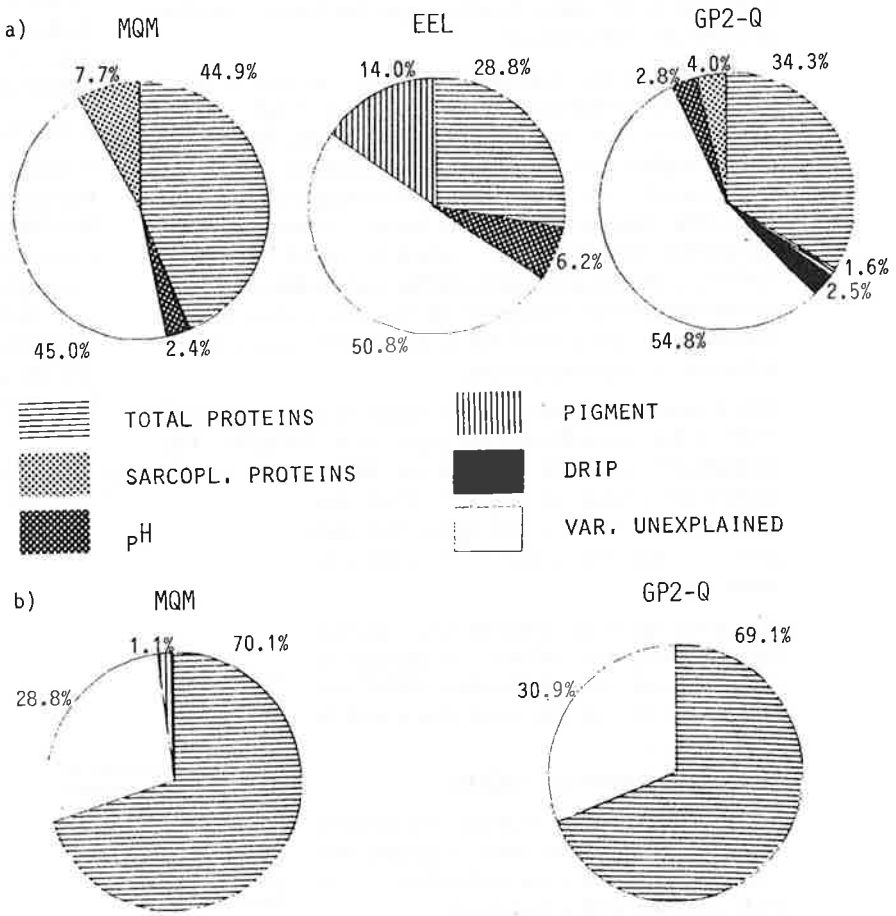
STATISTICAL METHODS

Data were analysed with the Statistical Analysis System (SAS Institute Inc., 1985) using among others the Stepwise Regression procedure.

RESULTS

The results from the meat quality measurements in the two materials with low or high incidence of PSE are given in Table 1. According to the classes obtained using the total soluble proteins, the incidence of PSE or slightly PSE were 1.9 and 25.6 %, respectively. The incidence of DFD was low, 1.2 and 3.7 %, respectively.

Relationships between the traits studied are shown in Table 2. Due to the various levels of PSE in the two materials, the correlations are presented separately. The correlations were as expected higher in the material with a high incidence of PSE. The only exception was a higher influence of pH when the incidence of PSE was low. Pigment was not influenced by protein denaturation, e.g. only very low and non significant correlations were obtained with soluble proteins. The influence of pigment on the EEL values was appreciable (r=-0.47), and a decrease of the pigment content with 1 ppm would increase the EEL-value with 0.4 units. The instruments using internal reflectance values showed only low or non-significant relationships with pigment (GP2-Q:



r = -0.28 or 0.02; MQM: r = -0.12 or 0.05 with low or high incidence of PSE, respectively).

The stepwise procedure was used with the instrumental recordings as dependent variables and protein solubility, pH, drip loss and pigment as independent variables. The results are depicted in Fig.1, with the percentage of variation explained by the independent variables as chosen by the programme in a stepwise manner. As can be seen from the figure, more of the total variation in instrumental readings is explained in the material with the high incidence of PSE. The solubility of the total proteins explained the highest proportion for all instruments. The solubility of the sarcoplasmic proteins when determined separately gave only a small additional contribution for MQM and GP2-Q in the material with the low incidence of PSE.

DISCUSSION

In this study we have measured both surface reflectance and internal reflectance. The surface reflectance was evaluated as visual brightness or Y according to the CIE standard. As pointed out by MacDougall (1984), the visual brightness depends on both the concentration of myoglobin and on the opacity of the structural proteins as affected by degree of denaturation. It is the integrated reflectance over the visual spectrum, heavily weighted in the green region of the spectrum. Factors affecting the distance of the light path in meat, i.e. pH, denaturation of proteins, fat content etc will influence reflectance (Krzywicki 1979).

Also the internal reflectance or back scatter will be influenced by various factors. The relative contribution to light scatter from the structural elements in the muscle tissue are not fully known. According to Offer and Trinick (1983), myofibrils act as the principal light scattering element of meat. The distance between the myofibrils are very much dependent on pH. With a high final pH in the muscle the repulsive forces between the myofibrils will be greater and thus also the distance. The light beam from an instrument can pass more easily, and the intensity from the reflected light will be less giving a low instrumental reading. With a low pH, the myofibrilar shrinkage will be greater with a more dense structure of the muscle. The denaturation of proteins also increases light scattering, giving the considerably higher light scattering properties of PSE meat as compared with normal meat with approximately the same final pH. The relative contributions of the variation in distance between the myofibrils and the denaturation of sarcoplasmic proteins to the increase in light scattering are still unsolved.

Light scatter increases when muscle enters the rigor state. Jeacocke (1981) showed on beef muscle, that the scattering increase induced by rigor was related to the extent of establishment of bonds between the thin and thick filaments. The high light scatter of PSE meat can, however, not be explained by a high number of rigor bonds. As shown by Honikel (1987), rigor shortening does not occur in PSE muscle. The denaturation of the heavy meromyosin or its subfragment occuring in PSE muscle as shown by Stabursvik et al. (1984) might lead to a destruction of the contracting power of myosin.

The influence of protein denaturation, pH_2, and pigment on instrumental readings varied depending on the type of instrument and incidence of PSE in the material. Protein denaturation was the most important factor irrespective of the incidence of PSE. pH_2 on the other hand, had a higher influence when the incidence of PSE was low. Pigment showed a high influence on EEL-values, and the brightness value will therefore be significantly influenced by the pigment content of the muscle. High EEL values (pale colour) can depend either on a low pigment content or on PSE. As can be expected from the wavelengths used in the other instruments, only GP2-Q was slightly influenced by the pigment content, and only in the material with a low incidence of PSE.

In the Swedish pig progeny testing, the reflectance value is included in the selection index. With the results from this study, it is quite clear that the pigment influence is considerable. With the low incidence of PSE in the carcasses from the progeny testing pigs, the selection is directed towards obtaining a higher pigment content together with the selection against PSE. The heritability for pigment is higher than for pure reflectance (Barton-Gade, unpublished material). The heritability estimates obtained for meat colour (measured as EEL Y-values) on Swedish materials (Lundström 1975; Lundeheim et al. 1980; Johansson 1987) are probably biased upwards. The consequences for other traits, with an indirect selection probably obtained against intramuscular fat, need to be evaluated. The influence of pigment as well as intramuscular fat content on the former Danish meat quality index used in the pig progeny testing in Denmark (Barton-Gade 1981), resulted in the development of the present MQM instrument (Barton-Gade 1987).

The combinations of several wavelengths can make it possible to calculate the relative importance of pigment in relation to the achromatic absorption of light, as shown by e.g. Krzywicki (1979). We are therefore now trying to use a combination of green and blue filters in addition to the original Y-filter. To evaluate the influence of pigment in an indirect way in the present study, different combinations of the MQM- and GP2-Q-values were made. No improvement compared with the simple correlations was, however, obtained.

It can therefore be concluded that as the Y-filter has a spectral distribution very close to that of the average naked eye, it can be used to identify pig meat having an optimal colour, whether due to an absence of PSE or to a normal pigment content. On the other hand, when only PSE is to be detected, the internal reflectance will give a better estimate. An instrument with no pigment influence, as the MQM instrument, is of course preferable especially when the incidence of PSE is low. In a commercial situation with a higher incidence of PSE in the material, the GP2-Q instrument can also be used to discriminate between normal and PSE-carcasses but there will be a small influence of pigment.

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