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Relationships between the subjective assessment of pork quality and objective measures of colour

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Introduction

After the ratio of fat to lean, muscle colour is probably the most important quality factor governing the choice of pork by the consumer. Colour, specifically paleness or darkness, directly affects saleability (Topel, Miller, Berger, Rust, Parrish and Ono, 1976; Wachholz, Kauffman, Henderson and Lochner, 1978). Despite this, there is a lack of information relating subjective assessment of pork colour-structure to objective instrumental measurements. This information would allow the definition of subjectively judged pale, soft, exudative (PSE) and dark, firm, dry (DFD) pork in terms of instrumental measures. Therefore, in the present work a study of the relationship of the colour of a large sample of pork *longissimus dorsi* (LD) muscles measured using the CIELAB L★ a★ b★ system to that assessed subjectively by a panel of seven judges was made. Measurements were also made of pH, water-holding capacity and light scattering.

Material and methods

The muscle samples used in this work have been described previously (Lopez-Bote, Warriss and Brown, 1989). They came from the carcasses (average weight 69·9 (s.e. 4·6) kg) of 100 pigs killed using normal commercial practices at the slaughterhouse of the Department of Meat Animal Science, University of Bristol and exhibited a wide range of meat quality in terms of colour-structure. At 45 min *post mortem* a small piece of LD was removed for measurement of pH (pH_{45}) after homogenization in 5 mmol/l sodium iodoacetate, 150 mmol/l potassium chloride, pH 7·0. The internal light scattering of the muscle was measured using the Fibre Optic Probe (FOP; MacDougall, 1984) and the average of triplicate readings recorded (FOP_{45}). These measurements were repeated at 20 h *post mortem* (pH_u and FOP_u) after overnight chilling. At this time a complete chop was removed at the level of the last rib and used for subjective assessment of the colour-structure of the LD independently by seven experienced judges using a five-point scale (1 = extremely DFD, 2 = slightly DFD, 3 = normal, 4 = slightly PSE, 5 = extremely PSE). Subjective assessment score was the mean of the values given by the seven judges. A length of the LD immediately posterior to the subjectively assessed chop was used for determination of water-holding capacity as drip loss (Warriss, 1982), reflectance using an EEL Reflectometer (MacDougall, Cuthbertson and Smith, 1969), haem pigments (Warriss, Brown, Adams and Lowe, 1990) and colour (MacDougall, 1986) using a Minolta Chromameter II Reflectance. Colour was measured after the samples had been allowed to bloom for 1 h at a temperature of 1°C and the mean of triplicate readings across the surface of the muscle was recorded. Hue and saturation values were calculated from the mean chromaticity coordinates as described by MacDougall and Rhodes (1972).

Results and discussion

The wide range of meat quality represented by the sample is illustrated by the variation in pH_{45} (5.30 to 6·74), pH_u (4·98 to 6·92), drip loss (0·9 to 16·9%) and reflectance (22·2 to 70·3 EEL units). For analysis, the values for all measurements were grouped into categories corresponding to subjective scores lying within intervals of 0·5 units. The relationships between the mean values of each category and subjective assessment score are shown in Figures 1, 2 and 3. Haem pigment concentration (overall mean 0·86 mg/g) did not vary significantly with subjective assessment score. There were excellent linear relationships between subjective score and lightness (L*) and reflectance (EEL units). This is in agreement with the findings of Elliot (1969) and MacDougall *et al.* (1969). There was also a good relation with saturation which increased with higher subjective assessment scores. The relationship with hue was curvilinear. Although the relationship with FOP_u

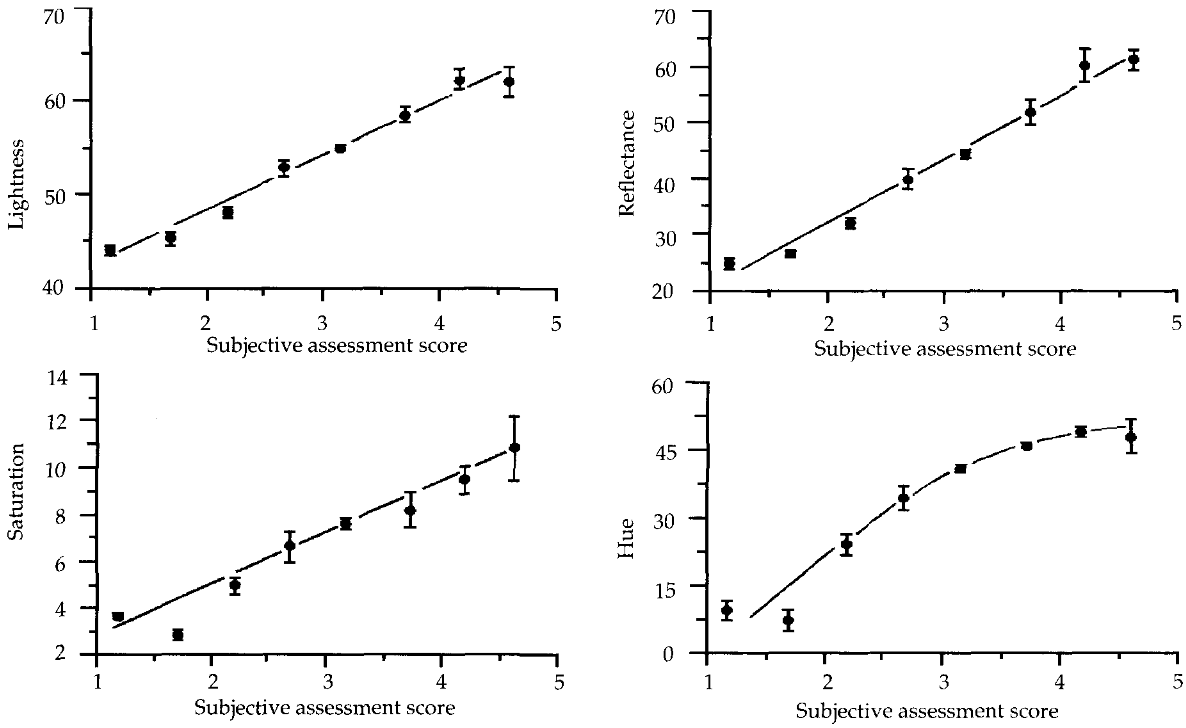

Figure 1 The relationship between mean lightness, reflectance, saturation and hue and subjective quality scores.

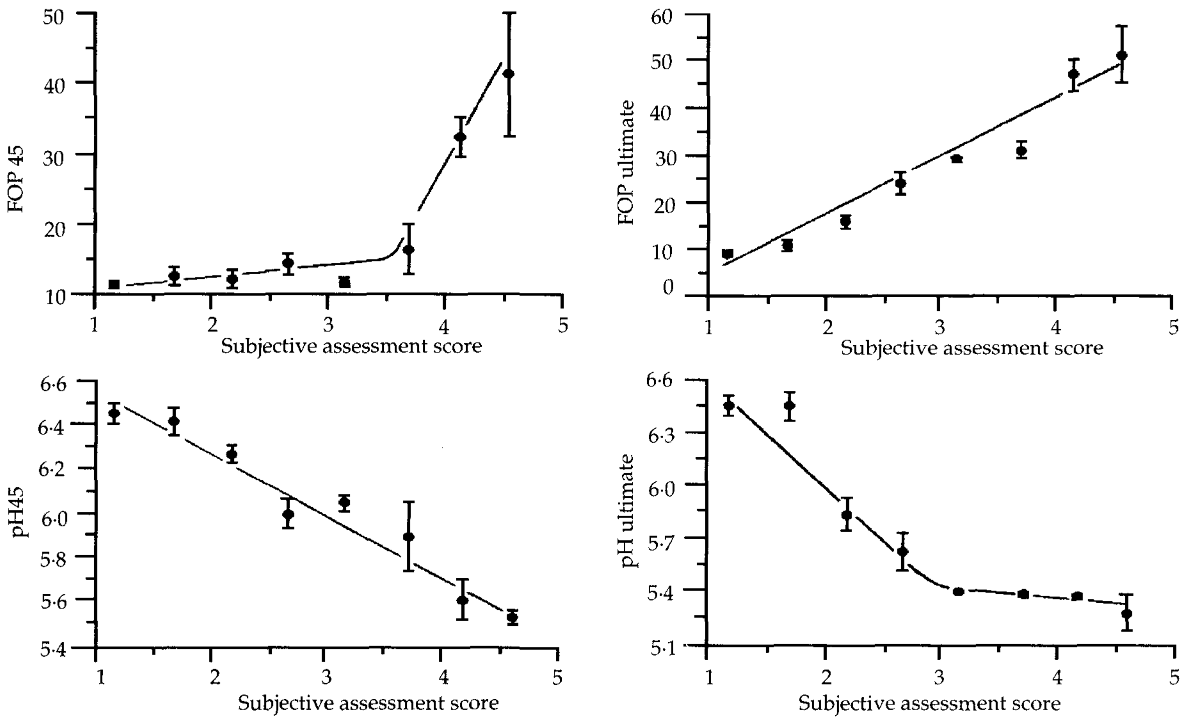

Figure 2 The relationship between pH and fibre optic probe (FOP) measurements (made 45 min and 20 h *post mortem*) and subjective quality scores.

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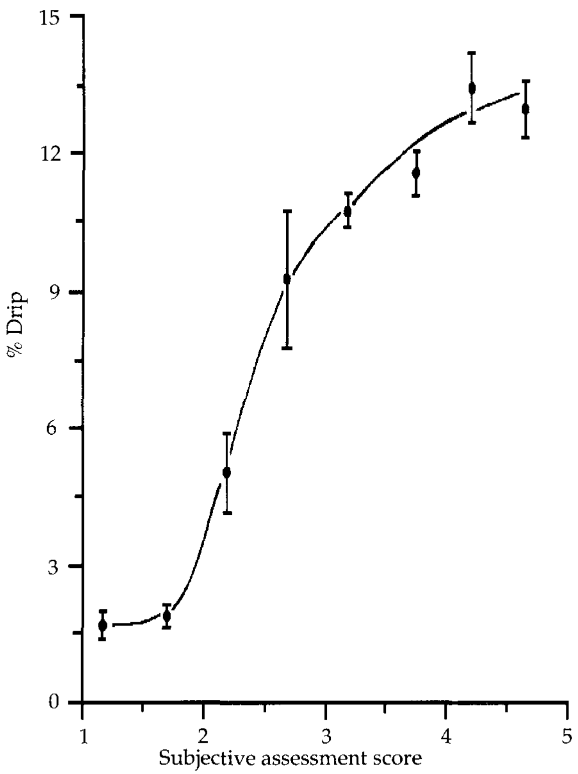

Figure 3 The relationship between water-holding capacity (measured as % drip loss) and subjective quality scores.

value was linear, that with FOP_{45} was not. As has been pointed out previously (Warris, Brown, Lopez-Bote, Bevis and Adams, 1989) this lack of linearity is because FOP_{45} values are not on average different in DFD meat compared with meat of normal quality. Only FOP_u values can differentiate between DFD and normal meat. The pH_{45} value was also reasonably linearly related to subjective assessment score but the relationship with pH_u was curvilinear

Table 1 *Regression equations and variation explained*†

	Proportion of variation explained (r^2)
Lightness (L*) = 36·0 + 5·92 score	0·854
Reflectance (EEL units) = 7·91 + 11·9 score	0·843
Saturation = 0·319 + 2·23 score	0·626
Hue = 29·6 score – 2·75 score^2 – 26·4	0·824
FOP_u = 11·8 score – 8·36	0·781
pH_{45} = 6·83 – 0·264 score	0·498
% drip loss = 8·32 score – 0·75 score^2 – 8·4	0·745

† Calculated from the ungrouped data. 'Score' is the mean of the subjective assessment scores given by the seven judges.

Table 2 *Values for each objective measurement of quality corresponding to the five subjectively assessed colour-structure categories and calculated from the equations in Table 1*

	Category				
	1 Extremely DFD	2 Slightly DFD	3 Normal	4 Slightly PSE	5 Extremely PSE
Lightness (L*)	42·0	47·9	53·8	59·7	65·6
Reflectance (EEL units)	19·8	31·7	43·6	55·5	67·4
Saturation	2·5	4·8	7·0	9·2	11·5
Hue	0·5	21·8	37·7	48·0	52·9
FOP_u	3·4	15·2	27·0	38·8	50·6
pH_{45}	6·57	6·30	6·04	5·77	5·51
% drip loss	0	5·2	9·8	12·9	14·5

reflecting the major effect that pH_u has in influencing the occurrence of DFD meat but the small effect it has in PSE meat. The relationship with drip loss was curvilinear. Regression equations relating objective measurements with subjective assessment score were calculated from the ungrouped data (Table 1). From these equations the values of each measurement corresponding to the five colour-structure categories ranging from extremely PSE to extremely DFD can be calculated. These are shown in Table 2. No values can be definitive of course, since every judge will have his own perceptions of the meaning of the different colour-structure categories. However, the values are useful in giving a working definition of each category and in indicating the size of change in value between categories. They therefore enable differences which may be observed in experimental situations to be assessed in terms of their likely importance.

Some evidence for the wider usefulness of the presently derived values comes from the work of Somers, Tarrant and Sherington (1985). These authors used similar categories to those employed here to evaluate different objective methods for measuring pork quality. Subjective assessments were made in a similar way to those used here by a panel of five or more judges. Two objective measurements which were identical to those used here, and for which regression equations relating subjective scores and objective measurements were given, were reflectance and FOP_u. A comparison of values derived using these equations with those derived in this present work is given in Table 3. The reflectance values show excellent agreement. The values for FOP_u agree less well although this may be because of the generally acknowledged difficulties in exactly standardizing individual FOP instruments and because of inter-operator variation in the method of use.

Table 3 *Comparison of reflectance and* FOP_u *values derived in this work with those derived by Somers* et al. *(1985)*†

		Category				
		1 Extremely DFD	2 Slightly DFD	3 Normal	4 Slightly PSE	5 Extremely PSE
Reflectance value (EEL units)	(a)	19·4	31·8	44·2	56·7	69·1
	(b)	19·8	31·7	43·6	55·5	67·4
FOP_u	(a)	4·1	18·7	33·3	47·9	62·5
	(b)	3·4	15·2	27·0	38·8	50·6

† (a) Value from Somers *et al.* (1985); (b) value from this work.

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