Meat colour in loin and ham muscles of normal meat quality from Hampshire, Swedish Landrace and Yorkshire pigs.

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SUMMARY: The aim of this study was to evaluate the colour of *longissimus dorsi* (LD) and *biceps femoris* (BF) muscles of normal meat quality from pure-bred Hampshire, Swedish Landrace and Swedish Yorkshire pigs in relation to meat pigment, fat content, ultimate pH and meat structure (FOP values). The colour was measured as surface reflectance. Pork from Hampshire had the highest and pork from Swedish Landrace the lowest pigment content and FOP value. The higher pigment content of Hampshire was not correlated to a darker colour because the different structure, indicated by the higher FOP value, counteracted the higher pigment content. The colour was redder and yellower in LD as well as in BF from Hampshire, compared to the other two breeds, due to more oxymyoglobin at the surface, which can be explained by lower pH. The colour of BF was darker and redder than that of LD, due to a higher pigment content.

INTRODUCTION: The colour of pork is an important quality property. The colour is a very complex concept comprising the meat pigment and the structure of the muscle proteins. Likewise, the fat content may influence the colour impression.

The colour of meat depends primarily on the amount of and the chemical form of myoglobin. The colour intensity mainly depends on the amount of myoglobin and the colour hue on the myoglobin form. Oxymyoglobin gives a redder and yellower meat than deoxymyoglobin. The ultimate pH influences the form of myoglobin that is predominantly present at the meat surface. A high pH results in more deoxymyoglobin and a low pH in more oxymyoglobin. The structure of the muscle proteins influences the light reflectance and thus the colour. The light reflectance increases when the proteins denature. This is most pronounced in PSE meat, but also in normal meat water soluble proteins can be denatured to a certain extent (LOPEZ et al., 1989; von SETH et al., 1991).

The aim of this study was to evaluate the colour of loin and ham muscles of normal meat quality from pure-bred Hampshire, Swedish Landrace and Swedish Yorkshire pigs in relation to meat pigment, fat content, ultimate pH and meat structure (FOP values).

MATERIALS and METHODS: Two muscles, *longissimus dorsi* (LD) and *biceps femoris* (BF) were obtained from pure-bred Hampshire, Swedish Landrace and Swedish Yorkshire pigs from Swedish pig progeny testing. Both muscles from 16 gilts and 16 castrates from 8 sires and 2 dams/sire were taken from every breed, in total 96 animals. All muscles were judged to be of normal quality. The pH value was $\leq$ 5.7 for LD and $\leq$ 5.9 for BF. The FOP value was $\leq$ 52 for LD and $\leq$ 57 for BF.

The meat was analysed for pigment content according to HORNSEY (1956), using a standard curve of hematin, instead of the factor used by HORNSEY (1956), and intramuscular fat content (IMF) according to NMKL method No. 88 (1974). Fibre optic probe values (FOP) (MK1, T.B.L. Fibres Ltd, Leeds, Great Britain) as well as pH values (Knick Portamess 651, Xerolyt electrode, W. Ingold Ltd, Urdorf, Switzerland) were measured. The meat was cut into 2 cm thick slices, placed in a petri dish and covered with an oxygen permeable film. After blooming, the reflectance was measured on a Hunterlab Color Quest instrument (specular excluded, 10° standard observer, CIELAB (1976) colour scale, illuminant D65 and 25 mm measuring aperture). The average of 4 measurements across the surface was calculated. K/S610 / K/S525 was calculated as a measure of MbO and K/S474 / K/S525 as a measure of Mb. All measurements and analyses were carried out three days after slaughter.

The results were analysed by variance analysis using the GLM procedure in SAS (SAS INSTITUTE INC.,1987). Two different models were used. (1) Effects of breed and sex: the model contained the effects of breed, sire within breed, dam within breed and sire, sex and the interaction between breed and sex. (2) Effect of muscle: the model contained the effects of breed, animal within breed, muscle and interaction between breed and muscle. The effects of sire, dam or animal were considered as random and the other effects as fixed. The effect of breed was tested against sire or animal. The results were also analysed using the principal component analysis procedure (PRINCOMP) in SAS (SAS INSTITUTE INC., 1987), using all variables after standardization.

RESULTS and DISCUSSION: There were differences between the breeds in most of the quality traits (Table 1), especially between Hampshire and the other two breeds. Furthermore, there were differences between the muscles within the breeds in all the quality traits (Table 2) . On the other hand, there were only differences between sexes within breeds in intramuscular fat content, where the castrates had a slightly higher fat content than the gilts (results not shown).

Both LD and BF from Hampshire had the lowest ultimate pH (Table 1). The Hampshire breed has a tendency towards a low ultimate pH (MONIN and SELLIER, 1985; FJELKNER-MODIG and PERSSON,1986; LUNDSTRÖM et al, 1989; MONIN, 1989) that is considered to be due to a high glycolytic potential (MONIN and SELLIER, 1985; MONIN, 1989). Ultimate pH was slightly higher in BF from Swedish Yorkshire, compared to Swedish Landrace (Table 1). Pork from Hampshire, LD as well as BF, had the highest and pork from Swedish Landrace the lowest pigment content and FOP value (Table 1). The same tendency with higher FOP values for Hampshire, compared to Swedish Landrace, has been obtained in other investigations at the Swedish Meat Research Institute (unpublished results). Since only meat of normal quality was investigated, it is difficult to compare the FOP values with other investigations where PSE or DFD meat is often included. The pigment content in BF was almost twice the quantity of that in LD for all the breeds (Tables 1 and 2). The same differences between the muscles were found in a Danish study (BARTON-GADE, 1990), although the pigment content was lower in that study. The intramuscular fat content was very low in both the muscles from all the breeds (Table 1).

Table 1. Least-squares means (LSM), standard errors (SE) and levels of significance for differences between the breeds in pH, FOP value, pigment content (PIGM), intramuscular fat content (IMF), lightness (L*), redness (a*), yellowness (b*) and relative amount of MbO and Mb.

Muscle	Trait	Breed				Levels of significance[2)]		
		H (n=32)	SL (n=32)	SY (n=32)		H-SL	H-SY	SL-SY
		LSM	LSM	LSM	SE[1)]			
LD								
	pH	5.33	5.41	5.44	0.01	***	***	ns
	FOP	43	31	36	1	***	***	***
	PIGM(mg/kg)	39.8	29.8	35.0	0.5	***	***	***
	IMF(%)	1.32	1.10	1.21	0.04	**	ns	ns
	L*	56.6	56.9	56.2	0.3	ns	ns	ns
	a*	7.5	5.13	5.3	0.2	***	***	ns
	b*	16.0	14.1	14.4	0.1	***	***	ns
	MbO(K/S-value)	0.419	0.479	0.475	0.004	***	***	ns
	Mb(K/S-value)	0.957	0.898	0.890	0.005	***	***	ns
BF								
	pH	5.41	5.54	5.60	0.01	***	***	**
	FOP	47	35	36	1	***	***	ns
	PIGM(mg/kg)	69.6	63.0	68.6	1.0	***	ns	***
	IMF(%)	1.63	1.48	1.50	0.05	*	ns	ns
	L*	48.3	45.7	46.6	0.3	***	***	*
	a*	11.0	9.3	9.1	0.2	***	***	ns
	b*	15.5	13.1	13.1	0.2	***	***	ns
	MbO(K/S-value)	0.402	0.455	0.456	0.004	***	***	ns
	Mb(K/S-value)	0.943	0.852	0.845	0.006	***	***	ns

1) Standard errors were the same for all the breeds as the material was totally balanced.
2) Levels of significance: *** P<0.001, ** P<0.01, * P<0.05, ns=not significant.

The colour of pork from Hampshire differed markedly from that of the other two breeds (Table 1). LD as well as BF was redder and yellower in Hampshire, compared to Swedish Landrace and Swedish Yorkshire (Table 1). On the other hand, there were no differences in lightness between the breeds in LD and only a small difference between Hampshire and the other two breeds in BF (Table 1). The relative amount of MbO and Mb was calculated since the hue depends on which myoglobin form is predominantly present at the surface. In this case there could not be any metmyoglobin, as the meat was newly cut prior to the colour measurements. There was more MbO (lower K/S value) and less Mb (higher K/S value), i.e. more blooming, in both muscles from Hampshire compared to the other two breeds (Table 1). This probably depends on lower enzymatic oxygen depletion, resulting in more oxygen binding to myoglobin. The reason for this may be the lower ultimate pH. MbO gives pork a clear pink colour while Mb gives a greyer and a little darker colour. The colour becomes lighter, redder and yellower when the relative amount of MbO increases. This explains the redder and yellower colour of the Hampshire pork. The fact that there were no differences in lightness between the breeds in LD, despite differences in pigment content, may be explained by structure differences. The different structure, indicated by the higher FOP value, counteracted the higher pigment content. Likewise, this could explain the lighter colour in BF from Hampshire with higher pigment content than that of the Swedish Landrace. More blooming in Hampshire may also contribute to a slightly lighter colour. The intramuscular fat content was too low to have any influence on the colour.

In order to summarize all parameters involved in colour formation, the principal component analysis procedure was performed. When the scores from the first two principal components for the LD muscle were plotted (Fig. 1), a clear differentiation between Hampshire pork and pork from the other two breeds was evident. The few significant differences between Swedish Landrace and Swedish Yorkshire in the various aspects of colour, were not at all appreciable in the first two principal components. Similar results were obtained from the principal component analysis on the BF muscle.

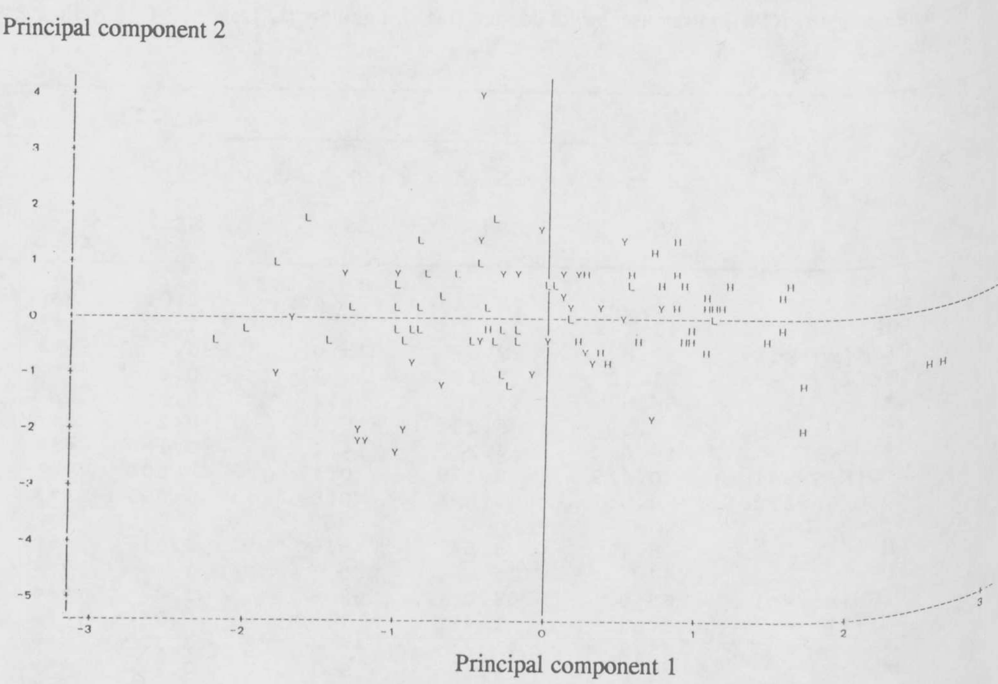

Fig. 1. Plot of the first and second principal component score vectors (objects) including all colour parameters studied for the LD muscle. H=Hampshire L=Swedish Landrace Y=Swedish Yorkshire

The colour of BF was darker, redder and slightly yellower than the colour of LD (Table 2). The K/S values for the relative amount of MbO are not quite comparable between the muscles LD and BF, since there were big differences in pigment content. Nevertheless, the K/S values show the tendency that there were bigger differences in blooming between the breeds in LD and BF, respectively, than between the muscles within the breeds. The colour differences between LD and BF depend mainly on the differences in pigment content since there were hardly any differences in structure (FOP value) or blooming.

Table 2. Differences between the muscles (BF - LD) in pH, FOP value, pigment content (PIGM), intramuscular fat content (IMF) , lightness (L*), redness (a*) and yellowness (b*).

Breed	H (n=32)		SL (n=32)		SY (n=32)	
Trait	Diff	Sign[1)]	Diff	Sign	Diff	Sign
pH	0.08	***	0.13	***	0.16	***
FOP	4	**	4	**	0	ns
PIGM(mg/kg)	29.8	***	33.2	***	33.6	***
IMF(%)	0.31	**	0.38	***	0.29	**
L*	-8.3	***	-11.2	***	-9.6	***
a*	3.5	***	4.2	***	3.8	***
b*	-0.5	*	-1.0	***	-1.3	***

1) Levels of significance: *** $P<0.001$, ** $P<0.01$, * $P<0.05$, ns=not significant

CONCLUSIONS: The colour was redder and yellower in LD as well as in BF from Hampshire, compared to the other two breeds, due to more MbO at the surface. The lower pH in pork from Hampshire can explain the differences in MbO. There were no differences between the breeds in lightness of LD and only small differences in BF. A higher pigment content was not correlated to a darker colour because the different structure, indicated by the higher FOP value, counteracted the higher pigment content. The colour of BF was darker than the colour of LD, mainly due to a higher pigment content.

ACKNOWLEDGEMENTS: This work was supported in part by the Swedish Council for Forestry and Agricultural Research and by the Farmers Research Council.

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