THE EFFECT OF BREED ON THE COLOUR OF THE MUSCLE *LONGISSIMUS DORSI* IN CATTLE

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SUMMARY

A number of factors, are known to infuence meat colour, however, information on the genetic influences on meat colour are scarce and the results conflicting this study concentrated on the effect of breed on meat colour in both *Bos indicus and Bos taurus* crosses. A secondary objective of the programme was to assess the reliability of the subjective meat colour score (MCS) by comparing the MCS to the objective assessment of colour using tristimilus colour analysis.

257 cattle from one southern Queensland feedlot consisting of 6 breeds or crosses were surveyed for meat colour of the LD muscle. The meat quality attributes measured were: age (dentition), fat thickness in mm at the P8 site (rump), hot standard carcass weight (kg), marbling (visual intramuscular fat) score 1-6 at the 10/11 rib site, fat (1-8) and meat colour (1-9) scores at the 10/11 rib site. The *longissimus dorsi* muscle was used to assess the meat colour, fat colour, marbling and texture by a certified assessor, using the AUSMEAT Chiller Assessment Scheme (AMLC Chiller Assessment Manual 1990).

The breeds and crosses used in the trial were: Santa Gertrudis (27), Santa Gertrudis X Hereford (14), Murray Grey (92), Hereford X Murray Grey (9), Angus (61), Angus X Hereford (52). All breeds were fed in the same feedlot on the Darling Downs using normal commercial procedures.

The cattle were all slaughtered at one abattoir and the carcass' processed conventionally. After chilling (24 hour post mortem), the carcass were quartered, between the 10th and 11th ribs, to expose the LD muscle.

A sample steak, at least 1.5cm thick, was taken from the 10/11 rib site of each carcass. The samples were then chilled and transported to the laboratory.

The colour of the lean (meat) of the samples was assessed using a Minolta Chromameter (CR231) using standard procedures (Minolta Chromameter CR231 users manual). Five replicate measurements were made on both surfaces of each sample. Colour was recorded as Light (L), (Chroma (C) and Hue (H).

There were significant differences in meat colour between breed groups. Part of the difference, presently undefined, is related to breed differences in growth rate and fatness (at a given carcass weight) and apparently, the differing age,weight and fatness at which breed groups were introduced into the feedlot. This means that the apparent breed differences could be different given differing feedlot practices in regard to these factors.

The relationships between meat colour scores and meat colour measurements were not very close. The reasons for this needs to be determined urgently, to further the development of a viable meat colour assessment/measurement scheme.

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1. INTRODUCTION

Australia exports 55% of its beef production. The top three markets (in quantity) are USA (50% at 333.7 thousand tonnes), Japan (27% at 184 thousand tonnes) and Korea (9% at 60.7 thousand tonnes) (AMLC Annual Report 89-90). The market specifications vary widely.(Refer table 1)

TABLE 1 - EXPORT MARKET SPECIFICATIONS

	EEC	USA - Frozen boneless beef	S E Asian Hotel Trade	Japanese (grain-fed beef) high quality
Dentition	4 teeth	All ages	0 - 2 teeth	4 Teeth
Fat (P8 site) cover[1]	4-15mm	10-15mm	12-22mm	15-32mm
Hot Standard Carcass Weight	up to 330 kg	220 kg	260-320 kg	280-380 kg
Meat Colour score 1=pink 9=dark red [2]	1,2,3	all colours	1-3	1-3
Fat colour score 1=white 8=yellow [3]	1,2,3	all colours	1-3	1-2
Marbling score [4]	Not required	Not required	1-3	3 upwards

Source: AMLC Area Managers Handbook

[1]. P8 (mm) Fat cover measurement at rump.

[2,3,4] AUSMEAT Chiller Assessment Manual.

All markets, with the exception of the USA (frozen manufacturing), consider meat colour a very important criterion (Table 1) (Jeremiah et.al. 1972), (Klettner & Stiebing 1980). The Japanese demand white fat colour, light red meat colour and high levels of marbling (Table 1). To achieve this product consistently, grain fed cattle must be used (Johnson 1991). Their major requirement is for a consistent quality product that is immediately attractive to the consumer.

Consumers equate dark colour with old meat and suspect spoilage.

Stress, preslaughter handling of the animal and post slaughter treatment will affect the light scattering properties of the meat (Tarrant and Casteels 1983). Glycogen depletion in the live animals results in translucent dark, firm, and dry (DFD) meat with a high pH (> 6.2) and a high oxygen uptake. Ultra rapid post-mortem glycolysis causes profound denaturing changes to the myofibrillar proteins leading to a cut muscle surface that is opaque and pale (P), soft (S) textured and possessing excessive drip characteristics (fluid or exudate-E). In meat of normal ultimate pH (pH of 5.4 - 5.6), colour is principally related to the concentration and chemical state of myoglobin; it is not due to haemoglobin unless bleeding has been faulty (Ledward 1969). Many factors influence the levels of myoglobin in beef muscle. Lawrie (1985) has reported that species, sex, age, and muscle type all contribute to this variability as does the level of metabolic activity. Rickansrud and Hendrickson (1967) showed an eightfold reduction in the total pigment concentration over four bovi muscles taken from the same side of beef.

The use of electrical stimulation to increase post mortem metabolic rate leads to a brighter meat colour (Sleper *et al* 1983). It is thought that this procedure produces a more open structure to the meat surface (Ledward 1986). Shorthose (1991) suggests that genetic differences also influence meat colour, differing growth rates will occur among animals slaughtered at the same age so that myoglobin concentration will differ because of differences in carcass weight. Among animals slaughtered at the same weight, age and fat cover levels will affect chilling rates, which in turn will affect the final meat colour. Temperament difference is likely to affect meat colour levels via the influence of stress on the ultimate pH (Shorthose 1991). It has been suggested that this temperament difference among breeds is related to the differing animal husbandry techniques used on different breeds (Wythes 1988). Wythes *et al* (1989) suggest that *Bos indicus* cross cattle do not produce darker meat than *Bos taurus* breeds (based on pH measurements).

Bonhomme and Foulley (1974) found a low but significant residual correlation (within sex, sire and maternal breed) between haematocrits and subjective colour grade. This may be due to the correlation between haemotocrit and carcass weight in trained animals or the relationship between stress and haematocrit. Breed was found to effect the chroma of meat colour in the study by Nakanishi *et al* (1989) but this is likely to have been caused by secondary effects including fatness and intramuscular fat content. Liboriussen *et al* 1977 (quoted in Dikeman 1990) reported that *M.longisimuss dorsi (LD)* and *M. semitendinosus* of Limousin, Romagnola, Charolais and Blonde d'Aquitaine crossbreds had a significantly lower myoglobin content and more light reflectance than those of Hereford and Chianina crossbreds.

Goszczynski *et al* (1985) used Polish Black and White Lowland (PBWL) cows crossed with Hereford, Angus, Charolais and PBWL bulls to test for the effect of breed on quality characteristics. They found a difference between the PBWL x Hereford and PBWL x Angus and PBWL X Charolais but not between PBWL x Hereford and PBWL x PBWL. The Australian Meat and Livestock Corporation run annual competitions ("Feedback Trials") designed to give farmers feedback on the standard of meat quality and yield characteristics. Animals of any breed are entered at the same age and fed the same diet for the same time period on the same farm and slaughtered together. The results suggest that the differences in meat colour within breeds were larger than the differences between breeds (Reppe & Meehan 1991).

Meat colour is a vital part of meat marketing, the world over and despite the overwhelming evidence of consumers use of meat colour as a major component in the decision of purchase (Sawyer In Cole and Lawrie 1974), no commercial national schemes exist to measure meat colour objectively. There is a definite need for the measurement of meat colour and an understanding of the factors that affect its formation.

2. MATERIALS AND METHODS

257 cattle from one southern Queensland feedlot consisting of 6 breeds or crosses were surveyed for meat colour of the LD muscle. The meat quality attributes measured were: age (dentition), fat thickness in mm at the P8 site (rump), hot standard carcass weight (kg), marbling (visual intramuscular fat) score 1-6 at the 10/11 rib site, fat (1-8) and meat colour (1-9) scores at the 10/11 rib site. The LD muscle was used to assess the meat colour, fat colour, marbling and texture by a certified assessor, using the AUSMEAT Chiller Assessment Scheme (AMLC Chiller Assessment Manual 1990).

The breeds and crosses used in the trial were: Santa Gertrudis (27), Santa Gertrudis X Hereford (14), Murray Grey (92), Hereford X Murray Grey (9), Angus (61), Angus X Hereford (52). All breeds were fed in the same feedlot on the Darling Downs (Long 151.°E East, Lat 27.2° South) using normal commercial procedures. Transportation ,a stress inducing factor, was minimised due to the short distances (10-15km) between the feedlot and the abattoir.

The cattle were all slaughtered at one abattoir and the carcass' processed conventionally (no electrical stimulation). After chilling (24 hour post mortem), the carcass were quartered, between the 10th and 11th ribs, to expose the LD muscle.

A sample steak, at least 1.5cm thick, was taken from the 10/11 rib site of each carcass. The samples were then chilled and transported to the laboratory. The 10/11 rib site is the most common quartering site for Australian Export Beef going to Japan.

The colour of the lean (meat) of the samples was assessed using a Minolta Chromameter (CR231) using standard procedures (Minolta Chromameter CR231 users manual). Five replicate measurements were made on both surfaces of each sample. Colour was recorded as Light (L), (Chroma (C) and Hue (H).

TABLE 2
A COMPARISON OF MEAT COLOUR VARIABLES IN RELATION TO BREED TYPES

Breed	No. of Samples	* Light	* Chroma	* Hue	●Subjective Meat Colour Scores
		x ± SD	x ± SD	x ± SD	Median Score
A	61	37.4 ± 2.5[ab]	20.3 ± 3.1[b]	19.3 ± 5.2[ab]	5[ab]
MG	92	38.1 ± 2.6[b]	21.0 ± 3.7[ab]	24.2 ± 8.2[c]	4[a]
SG	27	34.6 ± 2.0[a]	20.0 ± 1.7[b]	18.8 ± 1.7[a]	4, 5[a]
SG X HF	14	34.9 ± 2.4[a]	20.0 ± 2.5[b]	19.7 ± 3.7[ab]	6[a]
A X HF	52	38.4 ± 3.0[b]	21.6 ± 3.9[ab]	22.9 ± 6.8[bc]	5[ab]
HF X MG	9	37.8 ± 1.7[b]	18.4 ± 1.5[b]	35.8 ± 4.5[d]	4[b]
significance of breed difference		P = < 0.001	P = < 0.05	P = 0.001	

Breed Codes

A: Angus
MG: Murray Grey
SG: Santa Gertrudis
SG X HF: Santa Gertrudis x Hereford
A X HF: Angus x Hereford
HF X M: Hereford x Murray Grey
■ measured in accordance with Minolta CR231 Users Manual
• As per Ausmeat Chiller Assessment Scheme
* Derived from Angus & Shorthorn

TABLE 3

A COMPARISON OF VARIABLES EFFECT MEAT COLOUR IN RELATION TO BREED TYPES

Breed	No. of Samples	HSCW (kg) Hot Std carcass wt	• Fat Colour (score)	P8 (mm) Fat cover at rump	Dentition (∴ age)	• Marbling at 10/11 rib (score)
		x ± SD	Median Score	x ± SD	Median Score	Median Score
A	61	365.7 ± 74.7[c]	5, 6	19.0 ± 6.5[a]	2	2
MG	92	401.6 ± 41.0[b]	6	21.0 ± 6.0[abc]	4	2
SG	27	480.6 ± 53.4[a]	5	22.5 ± 6.7[bc]	6	2
SG X HF	14	504.4 ± 50.6[a]	5	25.8 ± 7.8[cd]	6	2
A X HF	52	390.7 ± 95.0[bc]	3	22.7 ± 9.7[abcd]	4	2
HF X MG	9	394.0 ± 19.0[b]	5	19.4 ± 3.6[ab]	4	2
Significance of breed difference		P =< 0.0001		P =< 0.01	no sig.	no sig.

RESULTS

There were significant (P<0.01) between breed differences in meat colour scores (Table 2), Lightness (L), Chroma (C) and Hue (Table 2). There were significant difference in mean age (dentition) (Table 3). The correlations are shown in Table 4.

Lightness was correlated with all variables except dentition and marbling scores (Table 4). Chroma and Hue were correlated with all variables except meat colour and marbling scores. Meat colour scores were correlated with all other variables with the exception of marbling scores, Chroma and Hue.

Fat colour became significantly yellow (higher) as carcass weight, fat cover and age increased.

TABLE 4

CORRELATION MATRIX

	Light	Chroma	Hue	Meat Colour	HSCW	Fat Colour	P8	Dent
Light	-	-	-	-	-	-	-	-
Chroma	0.351	-	-	-	-	-	-	-
Hue	0.550	0.274	-	-	-	-	-	-
Meat Colour	-0.286	0.081	-0.032	-	-	-	-	-
HSCW	-0.230	0.320	0.144	0.355	-	-	-	-
Fat Colour	-0.144	0.174	0.237	0.498	0.410	-	-	-
P8	-0.128	0.252	0.134	0.152	0.620	0.231	-	-
Dent	-0.112	0.256	0.138	0.293	0.506	0.325	0.359	-
Marbling 10/11	0.035	-0.043	-0.065	0.069	0.179	-0.018	0.117	0.069

For $P < 0.05$ $r \geq 0.121$

DISCUSSION

A number of factors, are known to influence meat colour, however, information on the genetic influences on meat colour was scarce and the results conflicting.

The design of the present study minimised, but did not eliminate the influence of factors other than breed on meat colour. All animals were being fattened on the same feedlot and slaughtered at the same abattoir.

Differences in objective colour measurements between breeds may have been due to breed differences in age at slaughter or breed differences in carcass weight and fatness (which both influence postmortem chilling rate of muscles) Liboriussen *et al* (quoted by

Dikeman, 1990) showed a breed effect for myoglobin levels and light reflectance which may have been an age/weight effect. Breed differences, as determined by subjective colour scores may, in addition, have been biased by other observed characteristics e.g. fat colour.

In this study there was an apparent effect of breed on meat colour; two breed/crosses (SG, SG & HF) were significantly darker in colour than the other breeds. They were also significantly heavier in slaughter weight. Age and marbling levels had no effect within the breeds. Nakanishi *et al* (1989) attributed the breed differences in chroma to marbling and fatness differences between breed groups and values were significantly related to carcass variables except age and marbling score.

Based on the correlations, a breed group would have had darker meat in the LD muscle if it had a greater mean carcass weight, was fatter and had yellower fat. The group (A x HF) with the lightest meat colour had a relatively low carcass weight, with a relatively thick fat cover, an average degree of marbling, a relatively white fat and was relatively young.
Unexpectedly (Nakanishi *et al* 1989), the extent of marbling did not influence any of the colour measurements but fat colour scores were correlated with meat colour scores and meat lightness (L), as well as C and H values. Perhaps, a factor which reduced lightness may have biased fat colour assessors to record yellower-than-actual scores?

Myoglobin (meat colour pigment) concentration would be expected to increase with age (Lawrie, 1985). Age and weight are related. Chilling rates can influence the usual colour relationships between age and meat lightness so that they can become curvilinear (Shorthose & Harris, 1991). When ranked the meat colour scores did not correspond well to the rankings of the other colour measurements. Meat colour scores were related only to the lightness values. This shows that the assessors could detect the differences in lightness of the meat colour but not in the chroma and hue.

Fat colour is influenced most by beta-carotene intake. Some breeds, particularly dairy breeds e.g. Jersey, accumulate the beta-carotene faster and to a greater degree than others (Morgan & Everitt, 1969). As the SG/crosses were older (median scores), heavier, with the highest fat cover and the darkest meat colour it would be expected that this group's fat colour would be the yellowest. As the Angus breed was the youngest breed (median scores) with the lightest weight, lowest fat cover and had the lowest light value they would be expected to have the whitest fat colour. The A and MG breeds had the yellowest fat colour score and the A x HF the lowest.

To alter the expected growth rate/maturity differences, the feedlot operators can introduce the differing breeds at different ages into the feedlot. Slow growing (lower mature weight) breeds/animals are introduced into the feedlot at heavier weights and much greater ages (due to their slower growth rates). As these animals have been on a grass fed diet longer and put on less fat than other breeds on the fixed duration of the grain feeding, so their level of beta carotene does not get reduced as much and their fat as yellower.

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