SOURCES OF VARIATION IN SUBCUTANEOUS FAT COLOUR OF BEEF CARCASSES

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SUMMARY

Yellow fat in beef carcasses incurs price penalties in many domestic and export markets. Sources of variation in subcutaneous fat colour of beef carcasses was investigated by objective measurements on 622 carcasses of various classes of cattle. Fat colour was subjectively assessed using a six point photographic colour chart . The majority of carcasses sampled (80.6%) had creamy-white to cream fat. The objective measurement of the yellowness of the subcutaneous fat (b* value) explained 46% of variation in subjective fat colour scores (r^2=0.46, r.s.d.=5.35; P<0.001). Multiple regression analysis of the results for British breeds of cattle showed significant effects of nutrition, age and sex and interactions between sex x age and age x hot carcass weight on the b* value of the subcutaneous fat (P<0.001 for all). Grassfed cattle and milk vealers had yellower fat than feedlot cattle. The subcutaneous fat of female cattle was yellower than that of steers across all age categories. Aged cattle (8 permanent incisors) had yellower fat. Breed also influenced the b* value of the subcutaneous fat (P<0.001) - dairy cattle breeds had yellower fat than British and European breeds.

INTRODUCTION

One of the most important characteristics of beef to consumers is its appearance (Naumann *et al.* 1966) and fat colour is an important parameter. Yellow fat in beef carcasses is less acceptable for both the domestic and export markets than whiter fat and generally such carcasses are sold on the lower priced, manufacturing beef market. The Japanese market in particular specifies a requirement for white fat in Australian beef. Factors affecting fat colour include diet, inheritance, age, carcass fat depot, chilling regime and processing technique (Morgan and Everitt 1969). Yellowness of fat is due to the presence of carotenoid pigments within adipocytes or to certain diseases. Beta-carotene, a major precursor of vitamin A, is the main contributing carotenoid pigment in beef fat although trace amounts of alpha-carotene and xanthophylls have also been found. The greater the concentration of carotenoids in the fat, the more intense is the yellow colouring (Morgan and Everitt 1969).

Many studies of fat colour have used subjective assessment of fat colour or laboratory methods to measure carotenoid concentration in a sample of excised fat. Advances in the technology of colour instruments have recently produced portable reflectance chromameters which measure in the three dimensional CIE-L*a*b* colour space as recommended by CIE (1978). L* represents the surface lightness/darkness, a*, the redness/greenness and b*, the yellowness/blueness. Thus, the b*- value is considered the ideal objective measurement of the yellowness of a fat surface.

The aim of this project was to quantify the relationship between objective measurement and subjective assessment of fat colour and also to investigate the sources of variation in subcutaneous fat colour of beef carcasses processed in Australian abattoirs.

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MATERIALS AND METHODS

Data was collected from 622 beef carcasses over the autumn/winter period during eleven visits to five Victorian abattoirs which ranged from small domestic meatworks to large export works. Measurements of subcutaneous fat colour were taken in the CIE-L*a*b* colour space using a Minolta CR200 chromameter at the P8 site, the site used for fat depth measurement (AUS-MEAT 1987). Triplicate measurements were taken on the hot carcass following the carcass wash and the average recorded. All data analyses used b* values as it is known to measure yellowness. All carcasses were given a subjective fat colour score using the 6-point photographic colour chart developed in Western Australia (Paul Frapple pers. comm.) where 1=white and 6=very yellow. Areas of fat exhibiting blood splash, bruising or air bubbles and carcasses with a fat depth less than three millimetres at the P8 site were excluded from measurement.

Carcasses were chosen from abattoir consignments of cattle to ensure the following four nutritional groups were represented in the sample; domestic feedlot beef (70 - 100 days on grain, destined for domestic market), export feedlot beef (greater than 100 days on grain, destined for Japanese market), grassfed beef (off autumn/winter pastures of southern Australia) and milk vealers. Breed, weight, sex, and dentition were also recorded, Breed was assessed visually prior to removal of the hide and classed as either British beef breeds and their crosses (Br), Channel Island dairy breeds and their crosses (CI), other dairy breeds and their crosses excluding Channel Island breeds (OD) or European beef breeds and their crosses with British beef breeds (E). Dentition categories were recorded as an estimate of th age of the animal and were consistent with AUS-MEAT definitions as follows; no permanent incisors with four or less mandibular molars (0/4), no permanent incisors and five mandibular molars (0/5), one to seven permanent incisors (l-7) and eight permanent incisors (8).

Linear regression was used to analyse the relationship between the subjective fat colour scores and objective measurements of b* values. The majority of carcasses sampled were British breeds, thus a stepwise multiple regression was performed on the b* values to assess the effects of breed, dentition, sex, hot carcass weight and nutritional background and the interactions for this subset of data. The effect of breed on b* value was analysed using multiple regression on the full data set.

RESULTS

Approximately equal numbers of castrates (51.3%) and females (48.7%) were surveyed and most of the cattle (87%) were British breeds. Pasture fed cattle (63.2% of total) were represented in all dentition categories and hot carcass weights were predominantly in the range of 190-250 kg. Some confounding occurred in the sample between categories as follows; many older male cattle and cattle on grain for more than 100 days had carcasses with hot weights in excess of 300 kg, most carcasses in dentition category 8 were female while most carcasses in dentition category l-7 were male, domestic feedlot cattle were all in dentition category 0/5 whereas the export feedlot cattle were in dentition category 0/5 or l-7 and milk vealers were only represented in dentition category 0/4. This confounding is typical of the categories of cattle slaughtered in Victoria, thus, although the analysis must be reported carefully, the results remain meaningful.

The mean b* value was 11.24 (S^2=51.59) and explained 46% of the variation in the subjective fat colour scores (r^2 = 0.46 $P<0.001$; Table 1). Most carcasses (80.6%) fell into fat colour scores 2 and 3 (creamy-white to cream) and very few carcasses had a fat colour score of 5 or more (yellow to very yellow) (Table 1).

The multiple regression analysis of the b* value for British breeds of cattle showed significant effects of nutritional category, dentition, sex and the interactions hot carcass weight x dentition and sex x dentition ($P<0.001$ for all). The model accounted for 63% (r^2) of the variation in fat yellowness. The regression coefficient of b* value on hot carcass weight (kg), was 0.05 (s.e. = 0.02). In addition, breed had a significant effect on the b* value ($P<0.001$) in the analysis of the full data set.

Table 1 Mean and variance for the CIE-b* values for each fat colour *score* and the coefficients and standard *errors* for the regression equation of b* values on fat colour scores.

Fat Colour Score (FCS)	No.	Mean	Variance(S^2)
1-white	29	4.2	6.36
2	264	8.0	14.44
3-cream	237	11.9	30.33
4	75	18.7	62.33
5-yellow	15	30.5	51.30
6	2	38.1	52.63
Total	622	11.2	51.59

Equation: $b^* = -3.56(\pm0.70) + 5.56(\pm0.25)$ FCS, (r^2=0.46, r.s.d.=5.35, $P<0.001$)

Feedlot cattle had lower b* values than he grassfed or milk vealer categories (domestic feedlot =8.1, export feedlot =4.2, grass-fed =13.8, milk vealers =9.0). For the British breeds of cattle, predicted b* values *were* similar between the dentition categories 0/4, 0/5 and 2-7 but *were* higher for cattle with eight incisors for both sexes (Table 2). The mean carcass weights *were* lower for females for all dentition categories with significantly lower mean carcass weights for females in dentition category 8 (Table 2). The predicted b* value *for* female cattle was 3.0-3.1 units higher than for steers up to dentition category 2-7 whereas for cattle in dentition category 8, the difference was only 1.0 unit (Table 2). For dentition category 2-7, the b* value of dairy breeds of cattle was higher than for the British breeds or European breeds (Br = 8.5, CI = 17.4, OD = 15.1, E = 11.5) and for cattle in dentition category 8, the differences between breeds were similar although the b* value was higher (Br= 20.7, CI= 28.1, OD= 24.1, E= 11.1).

Table 2 Predicted b* values, mean hot carcass weight (HCW) and number of carcasses (n) for the interaction between sex and dentition categories for British breeds.

Dentition[1]	0/4		0/5		2-7		8	
Sex	Male	Female	Male	Female	Male	Female	Male	Female
n	19	40	146	146	114	17	4	54
b*	6.7	10.8	7.8	10.9	10.3	13.3	17.7	18.8
HCW (kg)	196	152	249	185	340	259	373	217

[1] Dentition categories; 0/4: 0 incisors and 4 molars; 0/5: 0 incisors and 5 molars; 2 - 7: 2 to 7 incisors; 8: 8 incisors or broken mouth.

DISCUSSION

This study provides *new* objective information on the range in subcutaneous fat colour of beef carcasses from grass-fed and grain-fed cattle and milk vealers slaughtered in Victoria during the autumn/winter period. The results showed that the majority of carcasses sampled had relatively creamy-white to creamy fat or fat colour scores 2 and 3 (b^*= 3-15). As the domestic market accepts carcasses with scores 1-3 (b^* = 1-18) and the Japanese market accepts scores of 1-2 (b^* = 1-11), most carcasses would not have been discounted for fat colour.

The amount of variation in the subjective assessment of subcutaneous fat colour *score,* which was explained by objective measurement, was lower than expected (r^2 = 0.46). This could have been caused by inaccuracies in the subjective colour assessment system used. Murray et al. (1989) reported a high correlation (r = 0.96) between chromameter measurements and subjective meatcolour using a 5-point scale.

Most of the carcasses having extremely yellow fat occured in aged cattle of the dairy breeds as findings in other studies have shown (Morgan *et* al. 1969). This study does indicate the presence of very yellow fat in aged cattle as evidenced by the fat colour of Channel Island, British and other dairy breeds with 8 permanent incisors. Female cattle had yellower fat than castrates for the British breed cattle across all dentition categories which disagrees with Morgan et *al.* (1969) who found negligible fat colour difference between sexes.

The effect of feeding grain, for finishing cattle, has been reported to reduce yellow colour in the fat as a result of the low beta-carotene content of grain (Forrest 1981; Hidiroglou *et al.* 1987). Our results confirmed this as whiter fat was recorded in British breed cattle in the grain fed categories when compared with those of the grassfed category at the same age as indicated by dentition, Longer periods of grain feeding have been shown to cause continual reduction in yellow fat colour (Dinius and Cross 1978) up to at least 112 days in the feedlot (Forrest 1981). This effect was noted in the whiter fat of export feedlot cattle (in the feedlot for more than 100 days) compared with domestic feedlot cattle, The potential for reducing the yellowness of beef fat through dietary manipulation in the weeks/months pre-slaughter warrants further investigation under local conditions. It is particularly relevant for expanding export markets in Japan and the Pacific rim.

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