GENETIC AND ENVIRONMENTAL FACTORS AFFECTING FAT COLOUR IN CARCASSES OF BEEF CATTLE GRAZING AT PASTURE

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SUMMARY

Subcutaneous fat colour was scored at slaughter on a scale of 0 for very white fat to 10 for very yellow fat. Using data from 585 animals, age, breed, sex and season were found to have a significant effect (P<0.01) on fat colour. Fat colour was moderately heritable (0.32 Í 0.11 s.e.), indicating that fat colour can be improved through selection There was a poor phenotypic correlation (r=0.2) between fat colour and -carotene concentration in plasma. Options for reducing the problem of yellow fat are discussed.

INTRODUCTION

Yellow fat in bovine carcasses is a significant cause of downgrading, particularly in premium export markets. The Livestock and Meat Authority of Queensland estimated that in 1989, based on a downgrading of 10 % of export carcasses due to yellow fat, a reduction in incidence of 50% would yield an annual saving of $9.2 million. Pasture fed cattle, consuming a diet high in carotene which is abundant in green plants, have more yellow colour in their fat than grain fed animals (Steensburg 1934). Barton (1959) reported that fat colour intensifies with age. Sex differences in yellowness of fat have also been recorded (Sutton and Soldner 1945; Morgan et al. 1969). Morgan et al. (1969) also reported that post-slaughter chilling regime affected fat colour. A variation in the intensity of fat colour occurs between breeds, and Jersey cattle are well known for their yellow fat (Morgan et al. 1969). This suggests that fat colour in cattle may be under genetic control. Strong evidence suggests this is the case in sheep (Baker et al. 1985), but there is no known work to determine if this is true of cattle. This preliminary study was designed to determine whether colour of beef fat is heritable, and to quantify the relative importance of genetic and environmental factors that may affect the fat colour of bovine carcasses, particularly in animals which have grazed tropical pastures.

As assessing fat colour from a carcass currently entails slaughter, an alternative method of determining fat colour, particularly in breeding herds, is desirable. A high correlation (0.9) exists between concentration of carotenoids in plasma and perirenal fat in sheep (Karijord 1978). This study also assessed the value of -carotene concentration in plasma samples as a predictor of fat colour in cattle.

MATERIALS AND METHODS

Data were collected from 585 pedigreed animals from the National Cattle Breeding Station "Belmont" in Central Queensland, slaughtered from 1990 to 1994. Breeds and stabilised crossbreeds used included Brahman (B), Hereford x Shorthorn (HS), Brahman x HS (BX), Africander x HS (AX) and reciprocal AX

x BX crosses (AXBX). The progeny of F_1 Charolais x B bulls and AXBX dams (CBX) were also used. Steers, bulls and females (heifers and cows) were represented. For each animal sire, dam, breed, sex, date of birth, date of slaughter, carcass weight at slaughter (range 160 - 419 kg), and fat colour were recorded. Season of slaughter was recorded as "wet" (January-April) or "dry" (May-December) based on rainfall records over the experimental period. Subcutaneous fat colour was assessed on the rump area of the hot carcass using colour chips graded over the full range of a 0 to 10 scale, with 0 scored for very white fat and 10 for exceptionally yellow fat. A fat colour score of about four and above on this scale would result in downgrading of carcasses due to yellow fat in export grassfed markets (I. Loxton, pers. comm.) All animals grazed on pasture throughout their lives. Blood samples were collected by venipuncture prior to slaughter and carotene concentrations in the plasma were obtained using the procedure outlined by Van Steveninck and Goeij (1973), using 1 ml only of both plasma and ethanol in each sample.

Data were analysed by least squares methods (SAS, 1989), using breed, sex and season of slaughter as fixed effects. Age and carcass weight were fitted to the model as covariates. First and second order interactions were initially fitted but were subsequently pooled with error as they were not significant ($P>0.05$). A subset of the data (n=248), in which AXBX and CBX steers and heifers of the same age were grazed under identical conditions from birth, was analysed using the same model to determine unequivocally the effect of sex on fat colour. A third subset of data containing only females was also analysed to clarify the effect of age on fat colour, as data sets containing animals of all sexes were confounded (bulls and steers were slaughtered by 4 years of age, but some females remained in the herd until 10 years of age).

Fat colour was not normally distributed, so fat colour was analysed both with and without a square root transformation of fat colour + 0.5. As conclusions of both analyses were very similar, only the results of non-transformed data are presented in this paper. Differences between means were detected using the new multiple range test (Steel and Torrie, 1960).

Heritability of fat colour score and phenotypic correlation between fat colour score and -carotene concentration in plasma was estimated using DFREML (Meyer, 1989) by fitting an animal model with the same fixed effects identified above. The genetic correlation was also calculated but is not presented as the estimate was unreliable, perhaps due to the small data set.

RESULTS AND DISCUSSION

Least squares means showing the effects of sex and season are presented in Table 1. Both were highly significant ($P<0.01$). Bulls had significantly lower fat colour scores than steers and females, in agreement with Sutton and Soldner (1945). Where steers and heifers were grazed together from birth, heifers had a higher ($P<0.01$) fat colour score (2.86) than steers (1.76). This does not concur with the report of Morgan et al. (1969) that concluded heifers and steers had similar fat colour. The experiments cannot be compared directly due to differences in environment (ie. temperate *cf.* tropical environments), breed and pasture type, and this may explain some of the differences between results.

In all analyses, animals slaughtered in the dry season had more yellow fat ($P<0.01$) than animals slaughtered in the wet season. In the overall data set, season is confounded with age, as old cows were all slaughtered in the dry season and only young animals were slaughtered in the wet season. In the subset of data containing steers and heifers only, fat colour score of animals slaughtered in the wet season was 0.62 (n=42) *cf.* a fat colour score of 3.73 (n=135) in animals slaughtered in the dry season. Confounding and the small dataset prevent determination of causes for this effect.

Table 1. Mean fat colour scores for sex and season of slaughter

Values within columns with different superscripts vary significantly (P<0.05)

	No. of animals	Fat colour
Mean Ís.e.	585	3.31Í1.38
Sex		
Bull	45	1.29[a]
Female (Cow and heifers)	253	2.87[b]
Steer	287	2.25[b]
Season		
Dry	533	3.00[a]
Wet	52	1.27[b]

It is not possible to estimate a true breed effect, due to partial confounding of sex, age and breed (there was a greater proportion of old cows in the B, BX, AX and HS breeds). However, breed did have a significant effect on fat colour. Brahman, BX, AXBX and HS animals had the highest fat colour scores (2.84, 2.62, 2.58 and 2.46 respectively), while CBX animals had significantly lower fat scores (0.60) than all other breeds except AX (1.73). The differences between breeds are sufficiently great to confirm that between-breed variation exists and it may be possible to exploit this difference in breeding programs. These results agree with the conclusions of Morgan et al. (1969) which were based on *Bos taurus* breeds.

Fat colour increased with age for all sexes (P<0.01), as reported by Barton (1959). Figure 1 shows the relationship between age and fat colour score in females, derived from the non confounded data set.

Figure 1. Relationship between age and fat colour score in heifers and cows (fat score 0 = very white fat, fat score 10 = very yellow fat). Fat colour score = 0.34 (Í0.04) x age + 2.69 (Í 0.68.) The hatched area represents animals that have fat colour scores in acceptable ranges for the premium export markets.

Based on all data, the heritability of yellow fat score was 0.32Í0.11. There were 131 sires from 6 breeds represented in the data, so this estimate must be regarded as preliminary. Nevertheless, it is sufficiently high to suggest that fat colour could be improved by genetic means if desired. The phenotypic correlation between fat colour score and -carotene concentration in plasma was positive but low (0.20), supporting the conclusions of Morgan et al. (1969) and Strachan et al. (1993) that fat colour cannot reliably be predicted from plasma carotenoid concentration.

IMPLICATIONS

The northern Australian beef industry is based mainly on the use of pastures. Animals grazed at pasture generally have lower annual liveweight gains than those fed on grain-based diets, and take longer to reach market weights. These results show that if carcasses are to have acceptable fat colour for premium markets, animals must be slaughtered before they are 4 years of age (Figure 1). A number of options are available to the beef industry to produce carcasses that have fat colour within acceptable ranges.

Meat processors can influence fat colour of bovine carcasses through more rapid chilling or freezing as reported by Morgan et al. (1969). However, they would need to weigh up the benefits of improving fat colour by this method against the likely increase in cold-shortening (and its subsequent effect on meat tenderness.) Beef producers can use genetic and non-genetic options to increase annual liveweight gains, thereby reducing age of turnoff of sale animals. Short term feedlotting has been proposed to reduce fat colour in cattle (Jeffery et al. 1993). However this may not completely overcome all problems of yellow fat. Strachan et al. (1993) reported that, even after 105 to 175 days of grain feeding, some steers in their experiment still had unacceptably yellow fat. Another option for producers is to implement breeding programs that make use of the genetic variation in fat colour between animals and breeds, to specifically improve fat colour. However, to make rapid progress with direct selection for fat colour it would be desirable to have a measure in the live animal that is a useful predictor of fat colour in the carcass. This study shows that -carotene concentration in plasma is not a useful predictor of fat colour in the carcass. The earlier study of Morgan et al. (1969) also questioned the reliability of -carotene concentrations in subcutaneous fat samples as a predictor of yellow fat in the carcass, but this aspect may still warrant further investigation because of the small number of animals in that study.

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