SOME FACTORS AFFECTING YELLOW FAT COLOUR IN CATTLE

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SUMMARY

Yellow fat coloration, blood and fat carotene levels were measured in steers and heifers of three breeds and three crosses slaughtered at various ages up to 27 months.

Fat colour intensity and carotene levels were higher in the Jersey than in Friesian and Aberdeen Angus cattle. Jersey crosses with Friesian, Charolais and Hereford sires were generally intermediate in fat colour with evidence that the Charolais sire was more effective than the Hereford in reducing the colour. Appreciable variations within all breeds and crosses, especially in the Jersey, was observed with considerable overlap in breed distributions.

Neither colour intensity of fat, nor blood and fat carotene levels, were closely related to animal age, with no evidence of a sex effect.

Carotene levels in blood, channel and subcutaneous fat, and fat colour intensity, were all positively correlated but could not be reliably predicted from each other.

On carcass chilling, fat colour increased with surface drying but decreased with cooling of fat, the net result being largely dependent on chiller temperature. Rendering of fat did not eliminate the yellow coloration.

It was concluded that genetic manipulation such as within-breed selection, cross-breeding and breed replacement can effectively reduce fat colour and largely eliminate the marketing problem of yellow fat.

YELLOW coloured fat is disliked by most beef consumers, presenting a marketing problem, particularly in beef destined for European markets and in canned beef products.

The yellow coloration of body fat in cattle is normally due to the presence of carotenoid pigments absorbed from the diet (Hirzel, 1939; Yeates, 1965; Hill, 1968) and is commonly attributed to pasture feeding and to animals of the Channel Island breeds. The problem of yellow fat is of special significance to New Zealand with a predominant Jersey dairy cow population as the basis of a dairy beef industry and the reliance on pasture as the main source of cattle feed.

Genetic influence on fat colour is recognized (Hammond, 1935; Barton, 1959) but until recently little objective in-

formation on breed differences and within-breed variation was available. In a breed comparison trial conducted in New Zealand, the fat colour of Jersey steers, scored subjectively, was more yellow than that of Friesian steers with Friesian-Jersey cross steers intermediate in colour (Barton *et al.*, 1968). Another trial with steers showed a more yellow fat colour of Friesian and Friesian-Jersey crosses than that of Charolais-Jersey crosses, the latter being more coloured than Aberdeen Angus and Hereford cattle (Barton, 1968). Variation within breeds was observed in both these trials, while in another experiment (Morgan and Everitt, 1968) a fourfold variation in fat colour was recorded in identical twin steers of the Jersey breed, together with evidence suggesting that fat colour may be strongly inherited.

Fat colour reputedly intensifies with age (Hirzel, 1939; Barton, 1959). The frequently highly coloured fat of old cows tends to support this belief, but may also reflect periods of nutritional stress. The influence of age within the accepted age range for prime quality beef is not known.

Barton *et al.* (1968) observed a decrease in fat colour intensity on carcass chilling in Jersey and Friesian-Jersey cross steers, but not in Friesian carcasses assessed concurrently. Opinions solicited recently (pers. comm.) from meat companies in New Zealand suggested that the intensity of fat colour may decrease on chilling or freezing, but the colour returns on thawing, and reappears in canned products.

This paper presents information on the influence of breed, age and sex of animal, carcass chilling and rendering on fat colour.

MATERIALS AND METHODS

ANIMALS

Data presented relate to animals forming part of a breed comparison trial in progress at Ruakura, involving three pure-breeds (Jersey, Friesian and Aberdeen Angus), together with three cross-breds (Friesian-Jersey, Charolais-Jersey and Hereford-Jersey). Cattle have been slaughtered at 3, 9, 15, 21 and 27 months of age. Each breed or cross, except the Friesian with steers only, was represented by equal numbers of steers and heifers, sired by several bulls (a minimum of 10), within each slaughter-age group, but for various reasons, measurements were not obtained for all animals in some groups.

TABLE 1: YELLOW FAT COLOUR COMPARISONS

Descriptive Terminology	*White*	*Cream*	*Creamy-yellow*	*Slight to Medium Yellow*	*Medium to Very Yellow*	*Extremely Yellow*
A.R.C. Tintometer assessment	0	—	1Y	2Y	3Y	4Y
Lovibond tintometer range (approx.)	0-1.4	1.5-2.9	3.0-4.4	4.5-5.9	6.0-9.9	10.0 +
Carotene level range (approx.) (mg/100 g)	0-0.14	0.15-0.24	0.25-0.34	0.35-0.49	0.50-0.79	0.80 +

All cattle were reared on reconstituted buttermilk powder from 4 days of age, weaned at approximately 10 weeks of age, and grazed intensively at a stocking rate of approximately 10 ewe equivalents/acre using hay as supplementary winter feed.

MEASUREMENTS

Blood samples were obtained at slaughter and carotene content determined using a technique based on the method of Clausen and McCoord (1936). Samples of channel (retroperitoneal) fat and subcutaneous fat from the 13th rib region of the left carcass sides were taken three hours after slaughter. Channel fat samples were obtained from all age groups, but, because of insufficient fat cover on cattle killed at 3 and 9 months, subcutaneous fat samples were obtained from the 15, 21 and 27 months slaughter-age groups only.

Colour of the external surface of the subcutaneous fat samples (3 sq. cm), approximately 3 hours *post mortem*, was assessed at room temperature using a portable disc tintometer,* developed commercially in conjunction with the British Agricultural Research Council (Anon., 1965), and yellow colour intensity measured by a Lovibond filter tintometer†. Carotene content of channel and subcutaneous fat samples was determined as described by Morgan and Everitt (1968). Table 1 shows a yellow fat colour chart describing the range of colour intensities encountered in cattle, together with appropriate tintometer readings and carotene levels.

Effects of chiller storage and temperature were studied in subcutaneous fat samples secured from the blade or scapula region immediately following carcass dressing and colour intensity of the external surface of each sample assessed by both tintometers. Fat samples were then pinned back on to the carcasses, stored in a chiller at 7.5° C, and colour intensity measured at this temperature at 3, 24, and 48 hr *post mortem*. Further measurements were taken in a freezer at − 5° C, in which the sample had been stored for 24 hr and also at 15° C after another 24 hr at this room temperature. Finally, the subcutaneous fat samples were rendered, care being taken to avoid discoloration by overheating, returned to the freezer to solidify, and then measured twice more, in the freezer and at room temperature.

*AF 284, †AF 702, the Tintometer Company, Salisbury, England.

TABLE 2: AGE AND BREED EFFECTS ON YELLOW FAT COLOUR INTENSITY

Age in Months	*Season of Slaughter*	*Year Born*	*n*	*Jersey*	*Friesian*	*Aberdeen Angus*	*Friesian × Jersey*	*Charolais × Jersey*	*Hereford × Jersey*	*Group Mean*	*S.D.*
(a) BY LOVIBOND TINTOMETER (AF702)											
15	Spring	1967	44	4.60 a	3.08 c	3.34 bc	4.34 ab	4.06 abc	4.80 a	4.19 (a)	1.047
15	Spring	1966	48	4.35 a	3.28 ab	2.74 b	3.70 ab	3.41 ab	3.39 ab	3.48 (b)	0.932
21	Autumn	1966	48	8.58 a	3.38 bc	3.10 c	4.70 bc	3.20 c	4.8 b	4.63 (a)	1.411
27	Spring	1966	48	5.25 a	3.78 c	4.38 bc	4.88 ab	4.28 bc	4.40 bc	4.49 (a)	0.771
	Breed mean		188	5.69 (a)	3.40 (c)	3.39 (c)	4.40 (b)	3.86 (bc)	4.35 (b)	4.19	0.110
	Range			3.2-13.0	1.9-5.7	2.0-6.3	2.3-6.6	1.8-6.1	2.8-6.5	1.8-13.0	
	% over 6.0			34.4	0.0	3.1	9.4	3.2	12.5	10.5	
(b) BY A.R.C. TINTOMETER (AF284)											
15	Spring	1967	44	2.1	1.3	1.4	2.3	2.2	2.4	2.0	
15	Spring	1966	48	1.8	1.3	1.4	1.6	1.5	1.8	1.5	
21	Autumn	1966	48	2.8	1.1	1.4	1.9	1.1	2.0	1.7	
27	Spring	1966	48	3.0	2.1	2.1	2.8	2.5	2.7	2.5	
	Breed mean		188	2.4	1.4	1.6	2.1	1.7	2.2		

In this and subsequent tables the following abbreviations are used:
$^{*}P < 0.05$; $^{**}P < 0.01$; $^{***}P < 0.001$; n = number of animals.
a, b, c and d refer to Duncan's Multiple Range Test (means with the same letter do not differ significantly, $P < 0.05$) within slaughter-age groups; (a), (b), (c) and (d) are applicable to breed and slaughter-age group means only.

RESULTS

Fat Colour Intensity

Fat colour of the Jersey, as measured by the Lovibond tintometer, was more yellow than that of all other breeds and crosses (Table 2). Friesian-Jersey and Hereford-Jersey crosses were more yellow than Friesian and Aberdeen Angus pure-breeds. Charolais-Jersey crosses were intermediate and not significantly different from either the other Jersey crosses or the Friesian and Aberdeen Angus breeds.

Appreciable variation in intensity of fat colour existed within all breeds, but especially the Jersey. Several Jersey carcasses had less yellow fat than some of the carcasses from all other breeds, but the proportion of carcasses with fat meauring 6.0 units or more on the Lovibond tintometer was considerably higher in the Jersey than in the others. Proportionately fewer Jersey crossbreds recorded these high colour values than the purebred Jersey cattle, but the proportion was higher in the Friesian-Jersey and Hereford-Jersey crosses than in the Charolais-Jersey cross, Friesian and Aberdeen Angus breeds.

Fat colour intensity, as measured by either tintometer, appeared unrelated to animal age but was significantly lower in the 1966-born 15-month age group than in all other slaughter-age groups. Season of slaughter did not appear to influence fat colour but differences in slaughter age confounded these observations.

Breed and age effects indicated by the A.R.C. tintometer generally agreed with those recorded by the Lovibond tintometer, variations between the two instruments probably reflecting the greater subjectivity of assessment and lack of precision in the former.

Fat Carotene Content

Carotene contents of channel and subcutaneous fat were higher in the Jersey than all other breeds and crosses (Table 3). Differences between other breeds and crosses were inconsistent and not significant.

Fat carotene content and animal age were not closely related but channel fat carotene was higher at 3 months than in all other slaughter-age groups. Age trends in subcutaneous fat carotene were inconsistent within breeds, although significantly higher at 27 months than in all other slaughter-age groups.

TABLE 3: AGE AND BREED EFFECTS ON CHANNEL AND SUBCUTANEOUS RIB FAT CAROTENE (mg/100 g)

Age in Months	*Season of Slaughter*	*Year Born*	*n*	*Jersey*	*Friesian*	*Aberdeen Angus*	*Friesian × Jersey*	*Charolais × Jersey*	*Hereford × Jersey*	*Group Mean*	*S.D.*
(a) CHANNEL FAT											
3	Spring	1968	39	1.03 a	0.49 b	0.57 b	0.51 b	0.50 b	0.66 ab	0.64 (a)	0.357
9	Autumn	1967	48	0.27 a	0.19 ab	0.18 ab	0.15 b	0.21 ab	0.18 ab	0.20 (d)	0.082
15	Spring	1967	48	0.38 a	0.37 a	0.31 a	0.30 a	0.43 a	0.35 a	0.36 (b)	0.157
15	Spring	1966	22	0.27 ab	0.31 ab	0.21 b	0.29 ab	0.51 a	0.21 b	0.30 (bc)	0.134
21	Autumn	1966	48	0.44 a	0.23 b	0.17 b	0.22 b	0.17 b	0.26 b	0.25 (cd)	0.128
27	Spring	1966	48	0.37 a	0.29 b	0.33 a	0.41 a	0.36 a	0.29 b	0.34 (b)	0.103
	Breed mean		249	0.48 (a)	0.30 (b)	0.29 (b)	0.32 (b)	0.34 (b)	0.32 (b)		
	Range			0.11-2.35	0.09-0.64	0.07-0.79	0.10-0.86	0.07-0.70	0.11-1.40		
(b) SUBCUTANEOUS RIB FAT											
15	Spring	1967	48	0.31 a	0.28 a	0.23 a	0.23 a	0.32 a	0.27 a	0.27 (b)	0.107
15	Spring	1966	42	0.31 a	0.23 a	0.14 a	0.28 a	0.28 a	0.23 a	0.24 (b)	0.148
21	Autumn	1966	48	0.56 a	0.21 b	0.16 b	0.25 b	0.16 b	0.27 b	0.27 (b)	0.115
27	Spring	1966	48	0.42 a	0.23 b	0.29 b	0.37 ab	0.31 ab	0.32 ab	0.33 (a)	0.120
	Breed mean		186	0.40 (a)	0.24 (b)	0.21 (b)	0.28 (b)	0.27 (b)	0.27 (b)		
	Range			0.13-0.94	0.10-0.38	0.12-0.56	0.16-0.49	0.10-0.56	0.11-0.51		

TABLE 4: AGE AND BREED EFFECTS ON BLOOD CAROTENE LEVEL (mg/100 ml)

Age in months	*Season of Slaughter*	*Year Born*	*n*	*Jersey*	*Friesian*	*Aberdeen Angus*	*Friesian × Jersey*	*Charolais × Jersey*	*Hereford × Jersey*	*Group Mean*	*S.D.*
3	Spring	1968	47	0.44 a	0.20 b	0.25 b	0.28 b	0.27 b	0.22 b	0.26 (d)	0.126
9	Autumn	1967	48	0.58 a	0.58 a	0.56 a	0.70 a	0.59 a	0.60 a	0.60 (c)	0.281
15	Spring	1967	48	0.61 a	0.58 a	0.26 b	0.49 ab	0.57 a	0.60 a	0.52 (c)	0.216
15	Spring	1966	48	1.11 a	0.89 ab	0.62 b	1.08 a	0.83 ab	0.98 a	0.92 (a)	0.314
21	Autumn	1966	48	1.58 a	0.85 bc	0.59 b	0.96 b	0.55 c	0.80 bc	0.89 (a)	0.363
27	Spring	1966	48	0.85 a	0.56 bc	0.53 c	0.85 a	0.72 ab	0.77 a	0.71 (b)	0.170
	Breed mean		287	0.86 (a)	0.61 (bcd)	0.47 (d)	0.73 (b)	0.59 (cd)	0.66 (bc)		
	Range			0.16-2.79	0.10-1.60	0.12-0.98	0.09-1.71	0.13-1.52	0.07-1.40		

Blood Carotene Levels

Blood carotene levels were, generally, highest in the Jersey, intermediate in the Friesian, Friesian-Jersey, Hereford-Jersey, and least in the Aberdeen Angus and Charolais-Jersey (Table 4). Lowest values were recorded at 3 months of age with some tendency to increase with age.

Sex

Steers and heifers did not differ significantly in either fat colour intensity or subcutaneous fat carotene content within any slaughter-age group. Neither did blood and channel fat carotene levels differ between sexes except for inconsistent differences in the 9- and 21-months slaughter-age groups.

Carotene/Colour Relationships

Blood carotene level, channel and subcutaneous fat carotene contents and fat colour intensity were all positively correlated but residual standard deviations, although numerically low, were high in relation to the units of measurement (Table 5).

Table 5: Relations[1] Between Blood Carotene, Fat Carotene and Fat Colour

y	*x*	*r*	*RSD*	*Mean of Y*
Colour intensity of subcut. rib fat	Blood carotene	0.44**	1.148	
	Subcut. rib fat carotene	0.60***	1.024	4.179
	Channel fat carotene	0.31*	1.216	
Channel fat carotene	Blood carotene	0.39**	0.121	
	Subcut. rib fat carotene	0.75***	0.086	0.264
Subcut. rib fat carotene	Blood carotene	0.58***	0.091	0.254

[1]Derived from 15- and 21-months-old slaughter-age groups and adjusted for breed, sex and slaughter-age group.

Carcass Chilling Effects

Fat colour intensity increased during the first 3 hours of chiller storage but changed little from 3 to 48 hr *post mortem* (Table 6).

TABLE 6: EFFECTS OF CHILLING FOLLOWED BY FREEZING, THAWING AND RENDERING ON FAT COLOUR

Environment or Treatment	*Temp. (° C)*	*Hr Post Mortem*	*A.R.C.* Tintometer*	*Lovibond Tintometer Readings**		
				Mean	*S.D.*	*Range*
		0	1.8	3.30	0.74	1.7-5.9
Chiller	8	3	2.3	4.33	1.03	2.3-6.9
		24	2.3	4.27	1.02	2.2-7.4
		48	2.4	4.49	1.10	2.3-9.0
Freezer	— 5	72	1.9	3.99	0.92	2.2-8.0
Room	15	96	2.3	4.81	1.17	2.7-8.9
Rendered &	— 5	97	—	3.88	1.96	1.2-10.4
solidified	15	98	—	4.19	2.36	1.1-17.0

*Measured on the external surface of subcutaneous fat from the scapula region of 84 carcasses, of six breeds and crosses at 15 and 27 months of age.

TEMPERATURE

Temperature influenced fat colour intensity (Table 6), with lower tintometer readings on fat samples in the freezer (— 5° C) than in the chiller (8° C), but substantially higher values at room temperature.

RENDERING

Rendering and solidifying of fat did not eliminate yellow coloration but reduced colour intensity at room temperature (Table 6). In some samples, however, colour intensity increased noticeably on rendering.

DISCUSSION

These investigations reveal that fat colour in cattle is influenced greatly by breed and confirm that the body fat of the Jersey is more yellow than that of the Friesian and Aberdeen Angus breeds, Jersey crosses with the Friesian, Charolais and Hereford breeds being intermediate in fat colour.

Fat with a colour intensity of 6.0 or more yellow units on the Lovibond tintometer is likely to present a marketing problem in the sale of beef in most world markets other than that for manufacturing beef in the U.S.A. A carcass with fat of this colour intensity is liable to be downgraded, and such fat can therefore be described in trade terms as being "excessively yellow".

Out of the 32 Jersey carcasses examined for fat colour in this investigation, the fat of about 1 in every 3 was excessively yellow, but 26 were downgraded to Boner mainly because of their poor conformation and finish, the part played by fat colour being difficult to isolate. This proportion of Jersey cattle with excessively coloured fat is much higher than in the other breeds and crosses examined, and about twice the proportion encountered in 26 identical twin Jersey steers studied previously (Morgan and Everitt, 1968).

In the Jersey crossbreds, the Hereford cross had the highest, and the Charolais cross the least, proportion of carcasses with excessively yellow fat. Fat colour of Friesian-Jersey crosses lay, on average, mid-way between that of the parents, indicating a lack of heterosis.

The appreciable within-breed variation in fat colour, in all the breeds and crosses examined, but particularly the Jersey, together with the considerable overlap in breed distributions, is a common finding in the investigation of genetic differences (Taylor, 1968), and stresses the need for large numbers of animals, derived from several sires, for meaningful breed comparisons. The within-breed variation in fat colour, together with the apparent high heritability (Morgan and Everitt, 1968) suggests, too, that progress could be made in selection against fat colour, especially in artificial breeding programmes.

Fat colour appears little influenced by slaughter age, at least within the accepted age-range for young beef in New Zealand. Colour of fat may become increasingly obvious at older ages, however, owing to an increase in carcass fatness with greater subcutaneous fat cover.

The high carotene content of channel fat in the 3-month age-group, with a very small quantity of channel fat and total body fat, together with the low blood carotene levels at this age, suggests that the amount of body fat, or its rate of deposition, may also influence fat carotene content and, hence, fat colour.

The positive correlation between blood carotene level at slaughter and fat colour intensity supports the suggestion that blood carotene level plays a part in the determination of fat colour. The relationship is, however, insufficiently precise for predictive purposes, although comparable with that reported between blood and milk fat carotene levels in Jersey cows (McGillivray, 1960).

The correlation between the carotene content of subcutaneous fat and its yellow colour intensity was not as high as previously reported (Morgan and Everitt, 1968). Col-

our intensity in the earlier study was measured on the freshly trimmed surface of the subcutaneous fat while, in the present study, it was measured on the untrimmed external surface which is probably more susceptible to the influence of factors other than carotene content, such as surface drying.

Carotene contents of channel and subcutaneous fat samples were positively correlated but the considerable residual variation indicates that, although they may follow a general trend, the carotene content of fat from different parts of the carcass may vary independently.

Intensity of fat colour increased on post-mortem chiller storage, contrasting with the report of Barton *et al.* (1968). Carcass chilling may influence fat colour in two ways: first, through surface drying, intensifying the colour of the external surface, and starting to take effect immediately after skinning and washing of the carcass; secondly, by cooling and solidifying the fat, the effect of which is to reduce colour intensity. The net effect depends on chiller temperature and timing of the fat colour measurements. Chiller temperatures in this work were higher than is normal in commercial practice and it is likely that the surface drying effect dominated. It is important to realize, however, that the effect of temperature is temporary in that it can be reversed.

Rendering did not eliminate the yellow coloration, confirming reports from meat companies that the colour of yellow fat is retained in canned products.

CONCLUSIONS AND RECOMMENDATIONS

Genetic manipulation can effectively reduce the incidence and intensity of fat colour and, to a large extent, eliminate the problem of yellow fat in the marketing of New Zealand beef.

A beef industry based on either the Aberdeen Angus or Friesian breeds is unlikely to present marketing problems due to yellow fat. The fat colour of the Jersey breed, however, may present difficulties in markets other than those for manufacturing beef in the U.S.A. An opportunity exists for selection against fat colour in the Jersey if it is desirable to retain this breed in the interests of dairy production. Use of blood carotene levels for the prediction of fat colour in the selection of bulls, for example, cannot be recommended without reservation but further investigational work may make it possible to identify animals with excessively yellow fat. The use of fat biopsy techniques in this regard also needs examination.

The fat of crossbred progeny of beef bulls mated to Jersey cows is less coloured than that of the purebred Jersey, with evidence that the Charolais sire is more effective than the Hereford in reducing the colour; but as the crossbred heifer calves are unsuitable for dairy production, only a proportion of Jersey cows can be mated to beef bulls. Thus, cross-breeding with beef bulls offers only a temporary and partial solution to the problem.

Use of the Friesian sire over Jersey cows reduces fat colour to a level comparable with that of beef breed-Jersey crosses, but the greater versatility inherent in the Friesian-Jersey cross, providing for both dairy and beef production, renders this a more favourable alternative.

Neither carcass chilling nor rendering of yellow fat eliminates the coloration and, although a low temperature can reduce the colour intensity, its effect is only temporary and can be reversed.

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