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## Effect of breed on plasma carotene concentration in New Zealand dairy heifers

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### ABSTRACT

Factors affecting plasma carotene concentration were investigated in New Zealand dairy heifers. Blood samples were collected from 4000 dairy heifers in spring in November 1992. Significant ( $P < 0.001$ ) variation was found in plasma carotene concentrations due to region, breed and farm. Values for individual cows ranged from 1.7 to 56.2  $\mu\text{g/ml}$ . Purebred Jersey heifers had the highest plasma carotene levels ( $18.2 \pm 0.4 \mu\text{g/ml}$ ), purebred Friesians the lowest ( $14.4 \pm 0.2 \mu\text{g/ml}$ ), crossbreds were intermediate with 50 % Jersey and 50 % Friesian significantly different from the purebreds ( $16.9 \pm 0.6$  and  $15.4 \pm 0.4 \mu\text{g/ml}$  respectively).

**Keywords:** Dairy cattle; plasma carotene; breed.

### INTRODUCTION

Cattle differ from most farmed and experimental animals, including sheep, goats, rabbits and rats, in that they have significant B-carotene concentrations in their blood. The B-carotene concentration in plasma is dependant upon the concentration in the feed and is particularly high in animals grazing fresh forages, as in the majority of New Zealand dairy and beef cattle (Waghorn and Knight, 1992). High B-carotene concentrations result in yellow colouration of both body fat and milkfat. This yellow colouration of the fat in meat and dairy products reduces the acceptability of these products for many potential customers (Knight and Waghorn, 1992). Although there is no evidence that fat colour affects the palatability of the product, yellow fat is perceived by some customers to be undesirable.

Plasma carotene levels largely reflect what is being absorbed from the diet at that time. There is a strong association between plasma and milkfat carotene concentrations, with increases in plasma carotene quickly being associated with increases in concentrations of carotene in the milk (McGillivray, 1961; Thompson, 1968). However carotene concentrations in adipose tissue reflect the accumulation of carotene over the lifetime of the animal and not just the carotene concentration over a short period (Knight and Waghorn, 1992).

In this study factors affecting plasma carotene concentrations and the relationship between carotene concentrations in plasma and milk were investigated in New Zealand dairy heifers.

### MATERIALS AND METHODS

Blood samples were collected from approximately 4000 dairy heifers in spring in November 1992. Heifers were the progeny of 140 bulls in the Livestock Improvement Corporation Limited (LIC) Sire Proving Scheme. Farms within 3 regions, Waikato, Taranaki and Manawatu, were included in the study. A total of 58 farms using Jersey semen and 92 farms using Friesian semen were involved, providing 1500 Jersey

to determine plasma carotene concentrations involved a simple ethanol and petroleum spirit extraction, with colour being measured on a spectrometer at 450 nanometres.

For the analyses pedigree data were supplied by LIC. Factors affecting plasma carotene concentration were examined using SAS (SAS Institute, Cary, USA.).

### RESULTS AND DISCUSSION

The mean plasma carotene concentration in the spring was  $16.1 \pm 0.1 \mu\text{g/ml}$ , similar to values given as typical for New Zealand dairy cows in the 60's of 8 - 16  $\mu\text{g/ml}$  (McGillivray, 1961). Values for individual cows ranged from 1.7 to 56.2  $\mu\text{g/ml}$ . Reports of plasma carotene concentration range from 0.24  $\mu\text{g/ml}$  in cattle grazing dry summer pastures in California to 50  $\mu\text{g/ml}$  in cattle fed lush spring pastures in New Zealand (Waghorn and Knight, 1992).

The range in plasma carotene concentrations on individual farms where animals were grazing the same pasture and under the same management, varied from 7.5 to 43.6  $\mu\text{g/ml}$ . McGillivray (1960) found the difference in blood carotene levels in Jersey cows frequently exceeded five-fold and Knight *et al.* (1993) found a two to three fold range between individual cattle in plasma carotene concentration in Angus steers. McGillivray (1960) suggested that the large variability between individuals indicated marked differences in carotenoid metabolism and the explanation for these differences may lie in their initial absorption from the intestine, in the efficiency of conversion of absorbed carotene to vitamin A, or in the rate of destruction or removal from the blood of unchanged carotenoids.

There was no difference between the plasma carotene concentration in the Waikato and Manawatu regions ( $15.8 \pm 0.3$  and  $15.0 \pm 0.5 \mu\text{g/ml}$ , respectively), but levels were significantly higher ( $P < 0.001$ ) in the Taranaki region ( $17.7 \pm 0.2 \mu\text{g/ml}$ ).

Sire breed had a significant ( $P < 0.001$ ) effect on plasma carotene concentration with Jersey sired heifers having higher plasma carotene concentrations than Friesian sired heifers,  $17.4 \pm 0.45$  and  $15.0 \pm 0.3 \mu\text{g/ml}$  respectively. Other studies

(McGillivray, 1961; Thompson, 1968; Morgan *et al.*, 1969) have found similar differences, with average plasma carotene concentrations in Friesian about 3/4 that in Jerseys. There are clearly recognized species and breed differences in carotenoid metabolism (Goodwin, 1952 in McGillivray, 1960) and it is well recognized that breed has a marked effect on the carotenoid content of the blood of cows. Guernseys appear to have the highest levels of carotene in their blood. On the same feed, Jerseys reach about 60 per cent of the Guernsey figure, and Holsteins and Ayrshires about 50 and 45 per cent respectively (McGillivray, 1961).

**TABLE 1:** Effect of breed on plasma carotene concentration in 1990-born dairy heifers in November 1992.

Breed composition	Plasma carotene concentration ( $\mu\text{g/ml}$ )
100% Friesian	14.4 $\pm$ 0.2a
75% Friesian	14.5 $\pm$ 0.3a
63% Friesian	15.4 $\pm$ 0.8 ab
50% Friesian	15.4 $\pm$ 0.4 b
50% Jersey	16.9 $\pm$ 0.6 b
63% Jersey	17.3 $\pm$ 1.0 bc
75% Jersey	17.2 $\pm$ 0.6 b
100% Jersey	18.2 $\pm$ 0.4 c

where a,b,c indicate significant ( $P < 0.05$ ) differences between least square means.

The effect of breed was further considered as the proportion of Friesian or Jersey in the cow. There was a clear trend with breed composition, from the lowest plasma carotene concentrations in the Friesians to the highest in the Jerseys (Table 1). There was a significant difference between 100% Friesian and 50% Friesian cows, with 75% Friesian and 63% Friesian intermediate. Similarly, there was also a significant difference between 100% Jersey and 50% Jersey cows with 63% and 75% Jersey intermediate.

## CONCLUSIONS

Considerable variation was found in plasma carotene concentrations due to breed. Even on the same farm where cows are run on the same pasture under the same management conditions there was up to a 5-fold difference in carotene concentration. The large variation found within a group of animals indicates that, with a moderate heritability for plasma carotene concentration, selection would result in rapid change in plasma carotene concentrations.

The heritability of plasma carotene concentration needs to be accurately determined, although preliminary estimates

indicate a moderate heritability of around 0.35 (Newman, unpublished). This is supported by several studies where the uniformity of monozygotic twin-mates in blood carotenoid levels was in marked contrast with the variability of unrelated animals (McGillivray, 1960; Morgan *et al.*, 1969). No reported estimates of the genetic correlation between plasma and milkfat carotene concentrations were found but these will be determined later in this study.

A cost-benefit study is required to determine the economic significance of the problem of yellow fat colour in milk and subcutaneous fat. Screening and selection in dairy and beef herds for low carotene would provide the best long term solution to the problem. In the dairy industry, screening to improve milkfat colour would be based directly on the colour or carotene content of the milk for lactating cows and indirectly on plasma carotene levels for bulls, dry cows and young stock. As cows on many farms are a mixture of breeds, records must be corrected for breed effects prior to ranking of animals.

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