EFFECTS OF VITAMIN A SUPPLEMENTATION ON PLASMA CAROTENOID CONCENTRATIONS AND FAT COLOUR OF STEERS IN A FEEDLOT

T.W. KNIGHT and A.F. DEATH
AgResearch, Flock House Agricultural Centre, Private Bag 1900, Bulls, N.Z.

SUMMARY

The effects of daily dietary supplements of vitamin A on plasma, liver and fat carotenoid concentrations and fat colour were determined in steers fed low carotenoid diets. Seventy 3-year-old Angus steers were used in the experiment. Ten steers were slaughtered at the beginning of the trial. Three groups of 20 steers were then fed a diet of 70% barley and 30% pasture silage in a feedlot either without a vitamin A supplement, or with 1 x 10^6 IU or 0.5 x 10^6 IU vitamin A supplement/head/day. Ten steers from each group were slaughtered after 62 and 104 days of treatment. The vitamin A supplementation reduced plasma and liver carotenoid concentrations by 47% and 36% respectively, but had no effects on carotenoid concentration or colour of the subcutaneous fat. Dose of vitamin A had no effects except on the liver concentrations of vitamin A which increased with increasing dose of vitamin A. While fat colour progressively decreased during the experiment, fat carotenoid concentrations decreased only up to day 62 of the experiment; there were no further reductions by day 104.

Keywords: beef, carotenoids, fat colour, vitamin A

INTRODUCTION

Accumulation of carotenoids (β-carotene and lutein) is the major cause of the yellow colour in the fat of cattle which can cause rejection of the beef in the Japanese market (Morgan and Everitt 1969; Yang et al. 1992). Knight et al. (1996) have shown that daily oral supplementation with vitamin A can reduce plasma and liver carotenoid concentrations by 40-50% in cattle grazing green pastures. Earlier research showed that carotenoid concentrations in milkfat and plasma were reduced by the daily feeding of shark oil rich in vitamin A (Deuel et al. 1941; Blaxter et al. 1946) and by daily supplements of 0.7 x 10^6 IU vitamin A (Deuel et al. 1942). These workers suggested that vitamin A increased catabolism of absorbed carotenoids. If this was the case then the increased catabolism of absorbed carotenoids in cattle on low carotenoid diets should reduce fat carotenoid concentrations and fat colour.

The aim of the trial presented in this paper was to determine the effects of supplementary vitamin A on carotenoid concentrations in plasma, liver and fat, and on the fat colour in steers fed a grain based diet which had low carotenoid concentrations per kg dry matter (DM).

MATERIALS AND METHODS

Seventy 3-year-old Angus steers were weighed and randomly allocated to 1 group of 10 and 3 groups of 20 steers. They were fed pasture silage for 8 days and then the group of 10 steers was slaughtered. The other 3 groups were penned separately in a feedlot and fed a barley: pasture silage diet with the proportion of barley in the diet increasing over 20 days from 10 to 70% of the feed DM. A mineral mix (42.5 g) containing vitamin A was added to the barley to provide 0, 0.5 x 10^6, and 1 x 10^6 IU vitamin A (retinyl acetate: Lutavit® A 500Plus BASF Germany) /steer.day for the respective groups. Ten steers from each treatment were slaughtered after 62 and 104 days of vitamin A supplementation.

Steers were weighed and blood samples for analysis of plasma carotenoid (PC) concentrations were taken on days -8, 0, 20 and thereafter each 2 weeks. Samples of pasture, barley grain and pasture silage were taken for determination of carotenoid concentrations at the start of the trial. After slaughter the carcasses were weighed and liver samples were collected for vitamin A and carotenene analysis. Fat depths over M. longissimus dorsi muscle were measured 24 hours after slaughter. Subcutaneous fat samples were also collected at this time for the measurements of carotenoid concentration and fat colour.

PC concentrations were assayed according to Knight et al. (1994) and carotenoid concentrations in subcutaneous fat by the method of Kirton et al. (1975). The absorbance of both the plasma and fat extracts were measured at 450 nm using a spectrophotometer. β-Carotene and vitamin A (retinol) were extracted from liver by the method of Yang et al. (1992), and carotenoid in feeds (p-carotene and lutein) were extracted according to the method of Visser and Blair (1991). Concentrations of these components were measured by HPLC (Shimadzu LC 10A) with detection at 450 nm for β-carotene and lutein, and 325 nm...
for vitamin A. Fat colour was measured with a Minolta chromameter and chroma, which provides a single value for overall colour tone, was calculated by the formula:

\[ \text{chroma} = \sqrt{a^*^2 + b^*^2} \]  
(Seiner et al., 1992).

Chroma and b* values are similar because the a* values for fat are low.

Data were analysed using GLM procedures (SAS Institute Inc 1987) with repeated measures analysis being used to analyse PC concentrations and analysis of variance to compare other traits. The standard errors of the means are given with the means.

RESULTS

Liveweights of the steers were similar for the groups at the start of the trial (536 ± 8 kg). There were no effects of vitamin A supplementation on liveweight gains (0.8-1.4 kg/day), carcass weights or fat depths. The last 2 mentioned traits were higher (P<0.001) in steers slaughtered on day 104 (354 ± 4 kg and 14.5 ± 0.8 mm) than day 62 (322 ± 4 kg and 11.4 ± 0.8 mm).

The data for the 2 doses of vitamin A were pooled for all traits except liver vitamin A concentrations which was the only trait to show a significant effect of dose of vitamin A. PC concentrations were similar for all treatment groups on days -8 and 0, but between days 20 and 103 steers receiving vitamin A had lower (P<0.001) PC concentrations than steers not receiving vitamin A (Figure 1).

![Figure 1. Mean plasma carotenoid concentrations in steers on a low carotenoid supplement of vitamin A (squares) or no vitamin A supplement (diamonds)](attachment)

Despite the lower PC concentrations in steers supplemented with vitamin A, the carotenoid concentrations in the subcutaneous fat and fat colour on days 62 and 104 were not significantly different from steers not receiving vitamin A. Steers slaughtered on day 0 had higher (P<0.001) fat carotenoid concentrations and fat colour than those slaughtered on day 62 (Figure 2). While fat colour continued to decrease (P<0.05) from day 62 to 104, fat carotenoid concentrations did not continue to decrease.

The mean liver β-carotene concentrations for the last 2 slaughter dates were lower (P<0.01) for steers receiving vitamin A (4.3 ± 0.7 μg/g) than those not receiving vitamin A (6.7 ± 0.7 μg/g). Liver O-carotene concentrations for all the groups were lower (P<0.05) on day 104 (4.2 ± 0.7 μg/g) than day 62 (6.0 ± 0.7 μg/g), which in turn were lower (P<0.001) than on day 0 (17.7 ± 1.0 μg/g). Conversely, liver vitamin A concentrations increased (P<0.001) with the dose of vitamin A (129, 405, and 557 ± 18 μg vitamin A/g liver respectively for daily intakes of 0, 0.5 x 10^6, and 1 x 10^6 IU vitamin A, respectively) and with duration (P<0.01) of supplementation (405 and 572 ± 24 μg vitamin A/g liver on days 62 and 104, respectively).

The β-carotene and lutein concentrations in barley grain (20 and 10 mg/kg DM, respectively) and pasture silage (58 and 127 mg/kg DM, respectively) were low compared to pasture (755 and 832 mg/kg DM,
respectively). During the last 6 weeks of the trial daily DM intake was estimated to be 14.6 kg DM/head.day, suggesting intakes of 0.5-0.6 g p-carotene and 0.8-0.9 g lutein/head.day for the steers.

Figure 2. Mean carotenoid concentrations in the subcutaneous fat (broken lines) and fat colour chroma values (solid lines) in steers on a low carotenoid diet and receiving a daily supplement of vitamin A (squares) or no vitamin A (diamonds).

DISCUSSION

The 36% reduction in liver p-carotene concentrations and the 47% reduction in PC concentrations which were associated with vitamin A supplementation were similar to the decreases in these traits recorded when cattle grazing green grass were also supplemented with vitamin A (Knight et al. 1996). However, the absolute differences in liver p-carotene concentrations and PC concentrations between the vitamin A supplemented and unsupplemented steers in the feedlot were much smaller than the decreases of 6.3 µgβ-carotene/g liver and 3-4 µg carotenoid/ml found by Knight et al. (1996). These differences in results were possibly because the steers in this trial were being fed diets with 3-8% of the p-carotene and 2-15% of the lutein concentrations found in green grass. This low carotenoid diet lowers both liver p-carotene and PC concentrations and the daily supplement of vitamin A has limited scope to further reduce the carotenoid concentrations. This may also explain the lack of an effect of dose of vitamin A on these traits despite the liver retinol concentrations being 38% higher in the steers receiving 1 x 10^6 IU vitamin A than those receiving 0.5 x 10^6 IU vitamin A.

The supplements of vitamin A failed to decrease the carotenoid concentrations in the subcutaneous fat and reduce fat colour, despite the decreases in liver and plasma carotenoid concentrations and the 3-4 fold increase in liver vitamin A concentrations. This indicates that the vitamin A was not stimulating the catabolism of carotenoids in the fat or its removal from the fat and subsequent catabolism in the liver. The results support the suggestion that vitamin A reduces carotenoid absorption from the small intestine (Knight et al. 1996) rather than influencing catabolism of absorbed carotenoids (Deuel et al. 1942). The vitamin A supplements may have reduced fat carotenoid concentrations and fat colour if the feedlot diets had contained higher carotenoids concentrations. Based on the results of Knight et al. (1996), this could occur if as little as 10-20% of the diet was green grass.

The initial decrease in carotenoid concentrations in the subcutaneous fat by day 62 of feeding, with no further decrease by day 104, was similar to the change in fat carotenoid concentration found by Forrest (1981) in steers fed low carotenoid diets. The failure of fat carotenoid concentrations to decrease between days 62 and 104 of supplementation is difficult to explain, especially as the subcutaneous fat thickness increased by 3.1 mm during this period. Other workers have reported that fat carotenoid concentrations in steers fed low carotenoid diets decreased for 97-105 days (Seiner et al. 1992; Strachan et al. 1993). In contrast to fat carotenoid concentrations, fat colour (chroma) continued to decrease over the duration of the trial. This difference in response by the 2 traits to the continued feeding of the low carotenoid diet may reflect differences in the influence of increasing fat depth on these traits.
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REFERENCES