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PERFORMANCE AND CAROTENE CONVERSION IN HEREFORD HEIFERS FED DIFFERENT LEVELS OF NITRATE [1]

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WIDESPREAD use of high concentrate rations for beef cattle in recent years has prompted renewed interest in vitamin A research. Numerous workers cited by Goodrich *et al.* (1964) and Jordan *et al.* (1963) have implicated nitrate consumption with impaired carotene utilization and vitamin A nutrition of animals. Rations containing increased levels of nitrate have also been associated with reduced performance (Weichenthal *et al.*, 1963) and increased methemoglobin formation (Smith *et al.*, 1962). The harmful effects of nitrate intake appear to be less pronounced in high energy rations (Garner, 1958, and Hale *et al.*, 1961).

The purpose of the work reported in this paper was to study the influence of different levels of nitrate in growing rations of varied concentrate levels for Hereford calves and yearlings. Particular emphasis was placed on performance of animals and on conversion of carotene to vitamin A.

Experimental Procedure

Eighteen weaned heifer calves and 18 long yearling heifers were stratified by weight within each age group and randomly allotted to a 2 x 2 x 3 factorially designed experiment. Variables included age of animals, concentrate level, and nitrate level. At the beginning of the experiment the calves averaged 465 lb., while the long yearlings averaged 850 lb.

The animals were individually fed for a period of 100 days. Rations were weighed to the animals daily and refusals were weighed at weekly intervals. Daily feed offered was adjusted to allow a minimum of refusals and reduce selection of ration components. The heifers remained in stalls from 7:00 a.m. to 3:00 p.m. daily and were held in common lots by age class during the remainder of the day. Water was available to the animals at all times and iodized salt plus a salt:bonemeal mix were available in the common lots. Each animal was weighed at periodic intervals following an overnight shrink.

Components of experimental rations are shown in table 1. The nitrate source was a commercial fertilizer grade of calcium nitrate, Ca $(No_3)_2 \cdot H_2O$. The primary roughage constituent of all experimental rations was native meadow hay, which consisted of rush (*Juncus* spp.) and sedge (*Carex* spp.) with minor amounts of grass and clover (*Trifolium* spp.). The hay contained 8.5% crude protein, 18 mg. carotene/lb. and 0.012% nitrate-N (.088% KNO_3). An attempt was made to balance all experimental rations for carotene, calcium, phosphorus, and nitrogen (nitrate-free). Small amounts of oil rich in beta-carotene (9.3 mg. carotene/gm.) were used to balance carotene content among rations. Calculated digestible energy was also balanced within each level of concentrate fed. The concentrate portion of all rations including dehydrated alfalfa meal was processed into 3/8-inch pellets, and the meadow hay was coarsely chopped. Hay and concentrates were thoroughly mixed in the mangers prior to feeding each day.

The animals were taken off sagebrush-bunchgrass type summer range in October and placed on a low carotene ration for a 100-day period before they were allotted to experimental treatments. Carotene content of the grass component of the range forage was 1.8 mg./lb. when the animals were removed. The pretreatment ration consisted of sun-bleached meadow hay containing 2.7 mg. carotene/lb. plus a supplement of barley and cottonseed meal. The purpose of the pretreatment period was to lower vitamin A stores in order to provide a wider range in which to measure subsequent treatment effects.

Blood and liver biopsy samples were taken from a random group of animals within each age category in October and from all animals

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TABLE 1. PERCENT COMPOSITION OF EXPERIMENTAL RATIONS ON AN AIR-DRY BASIS

Concentrate, %	20			40		
Calcium nitrate, %	0.0	0.6	1.2	0.0	0.6	1.2
Ingredient						
Meadow hay	80.0	80.0	80.0	60.0	60.0	60.0
Barley	10.8	9.0	7.2	30.8	29.0	27.2
Potato starch	0.0	1.0	2.0	0.0	1.0	2.0
Cottonseed meal	5.4	5.9	6.4	3.5	4.0	4.5
Alfalfa meal, dehydrated	2.0	2.0	2.0	4.0	4.0	4.0
Calcium nitrate	0.0	0.6	1.2	0.0	0.6	1.2
Ground limestone	0.6	0.3	0.0	0.7	0.4	0.1
Salt, non-iodized	0.5	0.5	0.5	0.5	0.5	0.5
Phosphate, mono-sodium	0.7	0.7	0.7	0.5	0.5	0.5

at the beginning and termination of treatment. Liver biopsy samples were taken according to the aspiration technique (Bone, 1954). Carotene and vitamin A determinations were conducted using methods described by Byers *et al.* (1955). Hemoglobin was determined with a hemoglobin meter, and methemoglobin analyses were made according to Evelyn and Malloy (1938). Johnson and Ulrich (1950) described procedures used in nitrate determination of feed samples.

Results and Discussion

Neither feed consumption (table 2) nor daily gain (table 3) was significantly influenced by nitrate level in the diet regardless of animal class or concentrate level of the ration. In general, the results of this study are in agreement with the work of Smith *et al.* (1962) and Cline *et al.* (1963), but differ from the findings of Weichenthal *et al.* (1963) and Hale *et al.* (1961). Animals fed 40% concentrate diets consumed more feed ($P<.05$) and gained significantly faster ($P<.01$) than those fed diets containing 20% concentrate (tables 2 and 3). Feed consumption was greater ($P<.01$) for yearlings than for calves; however, gains were similar.

TABLE 2. AVERAGE FEED CONSUMPTION OF CALVES AND YEARLINGS FED DIFFERENT NITRATE AND CONCENTRATE LEVELS

Concentrate	Calcium nitrate	Animal class: Calf	Animal class: Yearling	Average
%	%	lb.	lb.	lb.
20	0.0	10.5	15.9	
	0.6	10.3	17.7	14.0
	1.2	10.6	19.0	
40	0.0	11.4	19.1	
	0.6	10.8	19.4	15.2[a]
	1.2	11.3	19.4	
Average	...	10.8	18.4[b]	

[a] Significantly ($P<.05$) greater than for animals fed 20% concentrate rations.
[b] Significantly ($P<.01$) greater than for calves.

Although differences were not significant, yearling animals fed increased nitrate levels gained slightly faster than did the control animals (table 3). Similar results were noted by Zimmerman *et al.* (1962) when steers fed corn silage containing 0.32% nitrate gained significantly faster than those fed corn silage containing 0.19% nitrate. Hatfield and Smith (1963) found that nitrate additions to the diet reduced gains of lambs fed soybean meal, but increased gains in those fed urea. According to Sokolowski *et al.* (1961), nitrate nitrogen (at least to a certain level) is apparently utilized in a manner similar to that of other non-protein nitrogen. Bloomfield *et al.* (1961) concluded that dietary level of iodine was highly important in the utilization of nitrate in the diets of both sheep and rats. Perhaps in this study the free-choice intake of iodized salt while animals were in common lots was sufficient to enhance utilization of the increased nitrate. The average daily intake of iodized salt for calves and yearlings was 0.18 lb. and 0.31 lb., respectively.

At the beginning of the pretreatment period, liver vitamin A values averaged 140 and 232 I.U./gm. in calves and yearlings, respectively. After approximately 100 days on the low carotene (pretreatment) ration these values had declined to an average of 51 and 100 I.U./gm., respectively. Other animals fed a non-bleached meadow hay ration containing 12 mg. carotene/lb. showed an increase of 45 I.U./gm. liver over this same period.

Level of calcium nitrate in the diet had no apparent effect on conversion of carotene to vitamin A. Over the 100-day feeding period control animals had an average increase

TABLE 3. AVERAGE DAILY GAIN OF CALVES AND YEARLINGS FED DIFFERENT NITRATE AND CONCENTRATE LEVELS

Concentrate	Calcium nitrate	Animal class Calf	Yearling	Average
%	%	lb.	lb.	lb.
	0.0	0.64	0.55	
20	0.6	0.71	0.69	0.64
	1.2	0.60	0.65	
	0.0	1.02	1.01	
40	0.6	0.90	1.06	1.06[a]
	1.2	1.12	1.22	
Average	...	0.83	0.81	

[a] Significantly ($P<.01$) higher than for animals fed 20% concentrate rations.

in liver vitamin A storage of 69 I.U./gm., while those fed 0.6% and 1.2% calcium nitrate averaged increases of 84 and 71 I.U./gm. respectively. In agreement with these findings, Weichenthal *et al.* (1963), Davison *et al.* (1963), and Cline *et al.* (1963) reported that feeding increased nitrate levels had no significant effect on liver vitamin A storage in steers, dairy heifers, or sheep. On the other hand Goodrich *et al.* (1964) found that feeding sheep a diet containing 3% sodium nitrate significantly reduced liver vitamin A storage. The increase in liver vitamin A during this study was significantly greater ($P<.01$) for calves (101 I.U./gm.) than for yearlings (48 I.U./gm.), but did not appear to be affected by concentrate level of the diet. Liver carotene was not affected by either nitrate level or concentrate level of the diet, but calves showed a significantly greater increase in liver carotene than yearlings (0.91 vs. 0.40 mcg./gm. liver).

The carotene and vitamin A contents of blood plasma as well as hemoglobin values for each class of animals receiving different levels of nitrate were essentially the same, but were higher for yearlings than calves. Average final plasma carotene, plasma vitamin A, and hemoglobin values for calves and yearlings were 1.35 and 2.31 mcg./ml.; 1.31 and 1.78 I.U./ml.; and 12.7 and 14.4 gm./100 ml., respectively.

Methemoglobin values were not significantly increased with increased level of nitrate in the diet. Average methemoglobin values of 0.41, 0.42, and 0.44 gm./100 ml. of blood were found for animals fed 0.0, 0.6, and 1.2% calcium nitrate, respectively. Weichenthal *et al.* (1963) reported that steers fed 1% sodium nitrate showed negligible amounts of methemoglobin formation, while Smith *et al.* (1962) found that the addition of 1 to 2% potassium nitrate to steer diets significantly increased methemoglobin formation.

Summary

Performance and the carotene-vitamin A status were studied in Hereford calves and yearlings fed 0.0, 0.6, and 1.2% calcium nitrate in diets containing 20% or 40% concentrates. The animals were fed a low carotene ration for approximately 100 days prior to the study in order to reduce liver vitamin A stores.

Daily gain and feed consumption were not significantly influenced by nitrate level in the diet. Animals fed diets containing 40% concentrate consumed more feed and gained at a faster rate than those fed 20% concentrate diets.

The addition of calcium nitrate to the ration had no apparent effect on carotene or vitamin A values of either the liver or plasma. Over the 100-day feeding period, increases in liver vitamin A storage were 69, 84, and 71 I.U./gm. liver for animals fed 0.0, 0.6, and 1.2% calcium nitrate, respectively.

Increases in liver vitamin A and carotene were greater for calves than for yearlings, while increases in plasma vitamin A and carotene were smaller. Methemoglobin showed no apparent treatment effects. Interactions of the different variables were non-significant on all blood, liver, and performance data.

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