Effect of Energy Level and Nitrate on Hepatic Vitamin A and Performance of Fattening Steers.* (27181)

W. H. HALE, FARRIS HUBBERT, JR., AND R. E. TAYLOR
(Introduced by A. R. Kemmerer)
Department of Animal Science, University of Arizona, Tucson

While the necessity of a dietary source of Vit. A for fattening steers is well recognized, little information is available on ration factors that may affect the requirement. Symptoms of Vit. A deficiency have been observed with ruminants grazing high-nitrate forage during drought seasons(1). Recent field observations suggest that Vit. A deficiency in feedlot steers is somewhat more common than previously believed. The present day ration for fattening steers is considerably higher in grain than formerly and the roughages are often harvested from fields which have been highly fertilized with nitrogen. This fertilization practice may result in a higher level of forage nitrate(2). Studies by O'Dell, *et al.* (3) have shown that ration nitrate increased liver Vit. A losses in rats. Nitrate is reduced to nitrite by rumen fermentation(4).

This study was designed to determine the effect of ration energy level (as estimated by total digestible nutrients, "TDN") and nitrate on liver Vit. A depletion in fattening steers fed a low carotene ration. Performance of the animals also was studied.

Procedure. Twelve steers were allotted to a 2×2 factorial experiment in which the factors were energy level of the ration (54.3 and 71.3% TDN) and KNO_3 addition to the ration (none and 1% KNO_3). The steers were individually penned and fed. The composition of the rations is given in Table I. All rations contained 14% crude protein. Milo grain was used at a high level to formulate the high TDN ration and was replaced with cottonseed hulls in the low TDN ration. The steers were fed *ad libitum.* Liver biopsies were taken at the initiation of experiment and at 28-day intervals by the method of Erwin, *et al.*(5). Allotment of the animals was on the basis of initial liver Vit. A values. Liver Vit. A was determined by the method of Gallup and Hoefer(6).

TABLE I. Experimental Rations.

	54.3% TDN	71.3% TDN
Cottonseed hulls	55	10
Molasses	7	7
Dry rolled milo	11	63
Cottonseed meal	25	18
Salt	1	1
Dicalcium phosphate	.5	—
Ground limestone	.5	1

Results. Feedlot performance of the animals and liver Vit. A losses for the 56-day experiment are presented in Table II. While there was no treatment effect upon average daily gains, there was a significant interaction ($P<0.05$) between TDN level and nitrate addition. This was due to the reduction in daily gains when nitrate was fed with the low TDN ration (3.18 lb. *vs* 2.01 lb) and an increase in gains due to nitrate with the high TDN ration (2.02 lb. *vs* 2.29 lb.). Both high TDN and nitrate reduced daily feed intake. The TDN effect was significant at the 5% confidence level and the nitrate addition significant at the 1% confidence level.

Initial liver values had a range of 24.9 to 59.7 μg of Vit. A/g of wet liver. These values are considered within normal range. Table III presents the liver Vit. A loss for each of the 4 treatments at the 28- and 56-day periods. This Table shows the effect of nitrate on the 2 TDN levels as well as the TDN effect independent of the nitrate addition. The lower liver Vit. A loss during the second 28 days can be explained on the basis that the loss of Vit. A at any time during dietary deprivation is proportional to the magnitude of the reserves remaining at that time(7). The 56-day effects are combined for statistical analysis and presented in Table II. The high TDN ration caused a significantly ($P<0.05$) larger depletion of liver Vit. A than did the low TDN ration. The same trend occurred with the nitrate addi-

* Arizona Agricultural Experiment Station Technical Paper No. 687.

TABLE II. Effect of Ration TDN Level and Nitrate on Liver Vit. A Depletion, Performance, and Feed Intake of Fattening Steers (56 Days).

	TDN level		Nitrate addition	
	54.3%	71.3%	No KNO_3	KNO_3
Avg initial wt, lb	699.4	716.7	725.4	690.7
Avg daily gain, lb	2.60	2.16	2.60	2.15
Avg daily feed, lb	26.60*	19.69*	25.14†	21.16†
Feed/lb gain, lb	10.50	9.19	9.75	9.94
Initial liver Vit. A, $\mu g/g$ wet liver	35.4	39.7	34.3	40.8
Final liver A value, $\mu g/g$ wet liver	7.9	4.8	6.8	5.9
Liver Vit. A loss, %	78.6*	88.0*	80.7	86.0

* Differences due to TDN level, significant $P < 0.05$.

† Differences due to nitrate addition, significant $P < 0.01$.

tion; however, the difference was not significant. Fifty-six-day liver values ranged from 1.6 to 14.4 μg Vit. A/g of wet liver. Liver Vit. A losses appeared to be negatively correlated with gains.

Discussion. These results indicate that a high TDN beef cattle fattening ration (71.3% TDN) in which milo grain supplied the high TDN component caused a more rapid depletion of liver Vit. A stores than a low TDN (54.3% TDN) ration. Thus, higher dietary Vit. A requirements would be expected with high TDN rations. This finding, no doubt, aids in explaining the frequent occurrence of Vit. A deficiency in steers fed high TDN rations.

TABLE III. Effect of Ration TDN Level and Nitrate Addition on Liver Vit. A Loss in Fattening Steers (3 Steers/Treatment).

	Treatments			
	54.3% TDN	54.3% TDN + 1% KNO_3	71.3% TDN	71.3% TDN + 1% KNO_3
28-day liver Vit. A loss, %	45.3	58.4	64.5	65.2
56-day liver Vit. A loss, %	74.7	82.5	86.6	89.4

The results show that the ration nitrate level used in this experiment reduced feed intake but that average daily gain was little affected when the ration contained high levels of TDN. With high TDN rations the reduction of nitrate to ammonia by rumen microorganisms is probably complete but with high-roughage rations a large portion of the nitrate may be absorbed as nitrite. Forages containing more than 1.5% KNO_3 are generally considered toxic for ruminants(8). Information from this study suggests that even lower levels have an effect upon performance. The nitrate effect on liver Vit. A depletion was greater for the low TDN ration.

Summary. (1) With fattening steers, a high TDN ration resulted in a significantly larger liver Vit. A depletion than did a low TDN ration. The addition of 1% KNO_3 reduced liver Vit. A stores but the reduction was not significant. (2) Neither TDN level nor nitrate addition had a significant effect on gain, but there was a significant interaction between TDN level and nitrate addition. (3) Feed intake was significantly affected by both TDN level and nitrate addition.

1. Muhrer, M. E., Case, A. A., Garner, G. B., Pfander, W. H., *J. Animal Sci.*, 1955, v14, 1251.

2. Kingsbury, John M., *J. Dairy Sci.*, 1958, v41, 875.

3. O'Dell, B. L., Brek, Z., Flynn, Laura, Garner, G. B., Muhrer, M. E., *J. Animal Sci.*, 1960, v19, 1280.

4. Lewis, D., *Biochem. J.*, 1951, v48, 175.

5. Erwin, E. S., Dyer, I. A., Meyer, T. O., Scott, K. W., *J. Animal Sci.*, 1956, v15, 428.

6. Gallup, W. D., Hoefer, J. A., *Ind. & Eng. Chem. Anal. Ed.*, 1946, v18, 288.

7. Davies, A. W., Moore, T., *Biochem. J.*, 1937, v31, 172.

8. Bradley, W. B., Eppson, H. F., Beath, O. A., *J. Am. Vet. Med. Assn.*, 1940, v94, 41.

Received September 5, 1961. P.S.E.B.M., 1962, v109.