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Vitamin A and Carotene Nutrition of Lambs

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Summary

Results of the experiment show that lambs with high liver storage of vitamin A require a lengthy period for depletion to levels indicative of a deficient state as measured by low blood levels of the vitamin A and deficiency signs. However, liver storage at levels to give blood vitamin A considered adequate for growth and absence of deficiency signs may be depleted to deficient levels over a period of as little as 2 months.

Blood levels of vitamin A responded to carotene and vitamin A supplementation promptly with levels of supplementation as low as 1 mg. carotene from dehydrated alfalfa meal or 400 IU of vitamin A palmitate per pound of feed. Levels of 1 and 2 mg. of carotene or 400 and 800 IU of vitamin A per pound of ration were not enough to have an appreciable effect on liver storage of the vitamin over a period of 91 days when liver vitamin A had been essentially depleted. Carotene at 4 mg. and vitamin A at 1600 IU per pound of ration resulted in substantial liver storage of the vitamin following 91 days of supplementation. Results indicated that the commonly used value of 400 IU of vitamin A per 1 mg. of carotene was an appropriate one at these levels of supplementation. The vitamin A value of carotene at 8 mg. per pound of ration appeared less effective than 3200 IU of vitamin A per pound of ration as measured by liver stores with depleted lambs. At this level, the vitamin A value of carotene appeared to be considerably less than when fed at 4 mg. per pound of ration.

Introduction

Past research has indicated that the need for and the level of vitamin A supplementation to feedlot lambs are related to the feeding program prior to entering the feedlot. It is fairly well-documented in research literature that early-weaned lambs may have low liver vitamin A stores and can be depleted very rapidly. In contrast, lambs that have been consuming high quality hay or coming off green pasture can have high liver vitamin A stores and can then consume diets low in vitamin A activity for extended periods of time (i.e., 200 days or more) before exhibiting any signs of deficiency.

In determining the level of vitamin A supplementation, one must consider the source of the feedstuffs available for feeding. Hay, grain and pasture, depending on kind and quality, will contain varying amounts of carotenoid pigments, primarily beta-carotene, which have a high degree of vitamin A activity. Preformed vitamin A is also commercially available to supplement sheep rations. Therefore, both sources of vitamin A should be considered in determining the level of supplementation for a given ration.

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Research on the vitamin A requirements of sheep, and more especially the vitamin A value of carotene, is more limited than that with cattle. The objective of this experiment was to study effects of various levels of vitamin A and carotene supplementation with lambs previously depleted of vitamin A stores. Liver storage and blood levels of vitamin A following repletion were considered the primary measures of the value of the various levels of supplementation.

Experimental Procedure

Vitamin A Depletion Phase

A group of 160 lambs of similar background consisting of an equal number of ewes and wethers was selected for the experiment. After weighing, the 10 heaviest lambs (five ewes and five wethers) were slaughtered to obtain initial blood and liver levels of vitamin A. The remaining lambs were allotted to 10 pens of 15 each on basis of sex group and weight.

The ration during this vitamin A depletion was rolled oats fed to appetite and top-dressed with .2 lb. per head daily of a ground oat supplement containing a calcium-phosphate supplement, trace mineral salt and aureomycin. This ration was practically devoid of carotene.

At approximately 2-month intervals and after weighing, the 10 heaviest lambs (five ewes and five wethers) from the group were sent to slaughter. Blood and liver samples were obtained to determine vitamin A stores at these periodic intervals. The depletion period was terminated after 333 days. A vitamin A repletion phase was initiated at this time. Final weights at this time were the initial weights for the repletion phase. Liver levels of vitamin A obtained from the slaughtered group were considered to represent the initial vitamin A status for the repletion phase with vitamin A and carotene supplementation.

Vitamin A Repletion Phase

Eighty lambs (40 ewes and 40 wethers) from the vitamin A-depleted group were used in the vitamin A repletion phase of the experiment. They were allotted into 16 pens of five each on basis of weight with ewes and wethers fed separately. Rations were rolled oats supplemented with a dehydrated alfalfa supplement or a vitamin A supplement. Two pens of five lambs each were fed one of eight rations during the repletion phase. Four rations provided carotene from dehydrated alfalfa meal at 1, 2, 3 or 4 mg. per pound of feed. Another four rations provided vitamin A as the palmitate at 400, 800, 1600 and 3200 IU per pound of ration. The carotene and vitamin A supplements were mixed with rolled oats to provide mixed rations approximately equal in all nutrients except for levels of vitamin A and carotene. The dehydrated alfalfa meal and the vitamin A primary premix were assayed for carotene and vitamin A each time supplements were mixed and appropriate amounts were used to obtain treatment levels of carotene and vitamin A.

The lambs were weighed and blood samples obtained for vitamin A analysis initially and at 4-week intervals during this phase of the experiment. The repletion phase was terminated at 91 days. The lambs were slaughtered and liver samples obtained to determine liver storage of vitamin A.

All blood and liver samples were also analyzed for carotene during the depletion and repletion phases of the experiment. Low levels of carotene were observed which have been shown to be characteristic for sheep. Therefore, carotene values are not reported.

Results and Discussion

Vitamin A Depletion

Feedlot performance data and blood and liver values for vitamin A at periodic intervals during the depletion phase of the experiment are shown in table 1.

Feed consumption was at a reasonable level for the oat ration throughout the 333 days of vitamin A depletion. There were no major variations during this time.

Weight gain was also at a reasonable level for the ration through the first 180 days. After this time, there was a marked reduction in rate of gain. The rate of gain remained at a low level for the remainder of the depletion period. At 180 days, the average weight of the lambs was about 120 pounds. This weight and the degree of finish were likely important factors affecting rate of gain after this time.

Blood serum vitamin A showed no major decrease in values until after 228 days. The value at this time is commonly considered to represent levels adequate for normal growth with absence of deficiency signs.

Liver vitamin A was quite high initially. There were marked reductions at each sampling through 180 days. The levels at 180 and 228 days, while representing marked depletion of initial stores, appeared adequate to maintain plasma A above levels associated with deficiency signs. Liver storage at 284 days was low and blood values were at a level associated with vitamin A deficiency. Signs of deficiency (trembling and unsteady gait) were observed in 36% of the lambs at this time.

The data show that a lengthy depletion period is required when initial liver vitamin A values are high as with these lambs. However, depletion could be quite rapid with apparent adequate blood values but low liver storage as shown at the 228-day period. It is evident that the level of liver storage rather than blood values would be the major factor in depletion time on ration devoid or low in carotene and vitamin A.

Repletion Phase with Carotene and Vitamin A

Feed consumption and weight gain data for vitamin A repletion phase of the experiment are shown in table 2. Feed intake was at a higher level than during the depletion phase. The lambs were larger and would be expected to have more feed capacity. Over the 91-day experiment, rates of gain were low. Weight gain would not be a useful measure of treatments with these lambs in view of an initial weight of nearly 140 pounds. The main measures for effects of carotene and vitamin A supplementation would be the blood and liver values for vitamin A.

Table 1. Feedlot Performance, Blood and Liver Data During Vitamin A Depletion of Lambs[a]

Time period	Daily gain lb.	Daily feed lb.	Blood serum vitamin A mcg./100 ml.	Liver vitamin A mcg./g.
Initial	60.0 lb. (init. wt.)		28.10	173.33
0-61 days	.310	2.25	24.41	86.94
62-117	.301	2.65	23.29	39.02
118-180	.355	2.88	17.44	10.31
181-228	.196	2.90	20.91	11.23
229-284	.128	2.64	11.20	2.91
285-333	.212	2.80	13.98	1.43
0-333	.266	2.66	--	--

[a] One hundred sixty lambs initially for the experimental group. Ten removed at periods indicated and slaughtered for blood and liver vitamin A analyses. Weight gain and feed data on basis of the decreasing numbers with a few death losses terminating the depletion phase with 91 lambs.

Blood serum vitamin A at the various periods during repletion and the final liver values are shown in table 3. It will be noted from this table that there was a marked rise in blood vitamin A after only 29 days of supplementation. This was accomplished with as little as 1 mg. of carotene from dehydrated alfalfa meal or 400 IU of vitamin A palmitate.

Carotene at 2 mg. per pound of feed or vitamin A at 800 IU did not offer any consistent advantage over the 1 mg. and 400 IU level during the 91 days of repletion. Higher levels of carotene (4 and 8 g. per lb. of feed) and vitamin A (1600 and 3200 IU per lb. of feed) resulted in higher blood vitamin A but with no major or consistent differences between carotene or vitamin A at these levels.

Values for liver vitamin A indicate that 1 and 2 mg. of carotene per pound of feed or 400 and 800 IU of vitamin A were not adequate levels to increase liver storage appreciably above the depleted levels during the 91-day repletion phase.

Carotene at 4 mg. or vitamin A at 1600 IU per pound of ration resulted in elevated liver storage along with rather high plasma values. At this level of carotene, the value of 400 IU per 1 mg. of carotene commonly used for the vitamin A value of carotene would appear to be an appropriate one.

Carotene at 8 mg. per pound of feed appeared to have somewhat less activity per unit of weight than the 4 mg. level on basis of liver vitamin A. Vitamin A at 3200 IU per pound of feed resulted in a substantial increase in liver storage over the 1600 IU level but with no major or consistent increase in blood values.

Table 2. Average Weights, Feed Consumption and Daily Gains - Supplementation Phase Following Depletion (December 13, 1976, to March 14, 1977--91 Days)

	Carotene treatments (mg./lb. of feed)				Vitamin A treatments (IU/lb. of feed)			
	1	2	4	8	400	800	1600	3200
No. of lambs	10	10	10	10	10	10	10	10
Avg. initial wt., lb.	137.0	136.8	134.8	137.7	133.1	133.8	137.0	135.7
Avg. final wt., lb.	149.7	153.7	153.2	157.6	147.8	147.2	147.4	146.6
Avg. daily feed consumption, lb.[a]								
0-29 days	2.99	2.86	3.11	3.26	2.58	2.42	2.37	2.40
30-57 days	3.26	3.30	3.09	3.49	3.02	3.19	2.80	2.70
58-91 days	2.74	2.91	3.01	3.30	2.66	3.01	2.95	2.94
0-91 days	2.98	3.01	3.07	3.35	2.75	2.88	2.70	2.70
Avg. daily gain, lb.[a]								
0-29 days	.236	.147	.259	.230	.143	.112	.023	.038
30-57 days	-.165	-.057	.043	-.020	-.054	-.018	.080	.029
58-91 days	.308	.418	.285	.406	.355	.312	.221	.263
0-91 days	.140	.185	.202	.219	.162	.147	.114	.119

[a] Average daily feed consumption and average daily gain based on sheep days per period.

Table 3. Blood and Liver Data of Lambs Fed Various Levels of Carotene or Vitamin A - Supplementation Phase Following Depletion

	Carotene treatment (mg./lb. feed)				Vitamin A treatment (IU/lb. feed)			
	1	2	4	8	400	800	1600	3200
No. of lambs[a]	10	10	10	10	10	10	10	10
Blood serum vitamin A (mcg./100 ml.)								
Initial	12.17	10.73	11.93	13.23	10.74	11.01	12.40	13.84
29 days	25.24	27.97	45.79	45.75	32.19	31.86	39.05	39.69
57 days	24.46	24.78	38.66	48.50	26.35	29.09	38.94	46.47
91 days	22.79	17.54	30.82	33.64	20.33	20.58	31.00	37.77
Liver vitamin A (mcg./gram)								
91 days	5.29	2.63	12.28	15.90	3.90	3.64	10.48	31.38

[a] Five ewes and five wethers.