VITAMIN A AND CAROTENE FOR CATTLE AND SHEEP

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THE INCREASED NUMBER of reported vitamin A deficiencies in the last 6 years has stimulated more interest in the vitamin A requirements of cattle and sheep than at any other time in our history. The recent re-evaluation of vitamin A requirements was necessary because of changes in feeding practices and, to some extent, faster growing animals. The present use of high-concentrate rations has reduced the carotene intake, since grains contain little carotene and total feed consumption is reduced.

The net effect of this reduced carotene intake may be a need for preformed vitamin A in the ration, even though the total amount required by the animal has not changed. Other reasons for occasionally observing vitamin A deficient animals in feedlots is that today's animals are gaining faster than those of only a few years ago and the stress imposed by confined feeding may actually increase the vitamin A requirements.

Relationship of Carotene and Vitamin A

Carotene is a yellow compound synthesized by plants that is converted to vitamin A in the body of all animals. Animals do not require carotene as such, but do need the vitamin A they derive from it. Plants do not contain any vitamin A; however, the vitamin A value or potency of plant materials is often reported and is based on known conversions of carotene to vitamin A. According to the National Research Council, in the rat 1 milligram (mg.) of carotene is converted to 1,667 international units (I.U.) of vitamin A, while 1 mg. of carotene equals 500 I.U. of vitamin A for pigs and 400 I.U. of vitamin A for ruminants.

Carotene is quite unstable and many factors contribute to its destruction during storage. The green color of plants and roughages is a good indicator of the carotene content (dark green indicates high carotene). However, it is not a perfect indicator, as the green pigment (chlorophyll) is not destroyed at the same rate as carotene.

Functions of Vitamin A

Vitamin A is required for the proper maintenance a function of the epithelial tissues of the body. These sues cover the exterior surface of the body and forn covering for nearly all free surfaces within. The alim tary canal, respiratory tract, urogenital tract, heart, lun and abdominal organs are all covered with epithe tissue. Many of the symptoms of vitamin A deficie result from a malfunction in those areas covered w epithelial tissue.

Vitamin A is required in the formation of rhodop (visual purple), a compound in the retina of the e that enables animals to see in dim light. Vitamin A also required for bone growth, as well as for norr weight gains.

Vitamin A Deficiency

Animals are protected, to some extent, against a ficiency of vitamin A by storing large quantities in liver during periods of high intake. Smaller amounts also stored in body fat. This storage is often suffici to last through the winter when carotene intakes are lo However, under some circumstances liver stores of vi min A become depleted and deficiency symptoms be- come apparent.

Night blindness, muscular incoordination and weakness, unthriftiness, rough hair coat, slow growth, diarrhea, respiratory infections, and reproductive disorders are often observed in cattle deficient in vitamin A. In the feedlot, vitamin A deficient cattle are often observed to pant excessively as a result of high temperatures, faint or go into convulsions when excited, develop edema of the brisket and forelegs, and have excessive watering of the eyes and a white or cloudy appearance of the cornea.

Vitamin A deficiency in bulls is characterized by a decline in sexual activity and a decrease in spermatozoa numbers. In cows, poor conception rates and retained placentae are often noted. Calves born to deficient cows may be blind or have cloudy, watering eyes; are weak and susceptible to pneumonia; and die shortly after birth. Recovery from the earliest visual symptoms of vitamin A deficiency is sometimes a slow process, even when the deficient animal is injected with massive doses of vitamin A.

Factors Affecting Vitamin A Metabolism and Storage

Several factors have been implicated as important in vitamin A and/or carotene utilization. It is not apparent whether dietary nitrates are detrimental to the utilization of vitamin A, but these probably present more of a problem from the standpoint of nitrate toxicity. High protein and energy levels seem to favor increased depletion of vitamin A from liver. In some cases this may be explained as a result of faster rates of gain. There is also evidence that vitamin A requirements are increased by high environmental temperatures and other stresses.

The liver contains most of the vitamin A stored in the body. During periods of lush carotene intake the liver stores vitamin A to meet body needs during periods of dietary inadequacy. In animals with low carotene or vitamin A intakes, blood levels of vitamin A remain normal until the liver is depleted. It is, therefore, not possible to estimate liver stores from plasma analyses before a deficiency occurs. Plasma vitamin A concentrations of 18 to 25 micrograms (m.c.g.) per 100 milliliters (ml.) are considered normal, while 6 to 10 m.c.g. per 100 ml. indicates a deficiency.

Table 1. Estimated carotene content and vitamin A value of feeds*

Feed	Carotene† mg./lb.	Vitamin A value for cattle and sheep‡ I.U./lb.
Alfalfa hay, 1/10 to 1/2 bloom	20.3	8,120
Alfalfa hay, ¾ to full bloom	8.5	3,400
Alfalfa hay, past bloom	3.3	1,320
Alfalfa hay, cured in rainy weather	2.7	1,080
Alfalfa-bromegrass hay	6.7	2,680
Clover hay, red, average analyses	7.3	2,920
Clover hay, red, cured in rainy weather	1.8	720
Mixed hay, first cutting	6.4	2,560
Mixed hay, second cutting	15.3	6,120
Timothy hay	4.4	1,760
Alfalfa, green chop	28.3	11,320
Bromegrass, green chop	31.6	12,640
Clover, red, green chop	20.9	8,360
Alfalfa silage, wilted	11.4	4,560
Corn silage	5.8	2,320
Oat silage	17.7	7,080
Barley	0.2	80
Corn, dent, Grade No. 2	1.3	520
Linseed meal, solvent process	0.1	40
Oats grain	0.05	20
Soybean meal, solvent process	0.1	40
Wheat bran	1.2	480

* Values taken by permission of the Morrison Publishing Co., Clinton, Iowa, from the 22nd edition, 3rd printing, 1959, of Feeds and Feeding, by F. B. Morrison and Associates.

† These are average values; producers may wish to have their feeds analyzed to determine actual carotene content.

‡ Calculated using conversion of 1 mg. of carotene equal to 400 I.U. of vitamin A.

Carotene Content of Feeds

The carotene contents of some common feeds are shown in table 1. Vitamin A values have been calculated using the conversion that 1 mg. of carotene equals 400 I.U. of vitamin A. Forages harvested during the growing stage with minimum exposure to rain or sunlight and stored for less than 6 months have a high vitamin A potency. The carotene content of forages decreases as plants mature, when exposure time to rain and sunlight is increased, and with long storage periods. Yellow corn is the only grain with any appreciable amount of vitamin A potency. Silage, properly preserved, holds its vitamin A potency for long periods.

Table 2. Estimated carotene and vitamin A requirements

	Carotene mg./100 lb. body wt.	Vitamin A I.U./100 lb. body wt.
Growing beef cattle and lambs	6.0	2,400
Wintering cattle and sheep	6.0	2,400
Fattening beef cattle and lambs	6.0	2,400
Pregnant beef cows and ewes	6.0	2,400
Lactating beef cows and ewes	10.0	4,000

Carotene and Vitamin A Requirements

Recommended carotene and vitamin A allowances for beef cattle and sheep are presented in table 2. The levels shown in this table are high enough to allow for some storage of vitamin A and to give an added level of intake to overcome increased needs such as those encountered during periods of stress. The vitamin A allowances presented in this table are calculated from the conversion that 1 mg. of carotene equals 400 I.U. of vitamin A.

The allowance listed in table 2 for normal growth of cattle and sheep is 6.0 mg. of carotene per 100 pounds of body weight. Expressed in terms of vitamin A this is 2,400 I.U. per 100 pounds of weight. The vitamin A requirements for animals of both species are increased to 4,000 I.U. per 100 pounds of body weight during lactation. The recommended allowances of carotene for cattle are taken from *Morrison's Feeds and Feeding*[1] while those for sheep are slightly higher than recommended in Morrison's book.

There are several periods when a deficiency of vitamin A is likely to occur in beef cattle. These are:

1. Young calves nursing cows during a dry summer, since there is not enough vitamin A in the milk under these conditions to meet requirements.
2. Calves born to cows wintered on poor quality roughage.

[1] *Taken by permission of the Morrison Publishing Co., Clinton, Iowa, from the* 22nd edition, 3rd printing, 1959, of Feeds and Feeding, by F. B. Morrison and Associates.

3. Feeder cattle from dry range areas.
4. Cows fed poor quality, sun-bleached roughages.
5. Finishing cattle fed over 100 days in drylot on high-concentrate rations.

Rations composed entirely of grain and protein supplement furnish little, if any, vitamin A potency and must be supplemented, especially during the hot summer months. To protect cattle under these conditions (or sheep under similar situations), vitamin A should be included in the supplement at the desired level. Upon arrival at the feedlot it is a common practice to feed beef cattle high levels (200,000 I.U. per head daily) of vitamin A for a 1-week period to prevent deficiencies caused by the stress of movement and the new environment.

General Recommendations

Table 3 shows suggested rates of vitamin A supplementation to rations composed of varying amounts and quality of roughage. In this table, high-quality roughage is considered to contain about 8 mg. of carotene per pound, and medium and low quality, 4 to 6 and 2 to 3 mg., respectively. No vitamin A activity is considered to be furnished by the grain portion of the ration.

Rations composed of 75 to 100 percent roughage need vitamin A supplementation only if the forage is poor quality. Rations with average quality roughage need supplementation if the ration contains less than 50 percent roughage. Those with less than 25 percent high-quality roughage need supplementation.

Table 3. Suggested rates of supplementing growing-finishing rations for cattle and sheep

Percent of roughage in total ration	Roughage quality	Rate of vitamin A supplementation, I.U. per 100 lb. of body weight
100	high	none
100	average	none
100	poor	500 I.U.
75	high	none
75	average	none
75	poor	1,000 I.U.
50	high	none
50	average	500 I.U.
50	poor	1,500 I.U.
25	high	500 I.U.
25	average	1,000 I.U.
25	poor	2,000 I.U.
0	....	2,400 I.U.

Table 3 is a useful guide in determining the rate of vitamin A supplementation, since the vitamin A activity values given in table 1 represent averages and may deviate considerably from the feeds being fed. If necessary to estimate supplemental needs for vitamin A, one may use average values and amounts of ration ingredients to arrive at the intake of vitamin A activity.

For example: A ration composed of 80 percent corn grain and 20 percent late-cut alfalfa hay, fed to 1,000-pound beef steers, at a rate of 20 pounds per day, furnishes 13,600 I.U. of vitamin A potency.

16 lb. corn × 520 I.U./lb. = 8,320 I.U.
4 lb. hay × 1,320 I.U./lb. = 5,280 I.U.

Total ..... 13,600 I.U.

The vitamin A requirement of a 1,000-pound fattening beef animal is about 24,000 I.U. (table 2). The above ration would therefore need to be supplemented with an additional 10,400 I.U. of vitamin A per animal daily.

Low-cost vitamin A concentrates may be purchased from local feed stores and mixed with the supplement to supply required amounts. Commercial supplements usually contain vitamin A.

Summary

1. Vitamin A deficiency is likely to occur when cattle and sheep are fed poor quality roughage that has been sun bleached, rained on, or cut when overripe. Cattle and sheep grazing pastures during drought conditions also need vitamin A supplementation.

2. Vitamin A supplementation is needed for finishing animals fed rations composed largely of grains.

3. Vitamin A requirements of cattle and sheep will be met by feeding 6.0 mg. of carotene or 2,400 I.U. of vitamin A per 100 pounds of body weight.

4. Three factors should guide cattle and sheep feeders in determining the amount of vitamin A to supplement: (1) The amount of previous vitamin A storage, (2) the quality of the roughage fed, and (3) the amount of roughage fed.

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