1969

Vitamin A in Beef Cattle Feeding

L.B. Embry
South Dakota State University

L.J. Kortan
South Dakota State University

Animal Husbandry Pamphlet 3

Vitamin A in Beef Cattle Feeding

Animal Husbandry Department
AGRICULTURAL EXPERIMENT STATION
South Dakota State College, Brookings

CONTENTS

Authors of this publication are L. B. Embry, professor of animal husbandry, and L. J. Kortan, associate extension livestock specialist.

Vitamin A in Beef Cattle Feeding

Vitamin A is essential for all cattle. The vitamin does not occur naturally in feeds of plant origin. Many cattle are never fed vitamin A as such but do not develop a deficiency of the vitamin. The reason for this is that many feeds (pasture, good quality hay, silage, and yellow corn) furnish carotene which is converted to vitamin A in the animal body.

CAROTENE AND VITAMIN A

Carotene in feeds is expressed as milligrams (mg) of carotene or as International Units (I.U.) or United States Pharmacopoeia (U.S.P.) units of vitamin A activity (also vitamin A value) per pound of feed. The I.U. and the U.S.P. unit are equal in vitamin A value.

Several factors have been shown to be or are believed to influence the conversion of carotene to vitamin A. Some work has indicated that phosphorus is necessary for this conversion. Nitrates and sulfates have been suggested as substances interfering with the conversion. These factors may explain why vitamin A deficiency sometimes develops with rations which appear to be adequate in vitamin A activity. The importance of these compounds in the conversion of carotene to vitamin A or in the destruction of either will require further research.

Cattle are inefficient converters of carotene to vitamin A, and it has been shown that the vitamin may be several times more effective per unit of weight for cattle than carotene. Efficiency of conversion is lower at higher levels of carotene intake. The efficiency of conversion is also impaired in vitamin A deficient cattle. Such cattle respond more quickly to vitamin A supplementation than to carotene.

Since several factors influence the vitamin A value of carotene for cattle, it is apparent that the value will not be a constant one. However, some value is necessary to estimate the vitamin A value of carotene in cattle rations in order to determine whether or not a supplementary source will be necessary. The Committee on Animal Nutrition of the National Research Council considers that 1 mg. of carotene is equal to 400 I.U. of vitamin A for cattle. This value assumes that vitamin A is about eight times more effective per unit of weight than carotene. It takes into consideration the average digestibility from various sources and the efficiency with which cattle convert carotene to vitamin A.

FUNCTIONS OF VITAMIN A AND DEFICIENCY SYMPTOMS

Vitamin A is essential for proper vision, and night blindness is one of the early clinical symptoms of a deficiency in beef cattle.

Another function of the vitamin is the maintenance of healthy epithelial tissues of the skin and mucous membranes of the respiratory, digestive, urinary, and reproductive tracts. Several deficiency symptoms result when this function is not properly performed because of a lack of vitamin A. A deficiency causes the normal epithelial tissues to become dry and cornified, which

interferes with their normal function of secretion and absorption. The resulting conditions are due in part to a basic change in the epithelial tissues and in part to the tissues being more easily invaded by microorganisms resulting in secondary infections. Thus, animals deficient in vitamin A are more susceptible to various diseases.

In a deficiency of vitamin A, the skin becomes dry and scaly and the animal exhibits a rough hair coat. The eyes are affected, with excessive watering being the most common symptom in cattle. In advanced deficiency, the eyes become cloudy and are more easily invaded by bacteria, which may result in ulceration and even total blindness.

Animals deficient in vitamin A are more susceptible to respiratory infections such as the shipping fever complex and pneumonia. Diarrhea in both young and adult cattle is characteristic in a deficiency of the vitamin.

Reproductive troubles such as failure of implantation, abortion, premature birth, and retained placenta may result from a deficiency. Calves at term may be stillborn or weak and die shortly after birth. A long period of vitamin A deficiency in bulls may affect fertility by degeneration of the sperm-producing cells. Sexual activity declines, spermatozoa decrease in number and motility, and there is an increase in abnormal forms.

Vitamin A is essential for proper development of nerves and bones. In a deficiency, the young may be born deformed. Blindness or even the absence of eyes have been reported in young when the dam was seriously deficient in vitamin A. Muscular incoordination, swollen joints, stiffness, staggering gait, and convulsive seizures are some of the deficiency symptoms attributable to nerve and bone changes. These symptoms appear most common in calves and in fattening cattle. In fattening cattle, edema may also occur with swelling in the brisket area.

Cattle deficient in vitamin A appear to suffer more from heat than those with adequate intakes of the vitamin.

While the symptoms described may result from a deficiency of vitamin A, similar conditions result from deficiencies of other nutrients. These symptoms should be considered as indications of vitamin A deficiency and not as absolute proof. An evaluation of the nutritional history of the animals (rations during the past several months as well as the current one) along with the deficiency symptoms will help one to determine if a lack of vitamin A is likely to be involved. Blood and liver analyses for vitamin A and carotene are useful in determining the status of vitamin A nutrition. These analyses may be necessary for proper diagnosis in some cases.

FEED SOURCES AND STABILITY OF VITAMIN A AND CAROTENE

Vitamin A is present only in feeds of animal origin. Fish oil, milk, egg yolk, and liver are the

only rich sources. These are not important feeds for cattle except milk for the young and fish oil, which may be used in vitamin A-rich supplements.

All green-leafed plants contain carotene and the amount present is positively correlated with the green color and the amount of leaves present. The content in plants decreases with advancing maturity. Roughages from mature forages with little green color and leaves are low sources. In these respects, carotene follows the same trend as phosphorus and protein. Low quality roughages low in carotene are also likely to be low in protein and phosphorus.

Harvested roughages with a good green color and with a good percentage of leaves are better sources of carotene than those which have lost much of the green color and leaves through weathering and fermentation during harvesting and storage. Rapid curing of harvested forage and good storage methods are conducive to a high retention. Forages dried rapidly such as by dehydration retain large amounts.

Good pasture, legume or nonlegume, provides a liberal supply of carotene and a deficiency of vitamin A is not likely when cattle have access to green, growing pasture grasses. On the other hand, grasses which have dried up during late fall and winter or during droughts will contain much less. Overgrazed and poorly managed pastures are much poorer sources of carotene than properly grazed and managed ones. These are important factors affecting the body reserves of vitamin A at onset of the winter feeding period and the need of winter supplementation.

Certain yellow-colored feeds contain carotene, but yellow corn is the only important one as a livestock feed in this area. The amount of color in yellow corn is not a good indication of its vitamin A value, since vitamin A activity is lost more rapidly during storage than is the yellow color. Yellow corn has been shown to lose as much as 60% of its carotene in less than 1 year of storage. It is likely to be rather low in carotene in comparison to most roughages, even low quality ones.

Several factors affect the carotene content of feeds and individual samples are likely to vary considerably from average analyses. Analysis of the feeds would be more accurate and would be desirable in many cases. Average analyses can be useful in estimating the need for supplemental sources of carotene or vitamin A. Some values for various feeds as influenced by appearance and method of conservation are presented in table 1.

The values in this table show that hay badly damaged during harvesting and storage may contain only about 10% as much carotene as excellent quality hay. Even average quality hay may have only about one-half as much carotene as hay with a good green color. Silage is a good source of carotene but storage methods that result in heating may destroy a major portion of the carotene. Some analyses

Table 1. Estimated Carotene Content of Feeds in Relation to Appearance and Methods of Conservation

Feedstuff	Carotene mg./lb.
Fresh green legumes and grasses, immature	15 to 40
Dehydrated alfalfa meal, fresh, dehydrated without field curing, very bright green color	110 to 135
Dehydrated alfalfa meal after considerable time in storage, bright green color	50 to 70
Dehydrated alfalfa leaf meal	63*
Dehydrated alfalfa meal, 17% protein	42*
Legume hays, including alfalfa, very quickly cured with minimum sun exposure, bright green color, leafy	35 to 40
Legume hays, including alfalfa, good green color, leafy	18 to 27
Legume hays, including alfalfa, partly bleached, moderate amount of green color	9 to 14
Legume hays, including alfalfa, badly bleached or discolored, traces of green color	4 to 8
Alfalfa-grass mixed hay	6 to 20*
Non-legume hays, including timothy, cereal and prairie hays, well cured, good green color	9 to 14
Non-legume hays, average quality, bleached, some green color	4 to 8
Non-legume hays, late cut, poor quality	2*
Corn and sorghum fodder and stover, dry	1 to 2*
Pasture grasses, mature and weathered	0.5 to 2*
Alfalfa silage, not wilted	15*
Alfalfa silage, wilted	11*
Grass silage, wilted, large amount legumes	20*
Grass silage, wilted, small amount legumes	6*
Corn and sorghum silage, medium to good green color	2 to 10
Corn, yellow dent, No. 2	1.3*

*Values taken from Morrison's *Feeds and Feeding* for these or similar feeds. Other values from National Research Council Publication 579, *Nutrient Requirements of Beef Cattle.*

on silage stored in outside stacks show practically no carotene remaining after a few months of storage.

Dehydrated alfalfa is a rich source of carotene when fresh or when stored under proper conditions. However, as shown in table 1, dehydrated alfalfa may lose 50% or more of its carotene in warehouse or farm storage. Even with this loss, it is a good source of carotene.

Many commercial protein and mineral supplements contain added vitamin A. Stability of vitamin A and carotene especially in contact with trace minerals is a problem. Additions of trace minerals have been shown to increase the losses of vitamin A and carotene in feeds during storage. Several vitamin A products, stabilized by use of gelatins and pectins, have been developed which have greatly increased the stability of vitamin A in com-

mercial supplements. More recently, synthetic vitamin A has become widely used in the feed industry. Gelatin-stabilized vitamin A acetate and palmitate have been shown to have a high degree of stability with the palmitate being more stable in high moisture and pelleted feeds. Vitamin A palmitate is widely used in commercial feeds today, both in protein and mineral supplements. A mineral supplement should contain several times the concentration of a protein supplement in vitamin A in order to have an effective level because of the low rate of consumption of mineral supplements.

VITAMIN A AND CAROTENE REQUIREMENTS OF BEEF CATTLE

Two common references for recommended requirements for vitamin A for beef cattle are Morripon's *Feeds and Feeding* and Bulletin 579, *Nutrient Requirements of Beef Cattle,* by the Committee on Animal Nutrition of the National Research Council.

Morrison gives the requirements as milligrams of carotene since this is the form present in plant material and the form which cattle will receive except when the rations contain vitamin A supplements. The National Research Council gives the requirements both as milligrams of carotene and as International Units (I.U.) of vitamin A.

It is important to know the requirements as units of vitamin A since the requirement is actually for the vitamin. Many commercial protein supplements contain vitamin A and the activity is stated as units of vitamin A. When using commercial supplements containing vitamin A, it will be necessary to convert carotene of roughages and yellow corn in the ration to units of vitamin A in order to know the total vitamin A value of the ration.

Morrison has computed the vitamin A value for feeds on the basis that 0.6 mcg. of carotene is equal to 1 I.U. (1 mg.=1,667 I.U.). In order to use the vitamin A values for feedstuffs given by Morrison in Appendix Table V of *Feeds and Feeding* in calculating the requirements for cattle as units of vitamin A, the values should first be divided by 4.

The vitamin A requirements of cattle are based on weight for the various types of production—maintenance, growth, fattening, reproduction, and lactation. The daily intake of carotene required to furnish the needs depends on the digestibility of the carotene in the feeds and the efficiency of conversion of carotene to vitamin A. The concentration of carotene in the feeds depends on the type of feed, harvesting and storage methods, and losses resulting during harvesting and storage. The value of a vitamin A supplement in supplying the needs depends upon the concentration of vitamin A in the supplement and the stability of the vitamin during processing and storage. Unless the concentration is stated, one does not know its value as a source of vitamin A.

Body reserves of vitamin A are also important in the need for a vitamin A supplement especially during short periods of low intake. Temporary periods of deficiency may not cause any harm since cattle are able to store body reserves of carotene and vitamin A during periods of liberal intakes. These reserves may be sufficient for periods as long as 4-6 months. Time required for depletion on rations deficient in vitamin A activity depends on the amount of body reserves. Calves become depleted more rapidly than adult cattle.

Since many factors are involved in determining the amount of supplemental carotene or vitamin A needed by cattle, it is difficult to state the amount needed in the ration in very exact terms. In an attempt to simplify recommended requirements as much as possible, they are stated in table 2 in terms of 100 pounds of body weight for various productive functions. These values are based on the Morrison Standards which amount to approximately 6 mg. of carotene per 100 pounds body weight for growth, fattening and reproduction, and approximately 9 mg. per 100 pounds body weight for lactation. They are higher than those of the National Research Council for growth and reproduction but about the same for lactation. Those of the National Research Council are about 4 mg. carotene per 100 pounds of body weight for reproduction and only about 2 mg. per 100 pounds of body weight for growth and fattening.

Table 2. Carotene and Vitamin A Requirements of Beef Cattle

Type of production	Mg. carotene per 100 lb. body wt.	I.U. vitamin A per 100 lb. body wt.*
Growth and fattening (all rates of gain)	6	2,400
Reproduction (pregnant cows and bulls in service)	6	2,400
Lactation (first 3-4 mo.)	9	3,600

*Based on assumption that 1 mg. carotene equals 400 I.U. vitamin A.

The requirements of Morrison have been used because of the wide difference between the requirements given for growth and fattening and for reproduction by the National Research Council. Such a wide difference in requirements between growth and reproduction does not usually exist. It is possible that the minimum amount of vitamin A for normal growth is lower than the minimum amount needed for high rates of gain and other beneficial functions such as resistance to diseases and infections and proper development and functions of nerves and bones.

The high requirement during lactation is to provide the need for the calf, especially during the first 3 to 4 months. The calf is born with very little storage of vitamin A in its body. If it is unable to nurse and receive the colostrum at birth, colostrum substitutes with high levels of vitamin A should be given. Products are sold for this purpose.

CAROTENE AND VITAMIN A VALUE OF BEEF CATTLE RATIONS

The carotene content of the ration can be readily calculated by taking the carotene content for the feeds in table 1 most similar to the feeds in the ration. (Grains, other than yellow corn, and high protein ingredients such as soybean and linseed meal have practically no vitamin A activity.) The values in table 1 are multiplied by the pounds of each corresponding feed in the ration. The total carotene obtained in the calculation is compared with the requirement for the class and weight of cattle shown in table 2. Any deficiency should be corrected by substituting high carotene feeds for low carotene feeds or by using a supplement containing an adequate amount of vitamin A activity. The necessary amount of vitamin A activity needed in the supplement can be determined by multiplying the milligrams of carotene needed by 400. (This assumes 1 mg. carotene is equal to 400 I.U. of vitamin A for beef cattle.)

An examination of the carotene content of feeds listed in table 1 and the requirements shown in table 2 shows that a deficiency of vitamin A should not be a common occurrence unless the ration is composed of low quality roughages or contains a large amount of grain and a low amount of roughage. However, several factors previously discussed affect the carotene content of feeds and the vitamin A requirements of cattle. A deficiency may be encountered on rations that appear adequate from tables of composition on similar feeds and average requirements of the cattle. In such cases, competent authorities should be consulted. This is advisable because symptoms described indicating a deficiency of vitamin A are not always the results of a deficiency of the vitamin.

Some example rations will show where deficiencies may exist and how to correct them.

Fattening 1,000 lb. steer	Mg. carotene
Daily requirement (table 2—1,000 x 6 mg./100 lb. wt.)	60
Ration:	
5 lb. alfalfa hay, bleached, some green color (table 1—5 x estimated 5 mg. carotene/lb.)	25
16 lb. yellow corn grain table 1—16 x 1.3)	21
1.5 lb. soybean meal (practically no carotene)	—
Total in ration	46
Short	14

Comments: This ration is calculated to be 14 mg. short on carotene or 5,600 I.U. of vitamin A (14 mg. carotene x 400 I.U. vitamin A per mg. carotene). The deficiency could be corrected by replacing the poor quality alfalfa hay with good quality alfalfa hay containing 10 mg. or more of carotene per pound or by using 1.5 pounds of protein supplement with about 4,000 I.U. of vitamin A per pound. A similar ration but using average quality nonlegume hay would need about the same type of supplementation to correct the shortage.

Wintering 500 lb.calf	Mg. carotene
Daily requirement (table 2—500 x 6 mg./100 lb. wt.)	30
Ration:	
12 lb. late-cut prairie hay, poor quality (table 1—12 x estimated 2 mg. carotene/lb.)	24
2 lb. soybean or linseed meal (practically no carotene)	---
Total in ration	24
Short	6

Comments: This ration is calculated to be 6 mg. short of carotene or 2,400 I.U. of vitamin A (6 mg. carotene x 400 I.U. vitamin A per mg. of carotene. This could be corrected by feeding 4-5 pounds of alfalfa hay containing about 10 mg. of carotene in place of 1 pound of the protein supplement. If the vitamin A is furnished by the 2 pounds of the protein supplement, it should contain at least 1,200 I. U. per pound.

Wintering 1,100 lb. pregnant cow on winter range	Mg. carotene
Daily requirement (table 2—1,100 x 6 mg./100 lb. wt.)	66
Ration:	
20 lb. dry grass, estimated (table 1—20 x 1 mg. estimated carotene/lb.)	20
1.5 lb. soybean meal (practically no carotene)	---
Total in ration	20
Short	46

Comments: This ration is calculated to be short 46 mg. of carotene or 18,400 I.U. of vitamin A (46 mg. carotene x 400 I.U. vitamin A per mg. carotene). It could be corrected by feeding about 5-6 pounds of alfalfa hay containing 10 mg. or more carotene per pound in place of the 1.5 pounds soybean meal. Feeding 1 pound of dehydrated alfalfa meal pellets and 1 pound soybean meal would meet the requirements for carotene and furnish about the same protein as in 1.5 pounds of soybean meal. If 1.5 pounds of protein supplement with about the same protein content as soybean meal is fed, it should contain 12,000 I.U. of vitamin A per pound.

There are numerous rations that could be listed. These few examples should show the general procedure to use in estimating the carotene content of rations, checking it against the recommended requirement, and the ways in which a deficiency may be corrected. If symptoms resembling those listed for vitamin A develop with an apparent adequate intake of vitamin A or carotene, a veterinarian or qualified livestock nutritionist should be consulted. Similar conditions occur in other diseases and nutritional deficiencies and an early diagnosis may prevent serious losses.