Beef Cattle Feeding: Vitamins and Minerals in the Rations
Michigan State University Extension Service
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Issued August 1964
6 pages

Extension Bulletin 466
FARM SCIENCE SERIES

August 1964

Beef Cattle Feeding

VITAMINS AND MINERALS IN THE RATION

COOPERATIVE EXTENSION SERVICE MICHIGAN STATE UNIVERSITY

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IT HAS LONG BEEN KNOWN that beef cattle need adequate amounts of vitamins and minerals for rapid and economical gains. But the exact role of these nutrients in beef feeding has never remained static. Over the years there have been (1) changes in types of rations, (2) improved growth rates, and (3) new knowledge of how various nutrients are interrelated. Because of these changes in beef feeding over time, it is necessary to re-evaluate the role of vitamins and minerals frequently. This bulletin reviews the established facts about vitamins and minerals in cattle feeding, and summarizes recent experimental work.

VITAMINS

Vitamins are indispensable for the normal growth and well-being of the animal. Although they all are important in this respect, they vary in their importance to the cattle feeder. For example, some vitamins are synthesized in the animal's rumen in adequate amounts and thus are not needed in the ration. Others are usually not a problem because of their wide distribution in natural feedstuffs consumed by cattle. Some vitamins, however, need to be added in growing and fattening rations if maximum gains are desired. The discussion of the vitamins which follows is, in general, in order of their importance to the cattle feeder.

Vitamin A

Until the 1950's little was heard about vitamin A in connection with cattle feeding. Frequent occurrence of vitamin A deficiency in recent years has given the subject headline attention and has stimulated much new research.

The Vitamin A Feedlot Problem

Natural feeds for cattle do not contain vitamin A, as such, but many basic feeds, especially green roughages, contain carotene which the animal converts to vitamin A. So, either form, carotene or vitamin A, is satisfactory in meeting beef requirements so long as the level is adequate. However, actual use in body function must be in the form of vitamin A, and anything which interferes with the conversion of carotene to vitamin A may bring about a deficiency of the latter.

Vitamin A deficiency in early stages has no visual symptoms but may be drastic to the cattle feeder since it results in reduced feed intake and liveweight gains. Later stages of the deficiency result in swelling of the leg joints, muscular incoordination, staggering gait, and night blindness.

The requirement for carotene or vitamin A for a few of the categories of beef cattle are listed in Table 1.

Table 1. Daily Vitamin A (carotene) Requirements of Fattening Beef Cattle.
(Taken from National Research Council Bulletin No. 1137)

Body weight		Daily requirement of	
		Carotene	Vitamin A
lb.		mg*	IU*
400	Fattening cattle	22	8,850
600		31	12,300
800		37	14,600
1000		44	17,300
700	Pregnant heifer	50	20,000
1000	Pregnant cow	45	18,000
1100	Lactating cow	106	42,000

* *Mg refers to milligrams; IU, to International Units.*

Feeds vary in carotene content and may lose much of it while in storage. For example, average analyses show the following:

Feed	Carotene	Vitamin A equivalent*
	mg/lb.	IU/lb.
ALFALFA HAY, EARLY BLOOM	51.9	21,000
ALFALFA HAY, LATE BLOOM	15.1	6,040
CLOVER HAY	15.0	6,000
BROME HAY	15.0	6,000
CORN SILAGE	4.4	1,800
SHELLED CORN, YELLOW	0.8	320
STRAW	0	0

*Assuming the beef animal converts 1 mg of carotene to 400 IU of vitamin A

It is apparent from the carotene content of some common feeds listed above that the vitamin A requirements may be easily met under many normal feeding programs (see Table 1 for requirements). However, some of the problems existing today may be due to less-than-normal situations which influence the conversion of carotene to vitamin A.

The answer does not appear to be a simple one. Some of the factors which may influence the conversion of carotene to vitamin A in the animal may be:

(a) type of ration and level of feeding
(b) content of nitrate in ration
(c) content of vitamin E in ration
(d) other ration factors not known
(e) stress conditions
(f) the individuality of the animal.

Included in the last factor is the variation in liver storage of vitamin A which animals may have. This vitamin is stored in the liver in large quantities when the animal is on high-carotene intakes and can thus provide for rather long periods of lack in the diet. This may explain the variation in response of different cattle or groups of cattle receiving what is considered to be similar rations.

To demonstrate the seriousness of the problem, yet the unspecific response from supplemental vitamin A under various conditions, a summary of experiments at several experiment stations is presented in Table 2. These results show a trend of response to vitamin A in cattle on various types of rations over a broad area of the United States.

Vitamin A deficiency symptoms occurred in the high-concentrate rations especially those on the longer feeding periods. Symptoms may well have occurred in several other cases, had the feeding period continued.

Even though no visual symptoms occurred, vitamin A supplement resulted in a marked increase in gains with the no-hay and low-hay rations, indicating a vitamin A shortage (carotene lack or destruction).

Table 2. Summary of Recent Experiments on the Effect of Supplemental Vitamin A in Various Kinds of Cattle Feeding Programs.

Station	Year	Average Daily Gain: No Vit. A Added	Average Daily Gain: Vit. A Added	Days on Exp.	Visual Deficiency Symptoms
No hay grain (corn, etc.), corn cobs, protein supplement					
IOWA	1962	2.94	3.29	132	yes
IOWA	1961	3.35	3.48	110	no
INDIANA	1961	1.82	2.18	256	yes
INDIANA	1963	1.77	2.05	182	yes
INDIANA	1961	2.31	2.67	119	no
FLORIDA	1963	2.35	2.69	138	no
CANADA	1962	1.90	2.26	141	no
	Av.	2.35	2.66		
10% to 20% hay, grain (corn, etc.), protein supplement					
ARIZONA	1960	2.40	2.60	112	no
INDIANA	1961	2.15	2.43	256	no
INDIANA	1961	2.76	2.90	119	no
MICHIGAN	1962	2.37	2.63	117	no
S. DAKOTA	1962	2.91	2.93	153	no
MINNESOTA	1962	2.23	2.16	110	no
	Av.	2.47	2.61		
Corn or sorghum silage, grain, protein supplement					
MICHIGAN	1960	2.37	2.32	184	no
MICHIGAN	1962	2.17	2.02	184	no
OHIO	1963	2.32	2.30	154	no
TEXAS	1963	2.42	2.37	104	no
S. DAKOTA	1964	1.93	1.87	260	no
	Av.	2.24	2.18		
Corn or sorghum silage, alfalfa, grain, protein supplement					
ARIZONA	1961	2.98	2.92	112	no
KANSAS	1963	2.30	2.37	138	no
KANSAS	1963	2.93	2.87	203	no
	Av.	2.74	2.72		

Vitamin A deficiency at a level which causes visual symptoms to be evident represents a very serious situation – poor efficiency and almost certain economic loss. Since vitamin A is stored in the liver for extended periods, deficiency symptoms do not show up until the cattle have already been through a long period of slow gains and poor feed conversion.

Cattlemen suspicious of a vitamin A deficiency might well add the vitamin with a protein supplement. Borderline deficiency in which weight gains are retarded but visual symptoms not evident, is serious from an efficiency standpoint.

The high-corn silage or sorghum silage and corn-silage-plus-hay rations, did not show much response from additional vitamin A. It should be pointed out, however, that the influence of nitrate on silage is not shown in this table.

Supplementing Rations With Vitamin A

When conditions indicate that the carotene in the ration may not supply sufficient vitamin A equivalent or that a vitamin A problem may exist, supplementation with a commercial form of vitamin A is recommended.

Considerable controversy exists as to when it should be used and the level necessary. Since it would be impossible to make recommendations to cover all situations, the following is suggested as a guide. (Note: levels for corn silage rations are too high under normal conditions, but provide a measure of safety to cover factors which may interfere with carotene conversion, such as nitrate).

Recent research has shown that high levels of nitrogen fertilizer increases the level of nitrate in the corn silage. The exact relationship of higher nitrate levels in corn silage to the vitamin A status in the animal or the problem in general, is still vague. Some research indicates that nitrate aggravates the vitamin A problem in cattle feeding, while others have shown no apparent relationship.

Basic ration	Supplemental vitamin A IU/head/day
FULL-FEED LEGUME HAY; LOW CORN	None
LIMIT LEGUME HAY; FULL-FEED CORN GRAIN	10,000
HIGH CORN SILAGE; LIMIT CORN; NO HAY	20,000 (winter)
HIGH CORN SILAGE; LIMIT CORN; NO HAY	30,000 (summer)
PAST HISTORY OF A VITAMIN A PROBLEM	30 to 50,000

Injectable vitamin A may have a place with newly acquired cattle from drought areas or in other situations promoting low carotene intake. In such cases 100,000 to 1,000,000 IU per dose provide readily available A and afford protection for a few weeks.

Thus, the situation in regard to vitamin A for fattening cattle leaves the cattle feeder in a rather confused state: he must decide whether or not a specific group of cattle on a specific feeding program should receive additional vitamin A. More research is necessary before more specific recommendations can be made.

Vitamin E

Vitamin E traditionally has not concerned the cattle feeder since most cattle feeds generally provide good sources of the vitamin. The cattle breeder, on the other hand, has been confronted with vitamin E deficiency resulting in "white muscle disease" or muscular dystrophy in calves, between 2 and 12 weeks of age.

Although the exact vitamin E requirement is not entirely worked out, estimates of requirements for young calves range from 20 to 80 IU per lb. per day. Under most conditions, natural feeds apparently supply adequate amounts of vitamin E (alpha-tocopherol) for adult cattle. Common deficiency symptoms are heart failure, paralysis – varying from a slight lameness in the legs to a complete inability to stand – and hollow or swayed back.

Vitamin E deficiency in calves may be prevented by supplementing the pregnant cow's ration with vitamin E or with 2 to 3 pounds of grain during the last 60 days of pregnancy. Prevention of the deficiency in calves is possible with daily oral supplementation of 250 to 500 IU of vitamin E. This is also effective in curing mild cases of deficiency. Oral is more effective than injections.

Vitamin E has many functions in the body but of interest here is the apparent relationship to vitamin A nutrition. With laboratory animals and chicks, it has been shown that in animals fed vitamin A-deficient rations, increased growth rate and liver vitamin A storage resulted when vitamin E was added to the diet. In cows, vitamin E supplementation resulted in increased vitamin A in the colostrum milk, and in hens vitamin E increased the vitamin A content of eggs.

In feedlot cattle the interrelationship of vitamins A and E is less clearcut. Recent experimental data, although limited, has shown that cattle responded to vitamin E, especially on low-hay rations. The response was on the same degree as with supplemental vitamin A. Other work has indicated no effect from vitamin E in alleviating a vitamin A storage. Further experimental work is necessary relative to this interrelationship.

Vitamin D

The vitamin D requirement of beef cattle is estimated to be 300 IU per 100 lb. of live weight daily. Under usual management conditions, beef cattle receive sufficient vitamin D from exposure to direct sunlight or from sun-cured hay.

Vitamin K

This vitamin is synthesized in the rumen in adequate amounts under most feeding conditions. Recent experiments have yielded some evidence that vitamin K supplement may improve carotene conversion or vitamin A utilization.

The "B" Complex Vitamins

The several B vitamins in this group such as thiamine, niacin, riboflavin, pantothenic acid, biotin and vitamin B^{12}, are synthesized in the rumen under normal feeding conditions in sufficient amounts and are thus not considered dietary essentials. Choline, which is also in this group, has shown some indication in recent tests, to improve feedlot response where high-urea diets were used. This response has been inconsistent however.

MINERALS

Experimental work in recent years has not shown a need for any particular change in recommendations for calcium, phosphorus and salt, the major minerals. Recent experimental work on minerals for fattening cattle has been directed more toward the trace minerals or those required in very small amounts as compared to calcium and phosphorus.

The Major Minerals (calcium, phosphorus, salt)

The requirements of calcium and phosphorus are shown in Table 3. A shortage of either of these will result in decreased performance.

Table 3. Calcium and Phosphorus Requirements of Beef Cattle

Body weight	Grams daily Ca	Grams daily P	Percent of ration Ca	Percent of ration P
Fattening calves finished as short yearlings				
400	20	15	0.37%	0.28%
600	20	17	0.28	0.23
800	20	18	0.22	0.20
1000	20	20	0.20	0.20
Fattening yearly cattle				
600	20	17	0.25	0.21
800	20	20	0.20	0.20
1000	20	24	0.17	0.20
1100	20	25	0.16	0.20
Fattening two-year olds				
800	20	22	0.18	0.20
1000	20	25	0.16	0.20
1200	20	26	0.15	0.20

With the usual fattening rations, it should not be difficult to meet the requirements since grains are a fair source of phosphorus and roughages (especially legume hay) a good source of calcium. When rations are especially high in concentrates and low or devoid of roughages or vice versa, however, an imbalance of calcium and phosphorus easily may occur. Therefore, cattle should have free access to minerals or a mixture such as the following, to balance any shortage in the ration. The type of mineral supplement necessary to furnish the requirements will vary according to the ration being fed. The following are suggested mixtures for some rather standard types of rations.

Mixture A. Rations containing fair amounts of legume hay.

50% Dicalcium phosphate or steamed bone meal
50% Trace mineralized salt

Mixture B. Rations containing little or no legume hay.

33 1/3% Dicalcium phosphate or steamed bone meal
33 1/3% Limestone (high calcium)
33 1/3% Trace mineralized salt

Mixture A is also satisfactory for the second ration, but since calcium is the mineral most needed here, mixture B is a more economical source.

In some cases, such as in feeding limestone-treated corn silage, a change may occur in the mineral consumption pattern by the cattle. In such cases, it is recommended that the respective mineral carriers each be fed free-choice in separate containers.

Salt (sodium chloride) requirements for fattening cattle is about 0.5% of the total ration. Salt deficiency results in abnormal appetites for salt, a reduced feed intake, unthrifty appearance. Since natural feeds are very low in sodium a supplemental source is necessary. Free access is recommended, even though most commercial protein supplements have some salt. Excessive salt intake is not likely providing the animals have access to good drinking water.

The Intermediate Minerals

Magnesium, potassium and sulfur are referred to here as intermediate since they are required in larger amounts than the "trace" minerals, but less than the "major" minerals. Under most conditions the natural feeds contain sufficient quantities of these minerals.

MAGNESIUM requirements of beef cattle has not been determined; however, no deficiencies have been observed. Apparently the dairy calf needs 0.6 gram of magnesium per 100 pounds body weight. Although "grass tetany" and "grass staggers" are sometimes attributed to magnesium deficiency, uncomplicated cases of deficiency have been produced only in purified diets or by prolonged feeding of calves on milk.

POTASSIUM requirements in laboratory rats, swine, and poultry are known to exceed sodium requirements in these species. Since forages commonly fed to cattle contain much more potassium than sodium, it seems unlikely that a deficiency would occur under most practical conditions.

SULFUR requirements have not been worked out exactly. Recent experimental work has shown that: (a) fattening cattle on certain rations respond to supplemental sulfur and, (b) the level of sulfur in the ration should apparently be in proportion to the protein (a nitrogen:sulfur ratio of 15:1 has been suggested).

Cattle feeds vary considerably in sulfur, the level being somewhat related to the protein level, since sulfur is a part of the protein molecule. For example, soybean meal is 0.40% sulfur compared to 0.05 to 0.10% in shelled corn, alfalfa hay 0.29% and corn silage 0.04% (Urea, containing 262% protein, contains no sulfur).

It has been generally considered that if the protein requirement is met (the sulfur-containing amino acids) then the sulfur content would be adequate also. With rations composed entirely of natural feeds then, there should be no problem regarding the sulfur requirements. However, when urea or other non-protein nitrogen sources are used, along with feeds low in sulfur, deficiency in sulfur may occur.

Cattle being full-fed corn silage and a protein supplement high in urea may be in a borderline area as far as sulfur intake is concerned. Therefore, it is advisable to furnish a supplemental source of this mineral. Trace mineral salt is usually a poor source of sulfur, thus the following ways of increasing the level in the ration are possibilities:

(a) Feed commercial protein supplement containing additional sulfur.

(b) Mix sodium sulfate in the protein at the rate of 16 pounds per ton of supplement (for a high protein supplement fed at the rate of one pound per day, or 10 pounds if two pounds supplement per day).

(c) Mix sodium sulfate in the salt at the rate of 8% (8 lb. per 100 lb. salt). This level is based on the assumption that the animals have free access to salt and that the intake is around 0.10 lbs. salt per day. If the intake of salt or minerals is below this, the supply of sulfur may be inadequate.

The Trace Minerals

Michigan is in a cobalt and iodine deficient area. Other trace minerals have been shown to improve the function of rumen microorganisms. Also, a mixture of the minerals listed in Table 4, have been shown to increase daily gains in fattening cattle on certain rations, although not in all feeding situations.

The exact requirement for many of the trace minerals have not been established and thus the levels listed in Table 4 are suggested levels based on the best available information. Also, the requirement of one mineral is frequently influenced by the level of other minerals in the diet. The suggested requirements listed have considerable range and refer to total daily intake, including the amount in the feed plus any mineral supplement.

Trace mineralized salt is readily available and is recommended for most feeding situations. Intake values for the various trace minerals are given from feeding T. M. salt at an assumed intake of .05 lb. per day which is in the area of average consumption. Under certain conditions the intake may be double this, and other times less.

Table 4. Trace Mineral Requirements for Fattening Cattle and the Supply from Trace Mineralized (T.M.) Salt.

Element		Dietary Requirement*	Intake from 0.05 lb. T. M. Salt†
		mg/day	mg/day
Manganese	(Mn)	35 to 50	102
Iodine	(I)	1.0 to 5.0	2.9
Copper	(Cu)	30 to 50	10.8
Cobalt	(Co)	0.5 to 1.0	2.7
Zinc	(Zn)		1.3
Iron	(Fe)	30§	4.1

* *Average values taken from National Research Council and Underwood, E. S. "Trace elements in human and animal nutrition." Acad. Press, New York, 1962.*

† *Assuming an animal consumes 0.05 lb. of typical trace mineralized salt per day, the intake of the respective minerals would be the amounts shown.*

§ *Requirements not established.*

Other Trace Minerals

SELENIUM is a mineral which is most frequently discussed in terms of its toxic effect on cattle grazing in Western states of alkali soil containing excessive selenium. Selenium has been effective in prevention of white muscle disease in calves. The incidence of white muscle disease may be greatly reduced when beef cows are fed 0.1 ppm (parts per million) of selenium during the gestation period. Vitamin E appears to be involved here also. Recent studies indicate that selenium may also be effective in replacing part of the vitamin E requirement in feedlot cattle, which thus make it interrelated to vitamin A.

MOLYBDENUM is essential for cattle. The requirement for beef cattle is unknown although it is extremely small since 10 to 20 ppm in the forages results in toxic symptoms. Toxic levels interfere with copper metabolism, thus increasing the copper requirement. More research is necessary regarding the use of molybdenum in cattle feeding rations.

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Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. N. P. Ralston, Director, Cooperative Extension Service, Michigan State University, E. Lansing, Mich.
2P-7:65-10M-WE