DS27

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Vitamin Needs of Dairy Cattle [1]

Barney Harris, Jr.[2]

The vitamins can be divided into two major groups: fat soluble and water soluble. The descriptive terms simply mean that solvents are used to extract certain vitamins whereas others are soluble in water. The fat soluble vitamins are stored in the fat or lipid portion of the feed and include vitamins A, D, E and K. The water soluble vitamins include all the B vitamins and vitamin C.

The new, 1988 National Research Council (NRC) nutrient guidelines for dairy cattle show a requirement for vitamins A, D, and E. These recommendations as listed below in Table 1 show that a cow consuming 40 lbs. of dry matter (DM) daily would be receiving 58,000 to 72,800 international units (IU) of vitamin A.

Vitamin A

All animals require a dietary source of vitamin A. The vitamin does not occur as vitamin A in grasses or legumes but rather as its precursor carotene. Carotene or provitamin A is transformed into vitamin A in the animal's body. The conversion occurs either in the intestinal wall or liver of the animal.

Vitamin A and carotene are rapidly destroyed by oxygen in the air. Exposure to light, high temperatures, rancid fats, and moisture have also been proven to hasten destruction. Various minerals, such as iron, copper, iodine, and manganese, act as powerful catalysts or "accelerators" in the destruction of carotene and vitamin A.

Further complications are introduced by widespread use of pelleting, crumbling, and cubing operations in recent years. The high pressures, temperatures, and steaming involved provide additional stress upon many micro-ingredients. In mineral concentrates, many vitamin A sources are destroyed in a matter of days.

One of the more important roles of vitamin A in the body is maintaining healthy tissues - the integrity of epithelial tissues. In the young calf, deficiency symptoms usually start with watery eyes; mild symptoms of respiratory problems such as nasal discharges, often accompanied by a cough; and scours or diarrhea. If this condition is allowed to persist, pneumonia usually follows. Night blindness is a common symptom of vitamin A deficiency and may be observed when animals are moved about in a dim light. A lack of vitamin A reduces the animal's protection against invading organisms, making animals more susceptible to infections. Increased

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2. Barney Harris, Jr., professor, extension dairy specialist, Department of Dairy Science, Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, 32611.

infections in the reproductive tract would quickly lead to reduced breeding efficiency.

One role of vitamin A is in the physiological mechanisms of vision. A deficiency of vitamin A, in terms of the needs for the resynthesis of visual purple, results in night blindness (Figure 1). The deficiency first manifests itself as a slow dark adaptation and progresses to total night blindness.

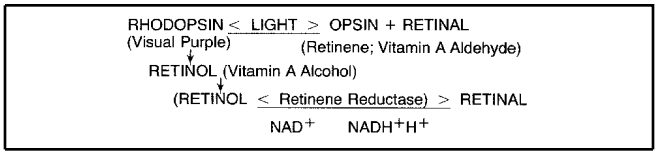

Figure 1.

Many factors affect the efficiency of absorption and utilization of vitamin A and carotene. Some of the factors that are thought to affect the utilization are: 1) free nitrates in feedstuffs, 2) inadequate protein level in the ration, 3) any stress condition, 4) high temperatures or hot climates, 5) the use of old corn or other stored grains, 6) long periods of storage, 7) low level of phosphorus in ration, and 8) interrelationships of vitamin A and carotene with other nutrients that may increase or decrease utilization. It has recently been reported that zinc is necessary to maintain normal concentrations of vitamin A in the plasma. By using animals deficient in both zinc and vitamin A, it was demonstrated that zinc is necessary for the normal mobilization of vitamin A from the liver.

Research shows that one mg. of carotene is equivalent to 400 USP (IU) units of vitamin A for ruminants. The 1988 NRC shows that a 1400-pound dairy cow consuming 40 lbs of dry matter daily needs about 65,000 USP units of vitamin A. Florida dairymen and feed men are encouraged to add 5 to 6 million units of vitamin A per ton of feed. About twice this level is recommended during the hot summer months, since under stress conditions more vitamin A is needed.

Vitamin D

The importance of vitamin D in the cure of rickets and for efficient utilization of calcium and phosphorus has been recognized for many years. Its principal actions are to increase the absorption of calcium and phosphorus from the intestine, and to aid in controlling the rate of accretion and resorption of minerals in bone. Also, vitamin D influences the handling of phosphate by the kidney. There are two sterol compounds - D2 (activated ergosterol or ergocalciferol) and D3 (activated 7-dehydrocholesterol or cholecalciferol) - that are the major sources of vitamin D. Provitamin D3 is the form found in nature in the fish liver oils, and D2 occurs in the plant kingdom. Man and other mammals can synthesize vitamin D3 in the body from the exposure of provitamin in the skin to sunlight as shown in Figure 2 .

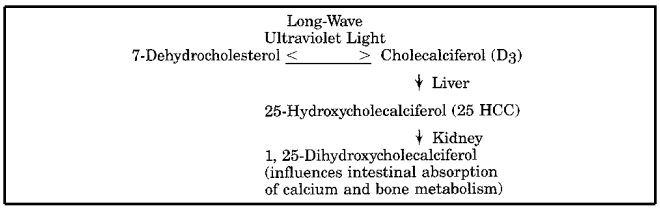

Figure 2.

It is well understood that vitamin D is needed for the normal calcification of the growing bone. The exact level needed, however, varies some with the mineral composition of the ration. Less vitamin D is needed when the level of calcium and phosphorus is optimum. Most work has demonstrated an optimum ratio of calcium to phosphorus to be between 1.3:1.0 to 2:1. Recent attempts at Kansas State University have been made to measure the influences of calcium intake and vitamin D supplementation on reproductive performance of dairy cattle. In all studies, the phosphorus level was reported to be adequate. Results of the studies suggested that vitamin D supplementation favorably influenced the intensity of expression of estrus (heat). The experimental cows showed estrus 16 days earlier and conceived on an average of 37 days sooner. Services per pregnancy and milk production were similar for both groups.

The new 1988 NRC guidelines recommend the addition of vitamin D to dairy cattle rations at the level of 450 units per pound of dry matter. Therefore, a 1400-pound cow consuming 40 pounds of dry matter daily would need about 18,000 units of vitamin D.

Vitamin E

Compounds having vitamin E activity are known chemically as tocopherols. The word tocopherol is derived from the Greek words tokos (childbirth) and pherein (to bear). While early work showed a requirement for vitamin E in the reproduction of laboratory animals, there is no reliable evidence that vitamin E is necessary for fertility in humans. The signs of vitamin E deficiency in humans are muscular weakness, creatinuria, and fragile erythrocytes (red blood cells).

Vitamin E has long been recognized as a natural biological antioxidant. Vitamin E appears to be the first line of defense against peroxidation (oxidation by peroxides) and is important for maintaining low tissue concentrations of peroxides, which if allowed to amass or accumulate in cells can severely damage the cell and tissues. Peroxides are continuously produced in tissues as oxygen is metabolized and, as such, must have a means of being removed. Vitamin E is a very efficient scavenger of free radicals such as peroxides in tissues.

In recent years, vitamin E and selenium have been frequently discussed together because of their close relationship. Selenium spares vitamin E or reduces the requirements for vitamin E. Likewise, vitamin E appears to reduce the requirements for selenium.

The most widely recognized vitamin E deficiency disorder in calves is nutritional muscular dystrophy or white muscle disease. Symptoms observed include weakness of leg muscle, difficulty in standing, trembling after standing, and a wobbly, staggering gait. The condition is prevented by the addition of either vitamin E or selenium to the calf's diet. For young calves, vitamin E requirements are estimated to range from 30 to 130 IU of vitamin E/lb of dry diet.

Vitamin E plays an important role in the functioning of the immune system. Research with dairy calves at Kansas State University showed that supplementation with vitamin E enhanced humoral immune response, thereby giving the calf more resistance to stress-related problems. Stress factors frequently encountered by calves include changes in routine, weather, dehorning, vaccinations, flies, and diseases. Supplemental vitamin E would give the calf more resistance to the ill effects caused by the above stress factors on the immune system.

Vitamin E and selenium have been used successfully in combination to reduce the incidence of retained placenta, metritis (uterine infection), and cystic ovaries in herds having low levels of these nutrients. Herds having such problems are frequently injected with a vitamin E-selenium compound containing 680 units of vitamin E and 50 mg. of selenium as selenite about three weeks prior to calving. Since other factors are related to retained placenta, such as reproductive diseases and stress conditions, added vitamin E and selenium may not always be helpful in correcting a problem. Diseases should be eliminated by developing a good herd health program. The 1988 NRC recommendations in the nutrient requirements of dairy cattle are 0.3 ppm selenium in the total ration dry matter and 7 IU of vitamin E per lb of dry matter (DM) intake. A Holstein cow consuming 40 lbs of DM daily would receive 280 IU of vitamin E.

Recent research at Ohio State University shows that vitamin E and selenium may help reduce the incidence and duration of mastitis outbreaks. These researchers reported that supplementation with vitamin E in the feed for cows in late gestation reduced the incidence of mastitis by 37%, and the injection of selenium and feeding of vitamin E reduced the duration of mastitis by 41%. The above study is the first research to indicate an improvement in the natural resistance of the cow to new cases of mastitis through better nutrition. (Table 2)

Selenium and vitamin E are two feed nutrients that complement each other in their action, and may be useful to your herd. Carefully evaluate your dairy ration and situation to determine:

1. Is your dairy ration low in selenium or vitamin E? Selenium - forage test is necessary. Vitamin E - high level of fermented silages with little or no fresh forage or hays may result in low vitamin E intake.

2. Do you have a high level of retained placenta or mastitis which cannot be improved by other management factors?

3. Is there a high level of mastitis or somatic cells, in spite of rigorous mastitis treatment, teat dipping, a clean environment, and proper milking machine function?

Supplementation may be useful in case of inadequacies. The 1988 NRC recommends 0.3 ppm selenium and 200 to 300 IU of vitamin E daily per cow. Feeding high levels of vitamin E (400 to 1000 lU/cow/day) has been helpful in reducing the incidence of oxidized flavor in milk, but the cost is high because the efficiency ofvitamin E transfer into milk is less than 2%.

Feeding cows differently during the prepartum period (last 3-6 weeks of dry period) has become more popular in recent months due to the advantages obtained in herd health and production performance. Adding 800 to 1000 IU of vitamin E and 3 mg. of selenium daily per cow during the prepartum period has been demonstrated as an effective means in reducing retained placentas, incidence of mastitis and improved reproductive performance.

Vitamin K

Vitamin K activity is essential for all species for the maintenance of normal blood coagulation. The best known function of K is in the formation of prothrombin, which is essential for normal clotting of the blood.

Dietary vitamin K deficiency is not likely to occur, since the vitamin is fairly well distributed in feeds and has been shown to be synthesized in the rumen and intestine.

B Vitamins

Since B vitamins are synthesized by microflora in the rumen, as well as being relatively abundant in ordinary feeds, they have been of less concern in the nutrition of dairy cattle. The vitamins of the B complex are thiamine (B1), Riboflavin(B2), Niacin, Pyridoxine (B6), Pantothenic acid, Biotin, Folic acid, Choline, and vitamin B12.

Until recently it was thought that the B vitamins were needed only with simple-stomached animals. Most nutritionists believed that microbial synthesis in the rumen would provide all the B-complex vitamins needed by ruminants. In recent findings, research has shown a beneficial effect from niacin supplementation for ruminants under certain situations.

Niacin was isolated in 1937 and demonstrated to be effective in curing black tongue in dogs and pellagra in man. In the 1940s, it was discovered that the amino acid tryptophan could be converted in the body to niacin in most animals. It is not known how much tryptophan is converted to niacin in the ruminant animal by rumen microorganisms, but they are known to synthesize some niacin.

Niacin, sometimes called nicotinic acid, is the vitamin component in two important coenzymes called NAD (nicotinamide adenine dinucleotide) and NADP (nicotinamide adenine dinucleotide phosphate). The coenzymes NAD and NADP are concerned with carbohydrate, fat, and protein metabolism systems for all animals.

A number of studies have shown a slight advantage in milk production in very early lactation (first two months) with the supplementation of 6 grams of niacin daily per cow. In a California study, niacin-fed cows had a non-significant advantage in milk production the first two months, but a significant advantage in fat percent. In both cases, the advantages were lost in the third month.

Pennsylvania State University researchers (*JDS* 69:69:1416) used five herds with 240 cows to determine the response to feeding 6 grams/day of supplemental niacin during the summer months. Diets consisted of corn silage, hay crop silage, hay, or pasture as the forage and concentrate. Cows producing 75 lbs. milk produced 5.2 lbs. more milk with supplemental niacin. Overall results are shown in Table 3 .

The influence of niacin supplementation on milk yield and composition in early lactation has been inconsistent and frequently not significant. Limited studies tend to suggest a response in milk production and/or fat percent to niacin supplementation in early

lactation when natural protein is fed and cows are in above-average body condition.

Symptoms of individual B vitamins have been developed and identified in young calves fed purified and semipurified diets. However, specific requirements have not been established, and the best recommendations available to date are those levels commonly used under which deficiencies have not developed.

Since the mineral cobalt is an integral part of the vitamin B12 molecule, a deficiency of cobalt would naturally lead to a deficiency of vitamin B12. A deficiency of cobalt and vitamin B12 will result in anemia.

Vitamin C

A dietary need of ascorbic acid or vitamin C is limited to man, the guinea pig, and the monkey. Other animals are able to synthesize vitamin C within their bodies. Ascorbic acid need not be added to dairy cattle rations.

Table 1.

Table 1.	
Vitamins	Level Suggested
A (IU/lb DM intake)	1450-1820
D (IU/lb DM intake)	450
E (IU/lb DM intake)	7

Table 2.

Table 2. Effect of vitamin E and selenium supplementation on incidence of clinical mastitis during lactation.

Treatment	Cows	Quarters (n)	Clinical Cases
E + Se	21	84	22
E	20	80	21
Se	19	76	27
Control	20	80	33

70 % of isolates were coliform bacteria and species of streptococci other than S. Agalactiae. JDS 67:1293.

Table 3.

Table 3. The effect of niacin supplementation on milk yield and composition.

	Milk (lb)	Fat (%)	Protein (%)	FCM* (lb)
Control	53.9	3.72	3.35	51.7
Niacin	55.9	3.70	3.34	53.5

* Fat corrected milk.