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Vitamin requirements of cattle

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Abstract
Ruminants and monogastric animals require same vitamins at the tissue level. Dietary supplementation of vitamins in ruminants improves the metabolic efficiency. Both fat soluble and water soluble vitamins can affect ruminant's production. This article discusses the importance of supplementation of vitamins in cattle.

Keywords: Vitamins, cattle, requirements, milk

1. Introduction
Vitamins are organic components that are needed in very small amounts for growth and for maintaining good health. Vitamin means life amine. There are 14 known vitamins. The usage of term vitamin is conditional and it depends upon organism which is in need of it because in actual sense the term vitamin means organic compound that the organism cannot synthesize by its own and should be supplied through diet. For example vitamin C is a vitamin for humans, but not for most other animals because humans cannot synthesize vitamin C and should be supplied through the diet.
Vitamins are broadly classified into fat soluble and water soluble vitamins. Fat soluble vitamins include A, D, E and K. Fat soluble vitamins can be stored in the fat cells when present in excess and also can be easily absorbed through the intestinal tract. Vitamins A and E should be supplied through diet. Fat soluble vitamins are having higher potential for toxicity and also it requires dietary fat for transport in blood. Water soluble vitamins include B vitamins, Choline and vitamin C. Water soluble vitamins cannot be stored and gets easily excreted from the body. It is having low potential for toxicity and can be easily transported in blood.
Vitamins have diverse functions including involvement in many metabolic pathways, immune cell function, and gene regulation. Deficiency of vitamins may result in deficiency diseases. In subclinical deficiencies there may not be any prominent signs but will affect the overall performance and animal health.

2. Vitamins for ruminants
At tissue level, ruminants require same vitamins as that of monogastric animals. Young ruminants require dietary sources of vitamins. Mature ruminants require dietary supplementation of vitamins A, D and E. Vitamin K is synthesized by ruminal and intestinal bacteria. Vitamin D can be synthesized by body from sunlight. Feedstuffs for ruminants contain vitamin A and E.But we cannot solely rely on all these factors, so supplementation through diet had to be made in correct proportions. High producing dairy animals had to be supplemented with vitamin B complex also.
Inadequate dietary vitamin intake can be due to many reasons like processing and storage effects, reduced feed intake, low concentration in feeds, bioavailability, level of production, rearing in confinement out of sunlight, stress and disease etc. All these factors affect the need of vitamins for animals.

3. Vitamin A
Vitamin A is the vitamin of most practical importance. One IU (International Unit) of vitamin A is equivalent to 0.3 µg of all trans retinol/ 0.344 µg of all trans retinyl acetate/ 0.550 µg of

all trans palmitate. Retinol is not present in plants but present as beta carotene i.e. provitamin form of vitamin A. This beta carotene gets converted to retinol by enzymes in intestinal mucosal cells. Ruminants do not efficiently convert beta carotene to vitamin A. Moreover beta carotenes are present in forages and most of the grains and grain byproducts are devoid of beta carotene. Mature forages contain low beta carotene. One milligram of carotene is equivalent to 400 IU of vitamin A.

Beta carotene —(Deoxygenase)→ Retinol —(Dehydrogenase)→ Retinal

Most forageis good source of vitamin A. Stored forages contain less beta carotene. Length of storage is inversely proportional to beta carotene content. Bioavailability of vitamin A depends on many factors like ruminal destruction, absorbability of small intestine and also the conversion efficiency of beta carotene to retinol. Only 40% of supplemental vitamin A will be available to animal fed with corn grain diet. Digestibility of carotene from different forages was found to be 77% in dairy steers. Vitamin A is stored in liver and is having a half life of four weeks.

Vitamin A helps in normal vision, immunity, reproduction, growth and development. Cows having a 100 ng/ml greater concentration of serum retinol the week before parturition were 2.5 times less likely to have mastitis in the first 30 d postpartum (Le Blanc *et al*., 2004) [10]. Number of viable embryos recovered from cows given vitamin A increased (3.6 vs. 6.1, 6.5 and 6.7 for 0, 500,000, 1,000,000 and 1,500,000 IU of retinol palmitate, respectively) (Amaral, 2004) [1]. Vitamin A supplementation increased ovulation rate when cows are super ovulated (Shaw *et al*., 1995) [16].

Requirements of Vitamin A

Group	NRC 1989 (IU/kg BW)	NRC 2001 (IU/kg BW)
Growing	42	80
Lactating/Dry	76	110

Safelimit for vitamin A in diet is about 66,000 IU/kg. According to NRC (2001), additional supplementation is required during low forage diets, diet containing large amount of corn silage, feeding of lower quality forages, exposure to pathogens and also when immune competence reduction. No data shows any positive effect on supplementation at rates higher than NRC. According to Weiss (2005) [19], dry/lactating animals can be given with 84,000 to 1, 00,000 IU/day. Grazing animals require additionally 24,000 to 28,000 IU/day.

4. Vitamin D

Vitamin D is found in two forms mainly.

- Ergocalciferol (Vitamin D_2) - found in plants
- Cholecalciferol (Vitamin D_3) - found in animals

In skin photochemical conversion occurs which converts 7 dehydro cholesterol to cholecalciferol. Liver sequesters vitamin D_3 and converts to 25 hydroxy vitamin D_3. In kidney, 25 hydroxy vitamin D_3 gets converted to 1, 25 dihydroxy vitamin D_3. It is the active form of vitamin. When sufficient calcium is present in the body parathyroid hormone won't be produced and this result in the catabolism of vitamin D. Vitamin D is involved in absorption of Ca and P and mobilization of Ca and P from bone, regulation of blood Ca and P, immune cell function, reproduction etc.

Requirements

Animals fed sun cured hays and/or kept in sunlight have limited needs for supplemental vitamin D. Dairy NRC does not give credit to feed and sunlight as sources of vitamin D. Adult dairy cows require 30 IU/kg body weight (NRC, 2001). McDermott *et al.,* (1985) [12] proposed that 17 IU/kg body weight supplementation is only required for maintenance of normal plasma concentration of vitamin D. Feeding of mega doses of vitamin D is done for prevention of milk fever, improving tenderness of meat. Hibbs and Conrad (1983) [7] found that milk production, reproductive and healthbenefits were improved at 70 IU/kg bodyweight. But supplementation of vitamin D in very huge doses results in toxicity.Feeding at level of 80 IU/kg BW is tolerated while 400 IU/kg BW is not (Mc Dermott *et al*., 1985) [12]. Feeding at 160 IU/kg BW reduced milk production in cows (Hibbs & Conrad, 1983) [7]. Maximum tolerable limit of vitamin D is 2200 IU/kg diet for long periods and 25000 IU/kg diet, when fed for short periods. Calcification of soft tissues will occur during extreme toxicity.

5. Vitamin E

Vitamin E is the generic name for tocopherols and tocotrienols. Alpha tocopherol is the most biologically active form. Among the isomers of alpha tocopherol, RRR alpha tocopherol is the most active one. Fresh forage plants contain 80-200 IU of vitamin E/kg DM. Exposure to oxygen and sunlight cause loss in activity. Vitamin E content is very low in concentrates except soybeans and cottonseeds. Supplemental form of vitamin E is all -rac – αtocopheryl acetate (NRC, 2001).

One IU of vitamin E is equals to one mg all -rac – αtocopheryl acetate and 1.49 IU vitamin E is equal to 1 mg RRR-α- tocopherol. Vitamin E got poorly absorbed from digesta. RRR-α- tocopherol had better bioavailability than all -rac – αtocopheryl acetate. Major functions of vitamin E include maintenance of cell membrane, immunity and reproduction. Deficiency of vitamin E results in white muscle disease and retained placenta.

Requirements

Plasma concentration of αtocopherol in peripartum cows should be approximately 3 µg/ml (Weiss *et al*., 1997) [20]. Dry cows and heifers fed stored forages during last 60 days of gestation require 1.6 IU of supplemental vitamin E/kg BW (80 IU/kg of DMI). According NRC (2001) lactating cows require 0.8 IU/kg body weight (20 IU/kg DMI). Upper limit is about 75 IU/kg body weight. Lactating cows had to be supplemented with 500 IU vitamin E per day, dry cows with 1000 IU/day and transition cows with 2000 to 4000 IU/day (Weiss, 2005) [19].

Injected vitamin E (3000 IU at 14 or 7 day prepartum) reduced prevalence of retained fetal membranes (LeBlanc *et al*., 2002) [11]. Cows fed 2000 IU/d of supplemental vitamin E from 2 weeks before until 1 week after calving had significantly lower SCC at 7 and 14 days in milk compared with cows fed 1000 IU/d of vitamin E (Baldi *et al*., 2000) [2]. Weiss *et al.,* (1997) [20] studied the effect of feeding different amounts of supplemental vitamin E during the dry period (100 IU/day for 60 days or 1000 IU/d for 46 days and 4000 IU/day for the last 14 days of the dry period) and found that increasing the amount of supplemental vitamin E reduces mastitis and mammary infections.

Trace mineral selenium and vitamin E functions together as excellent antioxidants. Studies had shown that supplementation of Vitamin E and Selenium together reduced the number of clinical cases of mastitis (Smith *et al.*, 1985) [18].

Vitamin E improves meat colour and reduce lipid oxidation in beef (Chan *et al*., 1996 and Lanari *et al*., 1996) [4, 9]. Feeding vitamin E 500 to 1000 IU/d for 100+ days prior to harvest increases concentration of α-tocopherol in muscle 1 ug/g to over 3.5 ug/g. Feeding a diet supplemented with 1000 IU vitamin E for 104 days before slaughter resulted in lower shear force in beef steaks from longissimus dorsi after 14 day of postmortem storage (Carnagey *et al.*, 2008) [3]. Vitamin E at 3000 IU/cow/day during dry period showed decreased amount of malondialdehyde (stress indicator).

Several factors decide the requirement of vitamin E supplementation. When animal is fed with fresh forage, then there is no need for vitamin E supplementation in diet. Cows in suboptimal selenium status had to be fed with more vitamin E. Additional vitamin E had to be given to freshly calved cows with colostralgenesis because colostrumcontains high vitamin E compared to milk. Immunosuppression period also requires extra vitamin E.

6. Vitamin K

Vitamin K is a generic name describing a group of quinine compounds i.e. phylloquinone (Vitamin K_1), menaquinone (Vitamin K_2) and menadione (Vitamin K_3). Vitamin K is required for the synthesis of clotting factors like prothrombin, factors VII, IX and X. No established supplemental requirements for ruminants because of microbial synthesis and vitamin K presence in feeds. Deficiency condition is known as sweet clover disease when animals are fed with sweet clover because it inhibits production of clotting factors.

7. Vitamin B complex

Typical diet fed to a lactating cow contains 4to 10 mg biotin per day. Biotin forms the cofactor for enzymes of carboxylation reactions. Biotin can be supplemented at 20 mg/d in order to reduce hoof deformities. Supplementation of biotin at 20 mg/d improved milkyield in lactating cows.

Niacin is the coenzyme for NAD (H) and NADP (H). Niacin playsimportant role in mitochondrial respiration and carbohydrate, lipid, amino acidmetabolisms. Supply of niacin to intestine exceeds intake when unsupplemented diets are fed to cattle. Only 17 to 30% of supplemental niacin reaches intestine.Calves fed synthetic milk is having higher chance for developing scours within 48 hrs due to niacin deficiency. Niacin increase microbial protein synthesis (Shields *et al*., 1983) [17]. Niacin supplementation during periparturient period (6 to 12g/day) reduced blood ketones & NEFA (Jaster *et al*., 1983) [8].

Folic acid is necessary for the synthesis of nucleic acids hence it has big role in cell division and protein synthesis. So it substantiates the requirement of folic acid for dairy cows as it synthesizes extensive amount of proteins and new tissues, with the fetus and mammary gland development. Girard (1998) [5] found that folic acid supplementation at 4 mg/kg body weight per day increased milk production from 8300 kg to 9000 kg.

Pantothenic acid forms part of coenzyme A and acyl carrier protein. But regarding the essentiality of supplementing pantothenic acid in ruminant's diet is still a question mark because studies prove that 80% of supplementary pantothenic acid disappears between mouth and duodenum (Ragaller *et al.,* 2011) [15]. Microorganisms in rumen can synthesize pantothenic acid but it depends on the ratio of concentrate and fodder in the diet.

Vitamin B_{12}/Cyanocobalamine performs two important functions. It's a coenzyme for methionine synthase. So it acts as an interface between folic acid and vitamin B12 metabolism. Even on sufficient folic acid supply, insufficient vitamin B_{12} causes folic acid deficiency. Vitamin B_{12}-dependent enzyme, methylmalonyl-coenzyme A mutase, plays a major role in ruminants for the entry of propionate in the Krebs cycle and gluconeogenesis (McDowell, 2000) [13].

Combined supply of vitamin B_{12} and folic acid improved energy corrected milk and blood parameters in first week of lactation (Girard and Matte, 2005) [6].

8. Conclusion

Vitamin supply for ruminants is actually the addition of vitamins ingested and not destroyed by the rumen microorganisms and those synthesized in the rumen. Lot of studies are going on in the field of vitamin requirements for ruminants. But the effect of supply of vitamins on milk production only be evident at the time when animal is in deficiency of particular vitamin. From the above studies and values it is clear that vitamin supplementation improves metabolic efficiency of dairy cattle especially during peak months of lactation.

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