

Livestock Vitamin Nutrition in Perspective

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Vitamins were identified as a group of unique and nutritionally essential organic compounds in the early 20th century. Prior to that time vitamin deficiency diseases were categorized along with infectious diseases with unknown causes. In a few cases such as vitamin C deficiency (scurvy) the presence or absence of certain foods in the diet (citrus fruits) were associated with the development or alleviation of deficiency symptoms. Development of the germ theory of disease helped pave the way for discovery of the vitamin deficiencies as the cause of non-infectious disease symptoms. Gradually, the persistence and ingenuity of researchers across several fields led to the identification of specific chemical compounds that were given the name vitamin based on their ability to alleviate specific deficiency symptoms and restore health in birds, rodents and other species, including humans.

While vitamins had been chemically identified it was not until the middle of the 20th century that large scale chemical synthesis and production of individual vitamins was achieved resulting in commercially available vitamin supplements. The synthesis and production of Vitamin A in the 1940's and 1950's was a classic example. Later, vitamin manufacturers studied factors affecting vitamin stability and developed specific product forms for individual vitamins that extended their shelf life and improved mixing and handling properties.

Prior to the advent of commercial vitamin sources, natural sources were used to prevent vitamin deficiency and improve livestock health and performance. Supplements such as wheat germ oil (vitamin E), liver extract (multiple vitamins), cod liver oil (fat soluble vitamins), alfalfa and other carotenes (vitamin A) and rose hips (ascorbic acid) were examples. Challenges with natural sources of vitamin activity include relatively low and variable vitamin concentrations coupled with poor stability.

As commercial vitamin supplements became more plentiful their cost came down. This trend continued into the early 2000's when additional global supplies became available. As a result, vitamin supplementation lost some prominence on the list of concerns for professional nutritionists. However, shortages have occurred when manufacturers have exited the market or experience production problems bringing vitamins supplementation levels and their justification back under scrutiny. These shortages can cause serious supply issues and cost increases for livestock producers. There are however, some upsides to the increased scrutiny of vitamin supplementation levels and rationales. Nutritionists are benefited by refocusing on this important class of micronutrients and their value to animal health and performance. Vitamin supplementation should be reviewed in the light of recent research to ensure that optimal levels

are being provided in diets. Optimal levels are those which provide the greatest overall health, performance and economic return from commercial livestock.

Stability and shelf life of vitamins are a valid concern. Vitamins are organic compounds with inherently unstable structures. Vitamins A, E, C, K and folic acid are the least stable, although it is not a straight forward relationship due to interactions of heat, light, free metals and pH in premixes and other media in which vitamin formulations are prepared and stored.

In addition, advanced product forms such as crossed linked beadlets (vitamin A,D), acetate esters (vitamin A, E), thiamin mononitrate and phosphorylated ascorbic acid are significantly more stable than less sophisticated product forms. A consultant would be wise to enquire as to the source(s) of vitamins used to prepare vitamin premixes and base mixes.

Straight vitamin product forms in the original, sealed container are stable for 12 months or longer as designated by the manufacturer. Vitamins in a well formulated premix without trace minerals or choline, with adequate levels of an appropriate carrier stored under cool, dry conditions are generally stable (>90%) for 3-6 months.

However, vitamins are commonly combined with trace minerals, choline and other nutrients in premixes of varying concentration and formulation. In these situations, the vitamins decay more rapidly in proportion to the relative “stress” of premix conditions. For example, a highly concentrated premix with copper sulfate is much more stressful on vitamins than one where copper is supplied by less reactive forms such as organically chelated or complexed sources or tribasic copper chloride. Oxidative reactions are especially damaging to the vitamins. Coelho (5) created a set of reference tables for vitamin stability and provided the following summary table as an example of net vitamin stability under a given set of conditions and storage times. The following Table 13 was prepared by Coelho (1).

Table 13. Vitamin stability in ruminant premixes and feeds

	1	2	3	4
	Vitamin Premix (TABLE 8)	Pelleting Temperature (TABLE 11)	Feed Storage Time (TABLE 10)	Total Vitamin Retention %
	2 Months	96°C	2 Weeks	1x2x3
A Beadlet	90	88	98	78
D ₃ Beadlet	91	91	99	82
E Acetate 50%	92	91	99	83
Thiamine Mono	77	82	99	63
Riboflavin	91	84	99	76
B ₁₂	96	95	100	90
Calcium Pantothenate	87	84	99	72
Biotin	89	84	99	74
Niacin	90	86	99	77

Synthetic antioxidants have been added to basic vitamin product forms such as cross-linked beadlets for many years to improve stability. Addition of antioxidants can help improve the stability of premixes containing both vitamins and trace minerals and/or choline and stored under conditions of elevated temperature and humidity. On-farm bulk storage of vitamin-mineral mixes in open bays would be a very good example of stressful storage conditions.

Stability of fat-soluble vitamins (A, D, E, K) are also affected by the presence or absence of unsaturated fats in the diet and the relative stability of the fat. Unsaturated fats are prone to oxidative rancidity. Oxidation is a progressive chain reaction that reduces the energy value of and leads to destruction of fat soluble vitamins in the diet and in the G.I. tract. Supplemental antioxidants can be used to stabilize unsaturated fats and prevent energy and vitamin losses.

During the recent period of vitamin shortages and price increases some nutrition consulting groups and feed companies have begun adding supplemental antioxidant blends to premixes and bagged feeds to help preserve vitamin activity during storage and feed out. Given the storage times and conditions of these products this is a prudent consideration.

From a practical standpoint the following guidelines may be used for premix formulation:

1. Use vitamin sources of known origin from a quality manufacturer with a strong quality assurance program. Such suppliers will have data available on vitamin product forms and their stability.

2. Follow manufacturer recommendations for premix formulation including the use of proper carrier materials to disperse the vitamins and bulk ingredients to meet bulk density and flow targets.
3. Use of a separate vitamin premix will improve storage stability compared to a vitamin-trace mineral combination. If vitamins and trace minerals must be combined then use of less reactive trace mineral sources (mainly copper, iron) and recommended levels of inert ingredients will aid stability.
4. Store vitamin premixes under the most favorable conditions available in the feed mill or storage facility avoiding extremes of temperature and humidity, keeping premixes in re-sealable containers and using up premixes within 4-6 months of receipt.
5. Consider addition of a high-quality antioxidant blend to higher cost, lower use rate premixes to improve shelf life and buffer against seasonal variations in temperature, humidity and use rates.

In addition, when a vitamin or vitamin-trace mineral premix is used in the formulation of a base mix or concentrate, resist the temptation to over-concentrate the final product, especially when liquids and reactive ingredients such as magnesium or calcium oxides, sulfates or chlorides, commercial fat sources and urea or ammonium salts are included in the formula. The use of 30-40% non-mineral, non-reactive ingredients such as ground corn, wheat midds, distiller's grains, rice hulls etc. will maintain dispersion and separation of reactive ingredients, improve handling characteristics, reduce the likelihood of chemical reactions and help protect the vitamins from oxidative damage. The economic benefits of proper premix formulation with adequate levels of an appropriate carrier far exceeds any "savings" from using zero carrier ("filler") premixes or base mixes.

References:

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