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Effect of metal specific amino acid complexes and inorganic trace minerals on vitamin stability in premixes

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ABSTRACT

Stability of vitamin activity in a swine premix containing metal specific amino acid complexes, inorganic trace minerals, or no trace minerals was evaluated over a 120-day storage period. Two vitamin-trace mineral premixes containing either metal specific amino acid complexes or inorganic trace mineral sources were formulated to contain 200% of NRC (1988) sow requirements for I, Cu, Zn, Mn, Fe, and Se based on a 5 g/kg dietary inclusion rate. A separate vitamin premix containing no trace minerals served as the control. The vitamin premix and the two vitamin-trace mineral premixes were formulated to contain the same level of vitamins. Vitamin levels exceeded NRC (1988) and were chosen to represent "typical" industry levels based on an informal survey of vitamin levels in commercial premixes in the U.S.A. Premixes were stored in an environmentally controlled feed storage room and samples were collected every month to determine vitamin activity. Minimal monthly vitamin stock losses in activity (0–1%) were observed for all vitamins except cyanocobalamin (2.8%) and choline (1.3%). Pantothenate, vitamin E, riboflavin, biotin and niacin were most resistant to destruction, while menadione, retinol, vitamin B-6, and thiamine were subject to the greatest loss of activity during the 120-day storage period. Use of metal specific amino acid complexes in vitamin-trace mineral premixes significantly reduced the loss of retinol, menadione, cyanocobalamin, thiamine, folates, vitamin B-6, and choline activity ($P<0.05$) compared to losses of vitamin activity in premixes containing inorganic trace minerals. Activity losses in retinol, cyanocobalamin, thiamine, and choline were similar between the vitamin premix and the vitamin-complexed trace mineral premix. Biotin activity was undetectable in the vitamin-complexed trace mineral premix due to unexplained analytical interference. Each vitamin was ranked according to relative vitamin assay cost, loss in vitamin activity per month, and susceptibility to multiple stress factors. This ranking was used to identify vitamins that could represent overall vitamin activity in a premix and could be assayed at a reasonable cost for a feed manufacturing quality control program. Retinol was identified as the best indicator vitamin, followed by thiamine, menadione, and cyanocobalamin. These results suggest that vitamin stability in swine vitamin-trace mineral premixes is improved when using metal specific amino acid complexes compared to inorganic trace mineral sources. More liberal safety margins for vitamins may be needed when formulating vitamin-trace mineral premixes using inorganic sources of trace minerals.

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Table 1
Nutrient levels and sources of experimental premixes[a].

Vitamin/mineral	Source	Source density	Vitamin premix, g	Vitamin-inorganic TM premix, g	Vitamin-complex TM premix, g
Retinol	Rovimix A-650	650,000 IU/g	1.37	1.37	1.37
Cholecalciferol	Rovimix AD_3	A 650,000 IU/g D 325,000 IU/g	1.37	1.37	1.37
Vitamin E	Rovimix E	227,000 IU/g	13.12	13.12	13.12
Menadione	Hetrazeen MPB	45.50%	2.94	2.94	2.94
Cyanocobalamin	Vitamin B_{12} 1%	10 mg/kg	0.78	0.78	0.78
Niacin	Niacin, 99%	99.00%	7.83	7.83	7.83
Riboflavin	Ribo 80% SD	80.00%	2.15	2.15	2.15
Thiamine	Rovimix B_1	91.90%	0.39	0.39	0.39
Folates	Folic acid, 80%	80.00%	0.98	0.98	0.98
Pantothenate	Ca pantothenate	97.50%	5.09	5.09	5.09
Vitamin B-6	B_6 HCl FG USP	82.30%	0.78	0.78	0.78
Choline	Choline chloride	60.00%	191.94	191.94	191.94
Biotin	Rovimix H 2%	2.00%	2.94	2.94	2.94
Cu	Copper sulfate	25.20%		8.03	
Fe	Iron sulfate, 31%	30.00%		107.72	
Zn	Zinc oxide	72.00%		27.81	
Mn	Mn sulfate	27.00%		14.89	
Cu	Cu Plex® 100	10.00%			19.98
Fe	METH-IRON®	15.00%			220.93
Zn	ZINPRO® 180	18.00%			111.25
Mn	MANPRO® 160	16.00%			25.07
I	EDD organic I	79.50%		0.07	0.07
Se	Selenium 20-X			15.08	15.08
Carrier	Calcite grits		195.86	23.5	0.2
Carrier	Rice by-product		570.89	569.65	374.17
Antioxidant	Santoquin	66.67%	1.57	1.57	1.57
Total			1000.00	1000.00	1000.00

[a] Designed to be included at 5 g/kg of the complete diet.

1. Introduction

Vitamins and trace minerals are required as co-factors in many metabolic processes necessary for efficient utilization of nutrients in animal diets. Loss of vitamin activity in premixes and complete feeds during storage may account for hidden depressions in growth, feed efficiency, and disease resistance due to subclinical vitamin deficiencies. Unfortunately, many vitamins are relatively unstable compounds which undergo significant deterioration under normal storage conditions (Coelho, 1991).

Individual vitamins have varying degrees of sensitivity to environmental degradation factors. Humidity (moisture), light, heat, pH, pelleting, extruding, and storage time (Scott, 1972; Bauernfeind, 1977; Gadient, 1986; Killeit, 1988; Coelho, 1991) are important factors that affect vitamin stability in premixes. When vitamins are exposed to oxidizing agents such as mineral salts, the ionic charges hasten the rate of vitamin destruction. Adams (1972) found that a multi-vitamin premix containing inorganic trace minerals, when stored at 36.7 °C for three months, lost 55% of its vitamin B-6 activity, compared to a 24% loss by a similar premix containing no trace minerals or choline chloride.

Trace minerals are commonly supplied in swine premixes as highly reactive, inorganic mineral salts. However, several sources of more expensive chelated, amino acid complexed, and encapsulated trace mineral sources are commercially available. These organic trace mineral forms may have the ability to protect vitamins from destructive ionic charges which are associated with inorganic trace minerals.

If organic trace minerals reduce the rate of vitamin destruction, their use may allow for extended "safe" storage periods for premixes, lower formulation safety margins for vitamins due to increased vitamin stability, and/or less potential for reductions in pig performance due to subclinical vitamin deficiencies. The objectives of this study were to determine the rate of vitamin losses in vitamin stock, and vitamin, vitamin-inorganic trace mineral, and vitamin-complexed trace mineral premixes; to compare the effect of metal specific amino acid complexes and inorganic trace minerals on vitamin stability during a 120-day storage period; and to determine key vitamins to assay in feed manufacturing quality control programs.

2. Materials and methods

2.1. Premix formulation and treatments

Two vitamin-trace mineral premixes were formulated to contain 200% of NRC (1988) requirements for I, Cu, Zn, Mn, Fe, and Se for sows. Premixes were designed to be added at a rate of 5 g/kg of the diet (Table 1). These levels were chosen because sow premixes have the highest concentrations of vitamins and trace minerals compared to premixes for growing pigs, and "typical" commercial premixes (BASF, 2000) are often formulated to provide dietary trace mineral levels near