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2014 U.S. Commercial Broiler Vitamin Survey



HEALTH • NUTRITION • MATERIALS

OPTIMUM VITAMIN NUTRITION

Vitamin Fortification is Crucial

Vitamins represent about 1% of feed costs in broiler feeds, yet, take no back seat to ensure optimal growth, feed efficiency and reproductive function. Naturally occurring vitamins in ingredients vary considerably in concentration and bioavailability. Seldom are levels able to meet nutritional requirements.

An array of functions are served by vitamins (Table 1). Water soluble vitamins are cofactors in carbohydrate, fat and protein metabolism, and for the development of the rapidly growing young bird, these vitamins are especially important. While vitamin D and 25-OH vitamin D3 are widely recognized for bone development, vitamins A, C and K are also needed for skeletal structure. Vitamin E improves immunity, and this can translate into lower whole

bird condemnations. Breeder fertility and improved meat quality are also associated with vitamin E, primarily through improved anti-oxidative avenues. Other vitamins, such as biotin, riboflavin and vitamin C function in skin integrity, an important aspect in minimizing cellulitis during growout or skin tears during processing.

Under commercial growout conditions, classical vitamin deficiencies (Table 2) are seldom observed because subtle shortages of vitamins is more the norm. This translates into low target weights, 1-2 point losses in FCR, or egg production or shell quality that lingers slightly below expectations. These losses are seldom distinguishable from poor management and housing, intestinal disruptions and stress-related factors. Vitamin shortages during disease or stress can magnify losses because the bird is less capable of coping with the challenge.

Vitamin Requirements are Dynamic

Broiler growth rates climb 3-4% every year with less feed (Zuidhof et al., 2014). The boost in skeleton and body weight directly impact requirements, and today's rapidly growing broilers respond to increased vitamin supplementation (Jiang et al., 2011) with greater economic returns (Mejia et al., 2013).

Age, rapid growth rates, and high egg production create an environment which prevents vitamin requirements from remaining stationary. This target is further influenced by stress factors that can disrupt absorption and turnover rates, or impede and change priorities for demands.

Defensive Vitamin Strategy is Costly

Defensive vitamin supplementation – a fortification strategy designed to avoid visual symptoms of deficiency – can inadvertently place upper limits on economic returns. While lower levels of vitamin supplemen- tation can restrain live performance, visual signs of deficiency are not apparent (Mejia et al., 2013). The elevation of specific vitamin levels for distinct purposes can improve profitability. And usually, these super-levels fed for only brief periods can achieve intended goals.

Thus, assessment criteria for some vitamins must go beyond body weight gain and FCR. Progressive economic benchmarks include carcass condemnations and breast yield (Mejia et al., 2014; Post et al., 2012). Higher vitamin E lowers inflammatory process while more biotin can increase Grade A footpads, and 25-OH vitamin D3 supplemented over growout correlates with breast meat yield. Fertility and hatchability are widely known to be vulnerable to insufficiencies in folic acid, pantothenic acid and biotin. However, the importance of vitamin Eand other antioxidants such as canthaxanthin is increasingly being recognized for roles in breeder management, fertility rates and embryonic development.

U.S. Commercial Vitamin Supplementation

Various sources of recommendations help decide vitamin supplementation levels used by commercial nutritionists. In a survey that accounted for more than 90% of the U.S. broiler industry, DSM Nutritional Products ascertained the vitamin fortification rates used commercially.

(continued)

Specifics of the Survey

U.S. broiler nutritionists provided vitamin premix fortification rates identified for starter, grower, finisher and withdrawal feeds. Broiler breeder fortification levels corresponded to a lay period from 24 to 65 weeks of age.

For each vitamin, three categories were calculated.

- Hi25: High 25% of industry (average of highest 25% of values)
- AVG: Average industry (overall average)
- •Lo25: Low 25% of industry (average of lowest 25% of values).

All averages are non-weighted means based on pure supplemented vitamin content. Percent coefficients of variation (CV = standard deviation divided by the mean times 100) were calculated to estimate the consistency of vitamin addition rates within feeds. The results do not include vitamin (high vitamin E, for example) supplemented separately from the premix.

Vitamin Supplementation

Broilers. In this survey, complete broiler vitamin premixes ranged between 0.50-2.00 lbs per ton (2,000 lbs) across all feeds. The vitamin premix inclusion rates declined from starter to withdrawal, as reflected in reduced fortification levels of the maturing bird (Table 3).

Vitamin supplementation averaged about 1.6-1.7 times higher in the starter period, as opposed to the withdrawal period (Table 2) when compared across starter, grower, finisher and withdrawal vitamin premixes. With no exceptions, the level of every vitamin declined from the starter period. Generally, across diets, the overall decline in supplementation was 30% going from Hi25 to Lo25 (Table 3). The biggest decline within this category occurred with vitamins D, E and K, and biotin, while vitamin A, niacin, riboflavin and pantothenic acid declined the least. Comparing AVG to Lo25, biotin experienced the greatest decline.

A tendency is present for vitamin levels to be decreased in the late stages of growout. This has been associated with performance losses, because although body reserves of some vitamins exist, a number of



factors affect the extent and reliability of tissue storage. Saving a few cents in vitamin costs can easily cost far more in lost performance.

Overall, commercial levels of several vitamins over the production periods within the Hi25 most nearly replicated Optimal Vitamin Nutrition (OVN) recommended levels (Table 4). The OVN was developed to account for a variety of factors in commercial production that can modify vitamin requirements (ie, lowered intestinal absorption, immunity challenges, etc.). Supplementation rates for the Lo25 were significantly lower than the Hi25 or OVN.

The CV was lowest in the early feeds, but increased in the finisher and withdrawal, indicating a wider disparity in fortification rates as broilers progressed through growout (Table 5). Supplementation rates of riboflavin, pantothenic acid, vitamin A and niacin were less variable, while biotin, vitamin D, E and K varied the most.

Breeders. Breeder fortification levels are summarized in Table 6. In breeders, vitamins serve maintenance and production purposes, and fortify eggs in preparation for embryonic development. Hence, it follows that levels are highest for this group. In fact, AVG breeder vitamin supplementation levels exceeded the AVG for broiler starter, as well as the Hi25% for broiler starter feed.

Overall vitamin variability for breeders was similar to that for broiler starter and broiler grower fortification rates. Vitamin A was least variable (15.8%) in the broiler breeder premix, while vitamin E and K and thiamine were the most variable (40% or more; Table 6) The remaining vitamins were fairly moderate in consistency in fortification rates.





25-OH Vitamin D3 Supplementation

The 25-OH vitamin D3 fortification level was also determined across groups and is expressed in Figure 1. Values were obtained from the same broiler companies that provided vitamin supplementation levels. Recommendations for the HyD® product form historically focused on starter and breeder feeds at 1.0 lb/ton. In recent years, studies find 25-OH vitamin D3 fed over the entire growout increased bird performance and breast yield, thus fortification in the grower and finisher feeds is becoming more commonplace.

Improved absorption and higher potency for metabolic purposes, as well as being the 'storage' form of vitamin D, accounts for 25-OH D3 increasingly becoming a common form of vitamin D supplementation in broiler and breeder feeds.

Conclusion

- Vitamin fortification levels for more than 90% of the U.S. broiler industry were tabulated.
- Values show a wide disparity between the lower and higher levels of vitamins.
- The highest fortification levels occurred in breeder feeds, followed by starter, grower and finisher.
- 25-OH vitamin D3 was highest in starter feeds, followed by breeder feeds, and is becoming more common in grower, finisher and withdrawal feeds.

Figure 1: 2014 US Average Supplementation Rates for 25-OH Vitamin D3 as HyD®







Table 1: Functions of Individual Vitamins

Vitamin	Primary Function
Vitamin A	Vision, reproduction, membranes, bone development, hatchability, ataxia and weakness, ruffled feathers
Vitamin D	Bone development (P, Ca absorption), immune function
Vitamin E	Antioxidant, cell membrane integrity, immune function, reduced platelet aggregation (blood clotting)
Menadione	Blood clotting, bone mineralization
Niacin	Energy production, and carbohydrate, fat and protein metabolism, nerve function
Thiamin	Energy production, and carbohydrate, fat and protein metabolism
Riboflavin	Energy production, and carbohydrate, fat and protein metabolism
Pyridoxine	Energy production, and carbohydrate, fat and protein metabolism
Vitamin B12	Energy metabolism
Pantothenic acid	Carbohydrate, fat and protein metabolism, glucose metabolism
Folic acid	Amino acid and energy metabolism, protein synthesis, immunity
Biotin	Related to methionine, choline and folacin metabolism, and fat and carbohydrate metabolism



Table 2: Deficiency Symptoms of Individual Vitamins							
Vitamin	Primary Deficiency Symptoms with Severe Deficiency						
Vitamin A	Eye lesions, muscle incoordination, lower disease resistance						
Vitamin D	Rickets, cartilage malformation, lameness, poor growth						
Vitamin E	Exudative diathesis, encephalomalacia, edema, reduced hatch						
Vitamin K	Impaired blood coagulation, hemorrhages on breast, legs & abdominal cavity, anemia						
Thiamin	Lack of appetite, neurological disorders, leg weakness, stargazing						
Riboflavin	Lowered growth & feed intake; skin, eye & nerve disorders; impaired walking & vigor						
Niacin	Metabolic skin & digestive organ disorders, weakness, low growth						
Pyridoxine	Dermatitis, poor growth, anemia, poor feathering, nerve disorders						
Pantothenic acid	Nerve and skin disorders, edema and hemorrhages, dermatitis						
Biotin	Footpad dermatitis, nerve disorders, low performance, leg disorders						
Folic acid	Blood disorders, anemic, lethargic, poor feathering, perosis						
Vitamin B12	Anemia, lowered feed intake, efficiency & growth, perosis						



Table 3: 2014 US Broiler Industry Starter, Grower, Finisher and Withdrawal Vitamin Fortification Levels

Vitamin, units/ 1,000 kg feed		Starter			Grower			Finisher		Withdrawal		
	Top 25%	Average	Low 25%	Top 25%	Average	Low 25%	Top 25%	Average	Low 25%	Top 25%	Average	Low 25%
Vitamin A ¹	10.4	8.58	6.70	9.30	7.44	5.12	7.94	5.98	3.63	7.36	5.23	4.15
Vitamin D ¹	5.37	3.69	2.43	4.68	3.08	1.85	3.97	2.56	1.41	3.77	2.34	1.40
Vitamin E ²	62	41	24	43	29	18	38	25	13	32	20	11
Menadione ³	3.38	2.09	1.40	3.04	1.89	1.05	2.71	1.62	0.89	2.40	1.36	0.80
Niacin ³	54	43	32	46	38	23	42	31	20	38	26	19
Thiamin ³	2.73	1.98	1.25	2.26	1.68	0.88	1.89	1.33	0.82	1.64	1.06	0.65
Riboflavin ³	9.72	7.61	5.79	8.20	6.57	4.41	6.80	5.37	3.53	6.05	4.47	3.44
Pyridoxine ³	4.15	2.98	1.91	3.55	2.59	1.62	3.16	2.17	1.21	2.80	1.79	1.13
Vitamin B12 ⁴	21	15	11	19	13	8	17	11	6	13	9	6
Pantothenic acid ³	15	12	9	13	10	7	11	9	6	10	7	5
Folic acid ⁴	1,430	1,030	730	1,240	880	570	1,050	690	420	1,000	630	420
Biotin⁴	195	114	69	160	93	39	142	85	45	108	72	39

¹units= MIU/MT of feed; ²units= TIU/MT of feed; ³units= g/MT of feed; ⁴units= mg/MT of feed



Table 4: 2014 US Broiler Industry Starter, Grower, Finisher, and Withdrawal Vitamin Fortification Levels

Vitamin units/	Starter			Grower		Finisher			Withdrawal				
2,000 lb of feed	Top 25%	Average	Low 25%	Top 25%	Average	Low 25%		Top 25%	Average	Low 25%	Top 25%	Average	Low 25%
Vitamin A ¹	9.46	7.78	6.07	8.44	6.75	4.64		7.20	5.43	3.30	6.68	4.75	3.76
Vitamin D ¹	4.87	3.35	2.20	4.25	2.80	1.68		3.61	2.32	1.28	3.42	2.12	1.27
Vitamin E ²	56	37	22	39	26	16		34	23	12	29	18	10
Menadione ³	3.07	1.90	1.27	2.76	1.71	0.95		2.46	1.47	0.81	2.18	1.23	0.73
Niacin ³	49	39	29	42	34	21		38	28	18	34	24	17
Thiamin ³	2.48	1.80	1.13	2.05	1.52	0.80		1.71	1.21	0.74	1.49	0.96	0.59
Riboflavin ³	8.82	6.90	5.25	7.44	5.96	4.00		6.17	4.87	3.20	5.49	4.06	3.12
Pyridoxine ³	3.76	2.70	1.73	3.22	2.35	1.47		2.87	1.97	1.10	2.54	1.62	1.03
Vitamin B12 ⁴	19	14	10	17	12	7.26		15	9.98	5.44	12	8.16	5.44
Pantothenic acid ³	14	11	8.16	12	9.07	6.35		9.98	8.16	5.44	9.07	6.35	4.54
Folic acid ⁴	1,297	934	662	1,125	798	517		953	626	381	907	572	381
Biotin ^₄	177	103	63	145	84	35		129	77	41	98	65	35

¹units= MIU/2,000 lb of feed; ²units= TIU/2,000 lb of feed; ³units= g/2,000 lb of feed; ⁴units= mg/2,000 lb of feed



Table 5: Comparison of Broiler Industry Vitamin Fortification Rates with Optimal Vitamin Nutrition (OVN)

Vitamin units/		Starter		Grower	Finisher		
1,000 kg feed	Average	OVN	Average	OVN	Average	OVN	
Vitamin A ¹	8.58	11-15	7.44	10-12.5	5.98	10-12.5	
Vitamin D ¹	3.69	3.0-5.0	3.08	3.0-5.0	2.56	3.0-5.0	
Vitamin E ²	41	150-300	29	50-100	25	50-100	
Menadione ³	2.09	3.0-4.5	1.89	3.0-4.0	1.62	3.0-4.0	
Niacin ³	43	60-80	38	60-80	31	60-80	
Thiamin ³	1.98	3.0-4.0	1.68	2.0-3.0	1.33	2.0-3.0	
Riboflavin³	7.61	8.0-10.0	6.57	7.0-9.0	5.37	7.0-9.0	
Pyridoxine ³	2.98	4.0-6.0	2.59	4.0-6.0	2.17	4.0-6.0	
Vitamin B12 ⁴	15	20-40	13	20-30	11	20-30	
Pantothenic acid ³	12	15-20	10	12-18	9	12-18	
Folic acid ⁴	1,030	2,000-2,500	880	2,000-2,500	690	2,000-2,500	
Biotin ⁴	114	200-400	93	200-300	85	200-300	

¹units= MIU/MT of feed; ²units= TIU/MT of feed; ³units= g/MT of feed; ⁴units= mg/MT of feed



Table 6: 2014 Coefficients of Variation (%) for US Vitamin Supplementation Levels of Broilers

Vitamin	Starter	Grower	Finisher	Withdrawal	Average
Vitamin A	19.5	24.5	33.3	31.3	27.2
Vitamin D	32.0	37.5	45.3	42.7	39.4
Vitamin E	36.4	34.8	42.4	46.1	39.4
Menadione	41.4	41.6	51.2	54.7	47.2
Niacin	20.6	25.9	30.9	31.8	27.3
Thiamin	29.2	34.8	35.0	41.5	35.1
Riboflavin	21.3	23.9	26.8	25.1	24.3
Pyridoxine	30.0	30.2	38.2	39.0	34.4
Vitamin B12	32.4	35.3	42.4	34.6	36.2
Pantothenic acid	20.4	22.5	27.3	28.4	24.6
Folic acid	27.1	32.4	47.1	53.2	40.0
Biotin	47.5	51.6	51.5	38.8	47.3
Average	29.8	32.9	39.3	38.9	35.2



Table 7: 2014 US Broiler Breeder Vitamin Levels and Coefficients of Variation

Vitamin, units/ 1,0000 kg of feed	Top 25%	Average	Low 25%	Coefficients of Variation	OVN
Vitamin A ¹	13	11	9.65	15.8	12-15
Vitamin D ¹	6.01	4.05	2.74	34.5	3.0-5.0
Vitamin E ²	102	62	36	45.5	100-150
Menadione ³	4.01	2.66	1.64	39.8	5-7
Niacin ³	59	45	37	22.6	50-60
Thiamin ³	4.44	2.92	1.74	45.7	3-3.5
Riboflavin ³	13.6	10.9	8.48	21.9	12-16
Pyridoxine ³	6.14	4.44	2.97	32.9	4-6
Vitamin B124	32	23	15	30.5	30-40
Pantothenic acid ³	21	17	14	25.9	15-25
Folic acid ⁴	2,360	1,790	1,130	29.9	2,000-4,000
Biotin ⁴	362	254	177	31.9	250-400
Average				31.4	

¹units= MIU/MT of feed; ²units= TIU/MT of feed; ³units= g/MT of feed; ⁴units= mg/MT of feed



Table 8: 2014 US Broiler Breeder Vitamin Levels

Vitamins, units/ 2,000 lb of feed	Top 25%	Average	Low 25%	OVN
Vitamin A ¹	12	10	8.75	11-14
Vitamin D ¹	5.46	3.68	2.48	2.72-4.54
Vitamin E ²	93	56	33	91-136
Menadione ³	3.64	2.41	1.49	4.5-6.4
Niacin ³	54	41	34	45-54
Thiamin ³	4.03	2.65	1.58	2.7-3.2
Riboflavin³	12	9.89	7.69	11-15
Pyridoxine ³	5.57	4.03	2.69	3.6-5.4
Vitamin B124	29	21	14	27-36
Pantothenic acid ³	19	15	13	14-23
Folic acid ⁴	2,141	1,624	1,025	1,814-3,629
Biotin ⁴	328	230	161	227-363

¹units= MIU/2,000 lb of feed; ²units= TIU/2,000 lb of feed; ³units= g/2,000 lb of feed; ⁴units= mg/2,000 lb of feed



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