Safety of Improved Milbond-TX When Fed in Broiler Diets Limiting in Available Phosphorus or Containing Variable Levels of Metabolizable Energy

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Primary Audience: Nutritionists, Researchers, Feed Mill Managers

SUMMARY

Improved Milbond-TX (IMTX), a hydrated sodium calcium aluminosilicate, was added to broiler diets at 0, 1, or 2% in 2 experiments. In experiment 1, three concentrations of available P, 0.22, 0.32, and 0.42%, were combined with the IMTX in isocaloric and isonitrogenous corn-soybean meal-based diets and fed to male broilers for 21 d. In experiment 2, the IMTX was added to isonitrogenous broiler diets calculated to contain 2,940, 3,020, or 3,100 kcal of ME/kg and also fed for 21 d. Deficient dietary P reduced feed intake and BW at 7, 14, and 21 d of age, but IMTX had no effect even when fed at 8 times the amount recommended by the manufacturer (0.25%) to ameliorate the toxic effects of feed mycotoxins. Similarly, increasing the energy level of the diet resulted in improved BW and feed conversion, but IMTX fed at 8 times the amount recommended by the manufacturer had no detrimental effect on chick performance. There was no interaction found between IMTX and energy or available P for any performance measure. Addition of IMTX to the diet above the recommended concentration of the manufacturer also had no detrimental effect on percentage of toe ash or excreta moisture.

Key words: broiler, performance, toe ash, excreta moisture, energy, phosphorus

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DESCRIPTION OF PROBLEM

Previous studies have indicated the advantages of using montmorillonite clay-based hydrated sodium calcium aluminosilicate (**HSCAS**) as a mycotoxin adsorbent when added to the diet at levels up to 1% [1, 2, 3, 4]. Schils [5] described the mechanisms involved in how HSCAS clays are able to bind mycotoxins and also serve as efficient moisture adsorbents. The adsorbent activities of these HSCAS products have raised questions regarding their influence on the utilization of nutrients such as carbohydrates, proteins, vitamins, and minerals [5, 6, 7, 8, 9].

Scheideler [10] and Dwyer et al. [11] reported that data collected from in vitro tests alone can be misleading when testing clay adsorbents in relation to their ability to bind and detoxify mycotoxins, esecially aflatoxin B_1 (**AFB_1**). These authors emphasized that any prediction made from in vitro data concerning the ability of inorganic adsorbents to protect poultry from the detrimental effects of mycotoxins should be approached with caution and should always be confirmed in vivo, paying particular attention to

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Table 1. Typical chemical analysis of Improved Milbond-TX[1]

Compound	Range (%)
SiO_2	54.6 to 65.6
Al_2O_3	14.5 to 19.7
Fe_2O_3	4.05 to 5.02
MgO	0.94 to 2.08
Na_2O	0.54 to 1.37
K_2O	0.60 to 1.19
TiO_2	0.63 to 0.77
CaO	0.64 to 0.97
Loss on ignition (at 1,000°C)	8.5 to 11.9

[1]Osuna [37].

the potential for nutrient interactions that would compromise performance. This would especially be true when clay-based adsorbents are supplemented to the diet of poultry at levels higher than the recommended level of the manufacturer, as would occur during a feed mill mixing error.

Improved Milbond-TX (**IMTX**) [12] is an inert montmorillonite clay-based adsorbent that originates from natural clay deposits mined from the earth. It is normally recommended by the manufacturer for use at a dietary concentration of 0.25% of the diet. The typical chemical analysis of IMTX as furnished by the manufacturer is presented in Table 1. Ledoux et al. [13] tested IMTX to determine its efficacy to ameliorate the toxic effects of AFB_1 present in poultry diets. The IMTX did not negatively affect chick performance, organ weights, or serum chemistry when included at 1% of the diet, and it was reported that IMTX fed at 1% of the diet was effective in preventing the toxic effects of AFB_1 that may be present in diets at levels up to 4 mg/kg of feed. Kubena et al. [14] also reported that an HSCAS fed at 0.5% in a diet containing no mycotoxins did not adversely affect performance of broilers raised to 21 d of age.

Although the USDA and Food and Drug Administration consider clay-based adsorbents, when used as dietary flow agents and carriers, to be generally recognized as safe animal feed additives, all dietary adsorbents should be evaluated for their safety in vivo. The importance of continually evaluating the safety of all dietary mycotoxin enterosorbents in vivo was emphasized and discussed by Pimpukdee et al. [15]. Dale [16] reported that many of the adsorbents on the market have not been adequately tested for in vivo efficacy, and previous data implying their efficacy and safety were based only on in vitro testing. Therefore, it is important that adsorbent supplements be subjected to in vivo evaluation to determine their efficacy, influence on nutrient and energy utilization, and overall safety when fed in animal diets at levels higher than the recommended level of the manufacturer.

Natural and synthetic HSCAS contain Al, which is known to sequester P in the intestinal tract and reduce the bioavailability of available P [17, 18, 19, 20, 21]. Storer and Nelson [22] found that levels of 0.1 to 0.4% Al, as Al_2SO_4, decreased growth, bone ash, and feed efficiency in Single Comb White Leghorn chicks. Due to the nature of IMTX, which contains 14.5 to 19.7% Al_2O_3 by weight (Table 1), it was of interest in this present study to determine its effect on the performance of broiler chicks fed a diet calculated to contain low levels of available P.

Previous studies [23, 24, 25] have indicated that BW and feed efficiency increased as dietary energy increased. Lipids, carbohydrates, and protein make up the sources of energy in the poultry diet. The majority of simple carbohydrates are soluble in water and easily absorbed through the intestinal tract of the monogastric animal. Following the digestive process, the water-soluble products of digestion are absorbed into the mucosal cells of the intestine [26]. Impeding the absorption of these products would not be in the best interest of chick performance. Because of the hydrophilic nature of HSCAS, it would be of interest to determine if any detrimental effects on performance would occur from feeding HSCAS to broilers that were fed diets of varying energy levels.

The objective of these experiments was to feed up to 8 times the recommended amount of IMTX of the manufacturer and determine its safety in the diet of broiler chicks fed diets calculated to contain varying amounts of available P (experiment 1) and varying amounts of energy (experiment 2).

MATERIALS AND METHODS

Bird Management and Treatments

In Experiments 1 and 2, male Ross × Ross broiler chicks (450) [27] were selected from a

Table 2. Composition of the basal diets

	Amount (%)	
Ingredient	Experiment 1	Experiment 2
Ground yellow corn	53.50	53.46
Soybean meal (48.5% CP)	37.15	35.94
Ground limestone	—	1.00
Dicalcium phosphate (22% Ca, 18.5% P)	—	1.80
DL-Met	0.25	0.20
Iodized salt	0.40	0.40
Corn oil	2.50	2.00
Vitamin premix[1]	0.25	0.25
Mineral premix[2]	0.25	0.25
Variables	5.70[3]	4.70[4]

[1]The vitamin premix supplied per kilogram of diet: biotin, 0.2 mg; cholecalciferol, 2,200 IU; choline, 500 mg; ethoxyquin, 65 mg; folic acid, 1 mg; niacin, 60 mg; pantothenic acid, 15 mg; pyridoxine, 5 mg; riboflavin, 5 mg; thiamin, 3 mg; vitamin A, 8,000 IU; vitamin B_{12}, 0.02 mg; vitamin E, 20 IU; and vitamin K, 2 mg.
[2]The mineral premix supplied per kilogram of diet: Cu, 10 mg; ethoxyquin, 65 mg; I, 2 mg; Fe, 60 mg; Mn, 90 mg; Se, 0.2 mg; and Zn, 80 mg.
[3]Variables consisted of dicalcium phosphate, limestone, Improved Milbond-TX, and white builder's sand.
[4]Variables consisted of corn oil, Improved Milbond-TX, and white builder's sand.

larger group of chicks, weighed, and allotted randomly with 5 birds per pen, 10 pens per treatment, in Petersime battery brooders [28]. Each pen contained approximately the same total weight of chicks to eliminate extremes in initial BW variability. Dietary treatments were assigned to pens randomly in a 3 × 3 complete factorial arrangement. In experiment 1, IMTX was added at 0, 1, and 2% to each of 3 corn-soybean meal diets (Table 2) formulated to contain 0.22, 0.32, or 0.42% available P. In experiment 2, IMTX was added at 0, 1, and 2% of the diet to each of 3 corn-soybean meal diets (Table 2) formulated to contain 2,940, 3,020, or 3,100 kcal of ME/kg of diet. All diets were isonitrogenous. In both experiments, the diets were formulated to contain all nutrients recommended by the NRC [29] except those as experimental variables. Feed and tap water were available ad libitum throughout the 21-d experimental period. Mortality was recorded on a daily basis and feed weight adjusted accordingly for calculation of feed conversion. Chicks were managed by methods approved by the University of Florida Institutional Animal Care and Use Committee.

Body weight and feed consumption were determined at 7-d intervals throughout the 21-d experimental period. At the end of experiment 1, the vents of all birds were examined for pasting. All birds were then killed by cervical dislocation, and the middle toe from the right foot of each bird was removed at the tarsometatarsal-P3 joint with the skin intact. The nail was removed and discarded, and the toes were pooled by pen for toe ash analysis. Each set (pen) of toes was dried in an oven for 48 h at 100°C then ashed in a muffle furnace at 550°C for 14 h to determine the toe ash weight.

In experiments 1 and 2, excreta moisture was determined to test the effect of the reversible water retention capabilities of IMTX, because the HSCAS clays are known to be efficient moisture adsorbents. In experiment 1, total excreta were collected from 5 pens each containing 5 birds per pen from each treatment over a 2-d period during the last week of the experiment. In experiment 2, total excreta were collected from 10 pens each containing 5 birds per pen for the 2-d period from the birds fed the lowest and highest dietary energy levels. The excreta were collected on Al trays placed under each pen of 5 birds. Excreta were homogenized following the removal of any feed and feathers that had accumulated on the trays during the collection period. Three subsamples were taken from excreta collected from each pen, weighed in individual Al weigh pans, dried for 48 h at 100°C, and percentage of moisture was determined.

Statistical Analysis

Data were analyzed using the GLM procedure [30]. Main effects of P and IMTX and

Table 3. Effect of available P (AVP) and Improved Milbond-TX (IMTX) on average weekly BW gain, feed consumption, and feed conversion for broiler chicks in experiment 1[1]

		BW gain (g)			Feed consumption (g)			Feed conversion (g/g)		
Item	IMTX (%)	7 d	14 d	21 d	7 d	14 d	21 d	7 d	14 d	21 d
AVP (%)										
0.22	0	82	245	546	103	367	859	1.26	1.50	1.57
0.22	1	87	265	550	109	396	887	1.25	1.49	1.61
0.22	2	82	248	557	107	378	857	1.30	1.52	1.54
0.32	0	89	286	619	118	431	1,004	1.32	1.51	1.62
0.32	1	85	278	602	114	418	946	1.34	1.50	1.57
0.32	2	90	273	616	115	417	968	1.28	1.53	1.57
0.42	0	96	316	681	125	462	1,043	1.30	1.46	1.53
0.42	1	94	314	680	118	449	1,053	1.26	1.43	1.55
0.42	2	94	307	674	120	447	1,022	1.28	1.46	1.52
Pooled SE		0.86	2.69	4.62	1.16	4.03	7.94	0.007	0.008	0.009
		ANOVA								
Source of variation										
AVP		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.01	NS	NS
IMTX		NS[2]	NS	NS	NS	NS	NS	NS	NS	NS
AVP × IMTX		NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Each value represents the mean of 10 pens of 5 chicks.
[2]$P > 0.10$.

Table 4. Effect of available P (AVP) and Improved Milbond-TX (IMTX) on toe ash, excreta moisture, and vent pasting of broiler chicks at 21 d in experiment 1

Item	IMTX (%)	Toe ash[1] (%)	Excreta moisture[2] (%)	Vent pasting[2] (% incidence)
AVP (%)				
0.22	0	12.4	69.8	46.0
0.22	1	12.8	69.0	21.5
0.22	2	12.3	67.8	41.5
0.32	0	13.9	68.6	21.0
0.32	1	13.4	67.3	40.0
0.32	2	13.6	67.7	37.0
0.42	0	13.5	67.8	26.5
0.42	1	14.0	66.1	37.0
0.42	2	14.3	71.2	26.0
Pooled SE		0.109	0.506	2.35
Source of variation			ANOVA	
AVP		<0.0001	NS	NS
IMTX		NS[3]	NS	NS
AVP × IMTX		NS	NS	<0.05

[1]Each value represents the mean of 10 pens of 5 chicks.
[2]Each value represents the mean of 5 pens of 5 chicks.
[3]$P > 0.10$.

their interaction were tested in experiment 1. In experiment 2, the main effects of energy level and IMTX and their interaction were used in the model. Pen was the experimental unit for all analyses. Main effect means were separated by Duncan's multiple range test [30].

RESULTS AND DISCUSSION

Experiment 1

Mortality (data not shown) was less than 2% throughout the experimental period and was not related to treatment. There was a main effect (*P*

Table 5. Effect of ME and Improved Milbond-TX (IMTX) on average weekly BW gain, feed consumption, and feed conversion of broiler chicks in experiment 2[1]

		BW gain (g)			Feed consumption (g)			Feed conversion (g/g)		
Item	IMTX (%)	7 d	14 d	21 d	7 d	14 d	21 d	7 d	14 d	21 d
Energy (kcal of ME/kg)										
2,940	0	82	296	629	122	450	949	1.49	1.52	1.51
2,940	1	82	288	631	124	442	958	1.51	1.53	1.52
2,940	2	84	303	663	122	462	992	1.45	1.52	1.50
3,020	0	83	305	660	122	446	949	1.47	1.46	1.44
3,020	1	89	312	666	127	459	964	1.43	1.47	1.45
3,020	2	84	309	672	126	453	999	1.50	1.48	1.49
3,100	0	90	324	688	124	452	971	1.38	1.40	1.41
3,100	1	82	309	670	116	430	949	1.42	1.39	1.42
3,100	2	85	317	681	121	450	963	1.42	1.42	1.41
Pooled SE		0.96	2.80	5.12	1.05	3.33	5.28	0.008	0.008	0.011
Source of variation						ANOVA				
Energy		NS[2]	<0.05	<0.05	NS	NS	NS	<0.05	<0.0001	<0.01
IMTX		NS	NS	NS	NS	NS	<0.05	NS	NS	NS
Energy × IMTX		NS	NS	NS	NS	NS	NS	NS	NS	NS

[1]Each value represents the mean of 10 pens of 5 chicks.
[2]$P > 0.10$.

Table 6. Effect of ME and Improved Milbond-TX (IMTX) on excreta moisture of broiler chicks in experiment 2[1]

Item	IMTX (%)	Excreta moisture (%)
Energy (kcal of ME/kg)		
2,940	0	61.7
2,940	1	58.9
2,940	2	60.4
3,100	0	66.8
3,100	1	65.3
3,100	2	65.4
Pooled SE		0.430
Source of variation		ANOVA
Energy		<0.0001
IMTX		NS[2]
Energy × IMTX		NS

[1]Each value represents the mean of 10 pens of 5 chicks.
[2]$P > 0.10$.

< 0.0001) of available P on BW at all ages (Table 3), which was in agreement with other published data [7, 31]. Both of the lower concentrations of available P were inadequate for maximal growth regardless of inclusion of IMTX in the diet. The effect of P was linear in nature at the levels tested. Feed consumption was also less ($P <$ 0.0001) in birds fed the 2 lower concentrations of available P (Table 3), with no effect from feeding the elevated concentrations of IMTX. Chung and Baker [7] conducted 2 experiments specifically designed to evaluate the effects of a HSCAS and P utilization of young broiler chicks. These authors reported that feeding up to 1% HSCAS was safe and did not impair utilization of either phytate or inorganic P in the diet. Feed conversion differed significantly ($P <$ 0.01) only at 7 d of age due to the level of available P in the diet, whereas there was no influence due to IMTX. These data are in agreement with those reported by Scheidler [10] in that feeding 1% HSCAS to broiler chicks did not influence BW or feed conversion up to 3 wk of age.

Toe ash was lower ($P < 0.0001$) when available P was deficient in the diet but was unaffected by addition of IMTX at any level (Table 4). Toe ash averaged 12.5, 13.6, and 14.0% for the 0.22, 0.32, and 0.42% available P levels, respectively. These results are consistent with the findings of Chung and Baker [7] and De Groote [32], who observed that increased P in the diet improved toe ash values. Aluminum is known to complex with P in the digestive tract, causing P depletion and increased bone reabsorption [20, 22]. Sorenson et al. [33] and Venugopal and Luckey [34] hypothesized that the mode of action of Al in the digestive tract was brought about by Al salts forming complexes with P and not with other minerals. This hypothesis is supported by the fact that the detrimental effects of Al can be totally reversed by the sole addition of P to the diet [20]. Because IMTX did not affect toe ash, even at the lowest level of available P in the diet, this indicates that the P was available for absorption and bone formation. Therefore, it is unlikely that the Al in IMTX was able to complex with P in the digestive tract, thus making it unavailable to the bird.

There were no differences observed in excreta moisture for any treatment (Table 4). Therefore, it is unlikely that wet litter will be a problem in the field in broiler houses as a result of feeding up to 2% IMTX in the diet of broilers up to 3 wk of age. There was an interaction ($P < 0.05$) of P and IMTX on the percentage of birds showing pasty vents (Table 4). At the lowest concentration of P, fewer birds given 1% IMTX had pasty vents than those given 0 or 2% IMTX. At the greatest amount of available P supplementation, more birds given 1% IMTX had pasty vents than those given 0 or 2% IMTX, and the authors have no explanation for this finding.

Experiment 2

Mortality (data not presented) was less than 1% of the total number of birds and was not related to dietary treatment. Increasing the amount of energy in the diet increased ($P < 0.05$) BW of birds at 14 and 21 d, but there was no influence on growth related to feeding IMTX (Table 5). Increasing energy in the diet also improved feed conversion at 7 ($P < 0.05$), 14 ($P < 0.0001$), and 21 d ($P < 0.01$; Table 5), and IMTX had no effect on feed conversion. Average daily feed consumption at 21 d was greater ($P < 0.05$) in birds given 2% IMTX (985 g) than in those fed 0 (956 g) or 1% (957 g) IMTX. The data in this experiment indicating an increased feed intake, BW, and improved feed conversion to increasing dietary energy levels are in agreement with previous reports in the literature [25, 35, 36].

Increasing dietary energy from 2,940 to 3,100 kcal of ME/kg increased (P < 0.0001) excreta moisture from 60.4 to 65.8% (Table 6). As observed in experiment 1, IMTX did not significantly affect overall percentage moisture in the excreta. However, there was a decreasing trend ($P = 0.13$) in excreta moisture, which averaged 64.2, 62.9, and 62.1% for birds fed 0, 1, and 2% IMTX, respectively.

CONCLUSIONS AND APPLICATIONS

1. Feeding up to 8 times the recommended level of IMTX of the manufacturer, a HSCAS, did not cause any negative effects on feed consumption, BW, feed conversion, toe ash, or excreta moisture of broilers fed diets varying in available P or ME up to 3 wk of age.
2. Based on the data collected in these 2 experiments, if a feed mill mixing error is made and IMTX is supplemented in the diet at up to 8 times the recommended level of the manufacturer from hatch to 3 wk of age, broiler producers should not expect any detrimental effect on chick performance.

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