Natural minerals can

Ultratrace minerals have been recommended for use in commercial broiler chicken feeds based on their observed beneficial productive and/or processing performance effects.

By **DANNY HOOGE***

TODAY, minerals make up roughly half of the 40 or so required nutrients in broiler chicken feeds, and these may be classified as essential major or macrominerals (calcium, phosphorus, potassium, sodium and magnesium) and trace or microminerals according to the dietary level needed.

Essential refers to the element necessary for one or more biological functions (Pérez-Granados and Vaquero, 2002). Historically, individual inorganic or organic compounds have been included in trace mineral or vitamin premixes to provide essential microminerals (manganese, zinc, iron, copper, iodine, selenium, cobalt — usually in the form of vitamin B_{12} — and sometimes molybdenum) to the basal diet.

Nielsen (1985) indicated that between 1970 and 1985, at least 11 elements were added to the list of elements essential in animal nutrition. Those proposed were arsenic, boron, bromine, cadmium, fluorine, lead, lithium, nickel, silicon, tin and vanadium.

Estimated dietary requirements for these elements are usually less than 1 mg/kg (parts per million) and often less than 50 µg/kg of dry diet. They have been designated as the ultratrace minerals.

Chromium has been legally approved in several countries around the world (200-400 parts per billion addition to the diet may be representative) for some animal species and purposes (Qinghua, 1996).

According to Uthus and Seaborn (1996), circumstantial evidence suggests that aluminum, rubidium and germanium are also essential. Tungsten, in the form of tungstate, exhibits a significant antihyperglycemic effect in both type 1 and 2 diabetic animals (Liu et al., 2004).

The lanthanide series of elements (lathanides or Ln^{3+} elements), atomic numbers 57 through 71, are particularly interesting as rare earth deposit elements and are well known in Chinese scientific literature for several beneficial effects in animal production.

In a trial in Germany, He and Rambeck (2000) reported that dietary lanthanum chloride improved average daily gain and feed conversion ratio in pigs, and a mixture of lanthanum, praesodymium and cerium chlorides improved pig performance to a greater extent than lanthanum chloride alone.

Nielsen (1996) suggested that the term ultratrace elements could be applied to at least 20 elements that have established, estimated or suspected requirements or have beneficial, if not essential, actions.

It is highly likely that continued research with the previously mentioned elements and other elements will reveal further requirements and dosages needed for specific positive benefits.

Dietary minerals have been scrutinized with regard to their efficacy for providing essential elements (for example, bioavailability and metabolic utilization), their toxicity and their environmental friendliness.

As a result, more natural rather than synthetic and more organically certified mineral products have come to market and are being welcomed for use in broiler chicken feeds by both producers and consumers of broiler meat products.

This article will review a unique commercial mineral product typically containing detectable concentrations of 75 of the 92 naturally occurring earth elements present in substantial quantities (silicon, aluminum, calcium, potassium, sodium, iron, magnesium, sulfur, phosphorus and manganese) down to intermediate and "trace" levels (e.g., iodine, zinc, copper, molybdenum, chromium, selenium, cobalt, boron, iron, bromine, lithium, nickel, etc.).

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benefit broiler diets

The product is mined from a "hogback" or large mound just east of Yuba Lake, near Levan, Utah. It has been marketed since 1942 first locally and later nationally and internationally (AZOMITE, Peak Minerals-Azomite Inc., Warrensburg, Mo.).

The product name AZOMITE came from an abbreviation of the phrase "A to Z of minerals including trace elements" (Tompkins and Bird, 1998). That requires a little stretch of the imagination, but it is not too far off considering that the product typically contains analyzable concentrations of all known essential elements for plants and animals and 87.5% of the 92 naturally occurring elements on Earth, minus the six gases.

It is said to have been used by Native Americans for fertilizing corn and by white settlers for making poultices for the skin.

Today, it is used on field crops such as rice, on gardens, on orchard trees to increase vigor and yields, on citrus or other trees beginning to go into decline (e.g., due to acid rain or opportunistic diseases and/or parasites) or with blight to remineralize and reinvigorate them, on house plants and on transplanted seedlings of many kinds.

Based on animal feeding trials, beneficial productive and/or processing performance effects have been observed with the dietary supplement for broilers, turkeys, laying hens, pigs, cattle, goats, fish, shrimp and sea cucumbers (worm-like sea creatures).

In vivo and *in vitro* results with the product have indicated mycotoxin binding properties, a well-known characteristic of hydrated aluminosilicate clays (commonly used at 0.50% level in animal diets).

Regular supplementation may offer an advantage when an undetected mycotoxin contamination occurs, when distillers dried grains with solubles of unknown origin are used or when cereal grain crops have been grown in regions that have experienced severe drought or excessive rainfall.

Mineralogically, the natural deposit can be described as "rhyolitic tuff breccia."

It was formed from loose beds of volcanic ash (breccia), brought to the surface and ejected from vents during a volcanic eruption(s), also either bringing up a marine deposit or depositing the volcanic material into an ancient seabed, which all consolidated into a type of rock (tuff) that is relatively easy to mine, mechanically crush and turn into a typically pinkish-beige colored powder.

Tuffs are classified according to the composition of the volcanic rock in them, and rhyolite tuffs contain pumiceous, glassy fragments and small scoriae with quartz, alkali feldspar, biotite, etc.

For regulatory and feed labeling purposes, this product is considered to be a hydrated sodium calcium aluminosilicate (Utah HSCAS), but it does have other minerals and trace elements present.

As an HSCAS, it is approved for use as a feed ingredient due to its listing in the U.S. *Code of Federal Regulations* (21 CRF 582.2729) as an anti-caking agent, and it is generally recognized as safe.

The maximum level of addition is 2% in complete feeds. The product has a specific gravity of about 0.75 (water = 1.00) and bulk density of about 48 lb./cu. ft. of material. Solubility is less than 1% in water. It is listed by the Organic Materials Review Institute and may be used in organic feeds or for organic crop production.

In an unpublished study by a Midwest swine feed producer, a 1% level of Utah HSCAS supplement in pig starter improved the anti-caking and flowability properties of fresh, 28-day stored and high-humidity 28-day stored feed as measured by a reduction in angle of repose (i.e., as measured for cone shape when poured on a flat surface) from 44.0-44.5 to 42.5-43.1.

A major Midwest turkey producer found in an unpublished trial that a 1% level of Utah HSCAS in five-ton batches of turkey feed increased mash temperature before pelleting by 7°F (186 versus 179°F), reduced electrical amps for pelleting by 3.65% (237 versus 246 amps) and improved percent pellets (82.4 versus 78.8%).

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1. Comparison of broiler chicken live performance results using negative control (NegCon; 0%) versus Utah HSCAS (-200 mesh)-supplemented diets in several U.S. feeding trials (1988-2005)

Reference (Gender, M or F/pen x pens/trt; age, days)	Utah HSCAS,% (vs. 0%)	Bodyweight, ----kg---- NegCon	HSCAS	Feed conversion ---ratio--- NegCon	HSCAS	Mortality, ---%--- NegCon	HSCAS
Nockels, 1988	0.5	2.200	2.233	2.495	2.386	6.94	2.87
(37 M/pen x 5; 49 days)	1.5	2.200	2.259	2.495	2.158	6.94	6.74
	3.0	2.200	2.271	2.495	2.267	6.94	5.11
Quarles, 1989	2.0	1.996	2.032	1.997	1.975	6.67	5.17
(60 M/pen x 10; 44 days)							
McDougald, 1989	1.0	1.779	1.775	1.993	1.958	4.88	4.13
(25 M + 25 F/pen x 8;	1.5	1.779	1.800	1.993	1.934	4.88	2.88
46 days)	2.0	1.779	1.838	1.993	1.995	4.88	5.88
Quarles, 1990[a]	1.0	1.999	2.014	1.963	1.929	7.15	5.33
(50 M/pen x 12; 44 days)	2.0	1.999	2.015	1.963	1.936	7.15	5.67
	1;2	1.999	2.002	1.963	1.951	7.15	5.83
Quarles, 1990[b]	1;1;0	2.462	2.480	1.882	1.829	7.04	5.23
(55 M/pen x 8; 48 days)	1;1;0.5	2.462	2.521	1.882	1.851	7.04	8.27
	2;0.5;0	2.462	2.485	1.882	1.833	7.04	5.46
	2;1;0	2.462	2.521	1.882	1.854	7.04	7.13
	2;1;0.5	2.462	2.430	1.882	1.890	7.04	7.79
	2;2;0	2.462	2.504	1.882	1.817	7.04	6.15
	2;2;2	2.462	2.465	1.882	1.858	7.04	5.76
McNaughton, 1993	0.5	2.156	2.190	1.901	1.875	4.55	3.25
(44 M + 44 F/pen x 7; 46 days)							
Quarles, 1994	2;0.5;0	2.498	2.495	1.965	1.947	5.37	5.12
(65 MF/pen x 12; 51 days)	0.5	2.498	2.484	1.965	1.959	5.37	6.02
Moran, 1998	0.5	2.695	2.766	1.815	1.763	3.80	3.80
(25 M/pen x 4; 49 days)							
Moran, 1999	0.5	2.351	2.408	2.085	2.060	21.4	18.4
(25 M/pen or 25 F/pen x 8 each; 49 days; heat)							
Kidd, 2004	0.5	2.613	2.631	1.805	1.792	7.50	7.17
(50 M/pen x 12; 41 days)	0.5/0.25/0	2.613	2.595	1.805	1.806	7.50	5.83
Mathis, 2005	0.3	1.152	1.192	1.633	1.549	40.8	25.0
(8 M/cage x 8; 28 days;	0.5	1.152	1.173	1.633	1.552	40.8	28.1
coccidia, clostridia)							
Paired t-test (n = 26 comparisons)							
Negative control	0	2.188[b]		1.964[a]		9.61[a]	
vs. Utah HCSAS	~1.05 est.		2.215[a]		1.913[b]		7.62[b]
P value			<0.001		0.002		0.014
Difference w/HCSAS			+0.027		-0.051		-1.99
Relative change, %			+1.23		-2.60		-20.7

[a,b]Means within a grouping (mean comparison) by trial and parameter with different letter superscripts differ significantly at P < 0.05.

2. Tibial dyschondroplasia (TD), dry carcass yield and breast yield results for broiler chickens fed negative control or Utah HSCAS-supplemented diets in several U.S litter pen trials (1989-2004)

Reference	Utah HSCAS,% (vs. 0%)	TD,% -(leg disorder)- Control	HSCAS	Dry carcass, % -of live weight- Control	HSCAS	Breast, % of -carcass weight- Control	HSCAS
Quarles, 1989	2.0	2.83	0.67	66.56	66.78	17.22	18.67
(16 M/pen x 10; 44 days)							
Quarles, 1990a	1.0	—	—	65.50	66.03	18.21	19.08
(8 M/pen x 12; 46 days;	2.0	—	—	65.50	65.70	18.21	19.41
80 M/trt. for breast)							
Quarles, 1990b	1;1;0.5	—	—	66.54	67.14	17.89	18.64
(60 M/trt,; 49 days)	2;0.5;0	—	—	66.54	66.89	17.89	18.24
	2;1;1	—	—	66.54	67.15	17.89	18.65
Quarles, 1994	2;0.5;0	—	—	66.42	66.38	18.57[1]	19.21
(6 M/pen x 12; 53 days)	0.5	—	—	66.42	66.62	18.57	19.38
Quarles, 1994	2:0.5:0	—	—	66.59	66.37	19.81[1]	20.39
(6 F/pen x 12; 54 days)	0.5	—	—	66.59	66.35	19.81	20.29
Moran, 1998	0.5	—	—	—	—	19.80[2]	20.40
(~23 M/pen x 4; 49 days)							
Moran, 1999	0.5	—	—	—	—	20.95[2]	20.95
(~20 M or F/pen x 8; 49 days)							
Kidd, 2004	0.5	—	—	70.33	71.14	27.10	27.30
(50 M/pen x 12; 41 days)	0.5;0.25;0	—	—	70.33	70.88	27.10	27.54
						(% of live weight)	
McNaughton, 1993	0.5	—	—	—	—	14.72[3]	14.92
(Sample; 46 d)							
T-test or paired t-test:							
Negative control	0	2.83[a]		66.99[b]		19.58[b]	
vs. Utah HCSAS	2-0.84-0.77 est.[4]		0.67[b]		67.29[a]		20.21[a]
P value			0.022		0.011		<0.001
Difference w/HCSAS			-2.16		+0.30		+0.63
Relative change, %			-67.0		+0.44		+3.22

[a,b]Means within a grouping (mean comparison) by trial and parameter with a different letter superscript do differ significantly at P < 0.05.
[1]Deboned breast meat (fillets), % of dry (hot) carcass weight.
[2]Deboned breast meat (fillets), % of chilled carcass weight.
[3]Deboned breast meat (fillets), % of live weight.
[4]For 1, 12 or 15 comparisons (TD, carcass yield or breast yield), the estimated levels of Utah HSCAS added to diets were 2.0, 0.84 and 0.77%, respectively.

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Broiler chicken trials

From 1989 to 2005, a total of 10 contract research trials sponsored by the manufacturer have been conducted using broiler chickens fed diets with and without supplemental Utah HSCAS. Live performance and processing results are presented in Tables 1 and 2.

Based on 26 comparisons of negative control diets versus Utah HSCAS-supplemented diets (Table 1), significant improvements ($P \leq 0.014$) were observed with the Utah HSCAS supplement in bodyweight (27 g; +1.23%), feed conversion ratio (-0.051; -2.60%) and mortality percentage (-1.99; 20.7%). In these comparisons, the average inclusion rate for the Utah HSCAS over those trials was about 1.05% in supplemented diets.

As shown in Table 2, only one trial examined tibial dyschondroplasia (TD) incidence, but a significant reduction was found (-2.16; -67.0%) with Utah HSCAS supplementation ($P = 0.022$).

There were 12 comparisons evaluating hot carcass yield as a percent of live weight, and the mineral additive significantly increased this parameter (+0.30; +0.44%) compared to negative control treatment results ($P = 0.011$).

In 15 comparisons using negative control diets versus Utah HCSAS-supplemented diets, there was a significant increase in breast yield (+0.63; +3.22%) due to Utah HSCAS ($P < 0.001$). Levels of Utah HSCAS inclusion were 2.0, about 0.84 and about 0.77%, respectively, for the comparisons in Table 2.

Conclusion

Therefore, based on this research summary, Utah HSCAS at 0.5-1.0% (maximum 2.0% allowed as an anti-caking agent) is recommended for use in commercial broiler chicken feeds, with improvements expected in bodyweight, feed conversion ratio, livability, bone structure, carcass yield and breast meat yield.

Utah HSCAS can be added to broiler feeds as an anti-caking agent, and it supplies other mineral elements and may provide mycotoxin binding protection as well.

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