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Local Limestone as a Source of Calcium for Laying Hens on Guam

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Abstract—Guam has abundant limestone which contains an average of 33.75% calcium, comparable to imported commercial limestone. Nevertheless, poultry feeds have relied on imported limestone. In Experiment 1, layers of the commercial "Gold Links" cross were fed diets with 3.8% or 4.5% commercial or local limestone. Experiment 2 was conducted with older layers after the first molt. Treatments consisted of 3 levels of calcium from a local source (4, 4.5, and 5%) and 2 levels of calcium from the commercial source (4%, 5%). Egg production rate, feed efficiency, egg weight, shell thickness, shell weight and shell strength are all as good with local limestone (crushed coral) as with commercial limestone. Crushed coral at a slightly higher inclusion rate (4.5%) significantly improved feed consumption by laying hens as compared to the commercial source, with no apparent signs of toxicity.

Introduction

Despite Guam's vast limestone deposits, none has been used in animal feeds. Even the feed mill on Guam during its years of operation imported ground limestone. Local limestone, referred to as crushed coral, is used for construction purposes only. A typical layer feed contains as much as 10% limestone to provide an average of 4% calcium in the diet of laying hens. Since Guam is almost totally dependant on imported feed, use of local calcium for layer feeds could translate into a considerable reduction in feed cost. In the Marshall Islands roughly 40 percent of the imported layer feed is substituted with local copra meal and crushed coral with satisfactory results (D. Garel, Min. Resource Devel., Majuro, pers. comm.). Research work at the University of Hawaii has shown that crushed coral could replace part or all of the oyster shell in layer diets with satisfactory performance except for egg size in one of their studies (Ross 1974). The bio-availability or possible toxicity of local limestone as an animal feed has not been determined. The present study was undertaken to investigate the suitability of Guam's crushed coral as a source of calcium for laying hens.

Materials and Methods

Two experiments were conducted to evaluate the suitability of feeding crushed coral as a source of calcium for poultry. Representative samples of filler grade, fine powder unwashed for plastering and washing sediment were obtained from Hawaiian Rock Construction Company, Guam. Duplicate samples were analyzed for calcium and other micro elements (Table 1). AOAC procedures outline for Atomic Absorption were followed (Association of Official Agricultural Chemists, 1990). Filler grade, particle size 0.5 mm, was used as the local source of calcium in the experiments.

In Experiment 1, one hundred and twenty eight 56-week old layers of the commercial "Gold Links" cross were randomly assigned to 4 dietary treatment groups of 32 birds each. A treatment consisted of 8 replications of four birds kept in pairs in adjacent standard cages. Treatment consisted of two levels each of commercial and local limestone (3.8%, 4.5%) in a completely randomized design experiment. Diets were isocaloric and isonitrogenous, providing 16% crude protein and 2779 kcal/kg of metabolizable energy. Water was provided *ad libitum*. Egg production was recorded daily. Feed consumption and body weight changes were measured over five consecutive 28-day periods. Egg weight and shell thickness were measured from 3 consecutive collections at the end of each 28-day period. Feed efficiency was computed for each 28-day period.

Prior to conducting Experiment 2, 76-week old hens were forced into molting by withdrawing water for 3 days and feed for 7 days. The hens body weight loss was 25%. In Experiment 2, one hundred twenty layers were selected from the post-molt stock. Hens were randomly allocated to 5 treatments of 6 replicates per treatment with 4 pair-caged layers per replicate. Dietary treatments included two sources of limestone (local and commercial) and 3 levels of calcium (4.0, 4.5, and 5.0%) in a completely randomized design experiment. Egg production was recorded daily. Egg weight, shell weight and shell thickness were measured twice per week. Feed consumption and body weight were measured monthly. Data were collected over a 4 month period.

Dietary treatments for Experiments 1 and 2 are summarized in Table 2. The composition and calculated analyses of experimental diets are shown in Tables 3 and 4. All data were subjected to statistical analysis using the ANOVA procedure of NCSS computer software package. Means were compared using Fisher's New Least Square Difference (LSD) Test (Hentze 1990).

Table 1. Analysis of crushed coral[1].

Source	Ca %	P %	Mg ppm	K ppm	Na ppm	Price $/ton
Imported	33.8	0.02	NA	NA	600	166
Local filler grade	33.7	0.02	1425	50	1171	25
Plastering powder	31.3	0.03	1950	50	1390	25
Washing sediment	28.7	0.02	1575	38	1463	25

[1] Values are mean of duplicate samples.

Table 2. Dietary treatments.

Treatment	Experiment 1	Experiment 2
1	3.8% commercial Ca	4.0% local Ca
2	3.8% local Ca	4.5% local Ca
3	4.5% commercial Ca	5.0% local Ca
4	4.5% local Ca	4.0% commercial Ca
5	—	5.0% commercial Ca

Table 3. Composition of experimental diets.

	Experiment 1*			
Treatments	1	2	3	4
Ingredients:		%		
Yellow corn	58.7	58.7	58.7	58.7
Soybean meal 48% C.P.	16.9	16.9	16.9	16.9
Meat & Bone Meal 59% C.P.	5.0	5.0	5.0	5.0
Fat (A-V blend)	3.0	3.0	3.0	3.0
Biophosphate	0.92	0.92	1.31	1.31
Salt	0.40	0.38	0.40	0.38
Vitamin-Mineral Premix**	0.30	0.30	0.30	0.30
Methionine	0.19	0.19	0.19	0.19
Silica Sand	6.6	5.6	4.6	3.3
Limestone	8.0	9.1	9.6	11.0
Calculated analysis:				
Energy, Kcal of ME per kg	2778	2779	2778	2779
Crude Protein %	16.0	16.0	16.0	16.0
Lysine %	0.79	0.79	0.79	0.79
Methionine %	0.45	0.45	0.45	0.45
Methionine+ Cystine %	0.70	0.70	0.70	0.70
Calcium %	3.8	3.8	4.5	4.5
Available Phosphorus %	0.49	0.49	0.58	0.58

*In Experiment 1 and 2, level of phosphorus was adjusted to maintain same Ca:P ratio when level of calcium was increased. Silica sand was used as a filler.
**Vitamin-Mineral Premix provided the following /kg of diet: 5500 IU vitamin A, 1800 ICU vitamin D_3, 0.75 mg menadione sodium bisulfite, 11 mg vitamin E, 6.6 mg riboflavin, 11 mg ca-pantothenate, 77 mg niacin, 0.22 mg d-biotin, 0.66 mg folacin, 0.011 mg B_{12}, 500 mg choline.Cl, 5 mg copper, 50 mg iron, 50 mg manganese, 50 mg zinc, 1.5 mg iodine, 0.5 mg cobalt and 46 mg calcium.

Results and Discussion

Analytical determinations done in our laboratory indicate that local limestone deposits (coral) on Guam contain 33.7 percent calcium, which is comparable to more expensive imported commercial limestone (Table 1).

Table 4. Composition of experimental diets.

	Experiment 2*				
Treatments	1	2	3	4	5
Ingredients:			%		
Yellow corn	60.3	56.8	53.3	63.1	56.9
Soybean meal 48% C.P.	21.8	22.4	23.1	21.3	22.4
Fat (A-V blend)	4.5	5.8	7.0	3.5	5.7
Biophosphate	1.8	2.0	2.3	1.8	2.3
Salt	0.51	0.51	0.51	0.53	0.53
Vitamin-Mineral Premix**	0.30	0.30	0.30	0.30	0.30
Methionine	0.18	0.19	0.19	0.18	0.19
Limestone	10.7	12.0	13.4	9.4	11.7
Calculated analysis:					
Energy, Kcal of ME per kg	2979	2979	2979	2978	2980
Crude Protein %	16.0	16.0	16.0	16.0	16.0
Lysine %	0.82	0.83	0.84	0.81	0.83
Methionine %	0.45	0.45	0.45	0.45	0.45
Methionine+ Cystine %	0.70	0.70	0.70	0.70	0.70
Calcium %	4.0	4.5	5.0	4.0	5.0
Available Phosphorus %	0.52	0.58	0.64	0.52	0.64

*,** Refer to footnotes on Table 3.

Table 5. Effect of source and varying levels of calcium on the performance of laying hens, Experiment 1[1,2]

Calcium (%)	Feed consumption g/hen/day	Feed efficiency		Hen-day egg production (%)	Egg weight (g)	Shell thickness (mm)
		kg/doz	kg/kg egg			
Crushed Coral						
3.8	121[a]	2.59[a]	3.18[a]	58.7[a]	67.5[a]	29.1[a]
4.5	118[a]	2.24[a]	2.79[a]	63.3[a]	66.9[a]	28.6[a]
Commercial Limestone						
3.8	119[a]	2.29[a]	2.87[a]	64.4[a]	66.4[a]	29.1[a]
4.5	120[a]	2.44[a]	3.07[a]	60.0[a]	66.3[a]	28.4[a]

[a] Means within columns are not significantly different from one another ($P>0.05$) according to Fisher's New LSD Test.
[1] Eight replicate pens containing 4 hens in paired cages received each treatment.
[2] Figures are mean values of five 28-day production periods.

From the results of Experiment 1 (Table 5), it is apparent that feed consumption, feed efficiency, hen-day production, egg weight and shell thickness were not significantly different for the two sources of calcium. In Experiment 2, feed efficiency, body weight changes, egg weight, shell weight, and shell strength were not significantly different with regard to the source and level of calcium (Tables

6, 7). Crushed coral tended to increase feed consumption. This trend was confirmed by further analysis when data of Experiment 2 were pooled and analyzed for main effects of source, level and interaction (Table 8). A significant ($p < 0.03$) effect of source was noted with regard to feed consumption. Feed consumption was significantly ($p < 0.05$) higher for hens receiving crushed coral (Table 9). There may be some beneficial trace elements in the crushed coral that could account for this increase. Further investigation is needed to substantiate this

Table 6. Effect of source and varying levels of calcium on the performance of laying hens, Experiment 2.[1,2]

Calcium (%)	Feed consumption g/hen/day	Feed efficiency kg/doz	Body weight change[3] (%)	Hen-day egg production (%)
Crushed Coral				
4.0	92[ab]	2.38[a]	105[a]	48.7[a]
4.5	84[ab]	2.30[a]	105[a]	44.9[a]
5.0	96[a]	2.45[a]	97[a]	49.6[a]
Limestone				
4.0	81[b]	2.39[a]	97[a]	41.7[a]
5.0	86[ab]	2.56[a]	98[a]	40.0[a]

[a-b] Means within each column with no common superscripts differ significantly ($P < 0.05$) according to Fisher's New LSD Test.
[1] Six replicate pens containing 4 hens in paired cages received each treatment.
[2] Figures are mean values of 4, 28-day periods of post molt production.
[3] Body weight change based on starting weight = 100%.

Table 7. Effect of source and varying levels of calcium on the performance of laying hens, Experiment 2.[1,2]

Calcium (%)	Egg weight (g)	Shell weight (g)	Shell thickness (mm)	Shell strength[3] (g.mm)
Crushed Coral				
4.0	70.3[a]	6.18[a]	0.288[ab]	1.78[a]
4.5	67.8[a]	6.24[a]	0.306[b]	1.91[a]
5.0	67.2[a]	6.04[a]	0.291[ab]	1.76[a]
Commercial Limestone				
4.0	66.6[a]	5.93[a]	0.298[ab]	1.76[a]
5.0	69.2[a]	6.18[a]	0.286[a]	1.76[a]

[a-b] Means within each column with no common superscripts differ significantly ($P < 0.05$) according to Fisher's New LSD Test.
[1] Six replicate pens containing 4 hens in paired cages received each treatment.
[2] Figures are mean values of 4, 28-day periods of post molt production.
[3] Shell strength = shell weight × shell thickness.

Table 8. Significance of calcium source, level and source × level interaction on 4 months post-molt performance, Experiment 2.

Effects	Feed consumption	Feed efficiency	Body weight change	Hen-day egg production
		Probability levels		
Calcium source	0.03*	0.30	0.28	0.15
Calcium level	0.29	0.26	0.32	0.94
Source × level Interaction	1.00	0.31	0.19	0.81

*Significant effect of calcium source on feed consumption ($p<0.05$).

Table 9. Significance of calcium source, level and source × level interaction on 4 months post-molt performance, Experiment 2.

Effects	Feed consumption (g)	Feed efficiency kg feed/doz	Body weight change* (%)	Hen-day egg production %
Calcium Source				
Local	94.4^{a}	2.41^{a}	101^{a}	49.2^{a}
Commercial	83.7^{b}	2.97^{a}	97^{a}	40.8^{a}
Calcium Level				
4%	86.6^{a}	2.38^{a}	101^{a}	45.2^{a}
5%	91.5^{a}	3.00^{a}	97^{a}	44.8^{a}

$^{a-b}$ Means within each column with no common superscripts differ significantly ($p<0.05$) according to Fisher's New LSD Test.
* Body weight change was based on starting weight = 100%.

speculation. From the results of Experiments 1 and 2, it is clear that local crushed coral is as good a source of calcium for poultry as commercial limestone. Since Guam is almost totally dependent on imported feed, substitution of locally competitive feed ingredients could substantially reduce the cost of feed and boost the animal industry.

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