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EVALUATION OF RAW ROCK PHOSPHATE AS SUBSTITUTE FOR BONE MEAL IN DIET OF LAYING HENS

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Target Audience: Animal nutritionists, livestock feed-millers, researchers and students.

ABSTRACT

Experiment was conducted to determine the optimal replacement level of Raw Rock Phosphate (RRP) for bone meal in layers diet. A total of 144, 55 week-old shavers X Hubbard cross-strain laying hens were used for the study. Triplicate groups of 12 hens per replicate were placed on four test diets containing 0, 1, 1.5 and 2% RRP which contributed 0, 350, 525 and 700 mg/kg fluorine (F) in the diets respectively.

Dietary RRP up to 2% had no significant (P>0.05) effects on egg production, feed intake, fed conversion and body weight of birds. Mortality was not related to dietary RRP levels. Egg weight, interior quality and shell quality of eggs were not affected by the different dietary treatments. Birds on 1% RRP diet produced egg shell with lower percent calcium (29.24%) than other group. RRP levels in all the groups did not affect phosphorus contents in egg shell. Hens feed on 2% dietary RRP produced eggs containing up to 0.398 mg/kg F and 0.382 mg/kg F in yolk and albumen respectively compared with control groups (0.307 mg/kg F in the yolk and 0.282 mg/kg F in the albumen). Shell fluorine content increased with increasing levels of RRP in diets.

It was found from this study that 2% RRP could replace 2% of bone meal and support good egg production in laying hens.

Key words: Raw rock phosphate, substitute, bone meal, laying hens.

DESCRIPTION OF PROBLEM

In livestock production, phosphorus is an indispensable mineral element. It is second only to calcium as the most abundant mineral element in animal body. Phosphorus is of major importance as a constituent of bone (about 16.82%), eggshell, and also an essential component of organic compounds involved in almost every aspect of metabolism (1). It has been reported that P in laying hen diets represents the third most expensive nutrient following energy and protein (2).

A continuing concern of the poultry industry in Nigeria is the high incidence

(about 6-12%) of egg losses in laying houses due mainly to poor egg shell quality. Often, these losses are enhanced by increasing age and hot environmental temperatures because Ca and P homeostasis are key factors in eggshell formation and vitamin D is a major control point for calcification (3). It was observed that a good percentage of eggs produced annually suffer low grading mainly because the shell is cracked. Some of the cracks are due to the shell being poorly formed if P and Ca are deficient, resulting in the shell incapable of withstanding even a weak impact or stress.

Supply of dietary bone meal in Nigeria has not only become scarce, but prices have become prohibitively high, price change has gone up from N800.00 per metric tone in 1999 to N8, 000.00 per metric tone, an average rise of about 900% (4). Thus the need to explore alternatives to bone meal in livestock production.

Raw rock phosphate (RRP) contains inorganic P and Ca in amounts similar to bone meal. However, the fluorine content of all calcium phosphate supplements must be considered, when using them because high levels of fluorine especially in rock phosphate in diets are detrimental to the well being of animals (5). Literature on raw rock phosphate as source of inorganic phosphate in layers diet is scanty. Said *et al*(6) tudied graded levels of containing 0, 216, 432 and 468 mg/kg fluorine in layers diets and noted that egg weight interior quality of the eggs, shell quality, fertility and hatchability were not affected by the different levels of dietary fluorine. Hens receiving raw rock phosphate produced eggs containing up to 0.48 and 0.66 mg/kg fluorine in the albumen and yolk respectively compared with control groups containing 0.23 mg/kg in albumen and 0.27-mg/kg fluorine in the yolk (7) in another study observed that egg quality and rate of production were not reduced by fluorine dietary treatments. Deposits of rock phosphate have been found in different parts of Nigeria, like Abeokuta in South West in the Dahomeyan basin (8) has reported occurrences of rock phosphate in Sokoto in the Illumedan basin. This discovery of rock phosphate in parts of Nigeria coupled with high cost of bone meal have given the drive for this investigation which was aimed at reassessing the use of high fluorine raw diets phosphate in laying hen diets.

MATERIALS AND METHODS

Chemical analysis of RRP and the bone meal (Table 1) was done at the Single Super Phosphate (SSP) fertilizer manufacturing company laboratory in Kaduna, using the Nigeria Federal Ministry of Industries fertilizer factory standard of analysis was used for determining fluoride in SSP (Volumetric Method – Thorium Nitrate).

Table 1: Analysis of Raw Rock Phosphate (RRP) and Ashed bone meal

Minerals	RRP (%)	Ashed bone meal (%)
Ca 0	52.75	-
Ca	37.7	35.94
P_2O_5	315	-
P	15.80	16.82
F	3.65	0.362
$Fe_2 0_3$	1.20	-
$Al_2 0_3$	0.89	-
Mg	0.25	0.50
SO_3	0.64	-
Si^0_2	2.34	-
Zn	-	-
Mn	-	0.047

A total of 144, 55-week-old shavers X Hubbard cross strain laying hens were used in this study. Triplicate groups of 12 hens perreplicate were randomly placed on four diets such that group average weights at the start of experiment were similar.

Composition of the experimental diets is as shown in Table 2 RRP replaced bone meal at 0 (control) , 1, 1.5 and 2% of the diets. The RRP contributed 0, 350, 525 and 700 mg/kg F respectively in the diets.

Laying hens were accommodated in two-tier wire battery cages located in tropical-type open sided poultry house. Diets and fresh clean water were provided ad libitum. Egg production was recorded daily; percent hen-day egg production and feed consumption were calculated every 28 days. Feed conversion efficiency was calculated and expressed in kg of feed consumed per dozen of eggs produced. Eggs from two consecutive days for every 28 days were collected from each lot for weight determination. The parameters measured included rate of egg production, egg weight, feed consumption, incidence of cracked or broken eggs and mortality. Data collection lasted for three months; at the end of the experiment three eggs per replicate were selected for haugh unit scores, egg shell thickness and chemical analysis on the eggs.

Data obtained from this experiment were subjected to analysis of variance and the least significant difference (LSD) test (9) to separate the means.

RESULTS AND DISCUSSION

Chemical composition of RRP as presented in Table 1 indicated that it contained 37.7% Ca, 15.8% P and 3.65% F. Data on the performance of

laying hens are shown in Table 3. Feed consumption and conversion were not significantly (P>0.05) affected by RRP in diets up to 2% (700 mg/kg F). In the earlier report (12) inclusion of 500 mg/kg F, as sodium fluoride did not significantly depress feed efficiency. Also, (6) noticed no adverse significant (P>0.05) effect on feed consumption and conversion by dietary

Table 2: Composition (%) of the Experimental diets.

Ingredients	Diets			
	1	2	3	4
Yellow maize	50.65	50.65	50.65	50.65
Wheat bran	10.00	10.00	10.00	10.00
Cotton seed meal	12.00	12.00	12.00	12.00
Soybean cake	7.50	7.50	7.50	7.50
Groundnut cake	8.50	8.50	8.50	8.50
Limestone	7.50	7.50	7.50	7.50
Bone meal	3.00	2.00	1.50	1.00
Raw rock phosphate (RRP)	-	1.00	1.50	2.00
Salt	0.35	0.35	0.35	0.35
Vitamin/TM Premix[1]	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Crude protein (%)	17.25	17.25	17.25	17.25
ME (Kcal/kg)	2456.95	2456.95	2456.95	2456.95
Crude fibre(%)	5.88	5.88	5.88	5.88
Calcium %	3.94	3.98	4.00	4.05
Phosphorus (%)	0.63	0.63	0.63	0.63
Fluorine (mg/kg)	-	350	525	700
Lysine (%)	0.84	0.84	0.84	0.84
Methionine[3] + Cystine	0.62	0.62	0.62	0.62

1Composition of premix: Vitamin and trace mineral for layers (Roche Nig.) Ltd. Supplied the following per kg of diet: Vit. A 0(stabilized) 6,670.000I.U., Vit. D_3 (stabilized) 1,340,000I.U., Vit E 6,670I.U., Menadione sodium sulphite (Vit. K. Stabilized) 134mg, Vit B_2 3,000mg, Vit. B_6 2,000mg, nicotinic acid 6,670mg, calcium d-pantothenate 5340mg, B12 8mg, Vit. C 13,3400mg, zinc 26,670mg, Copper 1,600mg, Iodine 934mg, Cobalt 134mg, Selenium 34mg.

RRP. Final body weight was unaffected by RRP levels in diets up to 2%. This tends to support suggestion that laying hens could tolerate fluorine levels as high as 700 mg/kg from RRP in diets. Hens on 2% RRP (700 mg/kg F) showed slightly higher, but not significant, percent hen – day value (67.17%) compared with control group (66.69%). This result tends to

Table 3: Performance of laying hens as influenced by dietary treatments

RRP added (g/100)	Feed consumption (g/hen/da)	Feed Conversion Kg/dozen eggs	Egg production (% hen-day)	Initial Body weight (g)	Body Weight gain (g)	Final Body weight (g)	Mortality (%)
0	120.2	2.18	65.7	1,823	396	2,219	-
1(350mg/kg)	122.4	2.27	65.1	1,945	361	2,306	5.56
1.5(525mg/kg F)	121.4	2.28	64.3	1,836	377	2,213	-
2(700mg/kg F)	120.8	2.24	67.2	1,972	350	2,322	2.8
SEM[1]	2.28	0.050	1.80	62.2	12.10	74	-

ISEM: Sandard Error of Means

suggest that laying hens can tolerate fluorine levels up to 700 mg/kg from RRP with no adverse effect on egg production. The observation is in line with (10) who reported that feeding 700 mg/kg F and 530 mg/kg (11) as raw rock phosphate had no observable effect upon the number of eggs laid. Also (12) noted that dietary fluorine as sodium fluoride up to 500 mg/kg F significantly increased egg production.

Mortality records were not related to dietary RRP levels, since birds on 1% RRP had highest mortality value (5.6%) while the group on 1.5% recorded no mortality.

Egg Quality Measurements

Data on egg weight; egg cracks, shell thickness, percent eggshell and Haugh unit score are presented in Table 4. Dietary RRP levels up to 2% (700mg\kg F) had no significant (P>0.05) effect on egg weight. Periods of dietary treatment also had no influence on egg weight, when test diets were compared to control group. The observation is in accordance with (6) who noted that dietary RRP had no significant effect on egg weight. Also, (11,13) reported no negative effect on egg size with the feeding of fluorine from RRP or sodium fluoride. However, (12) noted significant (P<0.05) increase in egg weight by addition of 500mg/kg F in diet.

Table 4: Egg quality measurement

RRP added (g/100)	Egg Weight g	Cracked/ Broken eggs (%)	Shell thickness (mm)	Percent egg Shell (%)	Haugh Unit
0	63.4	1.25	0.37	10.2	78.42[a]
1(350mg/kg)	64.19	1.11	0.39	10.55	73.25[b]
1.5(525mg/kg F)	64.56	1.13	0.38	10.19	74.43[b]
2(700mg/kgF)	64.74	1.16	0.37	9.90	76.58[ab]
SEM[1]	0.71	0.22	0.02	0.52	0.95

[ab] meansin the same column with the same superscripts are not significantly different (P<0.05)

SEM[1]: Standard Error of Means

Results of thickness and percent cracked eggs were not different from what was obtained for the control group. This is an indication that dietary fluorine levels from RRP up to 700mg/kg had no ill effect on egg shell thickness and egg shell cracks. Percent egg shell was also unaffected by dietary treatments in all the groups when compared with control group.

Interior quality of eggs as measured by Haugh unit score method reference showed that hens on control diet had significantly (P<0.05) superior Haugh Unit score, but not significantly (P>0.05) different from the group on 2%

RRP (700mg/kg F) diet. There was no significant difference among the groups on 1 and 1.5% RRP diets. The lower values of Haugh Unit score noticed in the groups on 1 and 1.5% RRP might not be attributed to effects of fluorine contents of the diets (350 and 525 mg/kg F respectively) because hens on 2% RRP (700mg/kg F) scored haugh Unit value that was not significantly different from control groups. However, (6) noticed no significant difference in haugh unit score among hens fed RRP levels in diets when compared with control groups.

Egg Shell Chemical Contents

Results on egg shell chemical analysis are shown in Table 5. Shell ash of eggs produced hens on 1% RRP and the control diets were lower than the shell ash of eggs produced by hens on1.5% and 2% RRP diets. Percentage calcium in shell of eggs produced by hens on 1% RRP diet significantly ($P<0.05$) had the least value (29.24%) compared with other groups. This lower calcium percentage from group on 1% RRP could be related to the lowest percent shell ash of eggs produced by hens on same diet (1% RRP). No reports of any effect of RRP on shell ash were found in the literature.

Table 5: Eggshell chemical contents

RRP added (g/100)	Shell dry matter (%)	Shell ash (%)	Ca in shell (%)	P in shell (%)
0 91.2	89.8b	34.39a	14.33	
1(350mg/kg)	91.8	84.1b	29.24b	14.13
1.5(525mg/kg F)	94.5	94.4a	37.95a	13.07
2(700mg/kg F)	91.8	92.3a	34.68a	15.55
SEM[1]	2.1	2.8	1.25	2.25

[ab] means in the same column with the same superscripts are not significantly different ($P<0.05$) ($P>0.05$)

1SEM: Standard Error of Means

Phosphorus in shell of eggs was not significantly ($P>0.5$) affected by dietary by RRP levels up to 2% (700ppm F). However, hens on 2% RRP diet produced eggs with highest phosphorus in shell of 15.55% as compared to other groups. This seems to suggests comparable availability of inorganic phosphorus in RRP and bone meal.

Flourine content of egg components

Results of egg yolk, albumen and shell fluorine contents are presented in Table 6. Fluorine content of yolk was higher on RRP diets compared with the control. However, values obtained for yolk fluorine content in eggs produced by birds on RRP diets were not different from one another.

Albumen fluorine content increased with increasing levels of RRP in the diets. Eggs produced by hens fed 2% RRP diet (700mg/kg F) contained the highest albumen fluorine content 0.382mg/kg. The result from this study indicates that, fluorine levels from RRP had increasing effect on yolk and albumen fluorine contents. This is in agreement with the report (6).

Table 6: Fluorine content of egg components as influenced by dietary treatments (mg/kg)

Egg Components	0	1(350mg/ kg F)	1.5(525mg/ kg F)	2(700mg/ kg F)	SEM[1] kg F)
Yolk	0.31[b]	0.38[a]	0.38[a]	0.39[a]	1.46
Albumen	0.28[b]	0.33[ab]	0.34[ab]	0.38[a]	0.08
Shell	33.38[d]	130.01[c]	145.25[b]	158.03[a]	3.02

[ab] means in the same column with the same superscripts are not significantly different (P>0.05)
1SEM: Standard Error of Means.

Egg shell fluorine content significantly (P<0.05) increased with higher levels RRP in the diet. The highest value of 158.03mg/kg F was recorded in the group fed on 700mg/kg F in the diet (6) have reported that dietary fluorine from increased the fluorine content of shell about four fold. In this study, about 99.5% of fluorine in the entire egg was located in the shell. The remaining 0.5% was distributed between yolk and albumen. This observation suggested that high fluorine RRP diets up to 2% (700mg/kg F) for laying hens pose no threat to human health relative to consumption of eggs, since egg shell is not normally consumed humans. Also this study showed that egg shell is an excretory channel for fluorine in laying hens.

CONCLUSION AND APPLICATION

1. Results from this study indicate that dietary RRP levels up to 2% (700mg/kg F) did not depress egg production during a 12 week feeding period, rather it increased egg production slightly though not at significant level.
2. Feed intake, feed efficiency and body weight of hens were not affected by dietary RRP up to 2% level.
3. Egg weight, interior quality of eggs and shell quality were unaffected by dietary RRP levels.
4. Calcium content of eggshell was significantly depressed in the group fed on 1% RRP in the diet.
5. Phosphorus levels of egg shell were however, unaffected in all the groups. Fluorine contents of egg yolk were significantly higher in the hens fed RRP diets compared with control.

6. Albumen fluorine content was not affected by dietary RRP levels up to 1.5% (525mg/kg F).
7. Increasing levels of added RRP in diets significantly raised fluorine in egg shell.
8. From this work 2% RRP can replace 2% bone meal resulting in good egg production. This level is 66% replacement of bone meal for laying hens.
9. Fluorine from RRP up to 700mg/kg can be tolerated by laying birds, while egg production was optimal when 2% RRP was added to diets.

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