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ORIGINAL RESEARCH ARTICLE

Effect of Heat-Treated Rock Phosphate Diets on Growth, Post Parturition Performances and Reproductive Efficiency of Rabbits

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ABSTRACT

Phosphorus and calcium are essential for controlling skeletal growth and metabolic processes in rabbits. Due to the potential zoonotic implications of Bone Meal (BM), its use as a calcium-phosphorus source in rabbit diets has decreased. An alternative to BM could be Rock Phosphate (RP), a naturally occurring mineral rich in calcium and phosphorus, however RP contains fluoride which is a potent toxicant at high levels of exposure. This study was therefore designed to leverage the volatility of fluoride at relatively high temperatures a safe alternative to BM for rabbits. Eleven-week-old does (n=25, average weight= 1744 ± 29.64 g) were randomly allotted to five diets with heat treated rock phosphate (HTRP) replacement for BM at 0, 25, 50, 75 and 100% for 31 weeks (r=5) in a CRD. Average Daily Feed Intake-ADFI (g), Litter Size at Birth-LSB (g), Litter Weight at 3 Weeks-LW3W (g) and Total Milk Yield-TMY (g) were recorded. Data were subjected to descriptive statistics and analysis of variance, using SAS 9.4 (2023). Means were separated using Tukey's HSD at $\alpha_{0.05.}$ The ADFI of 145.23±12.75 in rabbit does fed 100% HTRP was comparable with the control diet (151.74±12.87), but differed from 50% HTRP (104.46±61.43 g). The LSB of 4.60±1.14 g observed in rabbits fed 100%BM diet was significantly higher than 3.00±1.00 g (in 25%HTRP and 50%HTRP). The LW3W of 321.71±28.24 observed for 100% HTRP was comparable to control (336.13±28.50), while TMY of 1016.60±89.25 at 100% HTRP was similar to control group (1062.17±90.03) and better than other treatments. It was therefore concluded that replacement of bone meal with heat treated rock phosphate up to 100% did not affect growth, post-parturition performances and reproductive efficiency of rabbits.

Keywords: Heat-treated rock phosphate, performance, reproductive efficiency, rabbit does

INRODUCTION

The two essential elements included in animal feed formulations are calcium and phosphorus, which are crucial for controlling metabolic processes and skeletal growth in animals. The use of bone meal (BM) as calcium-phosphorus source for livestock diets has declined due to possible spread of zoonotic diseases, particularly, mad cow disease or bovine spongiform encephalopathy (Tion *et al*., 2012). Animal bones are also used to make a number of products, including glue, gelatin, ossein, dinner's foot, dicalcium phosphate, fertilizer, and ceramics thereby causing scarcity of BM (Agbu *et al*., 2017).

Rock Phosphate (RP), a naturally occurring calcium-phosphorus rich resource with high fluoride content holds promise as an alternative for BM. There is an abundance of rock phosphate deposit in various West African nations, particularly in Togo, Senegal, the Benin Republic, and Nigeria, with commercial quantities of the mineral present in Imo, Ogun and Sokoto states (Agedeson *et al*., 2021). However, its use is restricted due to its high fluoride content. Heat treatment is a method for lowering the fluoride content in raw rock phosphate. Heat-treated rock phosphate also known as defluorinated or soft rock phosphate, has fluoride contents that are significantly lower than those of raw rock phosphate (RRP) (Agbu *et al*., 2017). Therefore, the volatility of fluoride at high temperature informed the evaluation of Heat-Treated RP (HTRP) as replacement for BM in rabbit diets (Thomas *et al*., 2007). According to (Ramteke *et al*., 2018), heat-treated rock phosphate has almost the same levels of calcium and phosphorus as bone meal, which has 17% phosphorus and 34% calcium. Rock phosphate usage may improve the bioavailability of calcium and phosphorus in rabbit diets.

Rabbits, *Oryctolagus cuniculus* are classified as pseudo-ruminants because they occupy a niche between ruminants and monogastrics. As medium-sized, hopping animals with big ears and short tails, rabbits are known to adapt quickly to backyard rearing techniques. They are also known to efficiently convert feed into meat (Agedeson *et al*., 2021). Olaleru and Abu (2022) assert that the productivity and adaptability of modern rabbit breeds to tropical environments increase the likelihood of supplying Nigerians' protein needs. However, Kpodekon *et al*. (2006) reported that reproductive performance of does in litter size corresponds to a relative decrease in the weight of doe kits with time. As a result, rabbit kits make up for growth deficiencies brought on by variations in milk quality and quantity. Kpodekon *et al*. (2006) state that the first and fifth weeks of the doe rabbits' postpartum cycle are particularly important since high mortality was observed during that time, which is crucial for the survival of the pre-weaning kits. The difficulty facing rabbit producers is the rising issues of diseases from feed materials; despite the industry's remarkable expansion, the majority of farms operate at extremely low efficiency levels. The main causes of these are the low-quality feed materials and inadequate management of rabbits. To assess the nutritional values of rock phosphate and its metabolic fate in rabbits, this study tests the hypothesis that diets with HTRP could provide bioavailable calcium and phosphorus for good growth performance of kits of rabbit does, reproductive efficiency and post parturition performance and that it could be a safer and alternative calcium and phosphorus source.

MATERIALS AND METHODS

Experimental Site

The study was conducted at the Rabbitry Unit of the University of Ibadan Teaching and Research Farm, located on the Oyo State GPS at latitude 7.27 °N and longitude 3.54 °S.

Collection of Phosphate Rocks

Rock phosphate ore was obtained between Latitude 6.82 ^{0}N and Longitude 3.23 ^{0}E of Ifo in Ogun State Nigeria Adesanwo et al. (2010).

Methods of Rock Phosphate Processing

The ore was extracted, the slurry sent to a flotation plant, its particles were washed and dried, then milled (Agbu et al., 2017). The rock phosphate used in this study was further ground and sieved through a 200 µm sieve. 1000 g of the raw rock phosphate samples were heated for five hours at varying temperature rates of 10 °C/min up to 600 °C and until the colour changed from brownish grey to reddish brown (Fayiga and Obigbesan, 2017). Using inorganic geochemical x-ray fluorescence spectrophotometry, calcium and phosphorus were analysed.

Experimental Design and Layout

In a completely randomised design, a total of twenty five does (5 per treatment) were used, with average initial weight of 1744 ± 29.64 g at age of (12 weeks) and servicing for the first time at the age of six months through natural mating. The duration of the study was fifty-six (56) days for the reproductive circle. The composition of the five diets used in the experiment is presented in Table 1.

Statistical analysis:

Experimental design was Complete Randomised Design. Data were subjected to ANOVA using SAS (9.4 version) 2020. Means were separated using Tukey's HSD at $\alpha_{0.05.}$

Table 1 Gross Compositions (%) of Diets Containing Heat Treated Rock Phosphate for Rabbit Does

Ingredients	Percentage Replacement of Bone Meal				
	0 %	25 %	50 %	75 %	100 %
Maize	21.00	21.00	21.00	21.00	21.00
Soybean Meal	20.00	20.00	20.00	20.00	20.00
Corn bran	28.00	28.00	28.00	28.00	28.00
PKC	12.10	12.10	12.10	12.10	12.10
Rice Offal	15.00	15.00	15.00	15.00	15.00
Heated Phosphate Rock	0.00	0.75	1.50	2.25	3.00
Bone Meal	3.00	2.25	1.50	0.75	0.00
Methionine	0.30	0.30	0.30	0.30	0.30
Micro Grower mix	0.30	0.30	0.30	0.30	0.30
Industrial Salt	0.30	0.30	0.30	0.30	0.30
Calculated Nutrients					
M.E (kcal/kg)	2412.17	2412.17	2412.17	2412.17	2412.17
Crude Protein	16.92	16.92	16.92	16.92	16.92
Crude fibre	11.25	11.25	11.25	11.25	11.25
Fat	6.60	6.60	6.60	6.60	6.60
Calcium	1.03	0.05	0.15	0.23	0.30
Phosphorus	0.51	0.08	0.46	0.70	0.93

Micro-Mix Growers, Vitamin and Trace Minerals Supplied the following additional Micro and Macro nutrient Premix: Niacin 45,000.00 mg, Vitamin A, 10,000,000.00 I.U, Iron 120,000.00 mg, Cobalt 300,00 mg, D3 2,000,000.00 I.U, E, 20,000.00 mg, Vitamin B1 3,000.00 mg, B2 5,000.00 mg, Anti-oxidant 120,000.00 mg, Vitamin B6 4,000.00 mg, Vitamin B12 20.00 mg, Folic acid I,000.00 mg, Biotin 50.00 mg, Manganese 300,000.00 mg, Vitamin K3 mg, Copper 8,500.00 mg, Iodine 1,500.00 mg, Selenium 120.00 mg, Zinc 80,000.00 mg, Chlorine chloride 300,000.00 mg Calcium Pantothenate 10,000.00 mg and M.E – Metabolisable Energy (kcal/kg).

Table 2: Reproductive performance of rabbit does fed varied levels of Heat-treated rock phosphate in diets

Parameters	0%	25%	50%	75%	100%	SEM	P-value
Litter size at birth	4.60[a]	3.00[b]	3.00[b]	4.80[a]	3.80[ab]	0.243	0.025
Litter size at 3 weeks	2.40	1.80	2.40	2.20	2.20	0.231	0.938
Litter size at 6 weeks weaning	2.00	0.80	1.20	1.40	0-80	0.240	0.567
Litter weight at birth (g)	45.16	45.93	45.73	41.51	37.31	1.392	0.224
Litter weight at 3 weeks (g)	336.1[a]	293.8[ab]	238.1[a]	289.3[ab]	321.7[a]	10.40	0.015
Litter weight at 6 weeks (g)	567.9	534.7	492.9	539.9	538.2	10.25	0.266
Average daily weight gain (g)	87.11	82.44	74.67	82.92	83.48	1.712	0.269
Survival rate (%)	43.33	54.17	58.33	34.17	18.67	6.414	0.340

[ab] Significant differences exist between means on the same row (P<0.05).

Statistical analysis:
Experimental design was Complete Randomised Design. Data were subjected to ANOVA using SAS (9.4 version) 2020. Means were separated using Tukey's HSD at $\alpha_{0.05}$

RESULTS AND DISCUSSION
Chemical analysis of the BM, RRP and HTRP used in this study revealed calcium contents of 34.45%, 17.16% and 17.11% and proportions of phosphorus as 16.88%, 30.95% and 31.62%. The fluoride content of BM was 0.34% and RRP was 6.30% while HTRP was 0.09%, respectively. Results of calcium, phosphorus and fluoride content of bone meal from this research were similar to reports of Agbu et al. (2017). However, calcium in RRP and HTRP in the current study was lower than reported by the same author. Nevertheless, phosphorus and fluoride contents were significantly (P<0.05) higher compared to the report of Agbu et al. (2017). This could be attributed to different sources from geographical locations. The calcium and phosphorus analyses from this study agreed with the report of Fayiga and Obigbesan (2017). The growth performance of rabbit kits from does offered varying levels of dietary Heat-treated rock phosphate is presented in Table 2. Remarkably, a rise in litter size corresponds to a relative decrease in the weight of doe kits with time. As a result, rabbit kits make up for growth deficiencies brought on by variations in milk quality and quantity. The growth performance of kits of rabbit does fed supplementary HTRP diets are notable with the exception of litter size at birth and litter weight at 3 weeks, all parameters tested for the growth performance of rabbit kits offered supplemental HTRP diet showed no significant differences (P>0.05). The litter weight at 3 weeks of rabbit does fed 100% HTRP 321.71 g was comparable to control (336.13 g). Litter size at birth of rabbit does fed 75 and 100% HTRP (4.80 and 3.80 g) were statistically similar to that of control diet 4.60 g. However, 25 and 50% HTRP of litter size at birth (3.00 g) differed significantly (P<0.05) with control dietary treatment. This could be due to weak kits which were concerned about this as a disadvantage in the competition for space in the large litter, resulting from the influence of the state of the animal. The significant difference (P<0.05) may also be due to the largest kits that frequently take up the central position in the nest box, giving them more heat comfort than the other kits.
The reproductive efficiency of rabbit does fed heat treated rock phosphate is shown in Table 3. All the parameters measured with the exception of the average daily feed intake, had no significant impact (P>0.05) of HTRP levels in the diets. The average daily feed intake of rabbit does fed 100% HTRP 145.23 g was comparable with the control group 151.74 g.

Table 3: Reproductive efficiency of rabbit does fed varied levels of Heat-treated rock phosphate in diets

Parameters	0%	25%	50%	75%	100%	SEM	P-value
Initial weight (g)	1724.98	1736.60	1671.54	1774.58	1815.64	55.08	0.953
Body weight at service (g)	2270.78	2298.50	2085.50	2264.36	2291.28	766.33	0.439
Wt of doe at parturition (g)	2497.72	2550.92	2540.44	2530.38	2646.32	38.18	0.994
ADFI (g)	151.74[a]	132.63[ab]	104.46[b]	130.58[ab]	145.23[a]	4.69	0.015
Mean wt gain/week (g)	5.52	4.86	5.14	4.65	4.82	0.33	0.945
Gestation period (days)	30.40	30.60	30.20	31.20	30.40	0.20	0.602
FCR during gestation (g)	1.07	1.01	1.01	0.99	1.02	0.02	0.617
Wt of does after weaning (g)	2498.26	2417.50	2390.64	2426.06	2490.58	23.60	0.554
Survival rate (%)	100.00	80.00	60.00	80.00	80.00	0.00	0.130

[ab] Means with different superscripts on the same row differ significantly (P<0.05), feed conversion ratio; ADFI: average daily feed intake.

Table 4: Post Parturition Performance of Rabbit Does Fed inclusion levels of Heat Treated Rock Phosphate

Parameters	0%	25%	50%	75%	100%	SEM	P-value
Post-gestation weekly WG (g)	128.88	113.48	119.85	108.58	112.49	7.75	0.945
Post-gestation weekly FI (g)	665.58	643.20	644.14	618.48	648.70	9.98	0.717
Total milk yield (kg)	1062.2[a]	371.4[ab]	451.3[b]	731.3[ab]	1016.6[a]	32.86	0.015
Post-gestation FCR	6.63	6.44	6.74	6.38	6.49	0.066	0.424
an weekly weight gain (g)	5.52	4.86	5.14	4.65	4.82	0.332	0.945
Feed to gain ratio	7.46	7.44	7.55	7.14	7.27	0.074	0.446
Weight of does after weaning (g)	2498.3	2417.5	2390.6	2426.1	2490.6	23.60	0.554
Total number of kits at weaning	4.60	3.00	3.00	4.80	3.80	0.24	0.075
Male kits at weaning (number)	2.00	0.80	1.20	1.40	0.80	0.24	0.538
Female kits at weaning (number)	0.60	0.40	0.20	0.60	0.60	0.13	0.889
Sex ratio of kits	1.40	0.40	1.00	0.80	0.20	0.18	0.250
Total number of kits at birth	0.43[d]	1.00[b]	0.20[e]	0.75[c]	3.00[a]	0.20	0.657
Survival rate of does (%)	80.00	60.00	60.00	80.00	60.00	0.00	0.140

[ab]Means with different superscripts differ significantly (p<0.05) on the same row.
WG= weight gain; FI= Feed intake; FCR= Feed conversion ratio

However, it was observed that average daily feed intake in the control group differed significantly (P<0.05) from the 50% HTRP (104.46 g) group. The average daily feed intake reported in the current study was in contrast with the reports of (Agbu et al., 2017), when Sokoto rock phosphate (SRP) was substituted for DCP in the diets of chicken at varying inclusion levels, but agreed with the report of (Tahir et al., 2011) who substituted Hazara rock phosphate (HRP) for DCP in the diets of chicken at varying inclusion levels. The differences could be ascribed to extended periods of low calcium intake that may lower the appetite of the rabbits thus by decreasing feed intake.

The post parturition performance of rabbit does fed heat treated rock phosphate is illustrated in Table 4. The performance of does may be impacted by the size of litters, according to Olaleru and Abu (2021). Other studies confirmed this observation, pointing out that it might be because a kit's weight at weaning is a reflection of the amount of milk it consumes Kpodekon et al. (2006). The post parturition performance of rabbit does fed inclusion levels of heat treated rock phosphate showed that all parameters measured exception of total milk yield and total number of kits at birth, were not significantly affected (P>0.05). The total milk yield of 1016.60 g at 100% HTRP was similar to those fed control diet 1062.17 g) and better than other treatments. However, 50% HTRP diet fed to rabbit does group differed significantly (P<0.05) with those of 100% HTRP. The statistical analysis difference could be attributed to the doe's feed consumption quantities due to the dietary inclusion levels of HTRP. Nonetheless, the findings showed that the various inclusion levels had a substantial impact on all dietary interventions (P<0.05). Most importantly, prior to the 21st day, the kits were only fed doe milk. According to Olaleru and Abu (2021), the weight of the young rabbit is determined by the quality and amount of milk that is available to the kits.

Total number of kits at birth differed significantly (P<0.05) across treatments. However, rabbit does group fed 100% HTRP recorded high total number of kits at birth 3.00 compared to those fed control diet 0.43. The significant difference could be linked to the influence of the various inclusion levels of HTRP.

CONCLUSION

Integrated farming system of production systems such as mineral enhancement for rabbitry would require limited investment in the production of quality rabbit feeds through the utilisation of heat treated rock phosphate. The threat of nutrient loss to complexes was reduced through the adopted processing method of heat treatment which deflourinated rock phosphate and enhanced both growth performance and reproductive efficiency of rabbit does.

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Ethical Approval: University of Ibadan Animal Care and Use Research Ethics Committee approved experimental procedures before the commencement of the study. Approval ID: UI-ACUREC/049-0623/09

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Data availability: Data presented in this study are available on request from the corresponding author.

Conflict of interest: The authors declare that there is no conflict of interest that has influenced the content of this publication.

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