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Effect of Diets Containing Graded Levels of Eggshell Meal on Bone Parameters, Organ Weights and By-Products of Growing West African Dwarf Goats

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Abstract

A 12 week trial was conducted to investigate the effect of incorporating eggshell meal (ESM) at graded levels into the diets of West African Dwarf (WAD) bucks as a calcium source. Bone parameters as well as organ and by-products weights were evaluated. Twenty (20) WAD bucks weighing 5.7kg on the average were caged individually inside a conventional open-sided house. The bucks were randomly divided into four (4) groups, each group consisting of five (5) animals. The animals in groups 1, 2, 3 and 4 were provided with diets containing 0.0%, 0.5%, 1.0% and 1.5% ESM respectively with group 1 serving as the control. The animals were given known quantity of supplementary feed, forage (Andropogon gayanus corn) and water between 8 and 9am every morning. Two animals were randomly selected from each group and slaughtered for carcass analysis after which a pair of their femur bones were removed and measured and strength test using the Universal testing machine. Results showed that increase in the level of ESM inclusion across treatments yielded significant variability (P<0.05) on the bones Nominal diameter, Actual Length, Gauge Length and Breaking strength. The Weight of the bones also varied significantly (P<0.01) but non-significant difference was observed on Area of the bones. The organ weights (Heart, Liver, Kidney, Lungs and Spleen) did not show significant variability (P>0.05) across treatments. The horns weight varied significantly (P<0.05) but the other by-products weights (Hooves, Gastro intestinal tract full and empty as well as Abdominal fats) did not vary significantly (P>0.05) across the treatments. It was therefore concluded that growing WAD bucks can tolerate the inclusion of 1.5% properly sterilized ESM in their diet as source of Ca with no detrimental effect on bone parameters, organ and By-products weights.

Keywords

Eggshell Meal, Bone Strength, Organ Weight, By-Products, Goat

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1. Introduction

Nutrition is one of the most important factors that determine the development and expansion of livestock sector in the tropics. The inability of ruminant livestock farmers to feed their animals with high quality forages all year round remains the most widespread technical constraint facing ruminant productivity in the developing nations [1].

Contemporary ruminant feeding in a developing country like Nigeria is partly geared towards searching for inexpensive readily available feed resources which can partially or wholly serve as substitute for the scarce expensive feedstuffs and inadequate forages [2].

The supply of food of animal origin is not only made up of

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high quality and readily digestible protein and energy but is also a compact and efficient source of readily available macro nutrient [3].

Most nutritional experiments deals with the substitution of one ingredient by the other, not much has been made on the local alternative sources for mineral nutrients like Calcium and Phosphorus [4]. Calcium and Phosphorus belong to the group of macro minerals which are the most important elements required by animals, if inadequate in the diet of young growing animals, it results in abnormal bone development even if the diet contains adequate vitamin B_3. It is stated that calcium is the most prevalent mineral in the body and is required in the diet in larger quantities than any other mineral [5]. A deficiency of either Calcium or Phosphorus results in lack of normal skeletal calcification resulting in rickets.

The main sources of Calcium are oyster shells, bone ash, limestone and di-calcium phosphate [6]. Di-calcium phosphate has been found to be major source of calcium for livestock all over the world but is extremely costly following importation. Organic sources of calcium and phosphorus which are inexpensive and readily available except for the over dependence by the livestock industry include oyster shells and bone meal. It was also reported that calcium and phosphorus represent the third most expensive nutrient after energy and protein [7]. According to [8] Nigeria produces about 55.9 million eggs annually; this implies that over 250 metric tones of the shells are produced as by- product. This can be utilized as mineral supplement since eggshell is highly rich in calcium (90%) with little percentage (less than 5%) of phosphorus. It is therefore possible that optimum dietary level of calcium can be met using eggshell meal at little or no cost at all.

Calcium functions as a constituent of bones and teeth, regulation of nerve and muscle function. In blood coagulation, calcium activates the conversion of prothrombin to thrombin and also takes part in milk clotting. It plays a vital role in enzyme activation. Calcium activates large number of enzymes such as adenosine triphosphatase (ATP), succinic dehydrogenase, lipase etc. [9] stated that Calcium is also required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability.

2. Theoretical Background

Eggs are cheap source of animal protein consumed by most Nigerians. The eggshells are usually disposed as waste products by most households, eateries and hatcheries. The continuous search for cheap and readily available feed ingredients found eggshell meal to be highly rich in calcium and little phosphorus therefore there is need to delve into its possible uses in the animal industries. Eggshells require less heat/mechanical impact when processing in to eggshell meal. A lot of researches have been done using eggshell meal as source of calcium in poultry diet nevertheless; there is a dearth of information on its use as source of calcium in ruminant diet. This study, therefore, is designed to investigate the effects of graded levels of inclusion of eggshell meal in the diet of WAD goats.

3. Materials and Experiments

3.1. Experimental Site

The experiment was carried out in the Sheep and Goat Unit of the Livestock Teaching and Research farm of Kogi State University, Anyigba. The study site is located on the latitude 7°30'N and 6°43`E and with an average altitudes of 420m above sea level. The area falls within tropical wet and dry climate region of the guinea savannah with average rainfall of 1600mm. The daily temperature range is about 25°C-35°C [10].

3.2. Sourcing and Preparation of Egg Shell Meal

The egg shells were collected from eateries *(maishai),* hotels and restaurants. They were washed without removing the shell membranes and treated with boiling water for about one hour, sun dried and milled to obtain the egg shell meal.

3.3. Experimental Goats

Twenty (20) growing male West African Dwarf goats with initial weights ranging between 4.95 - 6.6 kg were sourced from Anyigba and its environs. The goats were each treated with 3mls of Abendazole, 1ml of Sulfanor, Oxybion LA, tylosin, and multivitamin to boost their appetite and stabilize them a day after their arrival at the research farm.

3.4. Experimental Design and Housing

The twenty (20) bucks were randomly allocated to four (4) treatment groups of five (5) replicates. There were thus five (5) animals per group in a Completely Randomized Design experiment. The goats were reared individually in partitioned cages which were washed and fumigated 2 weeks before the commencement of the experiment. The cages were about 15 inches above the floor and were kept inside an open sided house.

3.5. Feeding of Experimental Goats

The experimental animals West African Dwarf (WAD) Goats were fed with concentrate, forages and water during the experiment between the hours of 8am and 9am every day.

The supplementary diet was served to the animals according to the treatments while the forage (*Andropogon gayanus* corn) and water were served about 30 minutes later. The supplement was normally given to them at 200g/goat/day, forage 600g/goat/day and water 1000mls/goat/day.

3.6. Proximate Analysis of Forage and Eggshell Meal

Known quantity of forage was allowed to dry at room temperature and then taken to the Kogi State University Anyigba Biochemistry Labouratory for proximate analysis while the eggshell meal sample was analyzed at the Federal University of Agriculture Makurdi Animal Nutrition labouratory. The results of the proximate analysis is shown on Table 2.

3.7. Bone Measurements and Breaking Strength (BS) Test

At the end of the experiment, two (2) animals from each treatment were randomly selected, staved for 24hrs and slaughtered. The pair of their femur bones were then removed. The flesh around the bones was carefully removed with the aid of a sharp knife and oven dried. The bones were then subjected to the Breaking Strength (BS) test using the Universal Testing Machine in the Civil Engineering Laboratory of the Federal University of Agriculture Makurdi, Nigeria. The pair of bones obtained from each animal were weighed with an electronic weighing scale separately. The diameter and length of each bone was taken with the aid of a venial caliper [11]. The length and the diameter (at the point of breakage) were measured again at the end of the breaking strength test to determine the elasticity of the bone.

3.8. Statistical Analysis

Data collected were subjected to Analysis of Variance (ANOVA) using the Analyze - it Microsoft Excel software package version 2.21 of 2007. The differences between means were separated using the Least Significant Difference (LSD).

Table 1. Composition of Supplementary Diet.

Ingredients (%)	$T_1(ESM_{0.00})$	$T_2(ESM_{0.5})$	$T_3(ESM_{1.0})$	$T_4(ESM_{1.5})$
Brewers Dry Grain	49.25	49.00	49.25	49.00
Bambaranut Waste	29.00	29.00	29.00	29.00
Maize Offal	4.25	4.00	4.25	4.00
Rice Mill waste	2.00	2.00	1.00	1.00
Palm oil	4.50	4.50	4.50	4.50
Maize	9.00	9.00	9.00	9.00
Bone Meal	1.00	1.00	1.00	1.00
Eggshell Meal	0.00	0.50	1.00	1.50
Table Salt	1.00	1.00	1.00	1.00
Total	100	100	100	100
Calculated values				
Crude Protein (%)	17.17	17.13	17.10	17.02
Crude fibre (%)	16.63	16.45	16.26	16.19
Energy Kcal/kg	2745.44	2738.94	2732.44	2720.34

PROXIMATE ANALYSIS OF ESM AND *Andropogon gayanus* CORN

The result of proximate analysis of the ESM and *A. gayanus* fed to the animals are shown below:

Table 2. Proximate Composition of ESM and *A. gayanus*.

Nutrients	ESM(%)	*A. gayanus*(%)
Moisture	0.38	12.90
Ash	53.59	3.23
CF	0.40	11.19
Fat	0.00	6.2
CP	6.56	8.73
CHO	39.07	57.76

CF = Crude Fibre, CP = Crude Protein CHO = Carbohydrate

4. Results

4.1. Effect of Egg Shell Meal (ESM) on Bone Parameters of WAD Bucks

Shown on Table 3 are the means ± SE of Bone Parameters of the WAD Bucks. Significant difference ($P<0.05$) was observed on Nominal diameter (ND). The T_4 and T_3 with higher ESM inclusion showed highest (11.00±0.00 and 11.00±0.00mm) similar values followed by T_2 (10.50±0.29mm) while the least (10.25±0.25mm) was observed on the control. Actual length (AL) was observed to also show significant ($P<0.05$) variability with T_4 showing the highest (119.00±1.98mm) value followed by T_3 (118.75±0.75mm) and T_2 (113.25±1.65) while the least value (110.25±2.02mm) was observed on the control.

Significant effect was also observed on Gauge length (GL) as the highest level of ESM inclusion in T_4 showed the highest value (121.75±1.65mm). T_3 and T_2 yielded (120.50±0.29) and (115.50±1.44) respectively. The control with zero ESM inclusion yielded the least value (114.00±2.12mm).

The weight (WT) of the bones varied significantly ($P<0.01$) where the highest level of ESM inclusion (T_4) yielded the highest value (21.95±078g) followed by T_3 (19.60±0.80g) and T_2 (18.01±0.21g) while the control yielded the least value (17.30±0.54).

Breaking Strength (BS) which can also be referred to as load or stress at yielding point was observed to vary significantly ($P<0.05$) with T_4 having the highest value (600.00±14.72kN). The T_3 and T_2 yielded similar values (567.50±4.79kN) and (567.50±11.81kN) respectively. The control showed the least value (525.00±19.36kN).

Table 3. Means ± SE of the Bone Parameters of WAD Bucks.

TREATMENTS					
Parameter	**$T_1(ESM_{0.00})$**	**$T_2(ESM_{0.5})$**	**$T_3(ESM_{1.0})$**	**$T_4(ESM_{1.5})$**	**LS**
ND(mm)	10.25±0.25	10.50±0.29	11.00±0.00	11.00±0.00	*
AL(mm)	110.25±2.02	113.25±1.65	118.75±0.75	119.00±1.78	*
GL(mm)	114.00±2.12	115.50±1.44	120.50±0.29	121.75±1.65	*
WT(g)	17.30±0.54	18.01±0.21	19.60±0.80	21.95±0.78	**
AR(mm^2)	86.82±4.76	86.82±4.76	95.06±00	95.06±0.00	NS
BS(kN)	525.00±19.36	567.50±11.81	567.50±4.79	600.00±14.72	*

NOTE: * =P<0.05, ** =P<0.01 NS =Not Significant, ND = Nominal Diameter, AL= Actual length, GL= Gauge length, WT = Weight, AR= Area, BS = Breaking strength.

4.2. Effect of Eggshell Meal (ESM) on Organ Weights of WAD Bucks

All organ weights (the Heart, Liver, Kidney, Lungs and Spleen) as shown in Table 4 below did not vary significantly (P>0.05) across treatments.

Table 4. Means ± SE of the WAD Bucks Organ Weights.

TREATMENTS					
Parameter	**$T_1(ESM_{0.00})$**	**$T_2(ESM_{0.5})$**	**$T_3(ESM_{1.0})$**	**$T_4(ESM_{1.5})$**	**LS**
HRT(kg)	0.13±0.00	0.13±0.00	0.13±0.00	0.13±0.00	NS
LVR(kg)	0.19±0.00	0.19±0.00	0.20±0.01	0.20±0.02	NS
KDN(kg)	0.12±0.00	0.13±0.00	0.12±0.00	0.12±0.03	NS
SPL(kg)	0.11±0.00	0.11±0.00	0.11±0.00	0.11±0.00	NS
LUN(kg)	0.16±0.00	0.18±0.00	0.17±0.01	0.17±0.01	NS

NS =Not Significant(P>0.05), HRT=Heart, LVR=liver, KDN=kidney, SPL=Spleen, LUN=Lung,

4.3. Effect of Eggshell meal (ESM) on By-products of WAD Bucks

Shown on Table 5 are the means ± SE of weights of WAD Bucks By-products. Significant effect (P<0.05) was observed on horn (HN) weight. The control had the highest value (0.13±0.01) while the T_4, T_3 and T_2 all yielded the same value (0.10±0.00).

The Hooves, Gastro intestinal tract (full and empty) and Abdominal fats all showed non-significant variability (P>0.05) across treatments.

Table 5. Means ± SE of Weights of the WAD Bucks By-products.

TREATMENTS					
Parameters	**$T_1(ESM_{0.00})$**	**$T_2(ESM_{0.5})$**	**$T_3(ESM_{1.0})$**	**$T_4(ESM_{1.5})$**	**LS**
HN(kg)	0.13±0.01	0.10±0.00	0.10±0.00	0.10±0.00	*
HLV(kg)	0.19±0.07	0.12±0.00	0.11±0.00	0.12±0.00	NS
GTF(kg)	1.17±0.07	1.98±0.00	1.10±0.12	1.34±0.15	NS
GTE(kg)	0.35±0.03	0.35±0.00	0.33±0.02	0.34±0.03	NS
ADF (kg)	0.10±0.00	0.10±0.00	0.11±0.00	0.11±0.00	NS

NS =Not Significant(P>0.05), HN= Horn, HLV= Hooves, GTF = Gastro-intestinal tract (Full), GTE= Gastro-intestinal tract (Empty) ADF= Abdominal fat

5. Discussion

5.1. Effect of Eggshell Meal on Bone parameters of WAD Bucks

The effect of ESM on most of the bone parameters as presented in Table 3 varied significantly across treatments which disagrees with the findings of [12] who replaced limestone with ESM at 0.0%, 50% and 100% in cockerels diet. The breaking strengths of the left tibia of the cockerels showed that the control (0%), 50% ES and 100%ES birds were 57.20kg, 57.65kg and 50.33 kg, respectively (P > 0.05). It was also observed that the tibia length and weight did not vary significantly. A similar investigation conducted by [13] on broiler breeders showed significant variability on the tibia and humerus bones length, width and breaking strength after feeding dietary Ca at 1.5%, 2.5% and 3.5% for 18 weeks.

5.2. Effect of Eggshell Meal (ESM) on Organ Weights of WAD Bucks

The result of the organ weights in this study agrees with the result obtained by [14] who replaced limestone with ESM in broiler diet and reported non-significant differences when means of weights obtained from internal organs were compared. This suggests that ESM had no detrimental effect on organ weights. [12] also reported non-significant difference between means of comb weight, testes weight, ductus deferens weight and length and giblets weight after replacing limestone with ESM at 0.0%, 50% and 100% in cockerels diet.

5.3. Effect of Eggshell Meal (ESM) on By-Products Weights of WAD Bucks

The weights of By-products investigated showed non-significant variability (P>0.05) across the treatments except the horns weight with the highest horn weight observed on the control with zero ESM inclusion as shown in Table 5. Horns are known to develop from keratinous protein thus they may be need for further investigation to determine whether the increase in ESM inclusion in goat diet can suppress horn development in ruminants. When this is established, it may be an alternative means of dehorning animals or breeding for hornless animals.

6. Conclusion

The results obtained in the study shows that Eggshell meal if properly treated can serve as a source of Calcium in growing WAD goat diets to enhance healthy bones development. The non-significant effects observed on all the Organ weights and most of the By-products suggest that WAD goats can tolerate the inclusion of up to 1.5% ESM in their diet with no detrimental effects on the Bones, Internal organs and By-products. It is therefore recommended that properly treated Eggshell meal can be incorporated in goat diets particularly during the dry season when fresh forages are scarce so that the animals can meet their daily Calcium requirement necessary for healthier bone development and growth.

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