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Studies on Egg Shell Meal as Mineral Source for West African Dwarf Goats

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Authors' contributions

This work was carried out in collaboration among all authors. Authors UO, BOJ and OJW designed and setup the study. Authors BOJ and OJW also contributed financially to this study. Author UO performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors JSL and GACO read and approved the final manuscript.

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ABSTRACT

Aims: The studies on eggshell meal (ESM) as mineral source for West African Dwarf (WAD) goats was carried out the determine the effects of non-conventional mineral source on WAD goats.
Study design: The goats were randomly allotted to 4 dietary treatments, having five replicates with goats on T_1 receiving the control diet (0%) while those on T_2, T_3 and T_4 received 0.5%, 1.00% and 1.50% levels of ESM inclusion, respectively in aa completely randomized design (CRD).
Place and duration of study: The experiment was carried out at the Department of Animal Production, Kogi State University, Anyigba, Nigeria, between August and September, 2015.
Methodology: Twenty (20) WAD goats with an average body weight of 5.84kg were used for this experiment. Eggshell was obtained from food vendors *(mashayi),* and sterilized with hot water without removing the shell membranes. It was then sun- dried and milled. The forage (Northern gamba grass) were harvested fresh and allowed to wilt before feeding it to the goats. Parameters such as performance, haematology and serum biochemistry were assessed.
Results: Apart from the mean corpuscular haemoglobin (MCH) which was significantly affected (P<0.05) by the inclusion of ESM, none of the other haematological, performance and serum

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biochemical parameters were significantly affected. For MCH, T_1 and T_2 were significantly higher than T_3 and T_4.
Conclusion: the study showed that the inclusion of ESM did not adversely affect the performance, haematology and serum biochemistry of WAD goats. The use of ESM is strongly recommended as a source of mineral (especially calcium) for WAD goats. Egg shell meal is cheap and readily available. When it is harnessed in this way, it will not constitute environmental pollution but will rather reduce the cost of livestock feed since it is freely available, unlike bone meal which is expensive because of its high demand.

Keywords: Serum; haematology; egg shell meal; mineral; West African dwarf goats.

1. INTRODUCTION

Unlike proteins and carbohydrates, not much effort has been made on local alternative sources for the major mineral nutrients like calcium and phosphorus [1]. According to [2], natural Calcium sources are of interest because they contain not only Calcium but also other elements (e.g., Strontium, Sr and Florine, F), which may have a positive effect on bone metabolism. An example of this is chicken eggshells, which first serve to protect and provide nutrients to the enclosed embryo [3]. Chicken eggshell is a waste material from sources such as hatcheries, poultry farms, egg product factories, homes, and restaurants. The annual high production of egg shell waste (250 metric tonnes) in Nigeria according to [4], and it's potentially rich minerals (calcium 90 % and phosphorus less than 5%), makes it highly available and fit as a mineral source to animals.

According to [5] ESM has a beneficial composition with about 37% of elemental Calcium, relevant amounts of Strontium (Sr), and low levels of Aluminium (Al), Lead (Pb), Cadmium (Cd) and Mercury (Hg). Calcium value for chicken egg shell was reported by [6] and [7] to be 40% and 23% respectively. Chicken eggshell meal (ESM) was shown to have antirachitic effects in rats. *In vitro*, ESM stimulated the growth of chicken embryo cartilage cells [8]. According to [9], examination of blood provides the opportunity to clinically investigate the presence of several metabolites and other constituents in the body as it plays a vital role in the physiological, nutritional and pathological status of the animal. Haematological studies have been found useful for disease prognosis and for the therapeutic and feed stress monitoring [10]. Biochemical indices of animals may give some insight as to the production performance potentials of West African Dwarf goats [11].

There is a great variation in the biochemical parameters as observed between breeds of goats [12] and in this regard, it may be difficult to formulate a universal metabolic profile test for goats. These differences have further underlined the need to establish appropriate physiological baseline values for various breeds of livestock in Nigeria, which could help in the realistic evaluation of the management practice, nutrition and diagnosis of their health condition [13].

According to, [14] studied the performance and serum biochemistry of broiler birds fed egg shell meal and bone meal inclusions. At the starter phase, feed conversion ratio (FCR) and feed cost per kg gain, were significantly affected ($P < 0.05$). At the finisher phase, all the parameters analysed apart from initial weight and cost benefit ratio were significantly affected ($P < 0.05$) by the experimental diets. None of the serum parameters analysed was significantly affected ($P > 0.05$) by the experimental diets. [14] concluded that egg shell meal can be utilized by broiler chicken when properly processed and sun dried. They strongly advocated the utilization of egg shell to furnish calcium and phosphorus in broiler diet since egg shell is free, readily available and does not have any adverse effect on the performance and serum biochemistry of broiler birds.

Though much work has not been done and reported on the feeding values of egg shell meal, little or no work have been reported on the haematological and biochemical parameters of West African Dwarf (WAD) goats fed ESM. The use of ESM as a mineral source due to its potentials will reduce the competition with other industries for borne meal and also prevent environmental pollution caused by the accumulation of unused egg shell.

2. METHODS AND PROCEDURES

2.1 Management of Experimental Goats

Studies on eggshell meal (ESM) as mineral source for West African Dwarf (WAD) goats were carried out using 20 WAD goats with an average body weight of 5.84kg.

The goats were housed intensively in well-ventilated individual cages, in a pen were they were given prophylactic treatments, which consisted of intramuscular (IM) application of oxytetracycline and vitamin B complex following manufacturers' instruction. They were dewormed with albendazole and were treated against ectoparasites with 0.5 ml/10 kg body weight of Ivomec. They were allowed an adaptation period during which they were fed forages and concentrate supplement. Fresh water was supplied *ad libitum*.

2.2 Experimental Diets

Eggshell was obtained from food vendors *(mashayi),* and sterilized with hot water without removing the shell membranes. It was then sun-dried and milled. The forage (Northern gamba grass) were harvested fresh and allowed to wilt before feeding it to the goats. They goats were randomly allotted to 4 dietary treatments, having five replicates with goats on T_1 receiving the control diet (0%) while those on T_2, T_3 and T_4 received 0.5%, 1.00% and 1.50% levels of ESM inclusion, respectively**.** Other ingredients in the diets were dried brewers' grains, bambara nut waste, maize offal, rice milling waste, palm oil, salt and bone meal. Known quantity of concentrate supplements was given to the goats between 8.00am and 9.00am. After which wilted forages (Northern gamba grass) that had been harvested the previous day were also given to the goats.

2.3 Blood Collection and Analysis

At the end of the experiment, blood samples were collected from 2 replicates via jugular vein puncture using syringes. For serum analysis, blood was drawn into a plain Ethylene Diamine Tetra-Acetate or Tetra Acetic Acid (EDTA free) sample bottles to coagulate. Blood samples were analysed for cholesterol, protein, glucose and creatinine. For haematology analysis, blood was drawn into EDTA bottles.

2.4 Statistical Analyses

All data were subjected to Analysis of Variance (ANOVA) using the SPSS package and the differences between means were separated using the Fisher's Least Significant Difference (LSD).

3. RESULTS AND DISCUSSION

3.1 Performance Characteristics of Experimental Goats

As observed from Table 5, none of the performance parameters were significantly affected (P> 0.05) by the inclusion of ESM. The non significance shows that there is no difference in performance between goats feed the control and the experimental diets, i.e. the use of bone meal or egg shell gave the same result. The inclusion of ESM did not also result to an adverse effect on the goat's performance Feed intake which is a parameter under performance had been observed to be governed by some other factors apart from dietary crude protein and palatability. These include gut fill, body fat and changes in the body weight gain values of goats [17].

Table 1. Gross composition of experimental diets

	Treatments			
Ingredients	**T_1(0% ESM)**	**T_2(0.5% ESM)**	**T_3(1.00% ESM)**	**T_4(1.50% ESM)**
Brewer dried grain	49.25	49.25	49.25	49.00
Bambara nut waste	29.00	29.00	29.00	29.00
Maize offal	4.25	4.25	4.25	4.00
Rice milling waste	2.00	1.50	1.00	1.00
Palm oil	4.50	4.50	4.50	4.50
Maize	9.00	9.00	9.00	9.00
Salt	1.00	1.00	1.00	1.00
Bone meal	1.00	1.00	1.00	1.00
Egg shell meal	0.00	0.50	1.00	1.50
Total	100.00	100.00	100.00	100.00
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

Table 2. Mineral composition of egg shell meal and bone meal

Mineral	Egg shell meal	bone meal
Magnesium	0.365	0.595
Sodium	0.725	0.705
Calcium	43.170	29.450
Potassium	0.078	0.062
Phosphorus	1.135	17.910
Copper	BDL	BDL
Cobalt	BDL	BDL

BDL: Below detection level
Source: [15]

Table 3. Chemical Composition of Chicken Eggshell

Elements	Chicken Eggshell (mg/L)
Calcium	2300.33 ± 3.80
Magnesium	850.00 ± 1.24
Sodium	33.83 ± 0.72
Potassium	17.06 ± 1.04
Iron	1.4 ± 0.03
Zinc	0.99 ± 0.04
Copper	0.063 ± 0.01

Source: [7]

Table 4. Proximate composition of Northern gamba grass *(Andropogon gayanus kunth)*

Nutrients (%)	Northern gamba grass
Crude protein	8.51
Crude fiber	11.55
Nitrogen free extract	57.30
Ether extract	6.94
Ash	2.55
Moisture content	13.15
Total	100
Dry matter	86.85
Energy (kcal/kg)	2911.16

Source: [16]

Table 5. Performance characteristics of experimental goats fed bone meal and eggshell meal based diets

	Treatments				
Parameters	**1**	**2**	**3**	**4**	**LOS**
AIBW (g)	5520±225	5695±105	5750±350	6400±250	NS
FBW (g)	5650±150	6230±280	5885±365	6475±175	NS
TWG(g)	125±75	535±175	135±15	425±75	NS
DWG(g)	4.46±2.68	19.11±6.25	4.82±0.54	15.18±2.68	NS
TCI(g)	3560±220	3510±0.00	3460±90.50	4050±370	NS
DCI(g)	127±7.85	125±0.00	124±3.23	145±13.22	NS
TFI(g)	10220±220	10875±225	9387±193	10710±450	NS
DFI(g)	365±9.65	388±8.04	335±32.62	383±16.08	NS
TWI(ml)	5345±1135	4174±70	5583±709	5409±435	NS
DWI(ml)	191±40.54	149±2.49	199±25.32	193±15.54	NS
TFdI (g)	13780±490	14385±225	12846±1004	14760±80	NS
FCR	110±97.23	29.96±9.39	95.52±3.18	35.88±6.52	NS

NS= Not significant (P>0.05) AIBW= Average initial body weight, FBW= Final body weight, TWG= Total weight gain, DWG= Daily weight gain, TCI= Total concentrate intake, DCI= Daily concentrate intake, TFI= Total forage intake, DFI= Daily forage intake, TWI= Total water intake, DWI= Daily water intake, TFdI= Total feed intake, FCR= Feed conversion ratio

Table 6. Haematological indices of experimental goats fed bone meal and eggshell meal based diets

Parameters	Treatments 1(0.00%ESM)	2(0.05%ESM)	3(1.00%ESM)	4(1.50%ESM)	LOS
PCV (%)	26.50±1.50	23.00±5.00	22.50±2.50	18.00±2.00	NS
Hb g/dl	9.65±0.60	8.25±1.05	7.65±0.65	6.00±0.70	NS
WBC ×10^9/l	31.60±0.60	35.15±17.35	19.20±5.40	33.25±2.45	NS
RBC×10^9/l	6.95±0.81	6.00±0.60	7.05±0.24	7.20±0.92	NS
Plate×10^9/l	2.92±4.00	3.13±22.50	3.06±20.00	3.42±13.00	NS
Neut (%)	18.50±6.50	26.50±10.50	10.00±0.00	23.00±2.00	NS
Lymp (%)	81.50±6.50	72.00±12.00	90.00±0.00	77.00±2.00	NS
Mono (%)	0.00±0.00	0.50±0.50	0.00±0.00	0.00±0.00	NS
Eosi (%)	0.00±0.00	1.00±1.00	0.00±0.00	0.00±0.00	NS
Baso (%)	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	NS
MCH (pg)	14.00±1.00[a]	13.70±1.30[a]	10.85±0.55[ab]	8.35±0.05[b]	*
MCHC (g/l)	36.50±0.50	36.50±3.50	34.00±1.00	33.50±0.50	NS
MCV (fl)	38.40±2.30	38.10±7.10	31.80±2.40	25.05±0.45	NS

*NS: Not significant (P>0.05) *: significant (P<0.05) [abc]: Means with different superscript on the same row differ significantly (P<0.05). PCV= Packed cell volume, Hb= Haemoglobin, WBC= White blood cell, RBC= Red blood cell, Plate= Platelets, Neut= Neutrophils, Lymp= Lymphocytes, Mono= Monocytes, Eosi= Eosinophils, Baso= Basophils, MCH= Mean corpuscular haemoglobin, MCHC= Mean corpuscular haemoglobin concentration, MCV= Mean corpuscular volume*

Table 7. Serum characteristics of West African dwarf goat fed egg shell meal base diet

Parameters	Treatments 1	2	3	4	LOS
GLU. (mg/dl)	36.50±12.50	43.00±10.00	58.50±6.50	45.00±700	NS
CHOL. (mg/dl)	66.00±7.00	63.50±17.50	82.50±2.50	80.50±16.50	NS
PRO. (g/dl)	9.15±1.05	8.70±0.90	10.00±0.70	10.60±0.20	NS
CREAT. (mg/dl)	0.90±0.10	1.00±0.10	0.95±0.05	1.00±0.10	NS

GLU glucose, CHOL. Cholesterol, PRO. protein, CREAT. creatinine, LOS-Level of Significance, NS-No Significant Difference

3.2 Haematological Indices of Experimental Goats

From Table 6 above, apart from the values of mean corpuscular haemoglobin (MCH) which were significant affected (P <0.05); all the other haematological parameters were not significantly affected by the inclusion of ESM. The value for MCH in the control diet (0% ESM) and the treatment 2 (0.5 % ESM) were not statistically different. The MCH expresses the amount of haemoglobin (in picograms) in an average erythrocyte of a population of cells. The published goat normal values for MCH are in the range of 5.2 - 8.0 pg [18] and 5 – 8 pg [19].

Report from literature showed that blood indices are important in the assessment of nutritive component of a given ration [20]. Packed cell volume (PCV) is the total percentage of the blood that is compost of red blood cell. A low PCV can be the result of not enough red blood cells (Anemia) or the occasional state of over hydration and normal ranges for goat is 22-38% [21].

It has been reported that haematological indices give insight into the production potential and help to monitor and evaluate incidence of diseases in animal [11].

3.3 Serum Biochemistry of West African Dwarf Goats fed Eggshell Meal Diet

All the serum parameters tested for were not significantly affected by the infection of ESM. The non-significant values observed in this study suggest nutritional adequacy of the dietary proteins, significant protein intake by the animals and better utilization for protein synthesis. The non-significance of the cholesterol values in all the treatments may have suggested that replacing bone meal with egg shell meal did not cause any undue elevation in the cholesterol level of these goats fed diets containing egg shell meal. Also, the non-significance of the values

obtained in this study for glucose level may suggest that, it is worthwhile replacing Bone meal with egg shell meal in the diets of West African Dwarf goats. [22] and [23] reported that serum urea and total protein contents depend on quality and quantity of protein supplied in the diet. The serum biochemistry profile is also useful in monitoring the effects of various medications on the body.

4. CONCLUSION AND RECOMMENDATIONS

The results of this experiment showed that all the parameters assessed for performance and serum were not significantly affected. For haematological parameters however, only the MCH was significantly affected. The non significance of almost all the parameters assessed could mean that there is no difference in either the use of ESM or bone meal in supplying both calcium and phosphorus to WAD goats. It could also mean that ESM can be used in place of bone meal in the diets of growing West African dwarf goats since it had no adverse effect on the experimental goats. Further experiments including the use of other levels of ESM, different breed of goats and in a different environment are recommended.

ETHICAL APPROVAL

All authors hereby declare that "Principles of laboratory animal care" (NIH publication No. 85-23, revised 1985) were followed, as well as specific national laws where applicable. All experiments have been examined and approved by the appropriate ethics committee.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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