Utilization of Minerals in Pregnant West African Dwarf Goats Fed Cassava Peel and Leaf Meal as a replacement for wheat offal and Palm kernel cake in a Guinea Grass Based Diet

[1*]Egigba, G. O. and [2]Bamikole, M. A

[1, 2]Department of Animal Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria
**Corresponding Author: Email: gladys.egigba@uniben.edu; Tel: +2348038712693*

Abstract

The utilization of selected macro and micro minerals was evaluated in 16 pregnant West African dwarf goats of weight 19.38 ± 2.30 kg, fed Guinea grass basal diet and cassava peel-leaf meal concentrate supplement was conducted during the 19th and 20th week of pregnancy. Four pregnant does were allotted in a completely randomized design to each of the four experimental diets (treatments) of Guinea grass basal diets and concentrate supplements at 50%. The CPM partially replaced Wheat offal at 0, 25, 50, and 75% while CLM completely replaced the protein source- PKC at same levels as CPM. The diets were T1 (control), T2 (25% replacement of wheat offal (WO) and Palm kernel cake (PKC), with cassava peel meal (CPM) and cassava leaf meal (CLM), T3 (50 % replacement of WO and PKC, with CLM and CPM) and T4 (75% replacement of WO and PKC, with CLM and CPM). Feed was offered at 50 g DM /Kg BW, and the metabolism cages. The content of Ca, N, P, Mg, K, Mn, Cu and Zn in the Guinea grass and concentrate supplement fed the pregnant goats, in addition to the mineral content of faeces and urine voided was determined using the dry ashing and wet digestion methods using AOAC procedures. The concentration of each mineral was read using the atomic absorption spectrophotometer. Data obtained were subjected to analysis of variance (ANOVA) using (SAS, 2014) and significant differences were declared at 5 % probability level and means were separated using Duncan Multiple Range Test.

The content of the minerals studied in respective diets were between 0.231-0.423% Ca, 2.520-3.360% N, 0.0096-0.0135% Mn, 0.144-0.162% P, 0.155-0.160% K, 0.055-0.070% Mg, 0.0008-0.0012% Cu and 0.0051-0.0070% Zn. Significant variations were observed in the utilization of Ca, K and Cu. Retention and digestibility of Ca was highest in T2. However, no significant variations were observed in the retention and digestibility of Mn, P, Mg and Zn across the treatments. The N balance and digestibility was not significantly influenced by the replacement levels. Conclusively, positive balance, high retention and digestibility were obtained for all the minerals studied across the treatments. Thus, wheat offal and palm kernel cake can be replaced at 25,50 and 75% in the diets of pregnant West African dwarf goats without negatively affecting their utilization of Ca, N, P, Mg, K, Mn, Cu and Zn

Keywords: Pregnant WAD goats; retention; digestibility; mineral balance and mineral utilization
Running Title: Utilization of some minerals in pregnant WAD goats

Utilisation de minéraux chez les chèvres enceintes de West African Dwarf nourries avec de la peau et des feuilles de manioc en remplacement des abats de blé et des tourteaux de palmiste dans un régime à base d'herbe de Guinée

Résumé

L'utilisation de macro et micro minéraux sélectionnés a été évaluée chez 16 chèvres West African Dwarf gravides pesant 19,38 ± 2,30 kg, nourries avec un régime de base à base d'herbe de Guinée et un supplément concentré de farine de feuilles de manioc a été réalisée au cours des 19e et 20e semaines de gestation. Quatre femelles gestantes ont été réparties selon une conception complètement randomisée pour chacun des quatre régimes expérimentaux (traitements) de régimes de base à base d'herbe de Guinée et de suppléments concentrés à 50 %. Le FPM a partiellement remplacé les abats de blé à 0, 25, 50 et 75 %, *tandis que le FFM a complètement remplacé la source de protéines, le TP, aux mêmes niveaux que le FPM. Les régimes étaient T1 (témoin), T2 (remplacement de 25 % des abats de blé (AB) et des tourteaux de palmiste (TP), par de la farine de peau de manioc (FPM) et de la farine de feuilles de manioc (FFM), T3 (remplacement de 50 % de AB et TP, avec FFM et FPM) et T4 (remplacement de 75% de AB et TP, avec FFM et FPM). L'aliment était proposé à 50 g MS / Kg BW, et les cages métaboliques. La teneur en Ca, N, P, Mg Le K, le Mn, le Cu et le Zn dans l'herbe de Guinée et le supplément concentré nourris pour les chèvres gravides, en plus de la teneur en minéraux des fèces et de l'urine évacuée, ont été déterminés à l'aide des méthodes de cendres sèches et de digestion humide en utilisant les procédures AOAC a été lu à l'aide du spectrophotomètre d'absorption atomique. Les données obtenues ont été soumises à une analyse de variance (ANOVA) à l'aide de (SAS, 2014) et des différences significatives ont été déclarées à un niveau de probabilité de 5 % et les moyennes ont été séparées à l'aide du test Duncan Multiple Range.*

La teneur en minéraux étudiés dans les régimes respectifs était comprise entre 0,231 et 0,423 % de Ca, 2,520 à 3,360 % de N, 0,0096 à 0,0135 % de Mn, 0,144 à 0,162 % de P, 0,155 à 0,160 % de K, 0,055 à 0,070 % de Mg, 0,0008 à 0,0012. % Cu et 0,0051-0,0070 % Zn. Des variations significatives ont été observées dans l'utilisation du Ca, du K et du Cu. La rétention et la digestibilité du Ca étaient les plus élevées en T2. Cependant, aucune variation significative n'a été observée dans la rétention et la digestibilité du Mn, P, Mg et Zn d'un traitement à l'autre. Le bilan N et la digestibilité n'ont pas été influencés de manière significative par les niveaux de remplacement. En conclusion, un bilan positif, une rétention et une digestibilité élevées ont été obtenus pour tous les minéraux étudiés à travers les traitements. Ainsi, les abats de blé et les tourteaux de palmiste peuvent être remplacés à hauteur de 25,50 et 75 % dans l'alimentation des chèvres naines gestantes d'Afrique de l'Ouest sans affecter négativement leur utilisation de Ca, N, P, Mg, K, Mn, Cu et Zn.

Mots-clés : Chèvres WAD gestantes ; rétention; digestibilité; équilibre minéral et utilisation des minéraux

Introduction

The role of small ruminants in poverty alleviation and their contribution to sustainable livelihoods especially in rural area have been demonstrated by several research and development programmes in Sub-Saharan Africa (Relevant and up-to-date references needed to support this claim). This is buttressed by the steady increase in the population of small ruminants in Nigeria and consequently the income of farmers from production between 2009 and 2016. In 2009, the population of goats in Nigeria was put at about 53.8 million (FAOSTAT, 2009), while Federal Department of Livestock (FDL) (2010) reported an increase in goat population to about 55.15 million. This population in 2016, increased to about 72.5 million (Premium Times, June 2, 2016). In addition, the population of West African dwarf goat (WAD) in Nigeria increased from 9.3 million (RIM, 1992) to 28 million (FAOSTAT, 2006) requiring a proportionate increase in feed resources, most of which are expensive due to the competition for them by humans and animals. Thus, farmers have resorted to using feeds compounded from non-conventional feed ingredients which are inexpensive and locally available such as cassava peels and cassava leaves in order to keep up this increase. However, by-products from cassava processing are a very promising source based on the increasing productivity world-wide as its significance to man's everyday life cannot be over-emphasized. Pregnancy and lactation are important physiological phases in ruminant production, that constitute metabolic stress, associated with alterations in the minerals profile dependent on the reproductive status of small ruminants (Ceylan *et al*., 2009; Furthermore, Elnageeb and Abdelatif (2010) also demonstrated that minerals have critical roles in the reproductive performance of ewes and the deficiencies, excesses or malabsorption of minerals contribute to or cause several diseases for maternal or and fetus such as metabolic problems. Metabolism of minerals plays a significant role in the regulation of physiological functions of pregnancy and lactation (Khayat, 2017). For efficient utilization, it becomes imperative to compound quality and balanced rations (concentrate supplement) with these non-conventional feed ingredients for ruminants, hence this study to fully harness the potential of pregnant goats to utilize these substituted feed ingredients to meet the mineral requirements.

Materials and methods

Study area

The experiment was carried out in May 2017, at the Small Ruminant Unit of the University of Benin Farm Project, Benin City, Edo State, Nigeria. Benin City lies between latitude 6° and 30^{1}N and longitude 5° 40^1 and 6°E The area has an average annual rainfall and relative humidity of 2162 mm and 72.5 % respectively (CNES/Airbus, 2016).

Experimental Feeds, Animals and their Management

The oestruses of the goats were synchronized and they were serviced by selected bucks and sixteen pregnant West African dwarf (WAD) does weighing 19.38 ± 2.30 kg were selected (based on some phenotypic characteristics such as the number of teats, skin conditions) from a 14 day quarantined stock of twenty (20) goats bought from villages around Benin City, Edo State, Nigeria. The goats were dewormed with Albendazole (KEPRO B.V. Holland, 1 mL per 20 kg body weight) dipped and administered with long acting oxytetracycline 200 LA (Invesa, Spain, 1 mL per 10 kg body weight). They were also vaccinated against PPR (Pestes des petit ruminante) using the PPR vaccine, 1 mL per 50 kg BW. During the first week of adaptation period, the animals were fed *ad libitum* their familiar feed at the place of purchase and were gradually introduced to the experimental diets before the commencement of the feeding trial which lasted for 18 weeks and this was followed by a 2 week digestibility trial during the 19th and 20th weeks.

Four treatments were used for the study consisting of Guinea grass basal diet and supplement from graded levels of cassava peel and leaf meal based concentrate diets at 50% supplementation fed *ad libitum*.

The experimental diets are shown below:

Diet 1: Control diet (standard concentrate) + 50% Guinea grass

Diet 2: 25% replacement of energy source (wheat offal) of the concentrate with cassava peel meal + 25% replacement of protein source (palm kernel cake (PKC)) of the concentrate with cassava leaf meal + 50% Guinea grass

Diet 3: 50% replacement of energy source (wheat offal) of the concentrate with cassava peel meal + 50% replacement of protein source (palm kernel cake (PKC)) of the concentrate with cassava leaf meal + 50 % Guinea grass

Diet 4: 75% replacement of energy source (wheat offal) of the concentrate with cassava peel meal + 75% replacement of protein source (palm kernel cake (PKC)) of the concentrate with cassava leaf meal + 50% Guinea grass

Table 1: Ingredient compositions (%) of experimental diets for pregnant does with graded levels of cassava peel and leaf meal-based concentrate

Ingredient	Diets			
	T1	T2	T3	T4
Maize	17.00	17.00	17.00	17.00
Wheat offal	40.00	30.00	20.00	10.00
Cassava peel meal	0.00	10.00	20.00	30.00
Palm kernel cake	40.00	30.00	20.00	10.00
Cassava leaf meal	0.00	10.00	20.00	30.00
Common salt	1.00	1.00	1.00	1.00
Premix *	1.00	1.00	1.00	1.00
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated nutrient composition				
Metabolizable Energy (Kcal/kg DM)	2660.00	2589.73	2518.83	2447.93
Crude Protein (%)	16.17	15.62	15.09	14.49

*Contains vitamin A (I.U) 10,000.00; Vitamin D_2 (I.U) 2,000,000; Vitamin E (I.U) 20,000; Vitamin K (mg) 2,250; Riboflavin (mg) 5000; pyridoxine (mg) 275; Biotin (mg) 50; Pantothenic acid (mg) 7500; Vitamin B_1 (mg) 175; Vitamin B_{12} (mg) 15.0; Niacin (mg) 27,500; Folic acid (mg) 7500; choline chloride (mg) 400; antioxidant (mg) 125; Fe (g) 20.0; Zn (g) 50.0; Mn (g) 80.0; Cu (g) 5.0g; I (g) 12.0; Co (mg) 200; Se (mg) 200.

T1 = Control (0 % replacement); T2 = 25 % replacement; T3 = 50 % replacement; T4 = 75 % replacement

The basal and concentrate supplement was fed at 50 g DM/kg live weight daily at 8:00 hours and at 16:00 hours based on the quantity of leftover. In addition, clean drinking water was provided *ad libitum.* Leftover feeds were collected the following morning and weighed prior to serving fresh feed. All feed and body weight measurements were done using a digital weighing scale daily and weekly respectively. The variations in weight of the animals were recorded as the weight changes. The pregnant goats were weighed and housed in metabolic cages during the last two weeks of the digestibility trial, the first week been for adaptation of the animals to the metabolism cages, followed by separate collection of faeces and urine. About 25% of the total faeces collected during the digestibility study (last two weeks of the experiment) were oven-dried and bulked per replicate (that is, per animal). The oven-dried faecal samples, the respective experimental diets, cassava peel and leaf meal were milled separately, and each digested by dry ashing (AOAC, 2005) done by adding 10 mL of nitric acid to the ash of the respective samples, thoroughly mixed by shaking vigorously and stored in sample bottles for mineral analysis. The wet digestion method, which involved the use of 3:1 mixture of nitric and perchloric acid was used for the urine samples and the corresponding digests, washed into volumetric flasks and stored in digest bottles for analysis. The concentration of mineral elements (Ca, N, P, Mg, K, Mn, Cu and Zn) was read using atomic absorption spectrophotometer (Model 372) and the analyzed concentration of each mineral was used to calculate the mineral balance for each experimental diet.

The variables monitored were;

i) Apparent Digestibility (AD)

Apparent Digestibility (AD) of the macro minerals Calcium (Ca), Magnesium (Mg) Phosphorus (P), Potassium (K), and micro minerals Copper (Cu), Zinc (Zn), Manganese (Mn) was calculated using the formula:

$$\frac{\text{Mineral intake (DM basis)} - \text{Mineral output in faeces} \times 100}{\text{Mineral intake (DM basis)}}$$

ii) Mineral balance

Mineral balance was calculated using the formula:

Mineral intake (in concentrate + grass) (DM basis) – Mineral output (in faeces + urine)

iii) Mineral Retention calculated using the formula:

$$= \frac{\text{Mineral balance}}{\text{Mineral intake}} \times \frac{100}{1}$$

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA) using (SAS, 2014) and significant differences were declared at 5% probability level and means were separated using Duncan Multiple Range Test.

Results

Table 2: Chemical composition (g/100g DM) of the experimental diet fed to the pregnant WAD goats

Parameters (%)	T1 (0%)	T2 (25%)	T3 (50%)	T4 (75%)	SEM
Dry matter	91.39^{a}	87.540^{c}	83.95^{d}	89.16^{b}	0.061
Crude protein	15.75^{a}	17.50^{a}	19.25^{a}	21.00^{a}	3.200
Ether extract	14.40^{a}	12.60^{ab}	11.55^{ab}	10.15^{b}	0.842
Ash	5.45^{c}	10.85^{b}	10.65^{b}	16.80^{a}	0.266
Neutral Detergent Fibre	85.94^{a}	76.69^{b}	73.10^{c}	72.36^{c}	0.243
Acid Detergent Fibre	33.20^{b}	32.10^{b}	29.10^{c}	37.30^{a}	0.532
Hemi cellulose	31.90^{a}	27.90^{b}	24.10^{c}	21.10^{d}	0.640
Calcium	0.231^{d}	0.334^{b}	0.295^{c}	0.423^{a}	0.00744
Nitrogen	2.520^{c}	2.800^{bc}	3.080^{ab}	3.360^{a}	0.16200
Manganese	0.0135^{a}	0.0102^{c}	0.0112^{b}	0.0096^{d}	0.00006
Phosphorus	0.160^{a}	0.147^{b}	0.144^{c}	0.152^{b}	0.00160
Magnesium	0.055^{b}	0.070^{a}	0.070^{a}	0.070^{a}	0.000123
Potassium	0.160^{a}	0.156^{b}	0.156^{b}	0.155^{b}	0.000931
Copper	0.0012^{a}	0.0008^{b}	0.0008^{b}	0.0012^{a}	0.000025
Zinc	0.0064^{b}	0.0051^{c}	0.0064^{b}	0.0070^{a}	0.000055

***SEM=Standard error of mean;

^{ab}Means bearing different superscript letters within the same row differ significantly ($P < 0.05$)

Treatment 1: Control diet 0% CLM replacement of PKC + 0% CPM replacement of wheat offal

Treatment 2: 25% CLM replacement of PKC + 25% CPM replacement of wheat offal

Treatment 3: 50% CLM replacement of PKC + 50% CPM replacement of wheat offal

Treatment 4: 75% CLM replacement of PKC + 75% CPM replacement of wheat offal

CPM= Cassava peel meal; CLM= Cassava leaf meal; PKC = Palm Kernel cake

Calcium (Ca) and Manganese (Mn) utilization pattern in the pregnant West African dwarf goats shown in Table 3

Calcium (Ca) intake for the goats in T2, T3 and T4 as well as for T1, T2 and T3 did not vary significantly. But Calcium intake between pregnant goats in T1 and those in T4 showed significant variation while Calcium excreted in the faeces of the animals did not vary significantly. However, calcium output in the urine was significantly highest in T4, with T1, T2 and T3 showing no significant differences.

Digestibility of Ca was highest in T2 (90.13) and varied significantly from T1, though not significantly different from values obtained for T3 and T4. Pregnant goats in T4 and T2 had Ca balance values that did not vary significantly but Ca balance in T4 was significantly from T1 (control). Calcium retention was high across the treatments with no significant differences existing among T2, T3 and T4. Thus, showing the same trend as the Ca digestibility of the pregnant West African dwarf goats.

The Mn intake of pregnant goats in T1 did not vary significantly from those in T3. Also, no significant variations existed between the Mn values obtained for T2 and T4 and no significant variations were observed for both faecal and urine output across the treatments as well as the Mn digestibility and Mn retention observed for the pregnant goats across the treatments. Results of Mn balance obtained for the respective treatments followed the pattern of Mn intake during this study.

Table 3: Calcium (Ca) and Manganese (Mn) utilization by pregnant WAD goats fed Guinea grass basal diet and cassava peel and leaf meal based concentrate supplement

	Diets				
Parameter	**T1**	**T2**	**T3**	**T4**	**SEM**
Calcium					
Intake (g/d)	1.909^{b}	2.184^{ab}	2.159^{ab}	2.821^{a}	0.198
Output (g/d)					
Faeces	0.354^{a}	0.210^{a}	0.332^{a}	0.334^{a}	0.0524
Urine	0.019^{b}	0.020^{b}	0.015^{b}	0.030^{a}	0.003
Ca Digestibility (%)	81.66^{b}	90.13^{a}	84.99^{ab}	87.91^{ab}	1.903
Ca Balance (g/day)	1.536^{b}	1.954^{ab}	1.812^{b}	2.457^{a}	0.183
Ca Retention (%)	80.69^{b}	89.21^{a}	84.30^{ab}	86.84^{ab}	1.972
Manganese (Mn)					
Intake (g/d)	0.085^{a}	0.058^{b}	0.066^{ab}	0.061^{b}	0.0057
Output (g/d)					
Faeces	0.030^{a}	0.024^{a}	0.024^{a}	0.022^{a}	0.0029
Urine	0.0002^{a}	0.0001^{a}	0.0002^{a}	0.0002^{a}	0.00004
Digestibility (%)	56.68^{a}	64.87^{a}	63.20^{a}	66.71^{a}	3.646
Balance (g/d)	0.055^{a}	0.034^{b}	0.042^{ab}	0.039^{b}	0.0045
Retention (%)	64.74^{a}	57.96^{a}	63.88^{a}	63.25^{a}	3.678

Note*** Same as in Table 2 above

Nitrogen intake values obtained did not vary significantly. Excretion of nitrogen in the urine was higher than that in the faeces. Urine nitrogen (g/d) values varied significantly and ranged between 0.304-3.325 while faecal nitrogen (g/d) values were between 0.530-0.810 and showed no significant variation. Nitrogen digestibility across the treatments was higher than 90 % and values did not vary significantly. Also, nitrogen balance values across the treatments were positive and did not show significant variation. Nitrogen retention was highest in treatment 3 and value recorded was significantly different from T1, T2 and T4.

Phosphorus utilization (intake, faecal and urine output, digestibility, balance, retention) values obtained among the treatments were not influenced by the respective diets fed to the pregnant West African dwarf goats.

Table 4: Nitrogen (N) and Phosphorus (P) utilization by pregnant WAD goats fed Guinea grass basal diet and cassava peel and leaf meal-based concentrate supplement

	Diets				
Parameters	**T1**	**T2**	**T3**	**T4**	**SEM**
Nitrogen					
Intake (g/d)	15.080[a]	14.020[a]	16.080[a]	17.990[a]	1.530
Output (g/d)					
Faeces	0.810[a]	0.530[a]	0.675[a]	0.574[a]	0.007
Urine	1.365[b]	1.544[b]	0.304[c]	3.325[a]	0.210
Digestibility (%)	94.71[a]	95.94[a]	95.86[a]	96.80[a]	0.688
Balance (g/day)	12.910[a]	12.010[a]	15.100[a]	14.090[a]	1.455
Retention (%)	85.65[b]	84.89[b]	93.86[a]	78.16[c]	1.285
Phosphorus					
Intake (g/d)	0.981[a]	0.784[a]	0.810[a]	0.874[a]	0.0076
Output (g/d)					
Faeces	0.366[a]	0.223[a]	0.245[a]	0.262[a]	0.0446
Urine	0.0085[a]	0.0035[a]	0.0039[a]	0.0061[a]	0.0028
Digestibility (%)	63.11[a]	70.65[a]	70.45[a]	69.46[a]	4.1674
Balance (g/day)	0.973[a]	0.781[a]	0.806[a]	0.868[a]	0.0748
Retention (%)	62.27[a]	70.27[a]	69.92[a]	68.79[a]	4.0938

Note*** Same as in Table 2 above

Magnesium (Mg) and Potassium (K) utilization by pregnant WAD goats fed Guinea grass basal diet and cassava peel and leaf meal-based concentrate supplement is shown in Table 5. Magnesium intake and output (faeces and urine) values obtained during this study were not significantly influenced by the respective treatments fed to the pregnant animals. Output of Mg was more through the faecal route than the urinary route. Digestibility and retention of Mg was not significantly different among the treatments likewise the balance of Mg which was positive across the treatments.

Potassium intake was not significantly affected by diet. Faecal output of K was highest in T1, though not significantly different from those of T3 (0.374) and T4 (0.490). In addition, no significant variations were observed in the K values for T2 (0.332), T3 (0.374) and T4 (0.490). K excretion in the urine followed the pattern of K intake by the pregnant goats. The digestibility values of K were high and no significant differences were observed between values obtained for T2, T3 and T4 likewise between T1 and T4. Also, the K balance values were not significantly influenced by treatment results of Copper (Cu) and Zinc (Zn) utilization obtained during this study revealed that Cu excreted in the faeces (g/d) by the animals in the different treatment diets did not show any significant variations. The highest output in the urine was 0.0001 in all the treatments. Cu balance (g/d) obtained was positive for the respective treatments. The variations among the treatments were significant and followed the same pattern as observed in Cu intake from concentrate. The control had the highest Cu balance (0.0057) while the least balance was recorded in treatment 2 (0.0026). Cu retention (%) was influenced by the experimental diets fed to the pregnant WAD goats. Thus, treatments 1 (79.40) and 4 (79.23) which had similar and non-significant variations

Table 5: Magnesium (Mg) and Potassium (K) utilization by pregnant WAD goats fed Guinea grass basal diet and cassava peel and leaf meal based concentrate supplement

Parameters	Diets				
	T1	**T2**	**T3**	**T4**	**SEM**
Magnesium (Mg)					
intake (g/d)	0.755^{a}	0.798^{a}	0.873^{a}	0.808^{a}	0.138
Mg output (g/d)					
Faeces	0.330^{a}	0.276^{a}	0.328^{a}	0.264^{a}	0.098
Urine	0.016^{a}	0.021^{a}	0.024^{a}	0.030^{a}	0.018
Mg Digestibility (%)	56.68^{a}	64.87^{a}	63.20^{a}	66.71^{a}	9.428
Mg Balance (g/day)	0.409^{a}	0.501^{a}	0.521^{a}	0.515^{a}	0.110
Mg Retention (%)	53.86^{a}	62.80^{a}	60.56^{a}	63.24^{a}	9.220
Potassium (K)					
Intake (g/d)	1.584^{a}	1.455^{a}	1.580^{a}	1.603^{a}	0.129
Output (g/d)					
Faeces	0.618^{a}	0.332^{b}	0.374^{ab}	0.490^{ab}	0.072
Urine	0.169^{a}	0.106^{a}	0.056^{a}	0.136^{a}	0.036
Digestibility (%)	61.40^{b}	76.78^{a}	76.88^{a}	68.63^{ab}	4.062
Balance (g/day)	0.796^{a}	1.018^{a}	1.150^{a}	0.978^{a}	0.106
Retention (%)	50.83^{b}	69.85^{a}	73.22^{a}	60.25^{ab}	4.493

Note*** Same as in Table 2 above

were significantly different from treatment 2 (54.77) and treatment 3 (59.29) which were similar.

Digestibility of Cu was not significantly different between treatment 1 and treatment 4. Also Cu digestibility between treatments 2 and 3 was also not significant. However, digestibility of T1 (80.10) and T4 (80.41) were significantly different from those of T2 (55.16) and T3 (60.34). Zinc intake followed the same trend as the intake from the concentrate. Values obtained were 0.0354, 0.0240, 0.0309 and 0.0351 for T1, T2, T3 and T4 respectively. Zinc output (g/d) from both faeces and urine were similar ($P > 0.05$) in all the treatments.

Discussion

High Calcium digestibility (%) and retention (%) obtained during this study were in line with the works of Ekeocha (2012) who reported high retention and digestibility during a study on nutritional composition and mineral profile of pregnant West African dwarf ewes fed Mexican sunflower leaf meal based diets. The high Ca retention recorded in pregnant animals on all the treatments studied could be due to efficient use of mineral present and to the high absorptive rate in intestine in order to meet its physiological processes (Jarrige, 1999). The calcium intake from concentrate and grass recorded during this study were not significant. The positive Ca balance also showed that the diets were not Ca deficient, as there was no sign of calcium deficiency such as hypocalcaemia, hypercalciuria, osteomalacia, osteoporosis, rickets, knee knuckles in the pregnant animals fed the respective treatments and this implied that calcium was efficiently utilized and absorbed (Chesworth, 1992). The utilization of N which showed the N-intake, output, balance, retention and digestibility revealed that all the treatment

Table 6: Copper (Cu) and Zinc (Zn) utilization by pregnant WAD goats fed Guinea grass basal diet and cassava peel and leaf meal based concentrate supplement

Parameter	Diets				
	T1	T2	T3	T4	SEM
Copper (Cu)					
Intake (g/d)	0.0072[a]	0.0046[b]	0.0049[b]	0.0068[a]	0.0002
Output (g/d)					
Faeces	0.0015[a]	0.0020[a]	0.0020[a]	0.0013[a]	0.0001
Urine	0.0001[ab]	0.0002[b]	0.0001[ab]	0.0001[a]	0.0001
Digestibility (%)	80.10[a]	55.16[b]	60.34[b]	80.41[a]	1.9889
Balance (g/day)	0.0057[a]	0.0026[b]	0.0029[b]	0.0054[a]	0.0002
Retention (%)	79.40[a]	54.77[b]	59.29[b]	79.23[a]	1.9067
Zinc (Zn)					
Intake (g/d)	0.0354[a]	0.0240[b]	0.0309[ab]	0.0351[a]	0.0014
Output (g/d)					
Faeces	0.0107[a]	0.0085[a]	0.0090[a]	0.0120[a]	0.0008
Urine	0.0002[a]	0.0001[a]	0.0002[a]	0.0004[a]	0.0001
Digestibility (%)	70.14[a]	63.30[a]	71.61[a]	65.31[a]	2.0914
Balance (g/day)	0.0246[a]	0.0154[b]	0.0218[ab]	0.0227[ab]	0.0012
Retention (%)	70.14[a]	63.30[a]	71.61[a]	65.31[a]	2.0914

Note*** Same as in Table 2 above

diets were able to satisfy the protein requirement of the doe and the unborn kid for maintenance and development, as there were no still births during the study. Values obtained for faecal nitrogen were lower than values recorded for nitrogen in the urine. This according to Hadjipanayiotu *et al.* (1991) may be due to the high crude protein (CP) content of the diet resulting in high concentration of rumen ammonia nitrogen (NH_3–N), which rumen microorganisms cannot efficiently utilize, and the ammonia (NH_3) is excreted through the urine. This is at variance with the findings of Olomola *et al*. (2008). Positive N – balances ranging from 12.010 – 15.100 for the four respective dietary treatments (T1 – T4) during this study was close to the 15.0 to15.8 recorded by Olomola *et al*. (2008). The high nitrogen retention may have been the result of high digestibility of nutrients and reduction in N-loss in the urine of animals on all diets of cassava compared with the control (Oni *et al*., 2010). In addition, the N balance obtained during this study, was found to increase with a corresponding increase in cassava leaf meal for the respective treatments. This is in line with the findings of Oni *et al*. (2010) who reported increasing nitrogen levels with increasing inclusion levels of dried cassava leaves (*Manihot esculenta*, Crantz) based concentrates during a study of growing West African Dwarf goats. Manganese (Mn) is needed for normal reproduction in mammals, with its deficiency symptoms being delayed sexual maturity, irregular ovulation. The treatment effects on observed variations were not significant for Mn digestibility and retention which corroborates the findings of Ekeocha, (2012). This may be as a result of proper and uniform utilization of Mn in the respective diets. In addition, Mn balance was positive for all the respective diets studied. This agrees with earlier findings of Reid *et al*. (1987); Robertson *et al*. (1996) and Ekeocha, (2012). The foetus is completely dependent on the doe for its supply of minerals such as Manganese. Its deficiency in gestating ruminants has deleterious effect on the developing embryo, inadequate dietary Manganese induces an abnormal development of the epiphyseal foetal cartilage Deficiencies in Cu and Mn can cause abortion and lowered reproductive performance, Poor conception especially in young ewes, normally developed but still born kids.

Since there were no differences in the digestibility, balance and retention of Phophorus (P), there was no short-term deficiency in all diets and thus no need for supplementation to improve animal performance (McGowan *et al*, 1995). With the exception of animals on treatment D, higher intake lead to higher faecal and urinary excretion of P and this is in line with earlier reports (Reid *et al*, 1987). There was a concomitant increase in P intake and a decrease in urinary phosphorus. The high value of phosphorus obtained in this experiment did not elicit a decrease in Ca retained. Since the diet was adequate in phosphorus, with no calcium: phosphorus imbalance, there was no clinical sign of depraved appetite (pica also referred to as allotriophagia) (Elshahawy and Aly, 2016) in all the treatments.

The total magnesium intake ranging from 0.755-0.873 g/d and output ranging from 0.292 – 0.351 g/d observed during this study is in consonance with earlier reports of Reid *et al*. (1987) and Robertson *et al*. (1996). In addition, magnesium balance obtained was positive for the respective treatments with no clinical case or symptom of tetany suggesting magnesium sufficiency for the pregnant animals on the respective diets studied. The highest value obtained from animals on treatment 1 in respect to K digestibility and retention across all treatments are indications of efficient utilization of K and also a confirmation of high absorptive rate in intestine in order to meet its physiological needs (Jarrige, 1999). Digestibility values (61.80 – 76.88%) obtained during this study was similar to those reported by Ekeocha, (2012). These high values of K utilization may be as a result of the amount and distribution of potassium within the various cell wall fraction or bioavailability (Sera *et al*., 1996). If high mineral content is present in non-degradable fraction like ligno-cellulosic portion, it will not be easily solubilized but released for absorption (Serra *et al*., 1996). Furthermore, No potassium deficiency symptom was observed during this study, indicating that up to 75% replacement of wheat offal and PKC provided sufficient K amounts in the diets of the pregnant animals.

The respective values of Copper balance (g/day) and percentage retention (%) recorded during this study was similar to 59.12 to 70.70% and 4.04 to 9.95 mg/day obtained by Ekeocha, (2012). The intake was high and balance of copper was positive respectively and thus, the animals fed the respective diets during this study did not show any clinical sign of Cu deficiency symptoms such as anaemia, bone disorder, depigmentation of hair (loss of hair colour). Cu deficiency in a diet may be caused by inadequate intake. It is essential for development of central nervous system of the embryonic lamb, poor production, lighter or faded hair coat colour, infertility, poor health and slowed growth and some forms of metabolic bone disease, diaorrhea and possibly a greater susceptibility to internal parasites.A minimal level of 10 ppm in the diet prevents deficiencies. Excessive dietary calcium may increase the likelihood of Zinc deficiency in goats. The treatment effects on observed variations were not significant for absorbed, digestibility, balance and retention. The trend in intake, faecal and urinary excretion observed in this experiment was in consonance with earlier reports (Reid *et al*., 1987; Robertson *et al*., 1996) that excretion of minerals though the apparent retention was similar. The value obtained for retention revealed that CPM and CLM in concentrate supplements of pregnant WAD goats could sustain the physiological requirements for pregnancy. There was no sign of Zn deficiency like decreased appetite, retarded growth, gross lesion in the epithelial tissues i.e. tumor or disorder of the hair coat.

Conclusion

The retention and digestibility values of the understudied minerals obtained for the animals in treatments 2, 3 and 4 were high, and all the balance values obtained were positive in relation to the control. Thus, the mineral utilization of pregnant goats in the aforementioned treatments compared favourably with results of pregnant goats in control. Also, nitrogen balance significantly increased with increase in CLM. This investigation has shown that Wheat offal and PKC can be replaced at 25, 50 and 75 %, without negative effect on successful gestation as none of the animals in the respective treatments showed mineral deficiencies.

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