Mineral and fibre intake of West African dwarf sheep fed boiled cocoa seed testa and sorghum malt dust in cassava root meal based diets

Ettu, R.O. and Onwuka, C. F. I.

¹Agricultural Science Department, Tai Solarin University of Education, Ijebu Ode, Nigeria. ²College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Nigeria
tunjiettu@gmail.com

Abstract

The study was carried out to investigate the mineral and fibre intake of sheep fed Cocoa Seed Testa (CST) and Sorghum Malt Dust (SMD) in cassava root meal based diets. The feeding trial was conducted on the feed intake response of West African Dwarf (WAD) sheep in a completely randomized experimental design using boiled CST and SMD based-diets. A total of twenty-eight sheep were randomly allocated to 11 – 13 months of age of CST at 10, 20 and 30% levels, SMD at 10, 20 and 30% levels and a control. The experiment lasted 90 days. Data generated were computed and subjected to a one-way analysis of variance. In the trial, the Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL), Cellulose and Hemicellulose intake increase as the level of CST increased in the diet except for animals in treatment 3 (30% inclusion of CST). Also, NDF, ADF, ADL, Cellulose and Hemicellulose increased as the level of inclusion of SMD increased in the diet except treatment 6 (30% inclusion of SMD). The NDF intake from forage decreased as the level of SMD in the diets. The mineral intake Phosphorus, Calcium, Potassium, Magnesium, Iron, Zinc and Sulphur also followed the same pattern. The mineral intake increased as the level of inclusion of CST and SMD increased in the diet except in treatment 3 (30% inclusion of CST) and treatment 6 (30% inclusion of SMD) where the value obtained dropped. It was concluded that minerals available in the diets containing boiled Cocoa Seed Testa and Sorghum Malt Dust were significantly ($P < 0.05$) better in their utilization by sheep that consumed boiled Sorghum Malt Dust based diets.

Keywords: West African Dwarf, Cocoa Seed Testa, Sorghum Malt Dust.

Introduction

The long term survival of traditional livestock production system within the rapidly evolving national economy of Africa will depend on their capacity to provide products in quantities and at prices which satisfy the subsistence and income needs of livestock producers. Equally, the survival of these production systems will depend on the availability of feed materials in the right quantity and quality for animal intake. There are various factors which influence the nutritional requirement of sheep which should be put into consideration when formulating the sheep diets. Some of these factors are temperature, genetic factor, age, sex and

purpose of production (Durojaye, 1997). The requirement for any nutrient is the amount of that nutrient which must be supplied in the ration to meet the needs of the animals. Such level of nutrient must be capable of meeting the requirement for maintenance of the animals (Awujoola, 1999). Of primary importance in sheep nutrition are energy, protein, minerals, water and vitamins. Thirteen different minerals are essential in sheep nutrition with most deficient being salt and phosphorus (Clay, 2007). The crude protein and mineral contents of most browse plants are higher than what obtained in most grasses (Kapu, 1975; Milligan and Sule, 1980 and Agishi, 1983) and they

could be available for most parts of the dry season. Browse plants are quite rich in protein and minerals especially Calcium, Phosphorus and Magnesium (Carew, 1982). These are nutrients that grasses mostly lack during the dry season. Browse plants contain high percentage of crude protein in leaves, and pods and are well supplied with vitamin A (Andson and Garter, 1967) but are higher in fibre than other normal feed materials (Wilson, 1969). There is need to harness every available agricultural waste and agro-industrial by-products for livestock feeding after a nutritional evaluation which would lower the cost of production without sacrificing efficiency in livestock production. Thus, the study was conceived to determine the fibre intake (NDF, ADF, ADL, Cellulose and Hemicellulose) as well as mineral intake (P, Ca, K, Mg, Fe, Zn and S) by male West African Dwarf sheep.

Materials and Methods

Twenty-eight (28) West African Dwarf male sheep aged 11-13 months with average live weight ranged of 10.08 and 10.66 kg were used for the study. The sheep were sourced from villages around Ijebu-ode. The animals were dewormed with Levamisole at the beginning of the experiment. They were divided into seven groups balanced for weight in a completely randomized design. Each group contained four male animals while the trial lasted for 90 days. Cocoa Seed Testa was obtained from Cocoa Industry Limited, Lagos while Sorghum Malt Dust was obtained from Consolidated Breweries Limited, Imagbon, Ijebu-Ode. They were processed through boiling at 100°C to reduce the effect of the antinutritional factors. Seven experimental concentrate diets were prepared using the cocoa seed testa at 10, 20 and 30% and sorghum malt dust at 10, 20 and 30% levels with cassava root meal at 58, 48 and 38%,

Table 1: Composition of experimental diets fed to West African Dwarf sheep (%)

Ingredients	Diets						
	1	2	3	4	5	6	7
Cassava Root Meal	58	48	38	58	48	38	68
Boiled Cocoa Seed							
Testa	10	20	30	0	0	0	0
Boiled Sorghum Malt							
Dust	0	0	0	10	20	30	0
Wheat Offal	30	30	30	30	30	30	30
Premix*	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Salt	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total	100	100	100	100	100	100	100
Dry matter	89.59	89.48	89.66	89.91	89.78	89.55	89.63
Crude protein	15.18	14.37	14.28	14.57	14.89	14.76	12.06
Crude fibre	15.38	15.41	15.58	14.71	14.93	14.99	15.16

*Premix (each Kg contains):

Vitamin A: 10,000IU; Vitamin E: 70,000IU; Vitamin D: 1, 600, 000IU; Fe: 50g; Zn: 40g; Mn: 40g; Co: 0.1g; Cu: 10g; Se: 0.1g

Table 2: Chemical Composition of the Test Ingredients (g/100gDM)

Parameters	Unboiled CST	Boiled CST	Unboiled SMD	Boiled SMD	<i>Gliricidia sepium</i>
Dry matter	89.67	87.96	89.36	88.06	30.12
Crude protein	18.67	11.48	15.68	12.97	19.30
Crude fibre	21.29	19.37	13.23	12.17	12.80
Ash	8.75	6.28	5.74	4.38	10.12
Ether extract	0.85	0.81	3.27	2.96	2.16
Nitrogen free extract	40.11	50.02	51.44	55.58	55.62
Gross energy (Kcal/g)	2.974	2.869	2.968	2.925	4.61

*Average of 2 replicates

wheat offal 30%, vitamin and mineral premix 1.0% and salt 1%. Control ration was also prepared (cassava root meal 68%, wheat offal 30%, vitamin/mineral premix 1.0% and salt 1 % as shown in Table 1 The mineral and fibre intake were computed and subjected to a one-way analysis of variance using SPSS (1999). Differences between treatment means were separated using Duncan's Multiple Range Test (Duncan, 1955).

Results

The results of fibre and mineral intakes by WAD sheep fed graded levels of boiled CST and SMD based diets are shown in Table 6. The NDF and ADF intake from forage did not follow the same pattern. The NDF intake from forage increased ($P < 0.05$) as the level of inclusion of CST and SMD increased but declined significantly ($P < 0.05$) on 30% levels of inclusion of both CST and SMD. The lowest NDF intake

Table3: Mineral Composition of the Test Ingredients (g/100gDM)

	P	Ca	K	Mg	Fe	Zn	S
Sorghum Malt Dust	0.75	1.14	0.75	0.38	0.43	0.28	0.30
Cocoa Seed Testa	0.89	1.17	1.02	0.61	0.74	0.30	0.33

Table 4: Chemical composition of boiled Cocoa Seed Testa and Sorghum Malt Dust in cassava root meal based-diets (g/100gDM)

Parameters	Diets						
	1	2	3	4	5	6	7
Dry matter	89.59	89.48	89.66	89.71	89.78	89.55	89.63
Crude protein	15.18	14.37	14.28	14.57	14.89	14.76	12.06
Crude fibre	15.38	15.41	15.58	14.71	14.92	14.99	15.16
Ether extract	2.55	2.59	2.64	2.66	2.58	2.61	2.53
Ash	11.16	10.68	10.76	10.96	10.91	10.46	11.13
Nitrogen Free Extract	45.32	46.43	46.4	46.81	46.48	46.78	48.75
NDF	1.51	1.46	1.42	1.38	1.32	1.34	1.41
ADF	1.46	1.37	1.33	1.26	1.29	1.28	1.38
ADL	0.18	0.17	1.01	0.08	0.06	0.11	0.13

Diet 1 = 10% inclusion of CST, Diet 2 = 20% inclusion of CST, Diet 3 = 30% inclusion of CST, Diet 4 = 10% inclusion of SMD, Diet 5 = 20% inclusion of SMD, Diet 6 = 30% inclusion of SMD, Diet 7 = 0% inclusion of SCT and SMD

from forage came from diet 1 (10% inclusion of CST). NDF intake from forage were significantly ($P<0.05$) different from each other except diets 4 and 5 (10% and 20% inclusion of SMD) which were not significantly ($P>0.05$) different. The highest intake was from animals on diets 5. ADF intake from forage shows a significant difference ($P<0.05$) among the treatment, though, the highest value was from diet 5 (41.89g/d).

NDF and ADF intakes from concentrates were also significantly different ($P<0.05$) from each other with the highest value from diet 4 for NDF intake from concentrate (42.12g/d) and from diet 5 for ADF intake from concentrate (41.89g/d).

There were significant differences ($P<0.05$) in ADL intakes for both concentrate and forage in all the diets but the lowest intake of ADL from forage was observed in diet 1 while the lowest intake of ADL from concentrate was from diet 5. The Metabolic ADL intakes increased ($P<0.05$) from 13.34, 14.01, and 20.24 g/dW^{0.75} for CST inclusion in diets and also from 13.64 to 13.65 with a decline to 13.44g/dW^{0.75} for SMD inclusion in the diets.

The phosphorus intake values from concentrate in diets 1, 2 and 3 were lower

than the intakes from diets 4, 5 and 6. There was no significant difference ($P>0.06$) in P intake from concentrate between diets 1, 2 and 3 also and significant difference ($P>0.05$) in diets 4, 5 and 6 and control diet. P intake from forage showed a similar trend among diets 1, 2 and 3 (CST inclusion) and diets 4, 5 and 6 (SMD inclusion). There were significant differences ($P<0.05$) in the diets except diets 2, 4 and 6 where no significant difference ($P>0.05$) occurred.

Calcium intake did not significantly ($P>0.05$) decrease as the level of inclusion of CST increased from diets 1 to 2 with an increase in diet 3. Also, significant differences ($P>0.05$) were not observed in with the inclusion of SMD in diets 4, 5 and 6, though, the lowest Ca intake was from the control diet. The metabolic Ca intake significantly differed ($P<0.05$) except for diets 2, 4 and 5 on one side and diets 1, 3 and 6 on the other side.

Potassium intake from concentrate was significantly affected by dietary treatment because the value increased as the level of inclusion of CST increased (Diets 1, 2 and 3) but the value decreased as the levels of inclusion of SMD increased (Diets 4 and 5) with an increase in diet 6. The highest value of 2.91g/d was obtained in diet 4 and the

Table 5: Mineral composition of boiled Cocoa Seed Testa and Sorghum Malt Dust in cassava root meal based-diets (g/100gDM)

Parameters	Diets						
	1	2	3	4	5	6	7
Phosphorus	1.82	1.77	1.68	1.85	1.93	1.95	2.01
Calcium	0.91	0.83	0.88	0.82	0.79	0.61	0.69
Potassium	0.63	0.66	0.71	0.73	0.67	0.76	0.73
Magnesium	0.15	0.14	0.15	0.14	0.12	0.11	0.14
Iron	0.041	0.051	0.053	0.055	0.052	0.058	0.054
Zinc	0.012	0.014	0.012	0.011	0.012	0.015	0.013
Suplhur	0.16	0.15	0.17	0.16	0.15	0.14	0.13

Diet 1 = 10% inclusion of CST, Diet 2 = 20% inclusion of CST, Diet 3 = 30% inclusion of CST, Diet 4 = 10% inclusion of SMD, Diet 5 = 20% inclusion of SMD, Diet 6 = 30% inclusion of SMD, Diet 7 = 0% inclusion of SCT and SMD

lowest value of 2.19 g/d in diet 1.

Potassium intake from forage followed the pattern of that of concentrate, though, the highest value obtained was from diet 5 (3.58g/d) and lowest value from control diet (3.30g/d). Magnesium intake from concentrate was also significantly ($P<0.05$) affected by dietary treatments, although, there was no significant difference between diets 1 and 2 as well as diets 3 and 4. Highest total Mg intake was from diet 5 (3.24g/d) in numerical term. Higher metabolic Mg intake was also obtained in diet 5 (2.41g/dW^{0.75}) but not significantly different ($P>0.05$) from diets 1 and 3.

Zn intake from concentrate was significantly ($P>0.05$) affected by dietary treatments but as the value increases numerically for diets 4, 5 and 6 (SMD inclusion), it fluctuates in diets 1, 2 and 3 (CST inclusion). However, there were significant differences ($P<0.05$) in the metabolic Zn intakes across the diets excepts for diets 1, 3 and 7 on one side and diets 4 and 5 on the other side.

Fe intakes from concentrate and forage were significantly ($P<0.05$) affected by the levels of inclusion of CST and SMD. The only significant difference ($P<0.05$) in concentrate occurred between diet 1 and other diets as other diets (2, 3, 4, 5 and 6) were not significantly ($P>0.05$) different from each other. Highest metabolic Fe intake was observed in diet 5 (1.79g/dW^{0.75}) though not significantly different from diets 2, 4 and 6.

Sulphur intakes from concentrate and forage were also affected by dietary treatments. There was no significant difference in values obtained for diets 1, 2 and 6 as well as diets 3, 4 and 5 in the intakes from concentrate. There was also no significant difference in the total sulphur intakes in diets 1, 2 and 3 (CST inclusion). The highest value of total sulphur intake

was observed in diet 5 but not significantly different ($P>0.05$) from diet 4.

Discussion

Ruminant generally requires adequate coarse insoluble fibre for normal rumen function which is associated with adequate rumination and cellulose digestion. The level of fibre intake in this experiment was as a result of the nature of the feed consumed. The boiling method of processing CST and SMD was in line with the assertion of Olubamiwa *et al.* (2002) that boiling treatment was established to be the most effective physical method in detheobromising coca bean shell for feeding livestock and also, Sigma (1993) reported that heating and fermentation are ways of reducing toxicity level of anti-nutritional factors. Sigma (1993) reported that heating and fermentation are ways of reducing toxicity level of anti-nutritional factors. Bell (1997) reported that an increase in the NDF content of a feed results in decreased feed intake. Also, NDF of feed is better related to intake and gastro intestinal fill than any other measure of fibre (Van Soest 1994). Cellulose and hemicellulose intake depend on the intake of NDF, ADF and ADL, and the proportion of each in the diet. High protein contents of supplementary have been noted to enhance the intake of NDF (Egan and Doyle, 1985). The mineral composition of the basal diet fell within the values obtained for calcium, phosphorus and magnesium 1.3, 0.2 and 0.5%, respectively by Carew *et al.* (1980). According to Onwuka and Akinsoyinu (1988) the presence of mineral elements in animal feed is vital for the animal's metabolic processes. The Ca: P ratios were moderate in all the diets. NRC (1981) recommended ratio 1:2 for ruminants which was within the values obtained in this study. This may be as a result of moderate level of P in all the treatments. Values

Table 6: Fibre and Mineral intakes of West African Dwarf sheep fed graded levels of boiled Cocoa Seed Testa and Sorghum Malt Dust in cassava root meal based diets

Parameters	Diets							SEM
	1	2	3	4	5	6	7	
NDF intake from concentrate	39.39 ^a	40.94 ^a	38.60 ^a	42.12 ^a	40.54 ^b	37.88 ^c	38.07 ^c	0.77
NDF from forage	39.49 ^d	42.53 ^b	41.15 ^c	44.20 ^a	45.11 ^a	41.71 ^{bc}	40.29 ^d	0.99
Total NDF intake	78.88 ^a	83.47 ^c	79.75 ^d	86.32 ^a	85.65 ^b	79.59 ^d	78.36 ^e	0.61
Metabolic NDF intake ^b	26.46 ^a	27.61 ^b	26.68 ^a	28.31 ^a	28.15 ^a	26.64 ^c	26.33 ^c	0.35
ADF intake from concentrate	38.09 ^c	38.41 ^b	35.96 ^f	38.46 ^b	39.62 ^a	36.18 ^e	37.26 ^d	0.30
ADF intake from forage	36.67 ^d	39.50 ^a	38.21 ^a	41.04 ^b	41.89 ^a	38.73 ^d	37.41 ^f	0.48
Total ADF intake	74.76 ^d	77.91 ^a	73.90 ^a	79.58 ^b	81.51 ^a	74.91 ^d	74.67 ^d	0.50
Metabolic ADF intake ^b	25.42 ^d	26.22 ^a	25.20 ^a	26.62 ^b	27.12 ^a	25.46 ^d	25.40 ^d	0.35
ADL intake from concentrate	4.69 ^a	4.76 ^b	27.10 ^a	2.44 ^c	1.84 ^f	3.10 ^d	3.51 ^c	0.02
ADL intake from forage	26.95 ^b	29.03 ^a	28.09 ^a	30.17 ^b	30.79 ^a	28.87 ^d	27.50 ^f	0.44
Total ADL intake	31.64 ^{cd}	33.79 ^b	55.19 ^a	32.61 ^c	32.63 ^c	31.97 ^e	30.01 ^e	0.73
Metabolic ADL intake ^b	13.34 ^c	14.01 ^b	20.24 ^a	13.64 ^c	13.65 ^c	13.44 ^c	12.82 ^d	0.31
Cellulose intake from concentrate	1.90 ^d	2.53 ^c	2.91 ^b	3.66 ^a	0.92 ^f	1.70 ^e	0.81 ^f	0.12
Cellulose intake from forage	2.82 ^d	3.03 ^b	2.94 ^a	3.16 ^a	3.22 ^a	2.98 ^c	2.88 ^d	0.09
Total cellulose intake	4.72 ^d	5.56 ^c	5.85 ^b	6.82 ^a	4.14 ^e	4.68 ^c	3.69 ^f	0.13
Metabolic cellulose intake ^b	3.20 ^e	3.62 ^b	3.76 ^b	4.22 ^a	2.90 ^d	3.18 ^c	2.66 ^e	0.16
Hemicellulose intake from concentrate	33.40 ^c	33.65 ^c	8.59 ^d	36.02 ^b	37.78 ^a	33.08 ^c	33.75 ^c	0.82
Hemicellulose intake from forage	9.72 ^e	10.47 ^c	10.12 ^d	10.87 ^b	11.10 ^a	9.86 ^b	9.91 ^d	0.17
Total Hemicellulose intake	43.12 ^d	44.12 ^c	18.71 ^f	46.71 ^b	48.88 ^a	42.94 ^c	43.66 ^d	0.59
Metabolic cellulose intake ^b	16.82 ^d	17.11 ^c	8.99 ^e	17.91 ^b	18.48 ^a	16.77 ^d	16.98 ^d	0.46
P intake from concentrate	6.31 ^b	6.69 ^b	6.17 ^b	24.05 ^a	28.00 ^a	25.92 ^a	25.86 ^a	5.12
P intake from forage	8.19 ^c	8.47 ^b	8.02 ^d	8.31 ^d	8.65 ^a	8.44 ^b	7.96 ^d	0.15
Total P intake	14.50 ^c	15.16 ^c	14.19 ^c	32.36 ^b	36.65 ^b	43.36 ^a	33.82 ^b	6.30
Metabolic P intake ^b	7.43 ^b	7.68 ^b	7.31 ^b	13.56 ^a	14.89 ^a	14.19 ^a	14.02 ^c	1.92
Ca intake from concentrate	3.16 ^{ab}	3.14 ^{ab}	3.32 ^a	3.27 ^a	3.20 ^{ab}	2.52 ^b	2.47 ^b	0.70
Ca intake from forage	5.85 ^{bc}	6.05 ^{ab}	5.73 ^c	5.94 ^b	6.18 ^a	6.03 ^{ab}	5.70 ^c	0.20
Total Ca intake	9.01 ^b	9.19 ^{ab}	8.96 ^c	9.21 ^{ab}	9.38 ^a	8.55 ^c	8.17 ^d	0.35
Metabolic calcium intake ^b	5.20 ^{bc}	5.27 ^a	5.17 ^{bc}	5.28 ^a	5.35 ^a	5.00 ^c	4.83 ^d	0.10
K intake from concentrate	2.19 ^f	2.50 ^e	2.61 ^c	2.91 ^a	2.44 ^c	2.81 ^b	2.62 ^c	0.03
K intake from forage	3.39 ^d	3.51 ^b	3.32 ^e	3.44 ^a	3.58 ^b	3.50 ^b	3.30 ^c	0.02
Total K intake	5.58 ^c	6.01 ^b	5.93 ^b	6.35 ^a	6.02 ^b	6.31 ^{ab}	5.92 ^b	0.30
Metabolic K intake ^b	3.63 ^c	3.83 ^b	3.80 ^b	4.00 ^a	3.84 ^b	3.98 ^a	3.79 ^b	0.06
Mg intake from forage	2.61 ^d	2.70 ^c	2.56 ^e	2.65 ^c	2.76 ^c	2.69 ^c	2.54 ^d	0.01
Total Mg intake	3.13 ^c	3.23 ^a	3.11 ^{bc}	3.21 ^a	3.24 ^a	3.10 ^{bc}	3.04 ^c	0.07
Metabolic Mg intake ^b	2.35 ^b	2.40 ^{ab}	2.34 ^b	2.39 ^{ab}	2.41 ^a	2.33 ^b	2.30 ^b	0.05
Fe intake from concentrate	0.14 ^b	0.19 ^a	0.19 ^a	0.22 ^a	0.21 ^a	0.21 ^a	0.19 ^a	0.03
Fe intake from forage	1.86 ^d	1.92 ^b	1.82 ^c	1.89 ^c	1.97 ^a	1.91 ^{ab}	1.80 ^c	0.02
Total Fe intake	2.00 ^{de}	2.11 ^c	2.01 ^d	2.12 ^b	2.18 ^a	2.12 ^b	1.99 ^c	0.01
Metabolic Fe intake ^b	1.68 ^b	1.75 ^a	1.68 ^b	1.75 ^a	1.79 ^a	1.75 ^a	1.67 ^b	0.04
Zn intake from concentrate	0.04	0.05	0.04	0.04	0.04	0.05	0.04	0.02
Zn intake from forage	0.11 ^b	0.12 ^{ab}	0.11 ^b	0.12 ^{ab}	0.12 ^{ab}	0.13 ^a	0.11 ^b	0.01
Total Zn intake	0.15 ^a	0.17 ^{ab}	0.15 ^b	0.16 ^b	0.16 ^b	0.18 ^a	0.15 ^b	0.01
Metabolic Zn intake ^b	2.41 ^d	2.64 ^b	2.41 ^d	2.52 ^c	2.52 ^c	2.76 ^a	2.41 ^d	0.06
S intake from concentrate	0.56 ^b	0.57 ^a	0.62 ^a	0.64 ^a	0.61 ^{ab}	0.52 ^b	0.55 ^c	0.04
S intake from forage	1.32 ^d	1.27 ^b	1.30 ^{ab}	1.34 ^c	1.40 ^a	1.36 ^{bc}	1.28 ^c	0.02
Total S intake	1.88 ^b	1.94 ^b	1.92 ^a	1.98 ^a	2.01 ^a	1.88 ^b	1.33 ^c	0.06
Metabolic S intake ^b	1.60 ^b	1.64 ^{ab}	1.63 ^a	1.66 ^{ab}	1.68 ^a	1.60 ^b	1.23 ^c	0.04

b = g.dW^{0.75}, others = g.d¹.

abc means along the same row with different superscripts are significantly different (P < 0.05)

obtained for most of the minerals in this study can meet the nutrient requirements of ruminant (NRC, 1981).

The major minerals appeared adequate for ruminant animals based on the recommendation of 0.71 – 0.21g/100g Mg (ARC 1980; Suttle, 1983), 0.5 -1.5g/100gK (Mc Dowell, 1992) and 0.17 -1.53g/100g Ca (NRC, 1984, 1985, 1989).

According to Mc Dowell (1972), the minimum needs of Mg for sheep for growth can generally be met by pastures or diets containing 0.10% Mg. This assertion is in line with the results obtained for all diets in this study as it ranged between 0.11 and 0.15%Mg.

Conclusion

Minerals available in the diets containing boiled Cocoa Seed Testa and Sorghum Malt Dust were significantly better in their utilization by sheep fed boiled Sorghum Malt Dust based diets. The experimental animals were able to accommodate its presence in the Cocoa Seed Testa after processing (boiling) to reduce the theobromine inherent in the experimental material; thereby pose no threat to the productivity of the animals. The availability of SCT and SMD as agro-industrial by-products and its inclusion in the experimental diets after processing decreased feed cost and increase the supply of essential minerals.

References

- Agishi, E. C. 1983. Mineral contents of browse plants NAPRI Annual Report, 1983. Pp. 80-81.
- Agricultural Research Council (ARC) 1980. The nutrient requirement of ruminant livestock. Technical review by Agricultural Research Council Working Party. Commonwealth Agriculture Bureau, Farnham Royal, UK.
- Andson, R. J. and Gartner R. J. W. 1967. Mulga Supplies Ample Vitamin. A. *Qdagric J.* 93: 1967; 463-465.
- Awujoola, O. M. 1999. Sheep and Goat Nutrient Requirements. Heinemann Education Books (Nig) Plc. Ibadan.
- Bell, B. 1997. Forage and feed analysis. Ontario Ministry of Agriculture feed and forage Analysis. Ministry of Agriculture and Food. Pp 1-7.
- Carew, B.A.R. 1982. Free choice response of extensively managed goats in a tropical environment. Humid Zone Programme Documents, No. 8, ILCA, Ibadan, Nigeria.
- Clay, P. M. 2000. Sheep Production and Management New Mexico State University.
- Duncan, D.B. (1955). Multiple Range and Multiple F. Tests. *Biometrics*, 11: 1 – 42.
- Durojaiye, O. A. 1997. Sheep Production, Wisdom Publishers Limited. Ibadan.
- Egan, J.K. and Doyle, P.T. 1985. Effect of intra ruminal infusion of urea on the response in voluntary food intake by sheep. *Aust. J. Agric. Res.* 36: 483 – 495.
- Kapu, A. M. 1975. The natural forage of Northern Nigeria. Nitrogen and Mineral Composition of grasses and standing hays from different Savannah zones. *Nig. J. Anim. Prod.* 2: 235 - 246
- Mc Dowell, R. E. 1992. Minerals in Animal and Human Nutrition, 1st edn. Academic Press, San Diego, CA, New York. Pp 512
- Milligan, K. and Sule, B. 1980. Natural forage resources and their dietary value. In a paper presented at the Man and Biosphere state of knowledge workshop. Held at Kanji Lake Research Institute. April 12th - 20th, 1980.
- National Research Council (NRC) 1981.

- Nutrient requirement of Angora, Dairy and meat goats in temperate and tropical countries. National Academy of Science, National Research Council Washington D. C.
- National Research Council NRC 1984.** Nutrient Requirement of Domestic Animals, Nutrient Requirement of sheep (Sixth Ed.) National Academy of Science, National Research Council, Washington, D.C., USA.
- National Research Council NRC 1985.** Nutrient requirement of sheep. 6th revised edition. National Academy Press, Washington DC., USA.
- National Research Council NRC 1989.** Nutrient requirements of Domestic Animals, Nutrient Requirements of Beef Cattle, sixth ed. National Academy of Science, National Research Council, Washington DC, USA.
- Olubamiwa, O.A., Soetan, A.A. Olamijulo, O.A., Hamzat, R.A. and Longe, O.G. 2002.** Utilization of variously treated cocoa bean shell laying hens. Proc. Malaysian International Cocoa conference, July 18 - 19, 2002, Kuala Lumpur, Malaysia. Pp. 118-119
- Onwuka, C. F. I. and Akinsoyinu, A. O. 1988.** Mineral constituents of some browse plants used in ruminant feeding in Nigeria. Small Ruminant Research, 24: 233-237.
- Sigma Chemical Company 1993.** Biochemical and organic compounds for research and diagnostic reagents. St. Louis, Mo, U.S.A. Pp. 2071 - 2135.
- SPSS 1999.** Statistical Package for Social Sciences. Procedures and facilities for release. 6.0 Users' Manual, McGraw-Hill Book Co. NY.
- Suttle, N. F. 1983.** Meeting the mineral requirement of sheep. In Haresign, W. (Ed.), Sheep production, Butterworth, London, Pp. 167-183.
- Van Soest, P.J. 1994.** Nutritional ecology of ruminants. O and B Book Inc. Corvallis, Oregon, USA.

Received: 05/09/13

Accepted: 28/02/14