Continental J. Agricultural Science
Anya and Eburu (2019) 13 (1): 1 – 18 DOI: 10.5281/zenodo.2533235

Research Article

Nutrient Intake and Nitrogen Balance of West African Dwarf (WAD) Goats fed Cassava Peel Meal Supplemented with Varying Levels of African Yambean Concentrate

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Abstract

A total of eight (8) intact West African Dwarf (WAD) bucks with a mean live weight range of 18.85 – 19.94 kg and aged between 18 and 24 months was used in a 4 × 4 Latin square experiment to determine the intake and nitrogen balance of the cassava peel meal based – diets supplemented with African Yambean Meal (AYBM) in diets T_1, T_2, T_3 and T_4 with levels of 0, 10, 20 and 30% respectively. The respective dietary treatments were assigned to individual animals in metabolism cages. Weekly body weight values were recorded, feed and dry matter intake measured and nitrogen balance study conducted. Results showed that the Dry matter intake (DMI) (g/d) values were 608.52, 572.32, 548.60 and 552.93 for diets T_1, T_2, T_3 and T_4 respectively. The values were statistically similar (P>0.05).The values generally indicated that the animals on various dietary treatments showed positive DMI status. The metabolic faecal nitrogen (MFN) (g/100gDM), endogenous urinary nitrogen (EUN) (g/day/kg $W^{0.75}$) and digestible crude protein (DCP) (g/kg $W^{0.75}$) values were 0.17, 0.19, 0.22, 0.25; 0.24, 0.03, 0.02, 0.03 and 0.44, 0.56, 0.81, 1.81 respectively for diets T_1, T_2, T_3 and T_4. All the diets promoted a positive nitrogen balance between the treatment groups.The relationship between urinary nitrogen (g/day/Wkg$^{0.75}$) and absorbed nitrogen (g/day/Wkg$^{0.75}$) was significantly (P<0.05) correlated between the control diet T_1 and diet T_3 with values of 0.91

ISSN: 2141 - 4203 Science and Education Development Inst., Nigeria

and 0.82 respectively. The correlation coefficient, however showed some remarkable improvement from 0.49 to 0.64 for diets T_2 and T_4 respectively. While both parameters were positively correlated within the AYBM diets, the coefficient of correlation was only significant ($P<0.05$) for diet T_3 (30% AYBM). Energy digestibility coefficients were 43.04, 50.37, 53.35 and 53.30% respectively for WAD bucks fed diets T_1, T_2, T_3 and T_4. The values differed ($P<0.05$) significantly among the various dietary treatments. The study concludes that AYBM meal in cassava peel based diets improved nutrient digestibility, nitrogen intake and ensured a positive nitrogen balance, thereby boosting the maintenance requirements of WAD bucks. Therefore, farmers can supplement cassava peel meal based diets with African Yambean meal up to 30% without fear of compromising digestibility of nutrients.

Key words: Nitrogen balance, nutrient retention, African yam bean, WAD bucks

Received: 22/10/18 Accepted: 04/01/19

Introduction

The current focus in the livestock industry within the sub – Saharan region is feed sufficiency that will enhance production. Livestock is the world's fastest growing agricultural sub – sector that accounts for about 40% of agricultural Gross Domestic Product (GDP) globally (Richkowsky *et al*., 2016). While providing livelihood for millions of resource – poor farmers, feed sufficiency, whether from conventional or non – conventional sources; the common goal is to get the best out of the existing or available resources for optimum animal performance. In Nigeria, increasing population pressure (about 200 million) has led to most cropped area being extended to land hitherto considered unsuitable for this purpose. Thus, feeding ruminants becomes a challenge as the poorly developed grazing reserves and related infrastructure are put to other uses, resulting in frequent forage shortage and degradation of the natural rangeland which threatens the sustainability of this farming system. Goats are a very important animal resource to the people of sub-Saharan Africa. These animals are known to improve livelihoods of smallholder farmers across the region but the challenge has often been feed availability. However, food and feed production will have to compete for land and water resources in the prevailing variability of climate change environments.

Cassava is an important annual root crop grown widely by tropical and sub-tropical farmers. It is an important part of the diet of more than 800 million people in Africa. It is the highest supplier of carbohydrates among staple crops and ranks fourth among food crops in developing countries after maize, rice and wheat (FAO, 1991). Cassava has often been associated with the rural poor, yet it has the potential to transform economies (Reeve, 2017). Increasing the productivity of Cassava through the utilization of its peels will improve the livelihood of most resource-poor livestock farmers. Cassava peels are produced in large qualities in Southern Nigeria, from the processing of cassava for human consumption to industrial and export purposes. Unfortunately, this enormous feed resource has received very little attention and more than 50 million tonnes of peels is often discarded as waste annually. Cassava peel is rich in metabolizable energy (3.03 Mcal/Kg DM) but low in nitrogen (Smith *et al*., 1988). Generally fibrous crop residues are poor sources of fermentable nitrogen, as their crude protein is below the level required by rumen microorganisms. Also, these crop residues are also low in easily degraded carbohydrates, minerals and other nutrients required to balance the products of digestion to requirements (Anya, 2018). All these result in limited intake, poor rumen function, increased methane emission and low animal productivity.

The use of African yambean (*Sphenostylis stenocarpa),* an under-exploited and often classified minor grain legume that is cheap and readily available protein source in cassava peel meal based diets is a strategy that intends to overcome the nutritional constraints of using cassava peels, it will close the feed deficit gab, reduce feed cost and sufficiently tackle seasonal fluctuations in forage quality and quantity. This would on the long run encourage increases in flock sizes, provide insurance against external shocks as well as increase the productivity of goats.

In sub-Saharan African, dry season feeding of ruminants has always been a constant challenge to farmers, particularly the smallholders and their livelihoods as feed supplies are limited. Most crop residues are the major contributors to livestock diets during this critical period. However, poor feed utilization and seasonal fluctuations in feed availability and quality are contributory factors that lead to less-than-optimal productivity of animals on these diets (Lukuyu *et al.,* 2016). Overall livestock productivity and efficiency is largely determined by feed intake, excellent digestibility, adequate utilization and maintenance of physiological balance or homeostasis.

Livestock farmers therefore need all the information to identify available feed resources and diversify sources of nutrients that would enhance nutritional efficiency of the animal.

This study was therefore carried out to investigate the utilization cassava peel meal (CPM) based diets supplemented with varying levels of African yambean concentrate fed to WAD bucks in the humid zone of Nigeria.

Materials and methods

Location of study

The experiment was carried out in the Ruminant Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike – Abia State, Nigeria. Umudike is situated within the tropical rainforest zone and witnesses an annual rainfall of about 2177mm in 148 -155 rain days. Its relative humidity is over 72% during the rainy season with an average ambient temperature of 25.5^{0}C within a range of 22 - 32^{0}C (Okereke, 2008).

Processing of cassava peel and African yambean seed meal

Cassava peels of TMS 30555 variety were collected fresh from the Department of Crop Science commercial "Garri" processing unit of the University of Calabar, Calabar. The peels were from 10-12 months old plants. The peels were properly sun dried for a period of 3-6 days during which they were regularly turned to give even drying to a moisture content of 10%. The peels could sometimes have tuber linings as a result of the method of removing the peels. The sun-dried cassava peels were then milled into 2mm sieve size with the hammer mill and used in the study as dried cassava peel meal (CPM). African yambean (*Sphenostylis stenocarpa)* seeds (Nsukka brown variety) were purchased from local famers in Obudu and Obanliku Local Government Areas in the Northern parts of Cross River State. The undecorticated brown seeds were boiled for 30 minutes following the method of Ukachukwu and Obioha (2000) for Mucuna seeds. Water was made to boil at 100^{0}C in a large (mammoth) cooking pot before the seeds were poured in. The seeds were allowed to boil for 30 minutes. Water was decanted using local baskets and the seeds sun-dried on aluminum roofing sheets for 3 days before being milled and used as yambean seed meal (AYBM) to compound the experimental diets.

Experimental diets

Four experimental diets designated T_1, T_2, T_3 and T_4 were formulated as presented in Table 1. Diet T_1 served as the control and contained no African yambean (AYBM) seed meal. DietsT_2, T_3, and T_4, contained 10, 20, and 30% of AYBM respectively. The diets were allotted randomly to the four animal groups. Each animal within a group was offered 1kg of an assigned concentrate diet daily for 90 days. The concentrate diets were fed at 0800 hour daily. Clean drinking water was provided *ad-libitum* for each animal within the period. Each animal was provided with a salt lick block.

Proximate analyses of experimental diets

All the experimental diets including CPM and African yambean seed meal AYBSM were analyzed for proximate composition using AOAC (2000) methods (Table 2).

Table 1: Gross Composition of Experimental diets

Ingredients (%)	Diets			
	T_1	T_2	T_3	T_4
Cassava peel	46.00	46.00	46.00	46.00
African yambean seed meal	-	10.00	20.00	30.00
Wheat offal	33.00	23.00	13.00	3.00
Palm kernel cake	18.00	18.00	18.00	18.00
Bone meal	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00

Table 2: Proximate composition of experimental diets, cassava peel meal (CPM) and African yambean seed meal (AYBM)

Parameter (% DM)	T_1	T_2	T_3	T_4	CPM	AYBM
Dry matter	89.44	89.35	89.42	89.62	90.10	88.50
Crude protein	10.56	10.96	11.36	11.44	3.22	22.10
Crude fibre	12.47	11.05	10.31	10.11	14.73	5.92
Ether extract	4.50	4.61	4.80	4.94	0.91	7.53
N-free extract	51.38	53.61	54.33	54.62	65.67	47.67
Ash	10.35	9.12	8.62	8.49	5.57	5.28
Gross energy (kcal/g)*	3.45	3.42	3.31	3.28	3.60	5.23

*Calculated
Each determined value was obtained from triplicate samples per treatment

Management of experimental animals

A total of eight (8) intact WAD bucks averaging 19.39±0.36kg (range 18.85 - 19.94kg) in weight and aged 1 - 1 ½ years were used to determine the digestibility of nutrients in diets used in this study following a 4 x 4 Latin square design experiment that was replicated twice (4 buckseach). The animals were selected from the goat herd of the Teaching and Research farm. The animals were first dewormed and purged of external parasites using thiabenzole and pfizona respectively. The animals were previously zero-grazed and supplementary feeding of 0.4 – 0.5kg concentrates offered per head per day. The bucks were subsequently housed in previously disinfected individual metabolism cages measuring 1.0 x 0.8 x 0.6m and offered the experimental diets in 4 phases.

Before the first phase, a preliminary period of 7-day feeding was done to get the animals conditioned to the cage environment. Each period lasted for 21 days and each buck received 1kg of one of 4 experimental diets for 14 days. The animals had access to clean drinking water throughout the experimental period. Daily voluntary feed intake was measured and recorded. Total faeces and urine voided were collected during the last 7 days (14 - 21). This was usually, done in the morning before feeding and watering. Each buck was offered each of the remaining 3 experimental diets in rotational periods of 21 days each. The last 7 days in each of the feeding phases, was also used for total urine and faecal collection. Samples of the diets (T_1, T_2, T_3 and T_4) were analysed for dry matter and other chemical composition.

The faeces were weighed fresh, dried and bulked for each animal. A sub-sample from each was dried in a forced-draft oven at 100 - 105°C for 48 hour and used for dry matter (DM) determination. Another sample was dried at 60°C for 72 hour for determination of proximate components. Total urine for each animal was collected daily in the morning before feeding and watering. Urine was collected in a graduated transparent plastic container placed under each cage to which 10ml of 25% H_2SO_4 was added daily to reduce volatization of ammonia (NH_3) from the urine. Ten percent (10%) of the daily outputs of urine by each animal were kept in plastic bottles, numbered and stored in a deep freezer at -5^{0}C. The samples were collated for each animal, bulked and sub-samples taken for analyses at the end of every 7 days collection period.

Analytical procedure

All feed and faecal samples were analysed for proximate components using AOAC (2000) methods. Nitrogen in urine samples was also determined by AOAC (2000) methods.

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Statistical analysis
The data generated from the nutrient digestibility study were pooled since the experiment was replicated twice and all data obtained were subjected to analysis of variance (ANOVA) as applicable to a 4 x 4 Latin square design using SPSS 15.0 (2006) statistical package. Mean differences between treatments were separated using Duncan's Multiple Range Test (Duncan, 1955) as outlined by Obi (1991).

Results and Discussion

The dry matter (DM), nutrient intake and N-balance of WAD goats (bucks) fed the experimental diets are presented in Table 3. The DM intake (g/d) values were 608.52, 572.32, 548.60 and 552.93 for diets T_1, T_2, T_3 and T_4 respectively. The values were similar (P>0.05). Diet T_1recorded the highest DMI which was followed by T_2, T_4 and the least was T_3. DM in the control diet (T_1) was the highest consumed probably due to the fact that it contained the lowest crude protein content (Table 2). The low, though non-significant DM intake of the bucks fed the various dietary treatments in this study agrees with the findings of Swanson *et al.* (2000) who reported no difference in DM intake when ruminants fed low quality forages were supplemented with protein. The marginal differences among dietary treatments may also have been responsible for the non - significant increase in DM intake even as dietary nitrogen levels increased from diets T_1 to T_4. Increasing levels of AYBM in the test diets (T_2 – T_4), apart from improving the nitrogen levels, could also have made the rations increasingly palatable, but this was not the case in .this study. The presence of tannins in AYBM and the inclusion of palm kernel cake in the ration might have impacted some bitter taste as the level of AYBM increased in the rations. Also AYBM is known to cause flatulence (excessive accumulation of gases in the stomach) which invariably discourages feed intake (Janardhanan *et al.*, 2003; Azeke *et al.,* 2005). The low, though non-significant DMI of bucks fed diet T_3 and T_4 however agrees with the assertion that low nitrogen contents may have significantly reduce the DMI of such feeds (Sauvant *et al.,* 1991; Ukpabi, 2007).

DMI expressed as percentage of body weight was 3.16 for the control diet and 2.87; 2.91 and 2.84 for diets T_2, T_3 and T_4 respectively. Though the value for the control diet was higher than that of the test diets (T_2, T_3 and T_4), there was no significant (P>0.05) differences among them. The values generally indicated that the animals on various dietary treatments showed positive DM status. The values reported in this study seem low but falls within the range of 2.8 -3.0% recommended for meat type goats in the tropics (Devendra and Mcleroy, 1982; Akinsoyinu, 1985; Ahamefule, 2005; Ukpabi, 2007). Also the values obtained in this study falls within the range of 2.5- 4.0% recommended for indigenous goats of Nigeria (Nuru, 1985).

Table 3: Dry matter and N-balance of WAD goats fed the experimental diets

	Diets				
Parameter	T_1	T_2	T_3	T_4	SEM
Mean live weight (kg)	19.26	19.94	18.85	19.50	0.36
Mean live weight ($Wkg^{0.75}$)	9.19^{ab}	9.44	9.05^{b}	9.28^{ab}	0.11
DMI (g/d)	608.52	572.32	548.60	552.93	46.77
DMI (g/d/$Wkg^{0.75}$)	66.14	62.02	64.11	60.04	6.59
DMI as %BW	3.16	2.87	2.91	2.84	0.29
CP-intake (g/d)	63.78	62.72	60.00	62.40	5.34
N – Intake (g/d)	10.29	10.04	9.97	10.02	0.84
N – Faeces (g/d)	5.37	5.91	5.55	5.76	0.89
N – Urine (g/d)	2.82	3.17	3.38	3.26	0.58
N – Absorbed (g/d)	4.92	5.38	5.92	5.96	0.40
N – Balanced (g/d)	2.11	2.09	2.30	2.47	0.59
N – Absorbed (g/$wkg^{0.75}$)	0.54	0.63	0.66	0.63	0.04
N – Balance (g/$wkg^{0.75}$)	0.23	0.22	0.29	0.27	0.07
N – Intake (g/$wkg^{0.75}$)	1.12	1.09	1.11	1.10	0.10
Apparent N digestibility (%)	47.63^{b}	53.04^{ab}	59.27^{a}	55.83^{ab}	3.25

^{a,b}Means on the same row with different superscripts differ significantly (P<0.05)

Nitrogen (N) intake values (g/d) were 10.29, 10.04, 9.97 and 10.02 for diets T_1, T_2, T_3 and T_4 respectively. Though, N - intake in diet T_3 was the least, there were no significant differences (P>0.05) among the treatments. The least N-intake recorded for diet T_3 followed by T_4 further buttress the fact that DMI is positively correlated with N-intake (Sauvant *et al,* 1991; Ukpabi, 2007).Nitrogen output in faeces (g/d) followed a similar trend as N-intake. There were no significant differences (P>0.05) among the dietary treatments. However, AYBM diets had higher faecal-N value than the control. It has been reported that faecal-N increases as the N-intake increases (Ibeawuchi *et al*, 1993; Matenga *et al.,* 2003; Ukpabi, 2007). Nitrogen output in urine (g/d) followed a similar pattern to that of nitrogen in faeces. Animals on diet T_3 had the highest value (3.38) followed by T_4 (3.26), T_2 (3.17) and T_1 (2.83) respectively. The values recorded for the AYBM diets (T_2 – T_4) were consistently higher than that of the control (diet T_1), but these values did not however, show any significant difference (P>0.05). The trend observed in this study showed that faecal and urinary nitrogen increased with nitrogen ingestion

(McDonald *et al.*, 1995; Matenga *et al*, 2003; Ahamefule, 2005). Also, the non-significant faecal and urinary-N values observed among dietary treatments is in agreement with the reports of Preston (1986) and Ahamefule (2005) who had observed that faecal and urinary nitrogen was not significantly affected by nitrogen intake and any difference observed among animals on the different dietary treatments may be attributed to variation in nitrogen metabolism. Animals on diet A consumed more DM and more nitrogenand should excrete more nitrogen in its urine ideally. The deamination process in the rumen may have probably resulted in the production of more ammonia from the AYBM diets as opposed to the control. Hadjipanayiotu *et al.* (1991) reported that diets of high crude protein content result in high concentration of rumen ammonia – NH_3, which rumen microorganisms may not efficiently utilize, and ammonia is excreted through the urine. The low and non-significant ($P>0.05$) values of N in urine obtained in this study showed that rumen microorganisms efficiently utilized the CP in the control diet (diet T_1) and other diets containing AYBM.

The values of N - absorbed (g/d) were 4.92, 5.38, 5.92 and 5.96 for diets T_1, T_2, T_3 and T_4 while the N-balance (g/d) values were 2.11, 2.09, 2.30 and 2.47 respectively for diets T_1, T_2, T_3 and T_4. There were no significant ($P>0.05$) differences among the various values obtained for both parameters. The N-balance followed a similar trend as ingested N. All the animals were in positive N-balance, which indicated that their maintenance requirements were satisfied by the various diets. If the N-balance is considered in relation to N- intake, it may be observed that N-intake improved with the inclusion of AYBM. The values obtained for N-absorbed and N-balance in this study were however lower than those reported by Ahamefule (2005) with pigeon pea seed meal (PSM) and Ukpabi (2007) with mucuna seed meal (MSM). This observation could be due to the fact that the AYBM used in this study still contained some residual anti-nutrient even after boiling that may have affected N-absorbed and N-balance. In line with this observation, Matenga *et al.*(2003) advocated proper processing of legume seed meals before feeding to goats to improve N-intake and retention.

The relationship between faecal nitrogen (g/kg DM) and N-intake (g/d) is presented in Table 4. The correlation coefficients (r) were 0.80, 0.48, 0.99 and 0.97 respectively for diets T_1, T_2, T_3 and T_4. Except for diet T_2, the AYBM based diets (T_3 and T_4) had higher correlation coefficients than the control. All values except that of diet T_2 were however statisticallysignificant ($P<0.05$). The intercept on the ordinate axis (Table 4) shows the N-excreted inthe faeces for each of the diets when N-intake was hypothetically zero, which is the metabolic faecal N (MFN). The values (g/100gDM) were 0.17, 0.19, 0.22

and 0.25 respectively. The mean value of 0.21± 0.03g/100gDM obtained for WAD goats fed AYBM diets in this study compared favourably with the value of 0.24gN/100g DM often quoted for ruminants (Ahamefule, 2005) but lower than 0.43gN/100g DM reported by Akinsoyinu (1974) for WAD goats. Brun-Bellut *et al.* (1991) reported that very small estimates of endogenous losses of nitrogen in faeces may be obtained if rumen degradable protein (RDP) was not sufficient for microbial synthesis in which case endogenous-N which reached the rumen would be utilized. Thus, the portion of faecal microbial protein, which comes from endogenous-N, would not be accounted for in MFN. It is also possible that the low values for MFN obtained in this study may have resulted from the method used in processing the AYBM (i.e. boiling) which probably left some residual tannin and other anti-nutrients in the AYBM (Ezueh, 1984; Hernandez - Infante *et al.*,1998; Klu *et al.,* 2001; Azeke *et al.,* 2005). Also this low value according to Ahamefule (2005) could also be due to variations within breed as well as the type of feed (nutrition), management factors, environmental conditions and the effect of season in which this study was carried out.

The relationship between urinary nitrogen (g/day/Wkg$^{0.75}$) and absorbed nitrogen (g/day/Wkg$^{0.75}$) is presented in Table 5. In this study, both parameters were poorly but significantly ($P<0.05$) correlated in the control diet T_1 and diet T_3 with values of 0.91 and 0.82 respectively. The correlation coefficient however showed some remarkable improvement from 0.49 to 0.64 for diets T_2 and T_4 respectively. While both parameters were positively correlated within the AYBM diets, the coefficient of correlation was only significant ($P<0.05$) for diet T_3. The intercept on the urinary-N axis gave the urinary- N at zero N absorption, which is endogenous urinary-N (EUN) in g/d/kgW$^{0.75}$. The EUN values were0.024, 0.029, 0.020 and 0.031 respectively for diets T_1, T_2, T_3 and T_4. A mean EUN of 0.03 ± 0.004 was obtained for WAD goats on the AYBM diets in this study which was however lower; than the value of 0.06 g/day/Wkg$^{0.73}$ reported by Akinsoyinu (1974) for WAD goats. The control (diet T_1) had a seemingly high EUN value (0.024 g/day/Wkg$^{0.75}$) compared to the AYBM diets. This variation in the value of EUN observed within breed may be due to urea recycling in the rumen peculiar to ruminants (Akinsoyinu, 1974; Ahamefule, 2005; Ukpabi, 2007).

Nitrogen balance (g/day/KgW$^{0.75}$) was linearly correlated with Absorbed-N (g/d ay/Kg W$^{0.75}$) in all diets except in diet B, where it was non-significant ($r = 0.36$; $P>0.05$) as presented in Table 6. The Absorbed-N at zero N-balance multiplied by 6.25 gave the digestible crude protein (DCP) requirement for maintenance while the gradient of lines relating N-balance to Absorbed-N gave the indices of biological value (Mba *et al.,* 1975;

Ahamefule, 2005; Ukpabi, 2007). The value of 0.81g DCP/kg/$W^{0.75}$ for goats on diet T_3 in this study compares favourably with 0.76 - 0.88gDCP/KgW^{075} recommended by ARC (1980). The value of 1.81gDCP/kg$W^{0.75}$ obtained for diet T_4 in this study is higher than the range reported by ARC (1980). On the other hand, the value of 0.56gDCP/kg$W^{0.75}$ obtained for diet T_2 in this study compares favourably with earlier values of 0.51g/kg$W^{0.75}$ reported for WAD goats (Onwuka *et al.,*1985) while the value of 0.44gDCP/kg$W^{0.75}$ obtained for diet (T_1) fell below this value. However, the mean biological value of 0.73 ± 0.12 obtained for diets containing AYBM-compares favourably with 0.83 obtained for goats on the control diet and indicates that the efficiency of the AYBM based diets were as good as the control. The dry matter and nutrient digestibility coefficients are presented in Table 7. Dry matter digestibility (DMD) coefficients (%) were 41.36, 47.58, 51.07 and 47.67 respectively for diets T_1, T_2, T_3 and T_4. The values were significantly ($P<0.05$) different. The highest mean value obtained for bucks fed diet T_3 (51.07%) agrees with the reports of McDonald *et al.*(1995) that DMD decreases as DMI intake increases which depicts that DMD is negatively correlated with DMI (Table 3). The values for diets T_2 and T_4 did not strictly conform to the above report. However, the mean value of 48.77 ± 1.51% obtained for AYBM based diets is slightly higher than 41.36% obtained for diet T_1. This trend was reversed when mean DMI (551.95 g/day) for diets T_2, T_3 and T_4 was lower than.608.52g/d obtained for diet T_1 (Table 3). Thisalso confirms the negative correlation that exists between DMD and DMI. Crude protein digestibility coefficient values were 47.61, 51.65, 59.28 and 55.69% for diets T_1, T_2, T_3 and T_4 respectively. There were significant differences ($P<0.05$) between the treatments but the results showed that all diets containing AYBM (10 - 30%) had better CP digestibility than diet T_1. Diet T_3 was outstanding and differed ($P<0.05$) from other treatments, while diets T_2 and T_4 were similar ($P>0.05$) to diet T_3 and not different from the control. However, it has also been reported that thermal processing of seed meals improves CP digestibility (McDonald *et al.,* 1995). Crude fibre digestibility coefficient values were 14.95, 21.78, 31.75 and 42.24% for diets T_1,T_2, T_3 and T_4 respectively. There were significant differences ($P<0.05$) among the diets. Results showed that diet T_4 had better CF digestibility when compared to other diets. Though diet T_2 and T_3 were similar ($P>0.05$), diet T_3 was also not different from diet T_4, while diet T_2 was also similar to the control. All AYBM based diets had better digestibility compared to the control. Diet T_1 which had the least CP digestibility also had the lowest CF digestibility. Though, variations exist among breeds including other factors such as type of feed and season, the relatively low values of CF digestibility obtained in this study suggest that the cellulolytic activities of rumen microorganisms may have been hindered particularly among goats on diet T_1 (Crampton and Harris, 1969; Leng, 1993; McDonald *et al.*,1995; Ukpabi, 2007).

Ether extract (EE) digestibility was highest for bucks on diet T_2 (89.46%), followed by those on diet T_3 (89.43%), T_4 (88.34%) and T_1 (82.97%) respectively. The AYBM based diets were similar(P>0.05) but statistically different from the control. However, the mean value of 89.08%±0.01% for bucks fed diets containing AYBM (10 - 30%) was higher than 82.97% obtained for the control. The EE digestibility obtained in this study was outstanding when compared to that of pigeon pea meal (Ahamefule, 2005) and mucuna seed meal (Ukpabi, 2007). This might be due to the fact that AYBM is actually rich in oils (Santos *et al.*,1996; Oshodi *et al.*,1997; Gruneberg *et al.*, 1999) and the level of EE in the respective dietary treatments were also high (Table 2). Ikhatua and Adu (1984) reported similar high EE digestibility coefficient for Red Sokoto goats fed forage and groundnut haulm supplemented with concentrate.

Table 4: Regression equation between faecal-N (g/kgDM (Y) and N-intake (g/day) (X) in WAD goats fed the experimental diets.

Diets	Regression equation	Correlation Coefficient (r)	SE	Intercept on Y-axis	MFN (g/100g)
T_1	Y = 1.09 – 0.68X	0.80*	0.02	1.65	0.17
T_2	Y = 1.75 – 0.60X	0.48	0.09	1.88	0.19
T_3	Y = 1.96 – 0.57X	0.99*	0.12	2.21	0.22
T_4	Y = 1.25 – 0.47X	0.97*	0.03	2.54	0.25

* = Significant (P< 0.05)
SE = Standard Error
MFN = Metabolic Faecal Nitrogen.

Table 5: Regression analysis and correlation coefficients between urinary nitrogen (g/day/Wkg$^{0.75}$) (Y) and absorbed nitrogen (g/day/Wkg$^{0.75}$) (X) in WAD goats fed the experimental diets.

Diets	Regression equation	Correlation Coefficient (r)	SE	Intercept on Y-axis	EUN (Wkg$^{0.75}$/day)
T_1	Y = 4.38 – 12.06X	0.91*	0.04	0.226	0.024
T_2	Y = 0.91 – 4.48X	0.49	0.05	0.029	0.029
T_3	Y = 10.80 – 9.68X	0.82*	0.06	0.019	0.020
T_4	Y = 10.05 – 7.53X	0.64*	0.04	0.031	0.031

* = Significant (P< 0.05)
SE = Standard Error
EUN = Endogenous Urinary Nitrogen

Table 6: Regression analysis and correlation coefficients between N-balance g/day/Wkg$^{0.75}$) (Y) and N-absorbed (g/day/Wkg$^{0.75}$) (X) in WAD goats fed the experimental diets.

Diets	Regression equation	Correlation Coefficient (r)	SE	N-absorbed at zero N-balance	BV	DCP for maintenance (g/d/kgW$^{0.75}$)
T_1	Y = 1.38 – 0.68X	0.76*	0.06	0.07	0.83	0.44
T_2	Y = 0.04 – 0.910X	0.36	0.02	0.09	0.31	0.56
T_3	Y = 1.11 – 1.942X	0.94*	0.06	0.13	0.91	0.81
T_4	Y = 1.17 – 1.911X	0.90*	0.15	0.29	0.97	0.81

* = Significant (P< 0.05)
SE = Standard Error
DCP = Digestible Crude Protein
BV = Biological value

Table 7: Apparent digestibility coefficient (%) of nutrients in the experimental diets

	Diets				
Constituents	T_1	T_2	T_3	T_4	SEM
Dry matter	41.36^{b}	47.58^{ab}	51.07^{a}	47.67^{ab}	2.62
Crude Protein	47.61^{b}	51.65^{ab}	59.28a	55.69^{ab}	3.13
Crude Fibre	14.95^{c}	21.78^{bc}	31.75^{ab}	42.24^{a}	4.79
Ether Extract	82.97^{b}	89.46^{a}	89.43^{a}	88.34^{a}	1.25
N-Free Extract	39.55	46.42	49.01	48.37	3.23
Energy	43.04^{b}	50.37^{ab}	53.35^{a}	53.30^{a}	3.32

^{abc} Means on the same row with different superscripts differ significantly (P< 0.05).

Nitrogen free extract (NFE) digestibility values were 39.55, 4642, 49.01 and 48.37% respectively for diets T_1, T_2, T_3 and T_4. The values did not differ (P>0.05) significantly among treatment and did not reveal or show any definite pattern. The mean value of 47.93± 0.35% for diets containing AYBM was higher than 39.55% obtained for the control diet. This is an indication that NFE digestibility in AYBM diets was better when compared to the control. The NFE digestibility values obtained in this study were low when compared to that of pigeon pea meal (Ahamefule, 2005), mucuna seed meal (Ukpabi, 2007) and groundnut haulm supplemented with concentrates (Ikhatua and Adu, 1984). This might be probably due to the high oligosaccharide content of African yambean (Bergthaler *et al.*, 2001; Janardhanan *et al.*, 2003) coupled with the associative effect of other ingredients in the respective diets. Energy digestibility coefficients were

ISSN: 2141 - 4203 Science and Education Development Inst., Nigeria

43.04, 50.37, 53.35 and 53.30% respectively for bucks fed diets T_1, T_2, T_3 and T_4. The values differed ($P<0.05$) among the various dietary treatments. The mean value of 52.34±1.35% obtained for diets containing AYBM is lower than 43.04% obtained for the control, diet T_1. The coefficient of digestibility increased from diets T_1- T_4 as the energy contents of the diets declined. Since animals eat to meet their energy need, induced intake would suggest that more of the less or low energy diets would be consumed. This trend was not reflected as shown by the DMI in this study (Table 3). However, since it is known that energy digestibility is negatively correlated with energy intake (McDonald *et al.*,1995), then the non-significant energy digestibility coefficients of diets could find justification in this study, since energy intake were low for AYBM based diets but energy digestibility coefficients tend to be high compared to the control that hitherto recorded high energy intake (DMI) but lowest digestibility coefficient. Apparent N-digestibility (%) values were 47.63, 53.04, 59.27 and 55.83. Significant differences existed ($P<0.05$) among the respective dietary treatments in this study. However, apparent N-digestibility presented a similar trend as in apparent CP digestibility (Table 7). The mean value for AYBM based diets was 56.05± 0.31% which is higher than 47.63% for diet T_1, which suggest that N supplied by boiled AYBM based - diets was better utilized than that of the control diet.

Conclusion and recommendation

The study concludes that African yambean meal (AYBM) in cassava peel based diets improved nitrogen intake and ensured positive nitrogen balance, thereby boosting the maintenance requirements of WAD bucks. Dry matter intake was positively correlated with Nitrogen balance. Faecal and urinary nitrogen increased with nitrogen ingestion with the intake of AYBM. Diets containing AYBM had improved biological value and were outstanding in terms of crude protein digestibility. It is therefore recommended that farmers can supplement cassava peel meal based diets with African yambean meal up to 30% without fear of compromising digestibility of nutrients in West African Dwarf goats (bucks).

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