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Nutrient Intake and Utilization of Pigeon Pea-Cassava Peel Based Diets by West African Dwarf (WAD) Bucks

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Abstract: Four West African dwarf (WAD) bucks averaging 11.75 kg in weight and aged between 12-15 months were used to determine the nutrient intake and digestibility of pigeon pea-cassava peel based diets. The diets A, B, C and D were formulated (from cassava peel, palm kernel cake, brewers' dried grains, bone meal and common salt) to contain 0, 10, 20 and 30% pigeon pea seed meal (PSM), respectively. The diets were randomly allotted to the 4 animals in a 4x4 Latin square design. Parameters determined were feed intake, dry matter intake (DMI), nutrient digestibility and the nitrogen balance status of each animal. Also determined were metabolic faecal nitrogen (MFN), endogenous urinary nitrogen (EUN) and digestible crude protein (DCP) for maintenance. Results showed that incorporating PSM in cassava peel based diets generally enhanced intake in WAD goats. The dry matter (DM), crude protein (CP), crude fibre (CF) and energy digestibility coefficients (%) differed significantly ($P<0.05$) among treatments. The values were 63.70, 51.27, 56.65, 64.78; 64.93, 57.85, 58.13, 65.39; 68.08, 61.95, 64.65, 69.42 and 71.20, 66.25, 64.27, 72.64 for diets A, B, C and D, respectively. Faecal nitrogen, nitrogen balance and apparent nitrogen digestibility values did not differ ($P>0.05$) but tended to increase from diets A-D as nitrogen intake increased. Nitrogen content of urine was affected by dietary treatments ($P<0.05$). The values (g/d) were 0.74 for diet A, 0.79 for diet B and 0.80 and 0.82 for diets C and D, respectively. Metabolic faecal nitrogen (g/100gDM), endogenous urinary nitrogen (g/d/$Wkg^{0.75}$) and digestible crude protein (g/d/$Wkg^{0.75}$) values for maintenance were 0.19, 0.269, 1.50; 0.22, 0.031, 3.18; 025, 0.021, 4.87 and 0.34, 0.035 and 5.31 for the respective diets. The PSM fed bucks required 2.8 times as much DCP as the control fed bucks for maintenance. All diets promoted positive N-balance.

Key words: Dwarf bucks, crude protein, crude fibre

Introduction

The high cost of conventional feedstuffs for ruminants and other livestock in Nigeria has necessitated the search for cheap and available sources of feed ingredients. Attention has shifted lately towards the use of agro-industrial by-products that have little or no utilizable value for man (Akinmutimi, 2004). Some of these agro-industrial products otherwise referred to as non-conventional feedstuffs include brewers' dry grains (BDG) and palm kernel cake (PKC), among many others. Detailed investigations on the feed value of brewers' dry grains (Adeyanju and Ilori, 1976; Umoh *et al*., 1983; Ibeawuchi and Akinsoyinu, 1989) and palm kernel cake (Anonymous, 1987) have shown that these products, like cassava peel, can effectively be exploited for ruminant nutrition in Nigeria.

Cassava peel, a kitchen / industrial waste from cassava tuberous root (*Manihot utilisima*) processing, has recently become a feedstuff of great interest in livestock nutrition in Nigeria. Its nutritional content, value and limitations in livestock nutrition have been extensively studied (Smith, 1988). Due to the prevailing demand on the cassava crop as a staple in Nigeria, the by-products, especially the peels, are largely available but grossly under utilized and were hitherto discarded as waste. This abundant waste product however, holds inestimable potentials for ruminant livestock nutrition in Nigeria. According to Onyiro (1999), it can be used as a basal diet for goats in the dried state, but its low nitrogen content (2-3% CP), unless upgraded, cannot sustain growth, production and reproductive functions in ruminants (Asaolu, 1988).

Pigeon pea (*Cajanus cajan*) is a grain legume of relatively low human preference and demand in Nigeria. It is only mainly cultivated in the middle belt area as intercrops in cassava and / or yam plots. It grows wild in other parts of Nigeria where little is known of it as a food crop. Consumption is rare even in cultivated areas and occurs only during scarcity of other conventional grain legumes like soya, groundnut and cowpea. It is rich in nitrogen (21-30% CP) (Obioha, 1992; Olomu, 1995; Amaefule, 2000) and has no industrial uses for now. These attributes have elicited interest among animal nutritionist, to exploit further use of the crop as an alternative source of protein for ruminants and generally for other livestock in Nigeria. Information concerning the nutritional composition, anti-nutritional properties and processing methods of pigeon pea is well documented

(Amaefule, 2000).
In this study, pigeon pea seed was used to upgrade cassava peel based diets at 10, 20 and 30% levels of inclusion. The essence was to access the acceptability of the diets by goats and also to determine nutrient digestibility and nitrogen balance status of animals fed the experimental diets.

Materials and Methods

Processing of Cassava peel and Pigeon pea seed: Cassava peels (variety TMS 3055) from 12-14 month old plants were collected fresh from the commercial 'Garri' processing unit of the National Root Crop Research Institute (NRCRI), Umudike. The lot was subsequently sun-dried for 3 days to about 10% moisture content before being milled and used in this study as dried cassava peel meal.
Pigeon pea (*Cajanus cajan*) seeds (brown variety) were purchased from a grain market in Aba, Abia State of Nigeria. Known quantities of the seed were boiled in batches in mammoth cooking pots at 100°C for 30 minutes. Water was decanted, the boiled seeds were then sun-dried for 3 days before being milled and used as pigeon pea seed meal (PSM).

Experimental animals: Four WAD bucks averaging 11.75 kg (range 11.00 -12.00 kg) in weight and aged 12-15 months were selected from the goat herd of the Michael Okpara University of Agriculture Teaching and Research Farm. The animals were first dewormed and purged of external parasites using Ferbendazole and Pfizona, respectively. Prior to the study, the animals were kept under zero grazing and supplementary feeding of 0.4-0.5 kg concentrate per head per day depending on age and weight of animal. The concentrate diet was formulated from wheat offal, brewers dried grain, soya bean cake, palm kernel cake, bone meal and common salt.

Experimental design: The animals were transferred to and housed in separate metabolism cages provided with facilities for collecting faeces and urine and fed four experimental diets in a 4x4 latin square arrangement. Each animal constituted a replicate while each feeding phase represented an observation.
The experimental diets designated A, B, C, D were formulated (from cassava peel, brewers dried grain, bone meal, and common salt) to contain 0, 10, 20 and 30% pigeon pea seed meal (Table 1). Each animal received the experimental diets consecutively in 4 phases. During phase 1 which lasted for 28 days, each animal received 1 kg of an assigned diet. Drinking water was freely provided per animal daily. Daily voluntary feed intake was also determined. Total faeces and urine voided by the experimental animals were collected in the last 7 days (22-28) of this phase. During phases 2-4, each animal was offered each of the remaining 3 experimental diets in rotational periods of 28 days each. The last 7 days in each of the respective phases were used as in phase 1 for total urine and faecal collection. The quantity of each diet offered to goats daily during each phase ensured some left over. The residues were collected after 24-hours, then weighed and used to determine the voluntary intake. Samples of each diet were collected and used for dry mater (DM) determination and chemical composition analysis.
Total faeces were collected in the mornings before feeding and watering during days 22-28 of each period. The faeces were weighed fresh, dried and bulked for each animal. A sub-sample from each animal was dried in forced draft oven at 100-105°C for 48 hr and used for DM determination. Another sample was dried at 60°C for 48-72 hr for determination of proximate composition.
Total urine for each animal was collected daily in the morning before feeding and watering. The urine was trapped in a graduated transparent plastic container placed under each cage and to which 15ml of 25% H_2SO_4 had been added daily to curtail volatilization of ammonia from the urine. The total volume of urine output per animal was measured and about 10% of the daily outputs were saved in numbered plastic bottles and stored in a deep freezer at - 5°C. At the end of each 7 – day collection period, the sample collections were bulked for each animal and sub-samples taken for analysis.

Table 1: The composition of pigeon pea-cassava peel based diets

Diets ingredients (%)	A	B	C	D
Cassava peel	42	42	42	42
Pigeon pea	0	10	20	30
Brewers dry grain	35	25	15	5
Palm kernel cake	20	20	20	20
Bone meal	2	2	2	2
Common salt	1	1	1	1
Total	100	100	100	100

Analytical procedure: All feed and faecal samples were analyzed for proximate components using AOAC (1990) methods. Nitrogen in urine samples was also determined by AOAC (1990) methods.

Statistical analysis: The data obtained in this study were subjected to analysis of variance (ANOVA) appropriate for a 4x4 latin square experiment (Steel and Torrie, 1980). Differences between treatment means were determined by Duncan's Multiple Range Test (Duncan, 1955)

Results and Discussion

The composition and proximate constituents of the experimental diets, the cassava peels and pigeon seed meal used in this study are presented in Table 2. The proximate values for the cassava peel were similar to

Table 2: Chemical compositions of pigeon pea, cassava peel and pigeon pea-cassava peel based diets (%DM)

Diets	A	B	C	D	CSP	PSM
Dry matter (DM)	89.32	89.34	89.32	89.30	90.22	88.50
Crude protein (CP)	13.25	13.30	13.45	13.65	3.05	25.04
Crude fibre (CF)	9.62	10.94	12.42	12.68	14.50	7.50
Ether extract (EE)	4.46	4.32	4.28	4.14	0.70	2.33
Nitrogen free extract (NFE)	51.57	50.94	50.35	50.87	66.47	50.78
Ash	10.42	9.84	8.82	7.96	5.50	2.85
Gross energy (GE) (Kcal/g)*	3.44	3.32	3.21	3.09	1.82	3.95

* Calculated CSP = Cassava peel. PSM = Pigeon pea seed meal

Table 3: Apparent digestibility coefficients (%) of WAD goats fed pigeon pea-cassava peel based diets

Diets constituents	A	B	C	D	SEM
Dry matter (DM)	63.70^{b}	64.93^{ab}	68.08^{a}	71.20^{a}	1.95*
Crude protein (CP)	51.27^{b}	57.85^{ab}	61.95^{ab}	66.25^{a}	1.73*
Crude fibre (CF)	56.65^{b}	58.13^{ab}	64.65^{a}	64.47^{a}	1.11*
Ether extract (EE)	78.36	76.39	76.16	74.63	1.57
N – free extract (NFE)	75.40	74.05	74.92	76.70	0.96
Energy	64.78^{b}	65.39^{ab}	69.42^{a}	72.64^{a}	1.08

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

those reported by Smith (1988) and Ahamefule *et al.* (2002). The proximate constituents of the pigeon pea also fell within the range of values obtained by Amaefule (2002).

The dry matter percent of the PSM diets (B, C, D) compared favourably with the control diet (A). The crude protein and crude fibre contents of the PSM diets were also relatively higher than those of the control diet, and tended to increase with increasing levels of pigeon pea seed meal in the diets. Ether extract, ash and energy values declined from diets A-D while the nitrogen-free extract values did not show any consistent trend among the diets.

Dry matter contents of the PSM diets, except for B, were digested better (P<0.05) than those of the control diet. Dry matter digestibility (DMD) in this study tended to increase from diets A – D along with dry matter intake (DMI) (Table 4). This observation runs contrary to an earlier finding (McDonald *et al.*, 1995) which correlates DMD negatively with DMI. However, it is presumed that nutrient density and not DMD may be the over riding factor influencing DMI in this study. This may very well explain the rise in DMI just as the crude protein contents of the diets improved from the control A to D.

Crude protein and crude fiber digestibility coefficients also followed similar trend as DM, increasing from diets A - D. As in DM, the crude protein and crude fibre digestibility coefficients for the control diet did not differ significantly (P>0.05) from those of diet B, but however differed (P<0.05) significantly from the value for diet D. Crude protein and crude fibre are components of DM and therefore any factor that affects the DM of a feed would similarly affect the CP and CF component of same feed. This may explain why the digestibility coefficients of CP and CF increased from diet A to D, in the same pattern with DM.

The ether extract digestibility values decreased from the control diet A to D. The coefficients however did not differ significantly (P>0.05). NFE digestibility values also did not show any significant differences (P>0.05) among the diets.

The energy digestibility coefficients of diets C and D differed (P<0.05) significantly from that of the control. The coefficient of digestibility increased from diets A to D as the energy contents of the diets declined (Table 1). Since animals eat to meet their energy need, energy-induced intake would suggest that more of the low energy diets would be consumed, as was indeed reflected by the DMI (Table 4) in this study. But since energy digestibility correlates negatively with energy intake (McDonald *et al.*, 1995), the significant energy digestibility coefficients of diets C and D could not find justification since energy intake was high for both diets as dry matter intake increased from A to D.

Similar to the trend above, apparent N-digestibility values (Table 4) also increased from diet A (the control) through diets B and C to diet D. Though these values did not differ significantly (P>0.05), the increasing trend from A to D, in the same order as the N-intake and N-balance values, did not give credence to an earlier view (McDonald *et al.*,1995) which correlated N intake negatively with N digestibility.

The dry matter intake and nitrogen balance studies in WAD goats fed pigeon pea-cassava peel based diets are shown in Table 4. DM intake of the various diets did not differ significantly (P>0.05). Dry matter intake expressed as percentage of body weight also did not differ (P>0.05) significantly but generally indicated that the goats fed various treatment diets showed positive

Table 4: Dry matter intake and nitrogen balance studies in WAD goats fed pigeon pea-cassava peel based diets

Diets parameter	A	B	C	D	SEM
Mean final weight (Kg)	12.00	12.96	12.58	12.56	0.98
Mean final wt ($Wkg^{0.75}$)	6.41	6.78	6.64	6.62	0.39
DMI (g/day)	547.19	588.44	618.13	624.38	48.84
DMI per $Wkg^{0.75}$	83.26	85.83	92.02	94.03	3.61
DMI as % BW	4.48	4.42	4.78	4.90	0.18
CP intake (g/d)	70.50	76.26	80.13	83.21	6.56
N- intake (g/d)	10.25	11.60	12.23	12.65	0.78
N- faeces (g/d)	2.95	3.76	4.28	4.43	0.58
N-urine (g/d)	0.74^{b}	0.79^{ab}	0.80^{ab}	0.82^{a}	0.02
N- balance (g/d)	5.38	6.50	6.75	6.95	0.18
N- balance (g/d $Wkg^{0.75}$)	0.84	0.93	0.99	1.02	0.04
N- absorbed (g/d$Wkg^{0.75}$)	0.94	1.00	1.10	1.15	0.04
N- intake (g/d/ $Wkg^{0.75}$)	1.54	1.60	1.68	1.71	0.07
Apparent N-digestibility (%)	56.78	59.42	60.31	60.74	2.82

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

DM status by consuming at least 3% of their body weights which is the recommended daily dry matter requirement for meat type goats in the tropics (Devendra and Mcleroy, 1982).

Nitrogen intake values (g/d) were higher for the PSM diets relative to the control. However, there were no significant differences (P>0.05) among diets.

Nitrogen in faeces (g/d) did not differ significantly (P>0.05) among diets also but urinary nitrogen values (g/d) increased significantly (P<0.05) from diets A to D. The PSM diet D was significantly higher in value (P<0.05) than the control. The non-significant faecal nitrogen values observed among treatment groups is in consonance with the findings of Black *et al*. (1978) who observed that faecal nitrogen was not significantly affected by nitrogen intake. The significant urinary nitrogen values observed among treatment groups may be attributed to variation in nitrogen metabolism. The de-amination process in the rumen may have produced more ammonia from the PSM diets relative to the control, probably due to the nature and quality of their dietary protein. According to Ranjah (1980), the concentration of ammonia (and hence nitrogen) in the rumen fluid would depend on the quantity and solubility of protein fed to the animals. Nitrogen excreted in urine therefore would depend on urea recycling effect and the efficiency of utilization of ammonia produced in the rumen for microbial protein synthesis. It is possible that the protein moiety of the PSM diets was more soluble than that of the control. That also meant that more rumen ammonia would be produced with the PSM diets which surely would have increased as the nitrogen intake increased from diets B to D. This perhaps would have led to the significant urinary nitrogen value observed for the animals on diet D.

The N-balance (g/day) values were not significantly (P>0.05) different among the diets. The positive values of 5.38, 6.50, 6.75 and 6.95 obtained for diets A, B, C and D, respectively in this study were an indication that all the maintenance requirements of the experimental animals were adequately met by the diets they consumed. This is justified by the fact that none of the experimental animals lost weight during the study.

Faecal nitrogen (g/kg DM) was highly correlated with N-intake (g/day) as shown in Table 5. The coefficient of correlation (r) was 0.83, 0.93, 0.99 and 0.94 for diets A, B, C and D, respectively. The correlation coefficients were higher for the PSM diets than the control. All values were however statistically significant (P<0.05). The intercept of the line relating faecal nitrogen to N-intake, all expressed in metabolic body weight ($Wkg^{0.75}$) (Table 5.) gave the nitrogen excreted in faeces, for each diet, when the N- intake was hypothetically zero, that is the metabolic faecal nitrogen (MFN).

A mean MFN value of 0.27 ± 0.05 g/100g DM obtained for WAD goats fed the PSM diets in this study is lower than 0.43 g N/100gDM reported by Akinsoyinu (1974) for WAD goats. Variations within breed may occur due to nutrition, environmental conditions and season of study.

The relationship between urinary nitrogen (g/day/$Wkg^{0.75}$) and absorbed nitrogen (g/day / $Wkg^{0.75}$) in this study (Table 6.) showed that both parameters were poorly but significantly correlated in the control diet A (r = 0.10; P<0.05), fairly and significantly correlated in diets B (r = 0.32; P<0.05) and D (r = 0.46; P<0.05) and highly and significantly correlated in diet C (r = 0.75; P<0.05). The intercepts on the line relating urinary N to absorbed N, expressed in $Wkg^{0.75}$ gave the urinary nitrogen excretion at zero N absorption which is the endogenous urinary nitrogen (EUN) in g/day/$Wkg^{0.75}$. A mean EUN value of 0.03 ± 0.005 was obtained for WAD goats fed PSM diets which however, was lower than the value of 0.06 g/day/$Wkg^{0.75}$ reported by Akinsoyinu (1974) for WAD goats.

The seemingly high EUN value obtained for the control diet (0.27 g/day/$Wkg^{0.75}$) and variations in the EUN values observed within breed may be due to urea recycling effect as observed by Akinsoyinu (1974).

Nitrogen balance (g/day/$Wkg^{0.75}$) was highly and positively correlated with absorbed nitrogen

Table 5: Regression equation between faecal N (g/ kg DM) (Y) and N- intake (g/day) (X) in WAD goats fed pigeon pea-cassava peel based diets

Diets	Regression Equation	Correlation Coefficient (r)	Std. error	Faecal N at Zero N-intake	MFN (g/100gDM)
A	Y= 1.94 + 0.086 X	0.83 *	0.308	1.94	0.19
B	Y = 2.21 + 0.124 X	0.93 *	0.258	2.21	0.22
C	Y = 2.58 + 0.128 X	0.99 *	0.081	2.58	0.25
D	Y = 3.48 + 0.072 X	0.94 *	0.127	3.48	0.34

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

Diets	Regression Equation	Correlation Coefficient (r)	std. error	Urinary N-exeretion at zero N-absorbtion	EUN (Wkg$^{0.75}$/day)
A	Y = 0.269 + 118X	0.107 *	0.06	0.269	0.269
B	Y= 0.031 + 0.114 X	0.327*	0.04	0.031	0.031
C	Y = 0.021 + 0.102X	0.775*	0.02	0.021	0.021
D	Y = 0.035 + 0.110X	0.460 *	0.03	0.035	0.035*

Significant (P<0.05)

Table 7: Regression analysis and correlation coefficients between N-balance (g/day/Wkg$^{0.75}$) (Y) and absorbed-N (g/day/Wkg$^{0.75}$) (X) in WAD goats

Diets	Regression	Correlation Coefficient (r)	Std. error	N-absorbed at zero N-balance	Biological Value	DCP for maintenance (g/d/Wk $^{0.75}$)
A	Y= 0.25 + 0.50X	0.95**	0.03	0.25	50	1.56
B	Y= 0.519 + 0.51X	0.43 NS	0.15	0.51	51	3.18
C	Y = 0.781 + 0.680X	0.99**	0.07	0.78	68	4.87
D	Y = 0.851 + 0.60X	0.83**	0.07	0.85	60	5.31**

P<0.01; NS=P>0.05.

(g/day/Wkg$^{0.75}$) except in diet B, where it was non-significant (r = 0.43; P>0.05) (Table 7). The correlation coefficients for diets A, C, and D were 0.95, 0.99, and 0.83, respectively. The gradients of lines relating N-balance to absorbed nitrogen are the indices of biological value (BV) while the absorbed N at zero N-balance when multiplied by 6.25 gave the digestible crude protein (DCP) requirement for maintenance (Mba *et al*., 1975). The BV and DCP values obtained for WAD goats in this study (Table 7) ranged from 50 in diet A to 68 in diet C and 1.56g in diet A to 5.31g in diet D, respectively. Meanwhile, mean BV and DCP values of 59.66 ± 6.94 and 4.45 ± 0.91, respectively were obtained for WAD goats fed diets containing PSM. The relatively higher BV recorded for the PSM diet over the control was an indication that the protein N of PSM diets were of better quality and as such were better utilized than the N in the control diet.

Also the BV of 59.66 obtained for the PSM fed diets in this study is comparable to the value of 65 often quoted for ruminants (Akinsoyinu, 1974) but lower than the value of 98 obtained for Red Sokoto goats (Mba *et al*., 1975). Meanwhile the DCP values, obtained in this study per Wkg$^{0.75}$ ranged from 1.56g in the control to 5.31g obtained for goats fed diet D. Devendra and Mcleroy (1982) had observed that the minimum protein requirement for maintenance in the tropics (for goats) range from 0.590–2.57g DCP per Wkg$^{0.75}$. The higher mean DCP value (4.45±0.91g) recorded for the PSM diets over the control (1.56g) indicates that the PSM fed bucks required 2.8 times as much digestible protein as the control fed bucks for maintenance.

In conclusion, the PSM diets had higher biological values and hence were more qualitative than the control diet. This attribute perhaps was generally responsible for the enhanced dry matter intake observed with the PSM diets relative to the control. Goats fed the PSM diets also recorded relatively higher nitrogen balance status than goats fed the control diet, probably because they ingested more N and secreted less N in their urine and faeces. Incorporation of PSM in the diets of WAD goats therefore, would generally improve their performance.

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