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Dry matter intake, nutrient digestibility and nitrogen balance of West African dwarf bucks fed *Andropogon tectorum* supplemented differently processed cocoyam (*Colocasia esculenta*) concentrate meal

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Target Audience: Goat farmers, Feed millers, Extension specialists, Animal Scientists

Abstract

The study aimed to evaluate the dry matter intake, nutrient digestibility and nitrogen balance by West African dwarf bucks fed Andropogon tectorum supplemented with concentrate diets using differently processed cocoyam based meal in a 4× 4 Latin Square Design. Diets A, 0% cocoyam meal (CM), Diets B, C and D with raw, soaked and toasted processing methods respectively. Four West African dwarf (WAD) bucks averaging 8.28 ± 0.47kg were used. Each buck was housed individually in a metabolism cage with specification for feed and water and also offered the experimental diets (A-D). Each animal received the diet for 24 days. Daily feed intake was determined; while urine and faecal samples were taken for analysis. Results show that among the processing methods, toasted (CM) significantly influenced (P<0.05). Dry matter intake, nitrogen intake, N-balance and absorbed-N, and N-urine. The digestible crude protein (DCP) $g^{-1}d^{-1}Wkg^{0.75}$, metabolic faecal nitrogen (MFN) (g^{-1}100g DM) were significantly (P<0.05) different among the experimental bucks. The diets promoted positive N-balance.

Keywords: *Cocoyam, West African Dwarf goats, Processing methods, Digestibility.*

Description of Problem

Optimal productivity of small ruminant animals declines during the dry season due to inadequate nutrition occasioned by rapid shortage in quality and quantity of pastures. Under these conditions, animals have to survive on highly lignified forages (crop residues and/or industrial by products) which are relatively deficient of the essential nutrients. The West African dwarf goat is most prevalent in the humid forest zone of southern Nigeria. It is singled out as a breed of choice because of its relative tolerance to excessive humidity and trypanosomiasis (9).

Concerted efforts in research has been directed towards improvement and supplementation of grasses especially in the dry season with crop residues agro-industrial by products and other non-conventional feedstuff is cocoyam (*Colocasia esculenta*). Cocoyam is one of the most widespread of the root and tuber crops cultivated almost everywhere throughout the tropics (16) It has been reported by (1), that cocoyam is found to be nutritionally superior in the possession of higher protein, mineral and vitamin contents and digestible starch (2).

It also has nutritional value comparable to potato but easier to digest (20). *Colocasia esculenta* also contains easily fermentable carbohydrates in form of sugars. This feedstuff is available in excess of requirement because of its under-utilization (14). The presence of antinutrients can be eliminated using various processing methods like applying heat, soaking and drying etc. to render it wholesome for consumption (13). There is little documentation about its importance in animal production, hence the essence of thus research which seeks to evaluate the effect of processing methods of cocoyam on the dry matter intake and nutrient digestibility of WAD bucks.

Materials and Methods

Experimental site

The study was conducted in the research and teaching farm of Akwa Ibom state University, Obio Akpa campus in Akwa Ibom state. The area lies between latitude 4^0 30'N and 5^0 30'N and longitudes 7^0 30'E and 8^0 00'E of the Greenwich Meridian. It falls within the humid tropical region, characterized by rainy and dry seasons which last from March to November and November to March respectively. Average rainfall is 2000 – 2500mm, annual temperature range of 24^0 C - 30^0 C and relative humidity of 75 – 79% (21).

The cocoyam (*Colocasia esculentum*) used for the trials were collected from the wild around the university farm. The fresh cocoyams were peeled and divided into four groups; T_1(Control i.e. without T cocoyam), T_2 (Raw. 1kg of the T cocoyam dried for 3 days), T_3 (toasted). 1kg of T cocoyam was toasted in dry frying pan on a hot plate for 60 minutes, and T_4 (soaking), 1kg of cocoyam was soaked in two liters of water for 60 mins and then dried in the sun for 60 mins (6). All the groups were individually milled before being used for feed formulation as in Table 1.

Digestibility studies

Four West African Dwarf bucks averaging 8.0kg (7.5 to 9.0kg) in weight aged 8 – 10 months were purchased from nearby villages in Obio Akpa close to the university. The animals were quarantined during which they were vaccinated against PPR and dewormed with ivermectin (ivomec®) (1ml/animal). Each of the animal was assigned to one of the experimental diets (Table 1) in a 4x4 Latin square design and subsequently housed individually in previously disinfected metabolism cages and fed in 4 periods. Preliminary feeding phase was done for 14 days. Each animal received 1kg of one of the four experimental diets for 28 days, with fresh clean drinking water being provided ad libitum. Data was collected for daily feed intake. Total faeces and urine voided by the animals were also collected during the last 3 days and each animal was offered each of the remaining three experimental diets in rotation of 28 days each. Faeces and urine were collected in the morning before feeding and water supplied. The faeces were weighed fresh, dried and bulked for each animal. A representative faecal sample from each animal was dried in oven at 100 - 105^0 C for 48 hours used for DM determination while another sample was dried for 48 – 72 hours for the determination of proximate composition. Urine volumes were measured immediate ely after collection and 10% of the daily output saved. Concentrated sulphuric acid (5ml) was added to each of the urine collecting u-tube rubber containers used. The daily samples of urine for each animal were bulked and stored in a freezer at 0^0 C until time for analysis.

Analytical Procedure

All feed and faecal sample were analysed for proximate components (6) method. Nitrogen in urine sample was also determined by (6) methods.

Statistical Analysis

Data emanating from the experiment were subjected to analysis of variance (19), which is applicable to a 4x4 Latin square experiment (22) where ANOVA detected significantly treatment effects, differences among the treatment means were determined by Duncan's Multiple Range Test (8).

Results and Discussions

Table 1: Feed constituents and proximate composition of *Colocasia esculenta* meal based diets

Ingredients	A (T_1(Control))	B (T_2(Raw))	C (T_3(Toasted))	D (T_4(Boiled))
Brewer's spent grain	20.00	15.00	15.00	15.00
Rice meal	20.00	20.00	20.00	20.00
PKC	20.00	20.00	20.00	20.00
Cocoyam	0	5.00	5.00	5.00
Rice bran	36.00	36.00	36.00	36.00
Oyster shell	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50
Salt	0.50	0.50	0.50	0.50
Total	100	100	100	100
Calculated composition:				
Protein (%)	13.82	14.20	14.12	14.05
Energy (kcal/kg)	2037.6	3746.4	2712.5	2589.6
Dry matter (%)	89.71	89.78	89.47	89.58
Crude protein (%)	15.73	15.64	15.84	15.53
Ether extract (%)	3.78	3.86	4.02	3.74
Crude fiber (%)	9.66	9.77	9.57	10.14
Ash (%)	8.91	9.48	8.68	8.81
NFE (%)	51.65	51.25	51.36	51.37
G.E (kcal/kg)	3.98	3.99	3.97	3.99

The proximate composition of the experimental diets i.e. the Taro cocoyam used in this study for the various processing methods are shown in Table 1. There were no significant differences ($P<0.05$) for observed for all the parameters tested.

The dry matter was higher for diets A and B but tended to be lower for diets C and D. Crude protein and ether extract contents recorded in the experiment were similar though not significant for diets C, the highest and lowest values were recorded respectively. Crude fiber showed no definite pattern, but diet D had the highest while diet C (9.54%) recorded the least. The crude fiber recorded for raw cocoyam in this study is higher than 1.96% reported by (12).

The ash nitrogen free extract and energy did not show any consistent trend among the diets.

Table 2: Dry matter and nutrient digestibility of WAD goats fed differently processed *Colocasia esculenta* meal based diets

Parameters	A(T_1(Control)	B(T_2(Raw)	C(T_3(Toasted)	D(T_4(Boiled)	SEM
Mean body weight (kg)	8.50	8.00	8.50	8.10	0.47
Mean body weight ($Wkg^{0.75}$)	4.87	4.76	4.69	4.72	0.28
DMI (g/d)	102.71^{a}	101.25^{a}	72.71^{b}	70.83^{c}	0.67
DMI ($Wkg^{0.75}$)	32.26^{a}	31.92^{a}	24.42^{b}	24.73^{b}	0.24
DMI as % BW	1.25^{a}	1.28^{a}	0.83^{b}	0.92^{b}	0.10
CP-intake (g/d)	50.41^{c}	49.18^{d}	52.73^{a}	51.93^{b}	0.24
N-intake (g/d)	7.05^{a}	7.00^{b}	7.09^{a}	6.96^{b}	0.02
Faecal-N (g/d)	3.65^{b}	3.70^{a}	3.55^{c}	3.47^{d}	0.01
Urinary N (g/d)	0.61^{a}	0.62^{b}	0.61^{a}	0.63^{c}	0.00
Absorbed N (g/d)	3.39^{b}	3.30^{c}	3.54^{a}	3.49^{a}	0.02
N-balance (g/d)	2.78^{c}	2.67^{d}	2.93^{a}	2.20^{a}	0.51
N-intake (g/d/ $Wkg^{0.75}$)	4.33	4.30	4.34	4.16	0.02
N-balance (g/d/ $Wkg^{0.75}$)	2.85	2.09	2.24	2.20	0.51
N-absorbed (g/d/ $Wkg^{0.75}$)	2.49	2.45	2.58	2.60^{a}	10.70
Apparent digestibility %	48.19^{c}	52.76^{a}	49.84^{b}	49.86^{b}	0.31

$^{a, b, c, d}$ means in a row with different superscripts are significantly ($P<0.05$) different.
DMI: Dry Matter Intake
SEM: Standard Error of Mean

The dry matter, nutrient intake and digestibility of WAD goats fed taro cocoyam based diets is presented in Table 2. There were significant ($P<0.05$) differences in all the parameters tested except for N-intake (g/d/$Wkg^{0.75}$), N-balance (g/d/$Wkg^{0.75}$) and N-absorbed (g/d/$Wkg^{0.75}$).

The least (Dry matter intake) DMI was recorded by the goats on diets C (70.83g/d), the soaking method. However, the highest DMI was recorded in diet A, (102.71g/d) the control diet. This is contrary to the views of (24) who reported an inverse relationship between DMI and fiber content of feed. High DMI in diet A (102.71g/d) and that of crude fiber 9.66%, suggests possible palatability of the feed since ruminants are known for excellent digestion of fibers in feed. The faecal nitrogen increased from diets A to D and were significantly ($P<0.05$) different. Faecal nitrogen increased with nitrogen ingestion (12, 3). The N-balance (g/d) values were also higher for *Colocasia esculenta* meal (CEM) containing diets when compared with the control diet except for diets D (2.78, 2.67, 2.93 and 2.20). This might be an indication that the maintenance requirements of the experimental animals were sufficiently met by the rations consumed.

Table 3: Regression equation between faecal-N(g/d) (Y) and N-intake (g/d) (X) in WAD goats fed differently processed *Colocasia esculenta* meal based diets

Diets	Regression equation	Correlation coefficient (r)	Standard error	Faecal nitrogen zero N- intake	MFN(g)
A	Y = 6.43 – 395X	0.974	0.002	6.43	0.64
B	Y = 4.88 – 167X	-0.50	0.012	4.88	0.49
C	Y = 1.00 – 3.54X	1.00ns	0.000	3.54	0.35
D	Y = 1.00 – 3.49X	1.00ns	0.000	3.49	0.35

MFN: Metabolic faecal nitrogen, ^{ns} = not significant.

Table 3 shows faecal nitrogen (g/d) correlation with N-intake (g/d). The coefficient of correlation (r) were 0.974, 0.50, 1.00 and 1.00 for diets A, B, C and D respectively. Diet A had higher coefficient of correlation than diet B. The correlation coefficient for diets C and D were similar and negative. The values for metabolic faecal nitrogen (MFN) were 0.64, 0.49, 0.35 and 0.35g $100g^{-1}$ DM for diets A, B, C and D. The mean MFN value of 157 ± 0.004g $100g^{-1}$ DM obtained in this study for *Colocasia esculenta* diets is higher than 0.90 ± 0.1g $100g^{-1}$ DM reported by **(15)**, 0.43g N $100g^{-1}$ DM (5) and 0.45g N $100g^{-1}$ (16).

Table 4: Regression analysis and correlation coefficient between urinary nitrogen (g/d)(Y) and absorbed nitrogen (g/d/Wkg$^{0.75}$)(X) in WAD goats fed differently processed *Colocasia esculenta* meal based diets

Diets	Regression equation	Correlation coefficient (r)	Standard error	Urinary nitrogen zero N- intake	EUN/Wkg$^{0.75}$/day)
A	Y = 5.25 – 1.50X	0.50	0.010	5.25	5.25
B	Y = 5.24 – 1.50X	-0.786	0.040	5.24	5.24
C	Y = 1.69 + 0.50X	-0.500	0.012	1.69	1.69
D	Y = 1.75 + 0.50X	-0.500	0.012	1.75	1.75

Differences may occur within breed due to nutrition, season of study and environmental conditions. The relationship between urinary-N(g/day) and absorbed (g/day/Wkg0.75) (Table 4) shows that both parameters were positively correlated but the correlation coefficients were not significant (P<0.05). The coefficients of correlation were 0.50, 0.786, 0.500 and 0.500 for diets A, B, C and D respectively. The intercept on the urinary nitrogen (Y) axis gave the urinary nitrogen at zero nitrogen absorption which is the Endogenous Urinary Nitrogen (EUN) in g/day/Wkg0.75. The EUN values were 5.25, 5.24, 1.69 and 1.75 for diets A, B, C and D respectively. This result shows that control diet (A) had higher correlation (r) value than the Colocasia esculenta based diets. The values of 5.25 and 5.24 obtained for diets A and B in this study is higher than 0.92 and 0.86gday-1 reported by (25). The values of 1.69 and 1.75gday-1Wkg0.75 for diets C and D is equally higher than 1.66 and 0.10 - 0.17gday-1Wkg0.75 reported by (15). (5) stated that variation in EUN value within breed of animals may be due to urea recycling effect.

Table 5: Regression analysis and correlation coefficients between nitrogen balance (g/d/Wkg$^{0.75}$) (X) in WAD goats fed *Colocasia esculenta* meal based diets

Diets	Regression equation	Correlation coefficient (r)	Standard error	N – absorbed at zero - N balance	Biological value (BV)	DCP for maintenance (g/d/Wkg$^{0.75}$)
A	Y = 2.509 + 0.00X	-0.997	0.014	2.509	0.96	15.68
B	Y = 0.370 + 1.00X	0.143	0.370	0.370	0.96	2.31
C	Y = 0.340 + 1.00X	1.00^{ns}	0.340	0.340	0.96	2.12
D	Y = 3.705 – 0.500X	-0.500	3.705	3.705	1.00	23.16

^{ns} = not significant.

The relationship between nitrogen balance (gday-1Wkg0.75) and absorbed nitrogen is summarized in Table 5. The correlation coefficient were higher for diets A, B and D except for diet C which was not significant (P<0.05). the gradient of line relating N-balance to absorbed nitrogen were the indices of Biological values (BV) while the absorbed N at zero N-balance when multiplied by 6.25 gave the digestible crude protein DCP requirement for maintenance (11). The biological (BV) and DCP values recorded in this study for WAD bucks ranged from 0.96 in diet A to 1.00 in diet D and 15.68g in diet A to 23.16g in diet D respectively. A mean BV of 3.13 ± 0.051 was obtained for WAD bucks in this study. This is lower than a mean BV value of 59.65 reported by (3) for WAD goats. The highest value (1.00) recorded for diet D over others showed better utilization and animal's preference for toasted Colocasia esculenta meal. A mean value of 10.82 ± 0.051g DCP-1 Wkg0.75 obtained in this study is higher than 0.51gday-1 Wkg0.75 and 0.82 ± 0.49gday-1 Wkg0.75 reported by (17) and (15) respectively.

Table 6: Apparent digestibility coefficients (%) of WAD goats fed Colocasia esculenta meal based diets

			Diets		
Constituents	**A(Control)**	**B(Raw)**	**C(Soaked)**	**D(Toasted)**	**SEM**
Dry matter (%)	75.65	75.66	81.23	87.63	5.50
Crude Protein (%)	48.33^{b}	47.11^{c}	49.95^{a}	50.08^{a}	0.22
Crude fiber (%)	50.80^{b}	50.28^{b}	50.01^{b}	52.72^{a}	0.60
Ether extract (%)	55.10^{b}	57.39^{a}	57.28^{a}	56.64^{a}	0.40
NFE (%)	74.08	74.07	74.08	74.16	0.20
Energy (kcal/kg)	69.32^{c}	69.28^{c}	69.55^{b}	69.85^{a}	0.03

$^{a, b, c,}$ means on the same row with different superscripts differ significantly (P<0.05).
SEM: Standard Error of Mean

The results obtained in Table 6 shows that the dry matter and nutrient digestibility coefficient values were significantly (P<0.05) different across all the treatments except those for dry matter and nitrogen free extract. The digestibility coefficient of dry matter digestibility (DMD) in this study were numerically high and ranged from 75.65% (A, Control) to 87.63% (D, toasted). This is an indication that the diets were highly digested.

Apparent digestibility coefficient values between 78.2 and 82.6% was reported in the evaluation of *Moringa oleifera* leaves (10). The highest value obtained for diet D (87.63%) is consistent with the reports of (12) who outlined that DMD is negatively correlated with DMI. The values for diets B and C was higher than the control implying that the processing methods were mostly preferred by the bucks and also affirmed that DMD decreases as DMI increases. The apparent digestibility coefficient of CP, CF, NFE and energy followed to a high extent, a similar trend as the DM digestibility.

The crude protein digestibility coefficient values were 48.33, 47.11, 49.95 and 50.08 for diets A, B, C and D respectively. Diet D (toasted processing) had the highest (50.08%) CP digestibility coefficient values. This may imply that this method enhanced proper digestibility of CP as compared to others.

The crude fiber digestibility coefficient recorded the highest (52.72%) in diet D (toasted processing method), while diet C (50.01%) had the least crude fiber digestibility percentage. The crude fiber digestibility coefficient obtained in this study is higher than 51.64 – 69.03% and 27.93 – 36.19% for WAD goats reported by (15) and (25) respectively. Crude fiber is a component of dry matter, hence any factor that affects dry matter of feed also affects the crude fiber component of the feed (24). Ether extract digestibility values were 55.10, 57.39, 57.28, 56.64 for diets A, B, C and D respectively. The ether extract digestibility values obtained in the present study were lower than 79.57 – 86.41% for WAD goats on poultry waste – cassava peel based diets (23).

Nitrogen free extract digestibility did not differ ($P<0.05$) significantly and also did not follow any definite pattern. The NFE digestibility value for diet D (74.16%) was higher compared to other methods; implying that diet D was better digested by the animals than other treatments. The values were however, higher than those reported by (15) and (3).

Energy digestibility coefficient was highest in diet D and least recorded in diet B. Dry matter digestibility is inversely correlated with dry matter intake and energy digestibility is also negatively correlated with energy intake (12). There were significant ($P<0.05$) difference in the values of Apparent-N digestibility, a similar trend as in ether extract digestibility (Table 6) was observed. The Apparent-N digestibility values (Table 2) were 48.19, 52.76, 49.48, 49.86 for diets A, B, C and D respectively. The result indicated that diets on the various processing methods had better Apparent-N digestibility than the Control diet, hence better Utilization.

Conclusion and Application

1. Toasted processing method (Diet D), had significantly higher ratio of growth and digestibility coefficient.
2. Animal protein intake could be improved by incorporation of 5% toasted *Colocasia esculenta* in concentrate diets for WAD bucks to promote productivity.

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