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NUTRIENT INTAKE, DIGESTIBILITY AND NITROGEN BALANCE OF WEST AFRICAN DWARF GOATS FED CASSAVA ROOT SIEVATE AND CASSAVA LEAF MEAL MIXTURE IN THEIR DIETS

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ABSTRACT. Four West African Dwarf (WAD) bucks averaging 7.62 kg and aged 8–10 months were used to determine the intake, body weight changes, digestibility and nitrogen balance of cassava root sievate-cassava leaf meal mixture based diets. The four experimental diets (T_1, T_2, T_3 and T_4) were formulated to contain palm kernel cake, brewers' dried grain, molasses, bone meal, limestone, meal, common salt and 0, 20, 40 and 60% cassava root sievate-cassava leaf meal mixture at the rate of 3:1 respectively. The diets were assigned individually to the four animals in metabolism cages in a 4×4 Latin square design experiment. Feed intake, body weight gain, dry matter intake (DMI), nutrient digestibility and the nitrogen balance status of each animal were measured. Results on proximate composition revealed that the nutrient requirements of the goats were adequate. The DMI for the supplement, total DMI, total DMI (g (kg $W^{0.75}$)$^{-1}$), CF intake were highest ($P < 0.05$) for T_4. Average body weight gain (g day^{-1}) and average body weight gain (g (kg $W^{0.75}$)$^{-1}$) were best ($P < 0.05$) for T_3 and T_4. Crude protein digestibility was best ($P < 0.05$) for T_4. Neutral detergent fibre and acid detergent fibre digestibilities were best for T_3 and T_4. Nitrogen intake (g day^{-1}), nitrogen balance (g day^{-1}) (g (W kg$^{0.75}$)$^{-1}$), nitrogen retention (%), nitrogen absorbed (g day^{-1}) (g (kg $W^{0.75}$)$^{-1}$), apparent N digestibility (%) and the efficiency of nitrogen utilization were all best ($P < 0.05$) for and T_4. The diet (T_4) containing 60% CRSCLM mixture was recommended among the other diets for feeding goats, as it had better performance concerning nutrient intake, body weight gain, nutrient digestibility and utilization.

Introduction

In addition to income generation, goat farming is an economic activity that sustains both rural and peri-urban families, in Nigeria and most West African countries. Despite this, the increase in the consumption of goat meat (chevon) in Nigeria is still poorly explored. This may be partly attributed to feeding. Feeding is a very essential part of goat farming and may constitute the highest expense of any goat production. Feed availability has been the major factor against the expansion of goat production here and elsewhere. The high cost of conventional feedstuffs and seasonal variation in Nigeria has necessitated the search for cheap and readily available feed ingredients (Jiwuba, Udemba, 2019) to enhance goat production. Ruminant nutritionist needs to concentrate their research interest on agro-wastes that have no direct nutritional value to man for feeding various classes of goats. Agro-wastes are mostly fibrous materials considered valueless as they are discarded as waste and hence have no economic value and may constitute an environmental nuisance when not properly disposed of. Ojebiyi *et al.* (2002) earlier noted that a potential alternative feed ingredient must not be a staple item that is directly eaten by man to avoid scarcity. Among such interest in this research is cassava root sievate and cassava leaves, which are hitherto not eaten by man. The high fibre content of cassava root sievate (Jiwuba *et al.*, 2018a) makes it to serve as both fillers and nutrient providers in ruminant nutrition. However, their efficient utilization by ruminants can better be achieved when mixed with a higher nitrogenous source to augment for nitrogen deficiency (Jiwuba *et al.*, 2016a). These materials are cheap and readily available all year round, as Nigeria is the world highest producer of cassava (Jiwuba *et al.*, 2018a). Nitrogen is very essential in the synthesis of microbial protein in the rumen, which is essential for the rumen function, and the general performance of the ruminant. Nitrogen balance status shows the extent to which the body is maintaining adequate protein balance (Min *et al.*, 2015). Positive nitrogen balance is an anabolic state for optimal muscle growth. This study aims to evaluate the nutrient intake, nutrient digestibility and nitrogen balance of West African Dwarf goats fed cassava root sievate and cassava leaf meal mixture in their diets.

Material and methods

This trial was carried out at the small ruminant unit of Animal Production Technology, Federal College of Agriculture, Ishiagu, Ivo L.G.A., Ebonyi State, Nigeria. The College is located at latitude 5.56° N and longitude 7.31^0 E, with an average rainfall of 1653 mm and a prevailing temperature condition of 28.50 °C and relative humidity of about 80% (FCAI, Meteorological station, 2017).

The cassava root sievate (variety TMS 419) (CRS) and cassava leaf (variety TMS 419) were sourced and harvested within the Ishiagu community. The cassava root sievate is a by-product of cassava root processing which is acquired after the cassava roots meant for fufu (a popular food in Nigeria) production are peeled or not, washed clean and soaked in clean water for 3–5 days to ferment to reduce the hydrogen cyanide and also to soften the roots to enable sieving (Jiwuba *et al.*, 2018a). Thereafter, the soaked cassava roots were sieved, the sievate (waste) collected and sundried for about 5 days to reduce the moisture contents and possible anti-nutrients that were not removed during the fermentation (retting) process. After which, the retted-sundried cassava root sievate were coarsely milled and stored in batches for future use. The cassava leaves were harvested from the College cassava farms after root harvesting. They were also coarsely milled using a hammer mill to encourage chyme chewing. The cassava root sievate meal (CRSM) and cassava leaf meal (CLM) were mixed in the ratio of 3:1 and used in the formulation of the experimental diet. The cassava root sievate-cassava leaf meal (CRSCLM) mixture was included at the rate of 0%, 20%, 40% and 60% for T_1, T_2, T_3, and T_4, respectively as presented in Table 1.

Table 1. Composition of the experimental diets for West African Dwarf goats

Ingredients	T_1 (0)	T_2 (20)	T_3 (40)	T_4 (60)
CRSCLM	0	20	40	60
Palm kernel meal	48.0	38.0	30.0	20.5
Brewer's dried grain	47.5	37.5	25.5	15.0
Molasses	2.0	2.0	2.0	2.0
Bone meal	1.0	1.0	1.0	1.0
Limestone	1.0	1.0	1.0	1.0
Salt	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0

CRSCLMM =cassava root sievate meal, cassava leaf meal mixture

Four WAD bucks of about 8–10 months of age and averaging 7.62 kg in weight were selected from the College flock for this experiment. The experimental animals were managed following the permission and stipulated guidelines of the Federal College of Agriculture, Ishiagu (FCAI) Animal Ethics Committee. The WAD bucks were subsequently transferred to previously disinfected individual metabolism cages provided with facilities for collecting faeces and urine. Feed offered was based on 3.5% body weight per day. Regular access to fresh drinking water was made available. They were fed the four experimental diets in a 4 × 4 Latin square design. Each animal received the experimental diets consecutively in 4 phases. In each phase, initial live weights of the animals were taken at the beginning of the feeding trial and weekly thereafter. Final live weight was obtained by weighing the goats at the end of the experiment. During phase 1 which lasted for 28 days, each animal received an assigned experiment diet for 21 days. During this period, each animal had access to free drinking water daily. Daily voluntary feed intake was determined. Total faeces and urine voided by the experimental animals were collected during the last 7 days (22–28). 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 feeding periods, was used for total urine and faecal collection. Each animal constituted a replicate while each feeding phase represented an observation. The quantity of each diet offered to the goats during each period ensured about 5% leftover. The leftovers were collected after 24 hours, then weighted and used to determine the voluntary intake. Total faeces collected in the mornings before feeding and watering during days 22–28 of each period. The faeces weighed fresh, dried and bulked for each animal. A sub-sample from each animal was dried in a forced draft oven at 100–105 °C for 48 hours and used for DM determination. Another sample was dried at 60 °C for 48–72 hours for determination of proximate composition. Total urine for each animal collected daily in the morning before feeding and watering. The urine trapped in a graduated transparent plastic container placed under each cage and to which 15 ml of 25% H_2SO_4 was 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 was saved in plastic bottles numbered 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 took for analysis.

All the sample of feed and test ingredients were analyzed for their proximate composition using the method of AOAC (2000). The following were determined and analyzed; dry matter content (DM), crude protein (CP), crude fibre (CF), ether extract (EE), nitrogen-free extract (NFE), ash, neutral detergent fibre (NDF) and acid detergent fibre (ADF) and hemicellulose. Gross energy was calculated using the formula:

$$T = 5.72Z1 + 9.50Z2 + 4.79Z3 + 4.03Z4 \pm 0.9\%; \quad (1)$$

where T – gross energy, Z1 – crude protein, Z2 – crude fat, Z3 – crude fibre, Z4 – nitrogen-free extract (Nehring, Haelein, 1973).

Data obtained were analysed using analysis of variance (ANOVA) as described by SAS (2008). Significant means were separated using the Duncan Multiple New Range Test.

Results and discussion

The proximate composition of the experimental diets, CRSM, CLM and *Panicum maximum* are shown in Table 2. The DM, CF and gross energy of the experimental diets tend to increase with increasing levels of CRSCLM while NDF and ADF decreased with increasing levels of CRSCLM. Ash, EE, CP, NFE and hemicellulose failed to follow a specific pattern across the treatment groups. The CLM is comparable with the DM, CP, ash and NFE values reported by Akinfala *et al.* (2002). The crude protein content of the CRSM is below the acceptable 7% CP for ruminant performance as recommended by ARC (1980) and 8% suggested by Norton (1994) for ruminal function. The fibre fractions (NDF, ADF and hemicellulose) imply the digestibility of plants. The NDF is a measure of the plant cell wall contents, used in determining the rate of digestion of feed. The NDF comprises mainly the cell wall fraction of forages and roughages and includes a complex matrix of lignin, small amounts of protein, and various polysaccharides. Odedire and Babayemi (2008) noted that the higher the NDF, the lower the plant's digestible energy. The values obtained for the CRSM may imply moderate cell wall content, moderate digestible energy and DM intake. The ADF consists mainly the lignin and cellulose. Hemicellulose has been reported to be more digestible than cellulose (Gillespie, 1998). The reportedly lower values of the fibre fractions are in agreement with the findings of Boonnop *et al.* (2009) for the same cassava by product. The high energy value reported for the CRSM is in agreement with Khampa *et al.* (2009) who noted that cassava roots contain high levels of energy and have been used as a source of readily fermentable energy in ruminant rations. The high dry matter value reported is favourably compared with the values of Boonnop *et al.* (2009). The proximate composition of the experimental diets revealed that the crude protein and the energy requirements are within the ranges reported for goats (ARC, 1980; NRC, 1981; Norton, 1994). The DM, ash NDF, ADF and hemicellulose were higher in the control but compared to the treatment groups. The proximate composition of *Panicum maximum* in this study is in comparison with the values reported by Odedire and Babayemi (2008), Onyeonagu and Eze (2013) and Jiwuba *et al.* (2016b) for the same forage.

Table 2. Proximate composition of the experimental diets, cassava root sievate meal, cassava leaf meal and *Panicum maximum*

Nutrients, %	Treatment				Cassava root sieviate meal	Cassava leaf meal	*Panicum maximum*
	T_1 (0)	T_2 (20)	T_3 (40)	T_4 (60)			
Dry matter	89.95	90.40	91.00	91.44	88.60	89.12	30.93
Crude protein	13.00	14.87	13.64	15.36	2.57	17.66	5.34
Crude fibre	18.96	18.96	19.65	20.11	18.96	5.38	12.64
Ash	5.44	5.59	4.91	4.50	1.80	9.87	4.01
Ether extract	2.15	3.26	3.38	2.90	2.71	3.93	3.17
Nitrogen free extract	48.04	42.72	50.14	50.93	68.14	52.28	26.37
Gross energy, MJ g^{-1}	3.94	3.89	4.07	4.04	3.79	3.76	2.27
Neutral detergent fibre	62.44	42.08	35.75	33.93	25.34	39.90	58.31
Acid detergent fibre	58.35	38.30	25.11	23.69	6.68	33.25	28.60
Hemi cellulose	4.09	3.78	10.64	10.24	8.66	6.65	19.17

Nutrient intake and body weight gain of West African Dwarf goats fed cassava root sievate and cassava leaf meal mixture in their diets is presented in Table 3. DM intakes were improved with the inclusion of 20, 40 and 60% CRSCLM in the diets with values ranging from 367.32–407.00 g day^{-1} observed in bucks fed 0 and 60% CRSCLM supplement respectively. The observed increased ($P < 0.05$) DM intake is in agreement with earlier reports of Odusanya *et al.* (2017) and Okah *et al.* (2019) who reported significant improvement for WAD rams fed cassava leaf meal concentrate diets and WAD bucks fed replacement levels of cassava peel meal (CPM) for maize offal respectively. The increased DM intake above 20–60% inclusion of CRSCLM may be attributed to the increased palatability of the feed. The reduced feed DMI observed in the control may be due to high levels of palm kernel cake and brewer's dried grain. A similar result was reported by Adu (1985). This may be partly be attributed to the fact that goat general relish cassava and its products. The total DMI range (83.90 and 90.69 g (kg $W^{0.75}$)$^{-1}$) obtained in this study are well above the recommended voluntary feed intake of 75 g (kg $W^{0.75}$)$^{-1}$ and 65 g (kg $W^{0.75}$)$^{-1}$ by AFRC (1998) and 68 g (kg $W^{0.75}$)$^{-1}$ by Kearl (1982) for goat breeds commonly raise in developing countries. Crude protein intake (CPl) ranged between 55.84 and 64.42 g d^{-1} which, is lower than the range reported by Okah *et al.* (2019) for WAD goats fed cassava peel meal. However, the CPI reported in this study fall within the range of CPI required for goats in the Tropics (Devendra, McLeroy, 1982). Crude protein intake is vital in the performance of goats due to increased availability of fermentable nitrogen needed by rumen microbes and chances of increased bypass protein. In an earlier study by Promkot and Wanapat (2003) noted that cassava leaf meal is similar to that of cottonseed meal as a source of by-pass protein. Crude fibre intake (CFl) increased significantly ($P < 0.05$) from values for T_I (77.52 g day^{-1}) to those of T_4 (89.60 g day^{-1}). Similar, non-significant ($P > 0.05$) increase were also observed in metabolic CFI (g (kg $W^{0.75})^{-1}$). CFl (77.52–89.60 g day^{-1}) is lower than the range reported by Okah *et al.* (2019) for WAD goats fed cassava peel meal. The trend of the CFI is in agreement with an earlier report of Van Soest *et al.* (1991) which stated that the level of fibre in feed could be used to predict the intake. Hence, the CFI in this study followed a similar trend with DMI and CPI. Oni *et al.* (2010) noted that ruminants generally require ample coarse insoluble fibre for normal rumen function which is associated with adequate rumination and cellulose digestion. The higher fibre intakes reported for the treatment (T_2, T_3 and T_4) groups in this study may have facilitated colonization of ingesta by rumen microbes that in turn might induce higher fermentation rates, thus improved intake, digestibility and utilization of nutrients.

Average daily weight gain (ADWG) values ranged from 57.07 to 85.26 g day^{-1} across treatments. The variation could be attributed to the chemical constituents, a nutrient in the diet and age of animals. The higher weight gain observed in 40 and 60% inclusion of CRSCLM may suggest that higher levels of CRSCLM in the diet had a positive effect on the weight gain of the goats. The ADWG (57.07–85.26 g day^{-1}) obtained in the present study is higher than 33.8–52.9 g day^{-1} earlier reported by Oni *et al.* (2010) for WAD goats fed graded levels of dried cassava leaves but lower than the values (98.75–124.82 g day^{-1}) reported by Anya and Ozung (2018) for WAD goats fed diets containing African yam bean seed meal. The highest live weight gain obtained by goats on T_3 and T_4 diet may be attributed to the significant DM and CP intake of the goats. This is suggestive that increasing levels of cassava root sievate-cassava leaf meal mixture in the diets enhanced the growth rate of the goats. In an earlier study, Jiwuba *et al.* (2016b) reported that dry matter and crude protein intake as crucial to feed utilization and enhanced performance among goats. Feed conversion ratio although not ($P > 0.05$) affected were better for the T_3 and T_4 group. This could be attributed to the diets to overcome the nitrogen deficiency and boosted the multiplication of rumen microbes to enhance degradability and utilization of nutrients.

Table 3. Nutrient intake and body weight gain of West African Dwarf goats fed cassava root sievate and cassava leaf meal mixture in their diets

Parameters	Treatment				SEM
	T_1 (0%)	T_2 (20%)	T_3 (40%)	T_4 (60%)	
Daily feed intake, g day^{-1}	408.84	433.20	409.38	445.57	10.67
Dry matter intake (DMI), g day^{-1}					
Supplement	256.68^{c}	286.75^{b}	280.63^{b}	305.93^{a}	9.23
Forage	110.64	95.82	91.91	101.15	3.60
Total DMI	367.32^{c}	382.57^{b}	372.54^{b}	407.08^{a}	11.39
Total DMI, g (kg $W^{0.75})^{-1}$	83.90^{c}	86.50^{b}	84.80^{b}	90.69^{a}	2.74
CP intake, g day^{-1}	55.84	62.80	57.92	64.42	4.69
CP intake, g (kg $W^{0.75})^{-1}$	20.43	22.31	21.00	22.74	1.76
CF intake, g day^{-1}	77.52^{b}	82.10^{b}	80.44^{a}	89.60^{a}	3.56
CF intake, g $W^{0.75\ -1}$	26.12	27.27	26.86	29.12	1.23
Initial body weight, kg	5.85	6.96	6.90	7.15	0.26
Final body weight, kg	11.61	14.62	14.94	15.42	0.70
Total weight gain, kg	5.76	7.67	8.04	8.27	0.32
Average weight gain, g day^{-1}	59.38^{b}	57.07^{b}	82.89^{a}	85.26^{a}	7.74
Average weight gain, g (kg $W^{0.75})^{-1}$	21.39^{b}	20.76^{b}	27.47^{a}	28.06^{a}	1.86
Feed conversion ratio	6.89	7.59	4.94	5.23	0.63

$^{a-c}$ means within the same row with different superscripts are significantly different ($P < 0.05$)

Generally, digestibility values were high and the highest DM digestibility of 68.32% was obtained in T_1 but the value is similar ($P > 0.05$) with other treatments (Table 4). Apparent digestibilities of CP, Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were significantly ($P < 0.05$) affected across the treatments, whilst dry matter (DM) and crude fibre (CF) were similar ($P > 0.05$) for all the diets. CP digestibility was least digested in T_1 (53.66%) and best digested in T_4 (71.33%). The highest ($P < 0.05$) digestibility coefficient of crude protein obtained in treatment T_4 showed that the dietary protein was better utilized by the animals fed diet T_4 relative to other treatments. This could be attributed to the addition of a higher proportion of cassava leaf meal, which may have improved the available amino acid content of the diet. The protein and amino acid profile of cassava leaves have compared with that of soybean (Eggum, 1970; Ravindran, 1991). The CP content of T_4 diet seems to have encouraged rumen motility and microbial functions, which resulted in high nutrient utilization and comparable performance with the control group T_1. Further, Ahamefule (2005) observed that dietary protein-enhanced digestibility; hence, the improved CP digestibility coefficient in the present study may be attributed to inclusion level of CRSCLM, which might have increased more protein availability to rumen microbes to catalyze the digestion process. The reported CP digestibility coefficient in this study compared with 56.07–66.33% for WAD bucks fed cassava peel-cassava leaf meal-based diets reported by Ukanwoko *et al.* (2009). NDF digestibility was lowest for goats fed T_1 (65.48%) diets and highest for goats on T_3 (71.10%) and T_4 (73.97%) diets. ADF digestibility followed a similar pattern as the NDF. The differences observed in digestibility values of the fibre fractions among the goats might be due to the lignin contents in the feed mixtures. The cassava root sievate had been reported to be high in fibre (Jiwuba *et al.*, 2018b) and this could inhibit digestibility. Mertens (1977) reported that changes of the composition of cell wall involving lignin and possibly silica limited the potential extent of digestion whereas the rate of digestion is limited by the chemical entities other than by the crystalline or physical nature of the fibre.

Table 4. Apparent nutrient digestibility of West African Dwarf goats fed cassava root sievate and cassava leaf meal mixture in their diets

Parameters, %	Treatment				SEM
	T_1 (0)	T_2 (20)	T_3 (40)	T_4 (60)	
Dry Matter	68.32	66.97	68.04	67.45	0.68
Crude protein	53.66^{d}	64.78^{b}	59.06^{c}	71.33^{a}	1.45
Crude fibre	59.66	58.92	60.22	56.99	1.11
Neutral detergent fibre	60.22^{c}	67.67^{b}	71.09^{a}	73.97^{a}	1.34
Acid detergent fibre	58.07^{c}	63.77^{b}	68.86^{a}	69.56^{a}	0.89

$^{a-c}$ means within the same row with different superscripts are significantly different (P < 0.05)

Nitrogen intake were 10.62, 12.11, 11.67 and 14.67 g day^{-1} for goats fed T_1, T_2, T_3 and T_4 respectively. Nitrogen intake (g day^{-1}) was (P < 0.05) best for goats fed T_4 diet. The values failed to follow any particular trend. However, the values of nitrogen intake (g (W kg$^{0.75}$)$^{-1}$) were not influenced (P > 0.05) by the diets. These values are comparable to the values of 9.92–15.35 g day^{-1} reported by Okah *et al.* (2019) for WAD goats fed cassava peel meal but higher than 5.07–6.32 g day^{-1} reported by Oni *et al.* (2010) for WAD goat fed dried cassava leaves. The high N intake observed for T_4 may be attributed to the higher incremental level of CRSCLM. Ravindran (1991) and Promkot and Wanapat (2003) compared amino acid and protein profile of cassava leaves in earlier studies with soybean and cottonseed respectively. Urinary N, faecal N and total nitrogen excreted did not differ significantly (P > 0.05) among treatment groups. However, goats fed T_1 diet had higher urinary nitrogen, and goats on T_3 had the highest faecal N. The non-significant faecal nitrogen and urinary nitrogen values reported in this study among the treatment groups are in agreement with the findings of Okah *et al.* (2019) and Odoemelam *et al.* (2015) who observed that faecal nitrogen and urinary nitrogen were not significantly affected by nitrogen intake. In an earlier study, Hadjipanayiotu *et al.* (1991) reported that diets high in protein result to the high concentration of rumen NH_3–N, which rumen microbes cannot efficiently utilize, and the NH_3 is excreted through the urine in the form of urea. Hence, the lower and non-significant (P > 0.05) value of urinary N reported in this study may have indicated that the rumen microbes efficiently utilized the protein in the CRSCLM containing diets.

Nitrogen balance, nitrogen absorbed and retention values were higher in the treatment diets (T_2, T_3 and T_4) showed the potentials of CRSCLM to enhance nitrogen utilization. Nitrogen balance values obtained in this study were higher than previously reported values in WAD goats fed dried poultry waste-cassava peel based diets (Ukanwoko, Ibeawuchi, 2009) and those fed graded levels of dried cassava leaves (Oni *et al.*, 2010). When nitrogen balance and nitrogen absorbed were expressed on a metabolic weight basis, the results showed significantly (P < 0.05) higher values for the treatment groups. This may indicate that the animals were all in positive nitrogen balance. This may also suggest high utilization of the CP in the diets by the animals especially the CRSCLM containing diets. The high nitrogen retention in comparison with the control supports the report of Sarwar *et al.* (2003) that nitrogen retention depends on the intake of nitrogen, the amount of fermentable carbohydrate of the diet. Cassava root sievate have been reported (Jiwuba *et al.*, 2018a) to be high in fermentable carbohydrate and cassava leave protein content have been reported (Khieu *et al.*, 2005) to range from 16.6 to 39.9%. The positive N balance obtained in this study indicates the positive influence of increasing proportions of urea with CRSCLM based diets in feeding WAD goats. The differences in the quantity and routes of nitrogen excretion with consequent influences on nitrogen retention could reflect treatment feed differences in nitrogen metabolism, in which nitrogen retention is considered as the most common index of the protein nutrition status of ruminants (Owens, Zinn, 2005). T_4 gave the highest apparent nitrogen digestibility. This could probably be attributed to high rumen degradability of cassava and its by-products (Jiwuba, Jiwuba, 2020). This is justified by the fact that none of the experimental animals lost weight during the study.

Table 5. Nitrogen utilization of West African Dwarf goats fed cassava root sievate and cassava leaf meal mixture in their diets

Parameters, %	Dietary levels				SEM
	T_1 (0)	T_2 (20)	T_3 (40)	T_4 (60)	
Nitrogen intake, g day^{-1}	10.62^{c}	12.11^{b}	11.67^{bc}	14.67^{a}	0.48
Nitrogen intake, g (W kg$^{0.75}$)$^{-1}$	5.88	6.49	6.31	7.50	0.52
Urinary Nitrogen, g day^{-1}	1.23	1.17	1.19	1.20	0.07
Faecal Nitrogen, g day^{-1}	4.42	3.39	4.46	3.99	0.09
Total Nitrogen excreted, g day^{-1}	5.65	4.56	5.65	5.19	0.14
Total Nitrogen excreted, g (W kg$^{0.75}$)$^{-1}$	3.66	3.12	3.66	3.44	0.08
Nitrogen balance, g day^{-1}	4.97^{d}	7.55^{b}	6.02^{c}	9.48^{a}	0.34
Nitrogen balance, g (W kg$^{0.75}$)$^{-1}$	3.33^{d}	4.55^{b}	3.93^{c}	5.40^{a}	0.29
Nitrogen retention, %	46.80^{c}	62.35^{a}	51.59^{b}	64.62^{a}	1.57
Nitrogen absorbed, g day^{-1}	6.20^{d}	8.72^{b}	7.21^{c}	10.68^{a}	0.59
Nitrogen absorbed, g (W kg$^{0.75}$)$^{-1}$	3.93^{b}	5.07^{ab}	4.40^{ab}	5.91^{a}	0.38
Apparent N digestibility, %	58.38^{c}	72.01^{a}	61.78^{b}	72.80^{a}	1.21
Efficiency of N utilization (ENU)	0.47^{c}	0.62^{a}	0.52^{b}	0.65^{a}	0.03

$^{a-d}$ means within the same row with different superscripts are significantly different (P < 0.05)

Conclusions

Incorporation of cassava root sievate-cassava leaf meal in concentrate diets fed as supplements to WAD bucks on *Panicum maximum* positively influenced dry matter intake (DMI), body weight gain, apparent N-digestibility, nitrogen balance and utilization. It could be concluded that cassava root sievate-cassava leaf meal could be included in the diets of goats up to 60% in a dry season supplement to enhance intake, body weight gain, nutrient digestibility and nitrogen balance of West African Dwarf goats. The use of cassava root sievate-cassava leaf meal-based diets is therefore recommended for enhanced goat production.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Author contributions

PDCJ – conceptualization and planning; data collection, analysis and interpretation, original draft preparation, writing, review and editing.

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