

Performance of West African dwarf goats fed Agro-industrial by-products and *Pennisetum purpureum* hay as dry season feed

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Abstract

This study was carried out to evaluate the performance of West African dwarf goats fed agro-industrial by-products (cassava peels, dried poultry waste, molasses and saw dust ash) based diets. The study lasted for 120 days during which diets formulated with 0% (1), 20% (2), 25% (3) and 30% (4) dried poultry waste (DPW) replaced cassava peels meal (CPM) in the same proportion. The diets were fed as a supplement to Pennisetum purpureum hay (basal). The goats were arranged in a completely randomized design. Parameters included feed intake, digestibility, nitrogen utilization, and growth rate were studied. The dry matter (DM) and crude protein (CP) intakes (glkgW $^{0.75}$/ day) were not significantly (p< 0.05) different among treatment means. Animals placed on diet 1 (control) had values of 115.51gW$^{0.75}$/day and 20.99gW$^{0.75}$/day for DM and CP intakes respectively. The digestibility of diet 3 (67.35, 80.77, 70.32, 72.89, 72.69, 74.58 and 59.98%) DM, CP, EE, CF, ADF, NDF, ADL and NFE respectively compared favourably with diet 1. The nitrogen retention was highest in diet 3 (75.7%).The live weight gain (g / day) was highest in animals fed diet 1 and that on diet 3. There were significant (p < 0.05) differences in feed conversion ratio and the cost per kilogram live weight gain was highest in diet 4 with 30 % DPW inclusion. It was therefore concluded that feeding of diet 3 (25% DPW) could lead to improved feed intake, nutrient digestibility, nitrogen utilization and weight gain in WAD goats.

Keywords: Agro-industrial by-products, digestibility, nitrogen utilization, WAD goats

Introduction

Dry season feeding of ruminants especially goats in Nigeria has always been a challenge to farmers since good quality pastures are scarce, hence performance of these animals are seriously impaired. The situation becomes worse during this period as animals are unable to meet their protein and energy need from available poor quality herbage with consequent marked weight loss and reduced productivity (Ademosum, 1994). Attempt at improving animal protein intake in Nigeria must first address the perennial shortage of feed and dry season fodder for ruminant livestock. One possible way to alleviate this challenge and maintain production in Nigeria is to utilize locally available feed resources such as agro-industrial by-products which cannot be consumed by man but can be converted by ruminants into desirable human food. This will reduce the cost of animal production without a decrease in productivity (Oduguwa *et. al.,* 2013). Such wastes/ agro-industrial by-products include cassava peels, poultry waste, molasses and sawdust ash. Cassava peels is a by-product of garri processing in Nigeria and it contain 87.40% dry matter, 5.20% crude protein, 14% crude fibre, 5.80% and 1.40% ash (Aro and Aletor, 2012). Evidence so far shows that cassava is a good source of energy which when fortified with protein feedstuffs promotes positive and high performance in cattle, sheep and goats (Iyayi and Tewe, 1994). Poultry waste/manure is a potential source of protein. It has attracted the attention of nutritionist all over the world because of its high/ richness protein content, Ca (5.4%), potassium as K_2O and magnesium as MgO (0.335) and other minerals, being considered as one of the protein feedstuff. While saw dust ash from mixed wood species has been reported (Sowande *et al*., 2002) to contain high level of Ca, Mg, S and trace elements. Ibeawuchi *et al.* (1993) reported the use of molasses (a by-product of the sugar beet and sugar cane industries) to improve palatability of poultry waste by Borno white goats. Attempts have been made by various authors/ researchers to determine proximate composition, the processing techniques for each material to be maximally utilized and their levels of inclusion in the formulation of diets based on the requirements of the animals (Oladotun *et al.,* 2003). The availability of *Pennisetum purpureum* during the wet season which could be sundried and use to feed animals during the dry season as hay and availability of cassava peels, poultry waste, molasses and sawdust ash which is in abundance in the southwestern Nigeria made the development of dry season feed for goats in this area with these by-products imperative. This study was therefore designed to investigate the performance of WAD goats fed cassava peels, poultry waste, molasses and sawdust ash.

Materials and methods

Experimental location

The study was carried out at goat unit of small ruminant section of the directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta, south western Nigeria. The location is 76m above the sea level and it falls within latitude 7^0 $5.5^1 – 78.0^1$ N and longitude 3^0 $11.2^1 – 3^0$ 2.5^1 E during the late dry season (January to March).

Animals and their management

Sixteen West African dwarf goats between 8–10 months of age and weighing between 7 – 8 kg were used. The goats were divided into four groups of four animals each, balanced for body weight; each group of animals was randomly assigned to one of four experimental diets with *Pennisetum purpureum* serving as basal diet. Animals were fed at 50 g/kg BW during a 120 – day feeding trial and were allowed an adaptation period of 14 days prior to data collection.

Feed materials and processing

Pennisetum purpureum was collected around the premises of the University, chopped into small bits (about 2-3cm) and sun-dried for 4 – 5 days after which it was packed into sacks and kept in well ventilated room. Poultry waste was collected from birds (layers) reared using the battery cage system in the poultry unit of teaching and research farms of the institution. After collection, the waste was sun-dried to minimize bacterial activity that might lead to the loss of soluble nutrients particularly nitrogen and potassium. After drying, it was then milled to pass through a 1mm sieve and then stored in sacks. Wood ash sample was collected from saw mill at camp area of Abeokuta, Ogun State. Collection was done immediately after open air burning of sawdust. The ash was sieved through a 1mm screen ready for feed formulation. The cassava waste was collected from garri and cassava flour sites in Isolu area of Abeokuta. After collection, it was sun-dried for an average of 5 days to reduce the HCN content. The dried cassava waste was later crushed while molasses was collected from Dangote sugar factory at Apapa, Lagos. Four experimental diets were formulated; diet 1 contained dried brewers' grain as the protein source while diets 2, 3 and 4 contained 20.00, 25.00 and 30.00% by weight of dried poultry waste respectively as presented in table 1 below.

Experimental design

The experimental animals were allotted on weight equalization basis into four groups of four grown goats per treatment. Each animal was treated as a replicate in a completely random manner. The feeding trial lasted for 120 days. Feeding was based on 5% body weight of the animals.

Data collection

Feed intake and body weight

The goats were fed the experimental diets 8.00 am and *Pennisetum purpureum* hay (basal diet) at1.00 pm. Feeds refused were weighed on a daily basis to estimate the dry matter intake. The goats were weighed using hanging scale before the commencement of the experiment and weekly on the same day of the week before feeding.

Digestibility and nitrogen balance

Four goats were used per treatment for digestibility and nitrogen balance studies. Each goat was kept in an individual metabolic cage designed for separate collection of urine and faeces for 7 days. After one-week adjustment to the cage the quantity of feed offered, feed refused, faeces and urine from each goat were determined. Nitrogen loss from the urine by volatilization was prevented by introducing 10 ml of 10% H_2SO_4 into the urine sample (Chen and Gomez, 1992). Daily collections of feaces and urine were separately bulked and a 10% sub sample of each was taken. Faecal samples were oven dried at 70^oC for 48 hours. Urine samples were stored in a deep freezer until required for analysis.

Chemical analysis

Dried samples were milled with Thompson hammer mill using 2mm sieve. Samples were analyzed for nitrogen by the Micro-kjeldahl method. Dry matter, crude fire, ether extract and ash were determined according to the official Method of Analysis (A.O.A.C, 2005). Samples were analyzed in duplicate. Nitrogen free extract was obtained by calculation while acid detergent fiber, neutral detergent fiber and acid detergent lignin were determined (Van Soest *et al*., 1991). Mineral analyses of calcium and magnesium were read with atomic absorption spectrophotometer after ashing of sample in a muffle furnace at 550^0C and phosphorus by spectrophotometer (Spectronic 20).

Statistical Analysis

Data obtained were subjected to one way analysis of variance (ANOVA) using SAS (1990) procedure. Differences among means were separated by Duncan's multiple range test (Duncan, 1955).

Results

Table 2 shows the chemical composition of dried poultry waste, *Pennisetum purpureum* (hay) and experimental diets fed to WAD goats. The dry matter of dried poultry waste (DPW) and *Pennisetum purpureum* (hay) were both high. The crude protein content of DPW (22%) was higher than 4.0% in *Pennisetum purpureum* (hay).While the crude fibre content was higher (40.90%) in *Pennisetum purpureum* (hay) compared to 17.7% in DPW. The Ca and Mg contents (2.820% and 1.962%) were higher in DPW while the P content (3.165%) was higher in *Pennisetum purpureum* (hay). However, the ME value ranged between 1439 to 3839 Kcal/Kg being lower in *Pennisetum purpureum.* The dry matter contents of experimental diets varied between 93.5% and 95.5%. The crude protein was highest (15.4%) in diet 1 (control) that contained brewer's dried grains (BDG) as the protein source. However, it subsequently increased from diets 2 to 4 as the percentage of DPW inclusion increased (14.2% to 15.0%). The crude fibre content followed a similar trend with diet 1 (control) and diet 2 (20% DPW inclusion) having the same value of 12.2% and diets 3 and 4 with 11.2%. The ADF content was highest in diet 1 (12.5%). It increased with increasing levels of DPW. The NDF and ADL followed a similar trend. The ether extract was highest in diet 4, while diets 1 and 2 contained similar value (5.5%). The ash content increases from diets 1 to 4 (7.4 to 13.8%). The NFE in the diets ranged between 53.5% in diet 4 to 59.5% in diet 1. The Ca level was highest in diet 4 and lowest in diet 1. Magnesium content increased from 0.291% in diet to 2.219% in diet 4. The concentration of phosphorous was highest in diet 2. The energy level increased from diet 2 to 4 and diet 1 had the highest value (2814 Kcal/Kg).

The performance characteristics of the goats are shown in Table 3. There was no significant difference ($p>0.05$) in dry matter, ether extract, CF, NDF, Ash and NFE intakes across the dietary treatment, while the values of intake of CP, ADF, ADL, Ca, Mg and P were significantly influenced by the dietary treatments. Goats placed on diet 1 (control) consumed the highest values of DM and CP (115.51 and 94.58 g $W^{0.75}d^{-1}$ respectively). There were significantly differences ($p<0.05$) in live weight changes of the animals. The highest mean liveweight gain was recorded by goats on diet 1 (control) while the least was by diet 2 (2.45 kg). The feed conversion ratio (FCR) was significant ($p< 0.05$) among the dietary treatments. Animals on diet 4 had the highest FCR while goats on diet 1 recorded the lowest. The feed efficiency ratio was animals fed the control diet.

Table 4 presents the apparent digestibility of the nutrients by goats. Significant differences ($p<0.05$) were observed among the treatments in all the parameters measured. Animals on diet 1 had the highest apparent crude protein, ADF, NDF, and ADL digestibility, while the digestibility of animals on diet 3 compared favourably with those on diet 1 (control).

As shown in Table 5, the dietary treatments had a significant ($p<0.05$) effect on N utilization of goats. Animals on diets 1 (control) and 3 (40% DPW inclusion) had encouraging N utilization when compared with those on diets 2 and 4. The N retained were comparable for goats on diets 1 and 3 (6.36 and 6.35 gd^{-1}) respectively.

Table 1: Ingredient composition of experimental diets (g/kg)

Ingredients	Diets			
	1	2	3	4
Cassava waste	620.00	720.00	670.00	620.00
Brewer's dried waste	300.00	0.00	0.00	0.00
Poultry waste	0.00	200.00	250.00	300.00
Molasses	50.000	20.00	50.00	50.00
Sawdust ash	20.00	20.00	20.00	20.00
Salt	10.00	10.00	10.00	10.00
Total	1000.00	1000.00	1000.00	1000.00

Table 2: Nutrient composition (g/100g DM) of feeds and experiment diets fed to WAD goats

Components	Dried Poultry waste	*Pennisetum purpureum* (hay)	Experimental diets 1	2	3	4
Dry matter	96.0	93.5	95.5	95.0	94.5	93.5
Crude protein	22.0	4.0	15.4	14.2	14.6	15.0
Crude fibre	17.7	40.9	12.2	12.2	11.2	11.2
Acid detergent fibre	16.8	21.0	12.5	10.7	11.0	11.6
Neutral detergent fibre	25.7	32.4	15.3	11.4	13.1	14.6
Acid detergent lignin	5.7	2.2	4.9	3.3	3.2	2.7
Ether extract	2.0	7.5	5.5	5.5	5.5	6.5
Ash	27.1	10.2	7.4	10.0	10.1	13.8
Nitrogen free extract	31.2	37.4	56.5	58.1	58.6	53.5
Calcium	2.820	0.144	0.138	1.030	0.788	0.856
Magnesium	1.962	0.356	0.291	1.852	0.912	2.219
Phosphorus	2.918	3.165	0.918	2.432	0.554	1.581
Metabolizable energy (Kcal/kg)	3839	1439	2814	2438	2514	2632

Table 3: Performance characteristics of WAD goats Fed experimental diets

Parameters	Diets 1	2	3	4	SEM
Nutrient Intake g $W^{0.75}$ d^{-1}					
Dry matter	115.51	94.58	113.71	109.74	7.62
Crude Protein	20.99^a	15.89^c	19.43^b	19.05^b	1.15
Ether Extract	14.65	14.58	12.15	14.91	1.01
Crude Fibre	40.64	35.35	41.53	41.53	3.34
Acid Detergent Fibre	29.60	25.11	30.33	35.37	2.89
Neutral Detergent Fibre	38.19^a	29.94^b	37.06^a	35.37^a	2.89
Acid Detergent Lignin	9.79^a	6.43^b	7.63^b	6.81^b	0.54
Ash	18.43	18.43	18.81	22.70	1.41
Nitrogen Free Extract	68.44	59.39	61.88	62.20	4.21
Calcium	0.84^b	2.10^b	2.09^a	2.10^a	0.09
Magnesium	1.56^d	3.29^b	2.58^c	4.27^a	0.17
Phosphorus	8.40^a	6.46^b	7.89^a	6.58^b	0.54
Feed Intake and Growth Performance					
Initial liveweight (kg)	7.33	7.35	7.33	7.30	0.78
Final liveweight (kg)	11.56^a	9.80^b	10.28^a	10.05^a	0.71
Average liveweight (kg)	9.45	8.58	8.81	8.68	0.72
Metabolic weight ($Wkg^{0.75}$)	5.39	5.01	5.11	5.06	0.48
Total weight gain (kg)	4.23^a	2.45^b	2.95^b	2.75^b	0.89
Daily weight gain (gd^{-1})	35.21^a	20.42^b	24.48^b	22.91^b	2.34
Feed conversion ratio	16.03^b	21.16^a	22.62^a	23.34^a	1.72
Feed efficiency	0.060	0.050	0.040	0.040	1.16

a,b,c: means on the same row with different superscript are significantly ($p<0.05$) different.

Table 4: Apparent digestibility coefficient (%) of nutrients by WAD goats fed experimental diets

Nutrient	Diets 1	2	3	4	SEM
Dry matter	64.75^b	55.91^d	67.35^a	62.03^c	0.552
Crude Protein	80.89^a	66.87^c	80.77^a	76.26^b	0.764
Crude Fibre	70.81^b	62.42^d	72.89^a	63.72^c	0.369
Acid Detergent Fibre	76.64^a	71.16^a	72.69^a	70.54^b	0.530
Neutral Detergent Fibre	76.04^a	61.33^c	74.58^a	73.99^b	0.488
Ether	58.83^c	55.91^d	70.32^a	67.87^b	0.348
Nitrogen free extract	57.07^b	56.37^b	59.98^a	53.02^c	0.261

a,b,c,d means on the same row with different superscript are significantly ($p<0.05$) different.

Table 5: Nitrogen utilization by WAD goats fed experimental diet

	Diets				
Parameter	1	2	3	4	SEM
Nitrogen intake (gd^{-1})	9.31[a]	6.39[b]	8.36[a]	8.16[a]	0.493
N -intake ($gd^{-1}W^{0.75}$)	5.33[a]	4.02[b]	4.92[a]	4.83[a]	0.285
Feacal N output (gd^{-1})	2.18	1.95	1.87	2.11	0.102
Urinary N output (gd^{-1})	0.77[a]	0.32[b]	0.14[c]	0.77[a]	0.033
Total N output (gd^{-1})	2.95[a]	2.27[b]	2.01[b]	2.96[a]	0.174
Nitrogen Retained (gd^{-1})	6.36[a]	4.12[b]	6.35[a]	5.28[a]	0.366
N-Retention (%)	68.31[b]	64.48[c]	75.71[a]	64.46[c]	1.177

a,b,c means on the row with different superscript are significantly ($p<0.05$) different.

Discussion

The proximate composition of *P. purpureum* (hay) observed in this study (90.39%, 10.25%, 70. 81%, 41. 20% and 12.48% for DM, CP, NDF, ADF and Ash respectively) is comparable to that reported by Aye (2000). On the contrary, the DM (46.22%) reported by Omoniyi *et al.* (2013) for dried *P. purpureum* was lower than 90.39% obtained in the present study. This may be attributed to the period or stage of harvesting, varietal differences, physiological plant parts, and parts used for the study as well as the drying period observed in this study. The values of 90.00, 20.00, 16.50, 1.00 and 21.00% for DM, CP, CF, EE and ash of DPW respectively as reported by Ibeawuchi *et al.* (1993) were lower compared to those of 96.00, 22.00, 17.70, 2.00 and 27.10% obtained in the current study. The values of CF (16.50%) and NFE (31.2%) were lower when compared with the reported values by Belewu and Adeneye (1996). The CP of experimental diets ranged between 14.20 – 15.40% with the highest and the lowest values observed in diet 1 (control) and diet 2 respectively. The range was however lower to the reported range (15.75 – 21.68 g/kg) by Adegun and Aye (2013) for *Moringa oleifera* leaf meal concentrate but fell within the CP recommended (NRC, 1985) for weaning goats (14.0%) as well higher than 8% required to satisfy the maintenance requirements for ruminant (Norton, 2003). The values also compared favourably with the reported values (13.18 – 14.30%) of poultry droppings and maggots combination diets (Okah and Ogbonnaya, 2013). The crude fibre content of diets in this study was lower than the value (34.85%) reported by Oladotun *et al.* (2003). It may be as a result of inclusion of *P. purpureum* (hay) in the concentrate diet used in their study. However, the values of ADF, NDF and ADL for all the experimental diets were lower than the values (62.29% NDF, 47.83% ADF and 20.25% ADL) by Oladotun *et al.* (2003). Diets 1 (control) and 3 contained the lowest values of those components which indicate that diets 1 and 3 are likely to be more digestible than diets 2 and 4. The major minerals (Ca, P and Mg) appeared to be adequate for ruminant animals based on the recommendations (ARC, 1980 and Suttle, 1983). The dry matter intake (DMI) was generally high for all the experimental diets contrary to the report of Alikwe *et al;* (2011) that DMI decreased as the proportion of DPW in the diet increased. The high DMI obtained in this study may be due to the inclusion of molasses at 5% level. This is in line with the finding of Ibeawuchi *et al.* (1993) that molasses improved palatability of poultry waste diets when fed to Borno White Goat at 10% level of inclusion. The highest DMI recorded by goats that consumed diet 1 (control) might be as a result of brewer's dried grains (BDG) being more palatable than DPW. Better performance of WAD goats fed the experimental diets were obtained from WAD goats fed diet 1 (control) than others. This can be attributed to high nutrient intakes and digestibilities. This is corroborated by the report (Gatenby, 2002) that productivity in ruminants is primarily influenced by feed intake and digestibility. Average daily weight gain in this study ranged from 20.42 to 35.21 gd^{1} and this is lower than 46.00 to 56.00 gd^{1} reported by Babayemi *et al.* (2006) for goats on *Panicum maximum* and concentrate diets supplemented with legumes. But comparable to 28.4 gd^{-1} obtained by Adebowale and Taiwo (1996) for WAD goats fed diet containing 15% poultry litter. The highest mean digestibility coefficients of all the nutrients obtained for diet 1(control) may be as a result of associative effect of brewer,s dried grains (BDG) and cassava wastes in the diet. It can also be an indication that BDG is more digestible than cassava peels on the diets. However, the low mean digestibility coefficients of the nutrients of diet 2 could be due to the bulkiness of this diet as a result of high cassava wastes inclusion (72%) which is the highest because bulky diets tends to move more rapidly out the rumen (Adegbola *et al.* 1988) resulting in low nutrient digestibility .The highest nitrogen retained and percentage nitrogen retention values obtained in animals placed on diets 1 (control) and 3 is in agreement with the report of Babayemi *et al.* (2006) that nitrogen retention increase with protein supplementation. The values of nitrogen retained which varies from 4.12 to 6.36g/d were higher and in contrast to those reported by Alikwe *et al*. (2011) and Fadiyimu *et al.* (2015). They reported the values (0.24 – 2.19g/d) when WAD goats were fed soybean and dried poultry waste based concentrate as supplements to basal diets and (1.15 – 1.65g /d) when *Persea americana* leaves were fed as supplement to *Panicum maximum* respectively. These values compared favourably with (5.81 – 6.90 g/d) reported by Okah and Ogbonnaya (2013) when different levels of dietary poultry droppings/maggots combinations were fed to rams. The positive N – balance (g/d) values obtained for all the dietary treatments is an indication that the protein requirements for maintenance of small ruminants (goats) were adequately met.

Conclusion

The study showed that there were substantial benefits in productivity of goats fed with diets compounded from agro-industrial by-products namely: cassava peels, dried poultry wastes, molasses and sawdust ash. The best performance was recorded from diet 3 containing cassava peels (67%), poultry wastes (25%), molasses (5%) and sawdust ash (2%) when compared with the control diet in terms of average daily gain, feed efficiency, digestibility and nitrogen utilization. Therefore, besides minimizing its polluting concentration to the environment, the use of these by- products can fill the gap in feed availability in Nigeria during the dry season.

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