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Research Article
Effects of Graded Levels of *Gmelina arborea* and Brewer's Dried Grains on Growth and Haematology of West African Dwarf Rams

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Abstract
Background: The study was undertaken to determine the growth performance and haematology of West African dwarf rams fed diets containing dried cassava peels meal supplemented with graded levels of brewer's dried grain and *Gmelina arborea* leaf meal. **Methodology:** About 8 weeks feeding trial using 30 yearling West Africa dwarf rams were used in a completely randomised design involving five dietary treatments 1-5 (0, 10, 20, 30 and 40% *Gmelina arborea* leaf meal, respectively) and three replicates with two animals per replicate. **Results:** Animals on cassava peels meal with 0% *Gmelina arborea* leaf meal consumed 330.10 g day^{-1} feed on dry matter basis to produce average daily gain of 30.35 g day^{-1}, metabolic weight gain of 1.28 kg$^{0.75}$ and feed conversion ratio of 10.8. Animals on 40% *Gmelina arborea* leaf meal on the other hand, consumed 347.84 g day^{-1} feed on dry matter basis to produce average daily gain of 37.5 g day^{-1}, metabolic weight gain of 1.58 kg$^{0.75}$ and feed conversion ratio of 9.27. However, rams supplemented with 20% *Gmelina arborea* leaf meal diet had the best performance with dry matter intake, average daily gain, metabolic weight gain and feed conversion ratio of 347.47 and 39.29 g day^{-1}, 1.65 kg$^{0.75}$ and 8.84, respectively ($p<0.05$). There were significant differences ($p<0.05$) among means of packed cell volume, red blood cells and white blood cells of all the dietary treatments, with dietary treatment 1 having consistently poorer values. **Conclusion:** Concentrate supplements of cassava peels with graded levels of brewer's dried grain and *Gmelina arborea* leaf meal improved productivity and health status of West Africa dwarf rams. Brewer's dried grain and *Gmelina arborea* leaf meal can be supplemented at 20% in a cassava based concentrate feed to sheep.

Key words: Brewer's dried grain, effects, *Gmelina arborea,* rams

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Nigerian cassava production is by far the largest in the world, producing around 45 million tonnes, a third more than production in Brazil and almost double the production of Indonesia and Thailand[1]. Cassava peels are constant part of household and industrial waste products of cassava which are regularly fed to sheep and goats on small scale subsistence farms in Africa serving only small proportion as a grain substitute employed as the main basal diet or as a supplement[2].

Cassava peel, though a good energy source which degrades well in the rumen has very low protein content and could have goitrogenic activity on animals due to thiocyanic acid production[3]. These deficiences can be eliminated by further processing and incorporation of nutrient rich non conventional feedstuffs which contain iodine and high levels of sulphur amino acids, particularly cystine and methionine.

Concerted efforts at supplementation has been advocated if production of small ruminants must be improved. One of the ways to meet this need is the feeding of concentrate which consists of a balance of energy and protein with vitamins, minerals and other nutrients. This strategy results in improved feed intake, animal productivity and increased resistance to diseases[4].

Brewer's Dried Grain (BDG) is the dried extract residue in barley malt alone or in mixture with other cereal grains from the manufacture of beer. Breweries in Nigeria use maize and sorghum in combinations which vary from one brewery to another[5]. Brewer's dried grain is a medium level non conventional protein feedstuffs with high fibre used in various animal feeds including dairy and beef cattle, sheep and goats[6]. Although, BDG has a good amino acid profile, a source of by pass protein and fibre, the amino acid profile may not be balanced and its bulky nature affects digestibility and availability of amino acid and other nutrients[7]. As at 1986, the annual production of brewer's grain in Nigeria is under 10,000 t and only about 20% is being dried[8]. Furthermore, as a result of economic downturn, breweries in Nigeria are closing down thus, affecting availability coupled with prohibitive cost of transportation from production site to farms.

Browses of trees are cheap, readily available and less competitive sources of protein, vitamins and minerals compared with conventional feed concentrate sources[9]. *Gmelina arborea* is a fast growing deciduous tree which is being utilized for major forest restoration in South Western Nigeria. It is an exotic tree which was originally introduced to Nigeria for pulping purpose[10]. Study has shown that *Gmelina* contains high nutritional profile and high biomass yield which makes it suitable as a livestock feed resource. The leaf meal of *Gmelina arborea* contains a crude protein of more than 20% and a balance of other nutrients including the sulphur containing amino acids, vitamins, minerals and energy[11,12].

Efficient utilization of tree fodders in a complementary way with crop residues and industrial by-products for nutrients has to be worked out through studies in order to explore the nutritive value of feed sources. Nutritional studies should not be limited to growth performance alone, its effect on blood constituent is also very relevant to assess the effect of the test ingredients on the health status of animals[13].

This study was undertaken to determine the effect of feeding cassava peels with graded levels of brewer's dried grain and *Gmelina arborea* leaf meal concentrates on the growth and haematology of growing West African Dwarf (WAD) rams.

MATERIALS AND METHODS

Location of the experiment: The experiment was conducted at the small ruminants unit of the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, South Western Nigeria. Ado-Ekiti lies between latitude 07°37'15'' N and longitude 05°13'17'' E with an average relative humidity of 72%. It experiences a tropical climate with a temperature range of 20-28°C and a bimodal rainfall distribution between April and October with peaks in June and September and a break in August. The average precipitation in this area is 1367 mm.

Experimental animals and management: Thirty yearling West African dwarf rams with an average weight of 13.03±0.27 kg were source from weekly sheep and goats markets in Ekiti State. They were assigned to five treatment groups in a completely design experiment. Before the start of the experiment, the animals were quarantined for 30 days, using the routine treatment developed at NAPRI[14]. The house was partitioned into 15 equi dimensional well ventilated pens. Two weeks prior to the commencement of the experiment, two animals were randomly placed in individual pens after balancing for weight. The animals had *ad libitum* access to feed and water. The experiment lasted for 56 days.

Experimental diet: A basal diet of *Panicum maximum* grass was fed at 2.5% b.wt., of sheep while, graded levels of *Gmelina arborea* leaf meal and Brewer's Dried Grain (BDG) were formulated with dried cassava peels as the main concentrate supplements and offered at 1.0% b.wt., of the sheep. The composition of the five experimental diets are shown.

Data collection

Growth measurement studies: Body weight of the animals was recorded at the beginning of the experiment and weekly thereafter using a mobile hanging scale. Feed intake was measured by recording the quantities of feed (concentrates and forage) offered and quantities refused. Feed conversion ratio was calculated by computing the ratio of the dry matter intake to the weight gain of animals. Metabolic weight gain was calculated by muliplying weight gain by a fractional power of 0.75.

Blood sampling and analytical methods: Blood samples were drawn from each animal through the jugular vein using a 10 mL gauge (5 cm) needle to draw 4 mL of blood from each animal at the 4th, 8th and 12th weeks of the study. The blood samples were emptied into heparinized bottles containing about 40 mg of anti coagulant components of ethylene-diaminetetra-acetic acid (EDTA). The bottles were immediately capped and the content mixed gently for about 60 sec through repeated rocking. The blood smears were prepared immediately after the collection of samples. The Packed Cell Volume (PCV), the ratio of volume of cells to the volume of plasma was determined by the capillary haematocrit centrifuge as described by Kelly[15]. White Blood Cell (WBC) was determined by Wintrobe method Kelly[15]. Differential counts of WBC (neutrophils, eosinophils and lymphocytes) were determined by Giemsa's stain method Jain[16].

Chemical analysis: Feed samples were ground in a hammer mill to pass a 1 mm mesh sieve before proximate analyses were carried out according to the procedure described by AOAC[17]. Kjedahl analysis was used to measure the nitrogen contents of the samples. Crude protein was calculated from N×6.25. Ground samples were extracted with diethyl ether to measure the ether extract value. Crude fibre was determined by boiling the ether extracted sample in dilute base, filtering and burning in furnace. The difference in weight before and after burning is the crude fibre fraction. Gross energy of feed was measured by bomb calorimetre using benzoic acid as a standard (26437 J g^{-1}). Ash was obtained after all the combustible materials have been burnt off in the furnance. Calcium and phosphorus contents of the ashed sample were detemined using the atomic absorption spectrometer while, amino acid was assayed using gas chromatography method.

Statistical analysis: The haematological and growth performance data obtained were compared statistically on the basis of the different dietary treatments using analysis of variance procedure[18] for Completely Randomized Design (CRD) and differences between means separated using the duncan multiple range test[19].

RESULTS

Chemical composition of ingredients used as concentrate supplement to *Panicum maximum* in sheep diet is shown in Table 1. The dry matter ranged from 90.90 g DM^{-1} in *Gmelina arborea* leaf meal (GALM) to 92.50 g DM^{-1} in Brewer's Dried Grain (BDG). Crude Protein (CP) ranged from 4.30% in CPM to 24.6% in GALM. Crude fibre was reduced in GALM (6.5%) but high in both BDG and CPM (19.70 and 21.30%, respectively). Ether Extract (EE), ash, methionine and cysteine were highest in GALM (6.6%, 11.9%, 0.34 mg 100 g^{-1}, 4.06, 2.76 respectively), while CPM recorded lowest values in EE, ash and methionine (0.30%, 2.80%, 0.02, respectively). The values of metabolizable energy ranged from 2314, 3247 and 3852 kcal kg^{-1} in BDG, GALM and CPM respectively, while calcium was 0.025, 0.76 and 1.04 mg 100 g^{-1} in BDG, CPM and GALM, respectively.

Table 2 shows the ingredient and the proximate composition of the experimental diets. The dry matter content of the concentrate supplements ranged from 85.6% in diet 1-88.3% in diet 3. The crude protein content increased ($p<0.05$) as the *Gmelina arborea* leaf meal increased in the concentrate mixture (12.8, 13.2, 13.6, 14.2 and 15% in diet 1-5, respectively). The ether extract and ash content also followed the same pattern while, nitrogen free extract and crude fibre reduced ($p>0.05$) as *Gmelina arborea* increased in the diet from 0-40%. The crude protein content of the diets increased with increasing levels of GALM in the diet because GALM contain slightly higher CP than BDG.

The performance of West African Dwarf (WAD) sheep fed graded levels of *Gmelina arborea* leaf meal (GALM) and Brewer's Dried Grain (BDG) are shown in

Table 1: Proximate composition, Calcium, phosphorus, methionine and cysteine analyses of test ingredients

Nutrients (%)	CPM	GALM	BDG
DM	92.30	90.9	92.5
CP	4.30	24.6	21.5
CF	21.30	6.5	19.70
EE	0.30	6.6	3.45
Ash	2.80	11.9	3.62
ME (kcal kg^{-1})	3852	3247	2314
Ca (mg 100 g^{-1})	0.76	1.04	0.025
P (mg 100 g^{-1})	0.30	0.34	0.36
Methionine (g 100 g^{-1})	0.02	4.06	0.52
Cysteine (g 100 g^{-1})	0.03	2.76	0.02

*CPM: Cassava peels meal, GALM: *Gmelina arborea* leaf meal, BDG: Brewer's dried grain, DM: Dry matter, CP: Crude protein, CF: Crude fibre, EE: Ether extract, Ca: Calcium and P: Phosphorus

Table 3. The dry matter intake of sheep fed Dietary Treatment (DT) 3, 4 and 5 were statistically similar (p>0.05) and significantly higher (p<0.05) than the DMI of sheep on DT 1 and 2. The basal diet intake increased significantly (p<0.05) in animals on DT 4 at 270 g day^{-1}, whereas animals on DT 3 and 5 consumed similar quantities of *Panicum maximum* (266.67 and 267.64 g day^{-1}, respectively). Basal diet consumption was significantly lowest (p>0.05) for animals on DT 2 at 256.24 g day^{-1} closely followed by a value of 260.50 g day^{-1} obtained for animals on DT. Animals on diets 3 and 5 had the highest significant consumption (p<0.05) of the supplementary diets at 80.80 and 80.20 g day^{-1}, respectively. In addition, the animals on DT 1 (0% GALM) consumed the least supplementary diet at 69.60 g day^{-1} (p>0.05).

Metabolic Weight Gain (MWG) was increased significantly (p<0.05) in animals on diet 3 (20% GALM) at 1.65 $kg^{-0.75}$, while animals on DT 1 (0% GALM) had the lowest MWG of 1.28 $kg^{-0.75}$. The feed conversion ratio of 10.90 was poorest (p>0.05) in animals on DT 1 while the FCR of 8.84 obtained for animals on DT 3 was the best among all the experimental treatments.

Haematological indices of sheep fed graded levels of *Gmelina arborea* leaf meal (GALM) and Brewer's Dried Grain (BDG) diets are shown in Table 4. The Packed Cell Volume

Table 2: Ingredient and chemical composition of concentrate supplements

	Treatments				
Ingredients	1	2	3	4	5
CPM	54.5	54.5	54.5	54.5	54.5
BDG	40.0	30.0	20.0	10.0	0.0
GALM	0.0	10.0	20.0	30.0	40.0
Bone meal	2.0	2.0	2.0	2.0	2.0
Molasses	2.0	2.0	2.0	2.0	2.0
Salt	1.0	1.0	1.0	1.0	1.0
Premix*	0.5	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0	100.0
Chemical composition					
DM	85.6	86.2	88.3	86.1	85.8
CP	12.8	13.2	13.6	14.2	15.0
CF	17.6^a	15.8^b	12.0^c	10.4^d	9.6^d
EE	3.0^d	3.2^d	3.6^c	3.9^b	4.5^a
Ash	4.2^e	5.2^d	6.0^c	6.6^b	7.5^a
NFE	65.5^a	64.2^b	62.3^c	60.1^d	59.8^d
ME (kcal kg^{-1})	3245^a	2946^c	3050^b	3250^a	3247^a

$^{a-d}$Means with different superscript(s) within rows differ significantly (p<0.05), *Each kilogram of the premix contains Vit .A: 640,000 IU, Vit. D3: 120,000 IU, Vit. E: 640 IU, Selenium: 8 mg, Molybdenum: 60 mg, Copper: 360 mg

Table 3: Growth performance of WAD rams fed test concentrate supplements

	Treatments				
Parameters	1	2	3	4	5
DMI (g day^{-1})	330.10^b	329.82^b	347.47^a	346.90^a	347.84^a
Basal diet (g day^{-1})	260.50^c	256.32^d	266.67^b	270.00^a	267.64^b
Supplement	69.60^d	73.50^c	80.80^a	76.90^b	80.20^a
Initial weight (kg)	12.80	13.00	13.20	12.60	13.20
Final weight (kg)	14.50	15.00	15.40	14.60	15.30
Weight gain (kg)	1.70^c	2.00^b	2.20^a	2.00^b	2.10^b
MWG ($kg^{0.75}$)	1.28^d	1.50^c	1.65^a	1.50^c	1.58^b
ADG (g day^{-1})	30.35^d	35.71^c	39.29^a	35.71^c	37.50^b
FCR	10.90^a	9.23^c	8.84^d	9.71^b	9.27^c

$^{a-d}$Means with different superscript(s) within rows differ significantly (p<0.05), DMI: Dry matter intake, MWG: Metabolic weight gain, ADG: Average daily gain and FCR: Feed conversion ratio

Table 4: Haematological parameters of WAD rams fed ingredients

	Treatments					
Parameters	1	2	3	4	5	Means±SEM
PCV (%)	27.20^d	28.40^c	30.10^a	29.40^b	30.20^a	29.06±1.26
Hb (g L^{-1})	80.60	82.10	82.60	81.20	82.50	81.80±3.20
RBC×10^6 (μL)	9.20^b	10.40^a	10.80^a	10.60^a	10.80^a	10.36±1.12
WBC×10^3 (mm^{-1})	11.10^a	9.20^c	9.00^c	10.20^b	9.40^c	9.78±1.02
MCV μm^3	23.00	24.20	23.60	22.90	24.00	23.54±0.56
MCHC (%)	32.20	30.50	33.30	32.50	33.20	32.34±1.04
MCH (pg)	8.20	9.00	7.80	8.00	9.20	8.44±0.64
Differential leucocyte count						
Lymphocyte (%)	60.40^a	56.40^c	58.30^b	59.00^b	58.60^b	58.54±2.56
Monocyte (%)	3.40	3.20	3.00	3.10	3.00	3.14±0.26
Neutrophil (%)	43.00^a	40.00^c	42.00^b	39.20^c	41.80^b	41.20±2.30
Basophil (%)	0.10	0.10	0.20	0.10	0.10	0.12±0.02
Eosinophil (%)	4.40	4.00	4.20	4.20	4.20	4.20± 0.24

$^{a-d}$Means with different superscript(s) within rows differ significantly at p<0.05

(PCV) was increased significantly ($p<0.05$) in animals on DT 3 and 5 at 30.10 and 30.20%, respectively while, animals on DT 1 had the lowest value of PCV at 27.20%. The values of Hb and RBC also followed the same pattern with animals on DT 1 recording significantly lower ($p>0.05$) values. Animals on DT 1 had significantly increased ($p<0.05$) White Blood Cell (WBC) which was 11.1% compared with other treatment groups which recorded 9.2, 9.0, 10.2 and 9.45% in DT 2-5, respectively. However, there were non-significant differences in the differential leucocyte counts of monocyte, basophil and eosinophils in all the treatment groups while, lymphocyte and neutrophil counts were increased significantly ($p<0.05$) in animals on DT 1 compared to the animals on DT 2-5.

DISCUSSION

The proximate values of cassava peels meal obtained in this study was within the range of 2.80-6.50% for Crude Protein (CP), 0.50-2.20% for ether extract and 10.00-22.00% for crude fibre recorded by Smith[2] and Asaolu[20]. The CP value of cassava peels fell below the daily requirement of 14 g 100 g^{-1} for growing small ruminants[21]. The CP of GALM reported in this study was higher than the CP of 10.25 and 12.59% reported by Abdu *et al.*[22] but similar to 20.05 and 23.00% reported by Adamu *et al.*[12] Offor, respectively[11]. Reason could be due to environmental differences, stage of harvest and processing methods. The ash content of GALM observed in this study was higher than 5.30-5.39% reported by some studies[12,23] but comparable to the value of 11.30% reported by Okpara *et al.*[24]. High ash content is an indication of mineral composition which affects productivity of animals. Methionine and cysteine levels obtained in this study were in consonant with values of 4.11 and 2.67 g 100 g^{-1} obtained by Amata and Lebari[25]. Crude protein, ash and CF of BDG were in agreement with the values obtained by Etchu *et al.*[26] but the CP of BDG was lower than 30% obtained by Levic *et al.*[27]. Differences could be due to duration of fermentation, method of analyses and type of grains used for the fermentation process in the different breweries where the BDGs were obtained.

The CP values of all the concentrate supplements were within the range of the recommended CP of 14% for growing ruminants[21]. The reduction in the crude fibre components of the diets as GALM increased could be as a result of the lower fibre component of *Gmelina arborea*. This is consistent with the findings of Okoli *et al.*[28] that browses contain low to moderate ADF and NDF values which make them more available for degradation by rumen microbes. The high crude fibre component of TD 1 could be as a result of the high crude fibre in BDG. This is in line with the findings of Yaakugh and Tegbe[29] which revealed a high CF of upto 20% in BDG. According to Onwudike[30], the major limitation to the use of BDG as a medium level plant protein source is its high fibre content.

The lowest DMI obtained for animals on the control diet (40% BDG) could be as a result of the lower level of CP and higher CF. Minson observed that most of the crop by-products of tropical forage species have low intake due to lower protein level and high fibre content[31].

The poorer body weight gain, average daily gain and feed efficiency in animals fed with the DT 1 and 2 (40 and 30% BDG, respectively) is in line with the findings of Adebowale and Ademosun[32] that 30% BDG inclusion in sheep and goats diets did not improve growth rate and feed efficiency. This may be as a result of imbalanced amino acid profile in BDG and its bulky nature which affects digestibility and availability of amino acids and other nutrients[7]. Better nutrient (protein-energy) harmony in DT 3 might be responsible for the better weight gain and feed conversion ratio as this would have enhanced nutrient utilization in the animals. This is in line with the report of Njidda[33] that an efficient utilization of nutrients supplying adequate energy and protein is required for optimum growth performance in ruminants. The best result obtained in 20% inclusion of GALM is in line with the conclusion of Ukanwoko and Okehielem[34] that inclusion of 20% leaf meal of *Gmelina arborea* leaf meal in the diet of bucks is ideal for optimum performance. Further corroboration could be found in the report that feed intake is an important factor in the utilization of feed by livestock and is also a critical determinant of energy and protein as well as performance in small ruminants[35]. The better weight gain, feed conversion and average daily gain recorded for animals on DT 3 (20% GALM) despite the lower CP of 13.6% compared to 15% in DT 5 (40% GALM) could be due to better synchronization of energy and protein in the mixture of BDG with GALM coupled with the supply of calcium, phosphorus and sulphur containing amino acids. This is in agreement with the findings of Kiran and Mutsvangwa[36] that protein need not be overfed but ideal protein balanced with energy must be supplied for better productivity of growing ruminants.

Haemoglobin values obtained in this study (80.2-82.6 g L^{-1}) were similar to the values obtained when browse plants including *Gmelina arborea* were used as supplement to rice straw for djallonke sheep[37]. White Blood

Cells (WBC) obtained in all the animals in the treatment groups were within the normal range of $4\text{-}12 \times 10^3$ mm^{-1} for clinically healthy sheep[38] although, the WBC in DT 1 tend to be at the upper limit. This could be as a result of the lower nutritional plane of the animals in this group. The PCV, RBC, platelets and other calculated haematological values were within normal range for sheep[39,40]. The WBC and RBC values are indicators of the nutritive value of feed consumed, even though they are within normal limits for sheep, the values may affect their health status if challenged. Overall, the blood parameters of the animals improved as the GALM in the treatment groups increased. This may be as a result of better quality of the feed in terms of protein and presence of sulphur containing amino acids since, protein quality is positively linked with blood composition[41].

CONCLUSION

This study suggests that cassava peels based concentrate diets fed to sheep could be enriched with protein rich fodder sources such as *Gmelina arborea* at 40% for better and optimal performance. However, BDG and GALM can be supplemented at 20%, respectively for better protein- energy balance in a cassava based concentrate feed to sheep.

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