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Nutrition and Physiology

Effect of Gmelina leaf meal diets on productive and physiological parameters of West African dwarf goats

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Abstract. *West African Dwarf (WAD) goat plays an important socio-economic role, hence the effect of 82 days of feeding Gmelina leaf meal (GLM) diets on feed intake, body weight change and blood indices of WAD goats were investigated. A total of 36 WAD goats averaging 9.04 kg in weight were randomly divided into four groups of nine goats each with three goats constituting a replicate. The groups were randomly assigned four experimental diets (T_1, T_2, T_3, and T_4, containing GLM at 0%, 12%, 24% and 36%, respectively) in a completely randomized design. Results indicated significant ($p<0.05$) improvement for body weights and feed conversion ratio for T_2, T_3, and T_4. There was significant difference ($p<0.05$) for all the haematological parameters except packed cell volume (PCV). White blood cells (WBC) increased in their number ($p<0.05$) with incremental levels of GLM in the diets. All the serum biochemical indices showed significant ($p<0.05$) difference with glucose and cholesterol concentration reduced ($p<0.05$) with incremental levels of GLM. It could be concluded that GLM can be included in the diets of goats up to 36% without deleterious effects on the productive and physiological indices of WAD goats.*

Keywords: body weight, daily feed intake, feed conversion ratio, haematological parameters, phytogenic compounds

Introduction

West African Dwarf (WAD) goat is the most prolific ruminant in south eastern Nigeria capable of increasing the animal protein intake. They are multipurpose animals, producing meat, milk, skin and manure. Their reputation for short gestation interval, early maturity, easy management, remarkable capacity to convert roughages into meat and milk, unique ability to adapt and maintain itself in harsh environments, low cost of production, ability to trek long distances in search of feed, high dressing percentage, ability to adapt to a wide range of climatic conditions, high meat quality and their small body sizes make them indispensable livestock in Nigeria and beyond. The meat is generally accepted and consumed in Nigeria since there is no religious taboo against it. The demand for the meat is high and usually commands higher market price than beef and pork (Jiwuba et al., 2018a).

However, the production of this animal, with great potentials to alleviate animal protein inadequacy, is faced with various challenges. Jiwuba et al. (2017a) attributed high cost of feed and inadequate nutrient intake to undermine this goat breed in expressing their full potential. This may be as a result of little knowledge about the potentials of some non-conventional feed resources, the presence in some cases of anti-nutritional element and the lack of proper storage capabilities especially over long period (Ben Salem et al., 2009). In line with this, interests have been shifted to the search for cheaper, available and nutritionally viable feedstuffs with some phytogenic properties to enhance livestock production. Some leaf meals of tropical origin have been reported (Jiwuba, 2018; Jiwuba et al., 2017a, 2018b, 2020) to yield relatively higher levels of crude protein, dry matter and lower crude fiber levels than most tropical forages.

Gmelina arborea is an evergreen perennial fast growing medicinal tree, which is used as laxative and anthelmintic, improves appetite, is useful in hallucination, piles, abdominal pains, burning sensations, fevers, and urinary discharge (Kumaresan et al., 2014). The leaves are unconventional materials that can be explored for the production of feedstuff. The leaf is one of the tree leaves considered an important source of nutrient for ruminants and non-ruminants, especially in those areas with pronounced dry season. Previous records by Nkwocha et al. (2014) and Offor (2014) on the nutrient profile of *Gmelina arborea* have shown that the leaf meals contained 18.00-20.05% crude protein, 14.40-15.05% crude fiber, ash 4.55% and fat 0.79%. Metabolizable energy values

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were found to be appreciable (1368 Kcal kg^{-1}) - an indication of its suitability as an energy source for livestock diets (Amata, 2014). The leaves, flower, roots and bark are used in medicine. They are useful in the treatment of blood diseases; thus, the use of Gmelina leaf meal in the present study fits in the strategy of improving the productive and physiological responses of WAD goats. Therefore, this experiment was carried out to investigate the effects of graded levels of Gmelina leaf meal in the diets of WAD goats on the feed intake, body weight changes, haematological and serum biochemical indices.

Material and methods

Study area

The research work was carried out at Sheep and Goat unit of Federal College of Agriculture Ishiagu, Ivo Local Government Area of Ebonyi State, Nigeria. The College is located at about 3 km away from Ishiagu main town at latitude 5°6'N and longitude 7°31'E with average rainfall of 1000-1600 mm and a prevailing air temperature condition of 27-28°C relative humidity of about 88%, respectively.

Sourcing and processing of Gmelina leaf meal (GLM)

The Gmelina (*Gmelina arborea*) leaves were sourced within the College environs. Fresh, succulent, greenish non-over matured leaves were harvested to ensure lower value of lignin and higher nutrient availability. The leaves were air dried in batches to about 10% moisture before passing through a 10 mm hammer mill and further used in the formulation of the experimental diets. Four diets - T_1, T_2, T_3, and T_4, containing Gmelina leaf meal at 0%, 12%, 24% and 36%, respectively, were formulated (Table 1).

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

Ingredients, %	Dietary levels				SEM	GLM	PKM
	T_1	T_2	T_3	T_4			
Gmelina leaf meal	0.00	12.00	24.00	36.00			
Cassava peel meal	45.00	45.00	45.00	45.00			
Palm kernel meal	45.00	33.00	21.00	9.00			
Ground nut meal	5.00	5.00	5.00	5.00			
Molasses	2.00	2.00	2.00	2.00			
Bone meal	2.00	2.00	2.00	2.00			
Common salt	1.00	1.00	1.00	1.00			
Total	100.00	100.00	100.0	100.00			
Analyzed							
Dry matter	92.36	91.62	91.73	91.89	17.27	93.90	91.81
Crude protein	13.04	13.43	13.75	14.64	11.47	18.32	16.78
Crude fiber	16.67	16.58	17.01	17.65	9.59	15.18	13.42
Ash	4.49	4.54	4.67	4.69	0.05	3.96	3.87
Ether Extract	4.88^a	3.67^a	3.06^a	2.33^b	0.02	1.16	6.12
NFE	53.28	53.40	53.24	52.58	12.11	55.28	50.62
GE (MJ/g)	4.15^a	4.06^{ab}	4.05^{ab}	4.02^b	0.04	4.11	4.22

$^{a-b}$ means within a row with different superscript differ significantly ($p<0.05$); SEM= Standard error of mean; GLM= Gmelina leaf meal; PKM= Palm kernel meal; NFE= Nitrogen free extract; GE= Gross energy.

For the purpose of the study 36 West African dwarf (WAD) goats of about 10-12 months of age and averaging 9.04 kg in weight were selected from the College herd for this experiment. The goats were randomly divided into four groups of nine animals each with three goats constituting a replicate. The groups were randomly assigned the four experimental diets (T_1, T_2, T_3, and T_4) in a completely randomized design (CRD). The animals were housed individually in a well-ventilated cement floored pens equipped with feeders and drinkers. Each animal received a designated treatment diet in the morning (8 am) for 82 days. Feed offered was based on 3% body weight per day; the animals in addition were fed 1 kg wilted chopped *Pennisetum purpureum* later in the day (5 pm). Regular access to fresh drinking water was made available in accordance with the permission and stipulated guidelines of the Federal College of Agriculture, Ishiagu (FCAI) Animal Ethics Committee. 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. Daily weight gain, daily feed intake and feed conversion ratio (FCR) were calculated.

Feed and test ingredients analysis

All the samples of feed and test ingredients were analyzed for their proximate composition (dry matter - DM, crude protein - CP, crude fiber - CF, ash, ether extract - EE and nitrogen free extract - NFE) using the method of AOAC (2000). Gross energy was calculated by the formula:

$T = 5.72Z_1 + 9.50Z_2 + 4.79Z_3 + 4.03Z_4 \pm 0.9\%$,

Where: T = Gross energy (GE);

Z_l = Crude protein (CP);

Z_2 = Crude fat (CF);

Z_3 = Crude fibre (CF);

Z_4 = Nitrogen free extract (NFE), (Nehring and Haelein, 1973).

Blood parameters analysis

A blood sample (10 ml) was drawn from the jugular vein (*v. jugularis*) of each animal on the last day of the study. The samples (total 36, n=36) were separated into two lots and used for haematological and biochemical analysis. An initial 5 ml was collected from each sample in labelled sterile universal bottle containing 1.0 mg/ml ethyldiamine tetracetic acid (EDTA) and used for haematological analysis. Other 5 ml were collected over anti-coagulant free bottle and used for the serum biochemical studies. Serum biochemistry and haematological parameters were measured using Beckman Coulter Ac-T10 Laboratory Haematology Blood Analyzer and Bayer DCA 2000+HbA1c analyzer, respectively. White blood cell (WBC, $x10^9$/l), red blood cell (RBC, $x10^{12}$/l), packed cell volume (PCV, %), haemoglobin (g/dl), mean corpuscular haemoglobin (MCH, pg), mean corpuscular volume (MCV, fl) and mean corpuscular haemoglobin concentrations (MCHC, %) were calculated.

Statistical analysis

The results were analyzed using the Statistical Package for Social Sciences Window 17.0. One-way analysis of variance (ANOVA) was employed to determine the means and standard error. Treatment means were separated using Duncan's new multiple range test (Duncan, 1955).

Results and discussion

The proximate composition of the test diets and Gmelina leaf meal are presented in Table 1. The results show that the ether extract (EE) and gross energy (GE) were significantly ($p<0.05$) influenced by the treatments while DM, CP, CF, NFE and ash were not ($p>0.05$) influenced. The DM of the experimental diets failed to follow a particular trend. The DM ranged between 91.62% (T2) and 92.36% (T_1). The CP increased progressively with incremental levels of GLM in the diets with the highest value of 14.64% recorded for T_4 with a corresponding lowest value of 13.04% recorded for T_1. The CF and ash maintained a particular trend like the CP increasing with an increasing level of GLM. EE decreased ($p<0.05$) progressively with incremental levels of GLM. NFE and GE values failed to follow a specific trend, increasing or decreasing with increasing levels of GLM.

The body weight changes and feed intake of West African dwarf goats fed diets containing Gmelina leaf meal is presented in Table 2. There was significant ($p<0.05$) difference for final body weight, total weight gain (TWG), average daily weight gain (ADWG) and feed conversion ratio (FCR) among the experimental goats, while total feed intake (TFI) and average daily feed intake (ADFI) remained similar ($p>0.05$). There was improvement ($p<0.05$) in the body weight among the treatment groups (T_2, T_3 and T_4) in comparison with the control (T_1).

Table 2. Body weight changes and feed intake of WAD goats fed diets containing Gmelina leaf meal

Parameters	Treatments				
	T_1 (0%)	T_2 (12%)	T_3 (24%)	T_4 (36%)	SEM
Initial body weight (kg)	9.05	8.67	9.25	9.19	2.43
Final body weight (kg)	13.70^c	15.80^b	15.65^b	17.85^a	4.44
Total weight gain (kg)	4.65^c	7.13^b	6.40^b	8.66^a	1.01
Average daily weight gain (g/day)	56.71^d	86.95^b	78.05^c	105.61^a	32.31
Total feed intake (kg)	28.74	30.41	29.31	28.95	11.73
Average daily feed intake (g/day)	350.49	370.85	357.44	353.05	21.71
Feed conversion ratio	6.18^a	4.27^{bc}	4.58^b	3.34^c	0.06

$^{a-c}$ means within a row with different superscript differ significantly ($p<0.05$)

The results obtained for WBC (8.35-11.70$x10^9$/l) followed a particular trend of increasing with increasing the levels of GLM (Table 3). T_4 was significantly higher and better than T_3, T_2 and T_1, while T_2 and T_1 showed ($p>0.05$) similarities. PCV failed to follow a particular trend, but was numerically the highest in T_3, and the lowest in T_1. The PCV values were not significantly ($p>0.05$) affected across the treatment groups. Hb and RBC followed a similar trend as the WBC, increasing with increasing the levels of GLM, with T_4 (9.35g/dl) and (10.50 $x10^{12}$/l), respectively, having the highest value and T_1 (8.10 g/dl) and (9.05$x10^{12}$/l), respectively, the lowest. The MCH tended to decrease with increasing levels of GLM, with T1 (7.00 pg) and T2 (7.75 pg) having higher values than T3 (6.15pg) and T4 (5.95 pg). MCHC was similar ($p>0.05$) for T_1 and T_2 then differed ($p<0.05$) from T_3 and T_4. T_4 tended to be superior and higher than the other treatment groups. MCV, decreased with increasing levels of GLM, with T_1 (24.40 fl) having the highest value and differed ($p<0.05$) from T_3 and T_4, with T_4 (19.55 fl) having the corresponding lowest value.

The serum biochemical indices of WAD goats fed Gmelina leaf meal are shown in Table 4. The total protein was significantly ($p<0.05$) higher for the treatment groups (T_2, T_3 and T_4) in comparison with the control group (T_1). The albumen showed significant ($p<0.05$) difference across the treatment groups with T_1 having the lowest value and T_4 with the highest value. Glucose had a progressive decrease across the treatments with incremental levels of GLM in the diets. Glucose also showed ($p>0.05$) similarities between T_1 and T_2 while T_3 and T_4 differed significantly ($p<0.05$) across the treatments. Urea concentration had a linear decrease ($p<0.05$) from T_1 to T_4. The serum creatinine values of goats on diets T_1 and T_2 were significantly higher ($p<0.05$) than those on diets T_3 and T_4. Cholesterol values for the control diet were higher ($p<0.05$) than those on diets T_2, T_3 and T_4.

Table 3. The effect of Gmelina leaf meal on haematology of West African dwarf goats

Parameters	Treatment levels				
	T_1 (0%)	T_2 (12%)	T_3 (24%)	T_4 (36%)	SEM
White blood cell (x10^9/l)	8.35^c	8.90^c	10.70^b	11.70^a	1.51
Packed cell volume (%)	30.90	31.40	31.60	31.40	11.16
Haemoglobin (g/dl)	8.10^c	8.20^c	8.70^b	9.35^a	4.19
Red blood cell (x10^{12}/l)	9.05^b	9.16^b	10.10^a	10.50^a	2.23
MCH (pg)	7.00^a	7.75^a	6.15^b	5.95^b	1.77
MCHC (%)	25.65^c	26.65^c	27.35^b	29.40^a	5.75
MCV (fl)	24.40^a	24.25^a	20.50^b	19.55^c	8.80

$^{a-c}$Means within a row with different superscript differed significantly ($p<0.05$); MCH= Mean Corpuscular Haemoglobin; MCHC= Mean Corpuscular Haemoglobin Concentration; MCV= Mean Corpuscular Volume; SEM= Standard Error of Means.

Table 4. Serum biochemistry of West African dwarf goat fed Gmelina leaf meal

Parameters	Treatments				
	T_1 (0%)	T_2 (12%)	T_3 (24%)	T_4 (36%)	SEM
Total protein (g/dl)	6.46^d	6.94^c	7.35^b	8.13^a	0.23
Albumin (g/dl)	2.70^d	2.79^c	3.06^b	3.33^a	0.18
Glucose (mg/dl)	74.50^a	74.00^a	65.50^b	61.50^c	2.68
Urea (mg/dl)	17.06^a	15.88^b	15.12^c	13.16^d	0.53
Creatinine (mg/dl)	1.71^a	1.69^a	1.65^b	1.63^b	0.01
Cholesterol (mg/dl)	96.41^a	93.05^b	85.18^c	84.64^c	1.91

$^{a-d}$Means within a row with superscript differ significantly ($p<0.05$)

The dry matter range of 91.62-92.36% recorded in this study compared well with the range of 91.32-91.74% and 89.95-91.44% reported by Jiwuba et al. (2018a) for WAD goats fed yellow root cassava peel-centrosema leaf meal and Jiwuba et al. (2018c) for WAD goats fed cassava root sievate - cassava leaf meal based diets, respectively. The crude protein and gross energy values fall within the requirement for goats as recommended by ARC (1980), NRC (1981), and Norton et al. (1994). The crude fiber range of 16.67-17.65% obtained in this study followed a particular trend, increasing with increasing the levels of GLM in the diets. The values, however, compared with 16.83-18.63% for WAD goats fed *Moringa oleifera* leaf meal in their diets as reported by Jiwuba et al. (2017a). Adequate supply of dietary fiber tends to increase chyme chewing, salivation, reduces digestive problems, and promotes intestinal motility in ruminants (Jiwuba, 2018). The ash values (4.49-4.69%) followed a particular pattern increasing with increasing the levels of GLM; hence, indicating high mineral profile of GLM. The decreasing ($p<0.05$) values for EE and GE combined with incremental levels of GLM may be attributed to higher EE and GE values reported for palm kernel meal (PKM). The results of the proximate analysis of the GLM favourably compared with the results of Abdu et al. (2012) and Jiwuba et al. (2016a, 2020) for the same leaf meal. The proximate composition of PKM obtained in this study compared well with the reported values of Ezieshi and Olumo (2007) and Boateng et al. (2008).

The significantly high ADWG value at 36% inclusion level could be attributed to enhanced utilization of the diets; a view corroborated by Ukanwoko and Okehielem (2016) who established improved body weight gain and feed conversion ratio in WAD goats fed Gmelina leaf meal. The improved weight gain may also be attributed to the high nutrient profile of GLM. Okagbare et al. (2004) earlier reported GLM as a rich source of nutrients. This may have contributed to improving the nutritional quality of the diets which may have supported the enhanced performance of the goats. The non-significant high feed intakes observed among the treatment groups may indicate high palatability of the diets. Higher consumption is indicated in the experimental groups, provided that this is only the case for T_2. Therefore, it is difficult to assume that the inclusion of the additive leads to an improvement in the taste of the ration. The superior FCR of diet T_4 over the other diets is a reflection of the observed higher growth rate and higher feed utilization of the goats fed the respective diet.

The improvement of the white blood cells (WBC) among T_2, T_3 and T_4 groups in comparison with the T_1 group may be attributed to the medicinal and pharmacological properties of GLM; a view corroborated by Kumaresan et al. (2014) and Deepthi et al. (2015). Furthermore, the WBC range of 8.35 to 11.70x10^{12}/l fell within the range of 4 to 13x10^{12}/l as reported by Fraser and Mays (1986) for apparently healthy goat. This indicated that the animals were healthy; hence decreased WBC count below the normal range (leukocytopenia) is an indication of allergic conditions and certain parasitism, while elevated values (leukocytosis) indicate the existence of a recent infection (Jiwuba et al., 2016b). Hb concentrations obtained in this study, generally appeared to support high oxygen carrying capacity in the blood of the goats since they fell within the physiological range of 8-12 g/dl reported by Fraser and Mays (1986). The RBC counts (9.05-10.50x10^{12}/l) fell within the range of 8-18x10^{12}/l established by Fraser and Mays (1986), 7-15 g/dl reported by Daramola et al. (2005) and 9.98-10.88 g/dl reported by Jiwuba et al. (2017a). The improved RBC counts recorded for goats in the T_4 diets gave clear evidence of non-vulnerability to anaemia-related diseases by the goats. The MCH and MCV values obtained fell within the normal physiological range of 5.2-8.0 pg and 16-25 fl as reported by Fraser and Mays (1986) and Jiwuba et al. (2016c), respectively for apparently healthy goats. The reduced MCH counts recorded for goats in the T_3 and T_4 diets present a likely susceptibility to hypochromic anaemia-related disease conditions by these goats; since MCH is the average mass of haemoglobin per red blood cell in a blood sample. Ryan (2010) however opined that MCV has to be considered along with the MCH since MCV affects the content of haemoglobin present per cell. This thus indicated that the T_4 diet could present a likely susceptibility to anaemia-related disease conditions by the goats if fed for a longer time. The values of MCHC indicated that the nutritional quality of the ration was not compromised. Also, the MCHC values fell within normal physiological range of 30-36 g/dl reported by Fraser and Mays (1986); hence a clear indication of absence of anemia among the experimental goats.

The results for total protein content fell within the range of 6.3-8.5 g/dl reported by Daramola et al. (2005), for apparently healthy WAD goats. The serum protein values are comparable with the reported values of 7.3 g/dl and 6.2-7.3 g/dl by Taiwo and Ogunsanmi (2003) and Ukanwoko (2016), respectively, for WAD goats. The higher serum protein observed in T_4 may be attributed to the higher dietary protein of the diet as evidenced in the chemical composition of the diets. This is in agreement with the findings of Jiwuba et al. (2016d) who observed a positive relationship between serum protein and dietary protein. This further indicated better utilization of the dietary proteins by the T_4 goats. The range of 2.70-3.33 g/dl for serum albumen obtained in this study were within the normal physiological diapason of 2.7–3.9 g/dl reported by Kaneko et al. (2008) and favourably compared with 2.75-3.2 g/dl reported for WAD goats by Ukanwoko (2016). According to Jiwuba et al. (2017b) albumin functions chiefly in the regulation of colloidal osmotic pressure of the blood, assists the movement of fatty acids, hormones, bilirubin, cations and drugs in the blood. Nevertheless, the normal albumin concentration reported in this study gave evidence of dietary protein quality and adequacy among the treatment animals. Serum glucose concentration is of great importance in assessing the efficiency of sugar absorption in animals. The level of concentration of glucose in the goats was lower among the T_4 goats, which may indicate high glucagon and low insulin concentrations in the blood. However, the established range of glucose level (61.50-74.50 mg/dl) is within the referral range of 50-75 mg/dl reported by Kaneko et al. (2008) for goats; thus, an indication of absence of high glucagon and low insulin concentration in the body of the experimental goats. The range of urea concentration (13.16-17.06 mg/dl) recorded in this study compared well with 13.11-17.85 mg/dl reported by Jiwuba et al. (2016c) for WAD goats. The established values also fell within the reference range of 10-20 mg/dl reported by Kaneko et al. (2008) for goats. This suggested that the kidneys and liver of the goats were well functioning. However, the high serum urea nitrogen recorded in T_1 may be attributed to increased catabolism of amino acids when proteins of lower biological values are fed to animals. This thus affirms earlier reports (Jiwuba et al. 2017a, 2018b, 2020) that leaf meal produces protein of higher quality. The creatinine values (1.63-1.71 mg/dl) were higher than 0.48-0.88 mg/dl reported by Jiwuba et al. (2017a) for WAD goats, but however, fell within the baseline serum creatinine range of 1.0-1.8 mg/dl reported by Kaneko et al. (2008) for goats. The within normal physiological range obtained in this study implies that the animals have proper functioning kidneys. The blood cholesterol level ranged from 84.64-96.41 mg/dl with T_4 showing lower cholesterol level as against the T_1 group with the highest cholesterol level, respectively. The serum cholesterol concentrations recorded were higher than those established by Jiwuba et al. (2016c) for WAD but fell within the referral serum cholesterol concentrations of 80/130 mg/dl for apparently healthy goats as reported by Kaneko et al. (2008). This is an indication that the goats were healthy and not prone to heart related disease conditions, since a high level of serum cholesterol is an indicator of cardio-vascular related diseases.

Conclusion

It is concluded from this study that Gmelina leaf meal can be included in the diets of West African dwarf goats up to 36% without deleterious effects on their growth performance, haematological and serum biochemical parameters.

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