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Supplementation Effect of Different Levels of African Peach (*Nauclea latifolia*) Leaf Meal on the Performance of West African Dwarf Goats

Peter-Damian Chukwunomso JIWUBA[1*], Solomon Chinedu EGEDE[2], Ruth Chioma AKAZUE[3], Jecinta Nwakaego OMUMUABUIKE[4], Ugochukwu Onyenaucheya ANDREW[1], Terry Ujiagbe IRELEN[1]
[1]Department of Animal Production and Health Technology, [2]Department of Crop Production Technology,
[3]Department of Animal Production Technology,
Federal College of Agriculture, P.M.B.7008 Ishiagu, Ebonyi State, Nigeria
[4]Department of Animal Science, Chukwuemeka Odumegwu Ojukwu University Igbariam Campus,
P.M.B 6059, Awka, Anambra State Nigeria

ABSTRACT

The need to enhance animal protein intake and promote safe meat production has sparked the interest on the use of natural and consumer-accepted phytogenic feed additives. Information on the utilization of *Nauclea latifolia* leaf meal (NLLM) as phytogenic feed additive in goat production is scanty. Therefore, this study aimed to determine the effect of NLLM on nutrient intake, body weight changes, haematology and serum biochemistry of West African Dwarf (WAD) goats. Twenty-four WAD buck-kids between ten and twelve months old were randomly divided into four groups of six goats each. Four experimental diets were formulated to contain 0, 10, 20, and 30 % dietary inclusion levels of NLLM, respectively. The groups were randomly assigned to the four experimental diets (T1, T2, T3, and T4) for 105 days in a completely randomized design. Supplement dry matter intake (DMI) was significantly ($p < 0.05$) increased in the treatment groups (T2, T3, and T4). Basal DMI was significantly ($p < 0.05$) increased in T1. Total DMI (expressed as g/d or g/kgW$^{0.75}$) were significantly ($p < 0.05$) increased among the treatment groups. Supplement DMI as percentage of body weight (DMI % BW), Total DMI % BW and Total DMI % BW (g/kgW$^{0.75}$) were significantly influenced ($p < 0.05$) with T1 having lower value in comparison with other groups. Crude protein, ether extract, ash, neutral detergent fibre, acid detergent fibre and acid detergent lignin intakes were significantly ($p < 0.05$) higher among the treatment groups. Body weight gain and feed conversion ratio were significantly ($p < 0.05$) improved at the treatment groups. Blood parameters showed significant ($p < 0.05$) differences for packed cell volume, haemoglobin, red blood cell, white blood cells, lymphocyte, neutrophil, globulin, cholesterol, creatinine, aspartate aminotransferase and alanine aminotransferase. Conclusively, supplementing WAD goats diets with NLLM improved nutrient intake, weight gain, haematological and serum biochemical parameters, hence NLLM could be included up to 30 % in goat diets without any deleterious effect.

Key words: *Nauclea latifolia*, African peach, phytogenic feed additives, leaf meal, blood indices, West African Dwarf goats

INTRODUCTION

Browse plants play important roles in the nutrition of grazing animals, especially small ruminants that relish browses more than cattle. Akram et al. (2010) compared browse plant leaves nutritionally with that of leguminous fodder. This highlighted the nutritional adequacy of feeding small ruminants with browse plant leaves. Browses are used as protein, energy, fibre, mineral and vitamin sources for small ruminants. Aruwayo and Adeleke (2019) reported high contents of secondary metabolites such as tannins in browse leaves. Jiwuba et al. (2021a) noted that secondary plant metabolites are being re-evaluated in order to better understand how the elements influence growth, feed intake, gut health and animal general performance. Most of the secondary metabolites have been researched upon and are now utilized as phytogenic feed additives to enhance growth and health status of animals. Non-antibiotic growth promoters generated from herbs, spices, and other plants that are used as feed additives are known as phytogenic feed additives. Phytogenic compounds have recently received a lot of interest in animal nutrition due to their growth-promoting

**Correspondence to:*
E-mail: jiwubapc@gmail.com

and therapeutic properties (Jiwuba and Kadurumba, 2019).

Nauclea latifolia is one of such browse plants, belonging to the order *Gentianales* and family *Rubiaceae*. It is commonly known as Pincushion tree or African peach in English, *Uvuru ilu* or *Uburu inu* in Igbo, *Tafashiya*, *Marga, Tuwon biri* or *Tabashiya* in Hausa, *Egbo egbesi* in Yoruba and *Mbom-ibong* in Ibibio. It is a sprawling, evergreen, multi-stemmed shrub, native to tropical Africa and Asia. It can reach a height of 200 metres. It can be found in West and Central Africa humid tropical rainforests or savannah woods. Other three related species, *Nauclea pobeguini, N. diderichii*, and *N. vanderguchtii* are forest trees (Chukwuma et al., 2016). *Nauclea latifolia* is a multi-purpose shrub that produces significant quantity of fodder during the rainy and dry seasons. *Nauclea latifolia* leaf is moderately rich in protein and energy and high in iron, calcium, zinc, potassium, vitamin C and vitamin A. The value of the forage and its benefits as a high-quality supplement to low-quality roughages in small ruminant feeding systems has not been clearly considered or exploited. It has a long history of medicinal, pharmacological, and ethno-veterinary uses as well being relished by goats in the fresh and dried states. *Nauclea latifolia* has been shown to have anti-ulcer, antibacterial, anti-helminthic, anti-plasmodial, anti-viral, anti-trypanosomal, antioxidant, hypolipidemic, neuropharmacological, antidiabetic, hypoglycaemic, histomorphological, wound healing, anti-inflammatory, hepatoprotective, hypocholesterolemic, hepatotoxic, and nephrotoxic properties (Okeiei et al., 2011; Udobre et al., 2012; Solomon et al., 2014; Balogun et al., 2016). Therefore, incorporation of *Nauclea latifolia* leaf meal in the diets of West African dwarf goats has the potential to enhance goat production. The objective of this study was to assess the effects of the diets on the nutrient intake, body weight gain, haematological and serum biochemical indices of West African dwarf goats fed *Nauclea latifolia* leaf meal (NLLM) in their diets. We assume that inclusion of 10 to 30 % of *Nauclea latifolia* leaf meal will have a positive effect on nutrient intake, body weight gain, haematological and serum biochemical indices of West African dwarf goats, due to its high ethno-veterinary, nutritional and growth promoting properties.

MATERIALS AND METHODS

The experiment was carried out at the Sheep and Goat Unit of Animal Production Technology, Federal College of Agriculture, Ishiagu, Ivo L.G.A., Ebonyi state, Nigeria. The College is located about three kilometers away from Ishiagu main town. The College is situated at latitude 5.56 ^{0}N and longitude 7.31 ^{0}E, with an average rainfall of 1653 mm, prevailing temperature condition of 28.50 ^{0}C and relative humidity of about 80%.

Fresh non-over matured *Nauclea latifolia* leaves were sourced and harvested within Ishiagu environment along mile 2 road. The leaves were air-dried in batches to about 10 – 15% moisture contents. Thereafter, they were coarsely milled using hammer mill to produce *Nauclea latifolia* leaf meal (NLLM). Four diets T_1, T_2, T_3, and T_4, were formulated and NLLM was included at the rates of 0%, 10%, 20% and 30% 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	Dietary levels (%)			
	T_1	T_2	T_3	T_4
Nauclea latifolia leaf meal	0.00	10.00	20.00	30.00
Palm kernel cake	40.00	36.00	31.00	28.00
Brewers' dried grain	21.50	18.50	15.50	12.50
Cassava peel meal	30.00	27.00	25.00	21.00
Soya bean meal	5.00	5.00	5.00	5.00
Bone meal	2.00	2.00	2.00	2.00
Salt	1.00	1.00	1.00	1.00
Vitamin/mineral premix	0.50	0.50	0.50	0.50
Total	100	100	100	100

Twenty-four West African Dwarf (WAD) goats of about 10 to 12 months of age and averaging 7.85 kg in weight were selected from the departmental herd. The groups were randomly assigned the four experimental diets (T_1, T_2, T_3, and T_4) in a completely randomized design. The animals were housed individually in a well-ventilated concrete floored pens equipped with feeders and drinkers. Each animal received a designated treatment diet in the morning (8.00 a.m.) for 105 days. Feed offered was based on 3.5 % body weight per day; the animals in addition were fed 1.0 kg wilted chopped guinea grass (*Panicum maximum*) later in the day (5.00 p.m.). Regular access to fresh drinkable water was ensured. Voluntary feed intake was determined daily for each animal by subtracting feed refusals of the following day from feed supplied each day. Initial live weights of the animals were taken at the beginning of the feeding trial using spring balance and weekly thereafter in the morning before feeding. Final weight was obtained by weighing the goats at the end of the experiment. Other growth performance indices were calculated accordingly. The experimental goats were managed in accordance with the permission and stipulated guidelines of the Animal Ethics Committee, Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria.

Ten ml of blood samples were collected from each animal on the last day of the study. The goats were bled through the

jugular vein. The samples were separated into two groups and used for haematological and biochemical determinations. An initial 5 ml was collected in labelled sterile universal bottle containing 1.0 mg/ml ethyldiamine tetracetic acid (EDTA) and used for haematological analysis. The remaining 5 ml was 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.

The four feed samples and test ingredient (*Nauclea latifolia* leaf meal) were analyzed for their chemical composition using the method of AOAC (2000). The following were determined and analyzed; dry matter content (DM), crude protein (CP), ether extract (EE), ash, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL). Gross energy was calculated using the formula $T = 5.72 \times Z_1 + 9.50 \times Z_2 + 4.79 \times Z_3 + 4.03 \times Z_4 \pm 0.9\%$; where T = Gross energy, Z_1 = Crude protein, Z_2 = Crude fat, Z_3 = Crude fibre, Z_4 = Nitrogen free extract (Nehring and Haelein, 1973).

The data collected 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 compared using Duncan's new multiple range test (Duncan, 1955) at $p < 0.05$.

RESULTS

The chemical composition of *Nauclea latifolia* leaf meal is shown in Table 2. The result revealed the presence of DM, CP, EE, ash, NDF, ADF and ADL. Table 3 shows the chemical compositions of the experimental diets. All the parameters examined were not significantly ($p < 0.05$) influenced by the treatment diets. Table 4 shows the nutrient intake of West African dwarf goats fed graded levels of *Nauclea latifolia* leaf meal. All the parameters examined were significantly ($p < 0.05$) influenced except forage dry matter intake as percentage of body weight, crude protein intake (g/kg$W^{0.75}$), acid detergent fibre intake (g/kg$W^{0.75}$) and acid detergent lignin intake (g/kg$W^{0.75}$) by the treatment diets. The treatment groups showed significantly ($p < 0.05$) higher supplement dry matter intake (SDMI). Basal dry matter intake (BDMI) was higher ($p < 0.05$) in the control when compared to the treatment groups. The dry matter intake as percentage body weight (DMI % BW) differed significantly ($p < 0.05$) across the groups. The CP intakes (g/d and g/kg $W^{0.75}$) of the goats fed the control diet (T_1) had the lowest values (48.11 g/d and 18.27 g/kg $W^{0.75}$) in comparison with the treatment groups with values of 72.08 g/d, 24.74 g/kg $W^{0.75}$ for T_2, 70.85 g/d, 24.42 g/kg $W^{0.75}$ for T_3 and 69.00 g/d and 23.94 g/kg $W^{0.75}$ for T_4. The ether extract intakes were significantly ($p < 0.05$) affected by the treatment diets. T_3 was significantly ($p < 0.05$) higher than other groups, T_4 and T_2 were statistically similar ($p > 0.05$) but significantly ($p < 0.05$) higher than T_1. The ash intakes were significantly ($p < 0.05$) affected by the treatment diets. T1 was significantly ($p < 0.05$) lower than the treatment groups. NDF (g/d and g/kg$W^{0.75}$), ADF (g/d) and ADL intakes (g/d) were significantly ($p < 0.05$) influenced with goats on T_1 diet having the lowest intakes. Table 5 shows the body weight gain of West African dwarf goats fed graded levels *Nauclea latifolia* leaf meal. The average final weight showed significant ($p < 0.05$) increase for T_2, T_3 and T_4 when compared with T1. The total weight gain and daily weight gain of the animals followed same pattern as the final body weight. Total dry matter intake and feed conversion ratio were also significantly ($p<0.05$) higher in T_2, T_3 and T_4. The results of haematological parameters of West African dwarf goats fed graded levels *Nauclea latifolia* leaf meal is presented in Table 6. There was significant ($p < 0.05$) difference for packed cell volume (PCV); T_1 showed significantly ($p < 0.05$) lower value than the treatments containing graded levels *Nauclea latifolia* leaf meal. The haemoglobin (Hb) concentration showed significant ($p < 0.05$) difference, with T_1 having significantly ($p < 0.05$) lower value than other treatments. T_4 was similar ($p > 0.05$) to T_2 and T_3, but T_2 showed significantly ($p < 0.05$) higher value than T_3. Red blood cell concentration showed significant ($p < 0.05$) difference with the *Nauclea latifolia* leaf meal containing diets showing significantly higher values than the control. The white blood cell (WBC) was significantly ($p < 0.05$) influenced by the addition of *Nauclea latifolia* leaf meal with T_2, T_3 and T_4 showing significantly ($p < 0.05$) higher values than the control. Lymphocyte and neutrophil were significantly ($p < 0.05$) influenced by the treatment diets. Table 7 shows serum biochemical parameter of West African dwarf goats fed graded levels *Nauclea latifolia* leaf meal. Total protein, albumin, glucose, urea and total bilirubin showed no significant ($p > 0.05$) difference. Globulin, cholesterol, creatinine, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) were significantly ($p < 0.05$) influenced. The globulin values showed significant ($p < 0.05$) difference, with T_1 having significantly ($p < 0.05$) lower than other treatments. The creatinine concentration showed significant ($p < 0.05$) difference, with T_1 having significantly ($p < 0.05$) higher than other treatments. The AST and ALT concentrations showed significant ($p < 0.05$) difference, with T_1 having significantly ($p < 0.05$) higher than other treatment groups.

DISCUSSION

The chemical composition of *Nauclea latifolia* leaf meal varied slightly from values earlier reported (Eze and Obinwa, 2014; Faleye and Akinwumi, 2016; Jiwuba et al., 2021a, b) which may be attributed to differences in maturity of the leaves at harvesting, location and soil fertility. Dry matter content of the diets ranged from 88.93–91.47%, and was lower

Table 2: Chemical compositions of *Nauclea latifolia* leaf meal

Parameters	Composition
Dry matter (%)	88.76
Crude protein (%)	17.37
Ether extract (%)	3.98
Ash (%)	15.82
Gross energy (MJ/ kg)	3.37
Neutral detergent fibre (%)	38.55
Acid detergent fibre (%)	16.27
Acid detergent lignin (%)	10.43

Table 3: Chemical compositions of the experimental diets

Parameters	Dietary levels (%)				SEM
	T_1	T_2	T_3	T_4	
Dry matter (%)	90.23	88.93	91.47	90.72	3.77
Crude protein (%)	16.92	17.11	17.87	17.79	0.65
Ether extract (%)	3.76	3.95	4.87	4.32	0.25
Ash (%)	9.65	10.75	11.99	12.15	0.51
Gross energy (MJ/ kg)	3.87	3.47	3.32	3.29	0.22
Neutral detergent fibre (%)	31.54	32.18	30.78	31.11	1.08
Acid detergent fibre (%)	21.76	22.49	20.55	22.32	0.58
Acid detergent lignin (%)	10.33	10.47	9.99	11.31	0.34

Table 4: Nutrient intake of West African dwarf goats fed graded levels *Nauclea latifolia* leaf meal

Parameters	Dietary levels (%)				SEM
	T_1	T_2	T_3	T_4	
Supplement DMI (g/d)	256.55^{b}	374.64^{a}	362.65^{a}	351.88^{a}	17.54
Basal DMI (g/d)	28.96^{a}	21.00^{bc}	24.46^{b}	19.23^{c}	4.89
Total DMI (g/d)	285.51^{b}	395.64^{a}	387.11^{a}	371.11^{a}	21.58
Total DMI (g/kgW$^{0.75}$)	69.46^{b}	88.71^{a}	87.27^{a}	84.55^{a}	3.02
DMI as percentage BW (DMI % BW) (%)					
Supplement	2.89^{b}	4.69^{a}	4.23^{a}	4.40^{a}	0.47
Forage	0.32	0.26	0.29	0.24	0.09
Total DMI % BW	3.21^{b}	4.95^{a}	4.52^{a}	4.64^{a}	0.13
Total DMI % BW (g/kgW$^{0.75}$)	2.40^{b}	3.32^{a}	3.10^{a}	3.16^{a}	0.39
Crude protein intake (g/d)	48.11^{b}	72.08^{a}	70.85^{b}	69.00^{b}	2.98
Crude protein intake (g/kgW$^{0.75}$)	18.27	24.74	24.42	23.94	2.67
Ether extract intake (g/d)	10.69^{c}	16.68^{b}	19.31^{a}	16.76^{b}	1.73
Ether extract intake (g/kgW$^{0.75}$)	5.92^{b}	8.25^{a}	9.21^{a}	8.28^{a}	0.81
Ash intake (g/d)	27.44^{b}	45.29^{a}	47.54^{a}	47.13^{a}	2.77
Ash intake (g/kgW$^{0.75}$)	11.99^{b}	17.46^{a}	18.10^{a}	17.99^{a}	1.92
Neutral detergent fibre intake (g/d)	89.68^{b}	135.57^{a}	122.03^{a}	120.67^{a}	10.33
Neutral detergent fibre intake (g/kgW$^{0.75}$)	29.14^{b}	39.73^{a}	36.72^{a}	36.41^{a}	1.43
Acid detergent fibre intake (g/d)	61.87^{b}	94.75^{a}	81.47^{a}	86.57^{a}	7.21
Acid detergent fibre intake (g/kgW$^{0.75}$)	20.06	30.37	27.12	28.38	3.57
Acid detergent lignin intake (g/d)	29.37^{b}	44.11^{a}	39.62^{a}	43.87^{a}	3.18
Acid detergent lignin intake (g/kgW$^{0.75}$)	12.62	17.12	15.79	17.05	1.11

$^{a-c}$ means within the same row with different superscripts are significantly different ($P < 0.05$); DMI – dry matter intake; BW – body weight

Table 5: Body weight changes of West African dwarf goats fed graded levels *Nauclea latifolia* leaf meal

Parameters	Dietary levels (%)				SEM
	T_1	T_2	T_3	T_4	
Initial body weight (kg)	7.87	7.98	7.57	7.99	0.41
Final body weight (kg)	11.39[b]	15.97[a]	14.32[a]	14.44[a]	1.66
Total body weight gain (kg)	3.52[b]	7.99[a]	6.75[a]	6.45[a]	0.87
Daily body weight gain (g/d)	33.52[b]	76.10[a]	64.29[a]	61.43[a]	5.76
Total dry matter intake (g/d)	285.51[b]	395.64[a]	387.11[a]	371.11[a]	21.58
Feed conversion ratio	8.52[a]	5.20b	6.02[b]	6.04[b]	1.56

[a-c] means within the same row with different superscripts are significantly different ($P < 0.05$)

Table 6: Haematological parameter of West African dwarf goats fed graded levels *Nauclea latifolia* leaf meal

Parameters	Normal range	T_1	T_2	T_3	T_4	SEM
Packed cell volume (%)	22–38	26.04[b]	33.55[a]	32.55[a]	32.86[a]	1.76
Haemoglobin (g/dl)	8.0–12.0	8.11[c]	11.17[a]	9.50[b]	10.17[ab]	0.75
Red blood cell ($x10^6$/µl)	8.0–18.0	10.05[b]	12.97[a]	12.51[a]	12.65[a]	1.04
Mean cell volume (fL)	16–25	20.43	24.44	20.55	23.14	2.22
Mean cell haemoglobin conc. (%)	30–36	30.99	34.19	33.01	32.22	1.71
Mean cell haemoglobin (pg)	5.2–8.0	5.53	7.11	6.54	7.54	0.47
White blood cell counts ($x10^9$/L)	4.0–13.0	8.43[c]	13.43[b]	13.73[b]	15.87[a]	1.13
Lymphocyte (%)	47–82	59.66[b]	64.43[a]	66.65[a]	64.87[a]	3.43
Neutrophil (%)	17–52	22.76[c]	43.88[b]	47.44[a]	47.09[a]	1.98

[a-c] means within the same row with different superscripts are significantly different ($P < 0.05$)

Table 7: Serum biochemical parameter of West African dwarf goats fed graded levels *Nauclea latifolia* leaf meal

Parameters	Normal range	T_1	T_2	T_3	T_4	SEM
Total protein (g/I)	64.0–70.0	64.48	65.34	66.92	65.88	4.41
Globulin (g/I)	27.0–41.0	30.54[b]	35.77[a]	37.53[a]	37.84[a]	2.05
Albumin (g/I)	27.0–39.0	29.94	29.57	30.39	30.04	2.84
Glucose (mmol/l)	2.78–4.16	3.11	3.04	2.99	3.13	0.09
Cholesterol (mmol/l)	2.07–3.37	3.35[a]	2.61[b]	2.39[c]	2.16[c]	0.07
Creatinine (µmol/ l)	88.4–159	76.83[b]	91.47[a]	90.13[a]	86.75[a]	2.94
Urea (mmol/l)	10–20.00	7.44	5.44	4.22	5.54	0.49
Total Bilirubin (µmol/l)	0–1.71	0.43	0.54	0.49	0.46	0.11
Aspartate aminotransferase (U/L)	167–513	79.43[a]	54.87[b]	58.12[b]	53.33[b]	2.11
Alanine aminotransferase (U/L)	6–19	24.65[a]	23.44[a]	17.33[b]	17.59[b]	1.87

[a-c] means within the same row with different superscripts are significantly different ($P < 0.05$)

than 92.10–93.01 % reported by Jiwuba et al. (2021b) for WAD goats fed four phytogenic feed additives, but comparable with 88.15–90.92 % by Jiwuba et al. (2016) for WAD goats fed Moringa oleifera leaf meal. The CP content of 16.92 % for T_1 (0 % NLLM) was lowest, followed by CP content of 17.11 % for T_2, 17.87 % for T_3 and 17.79 for T_4. The inclusion of *Nauclea latifolia* leaf meal in the diets (T_2, T_3 and T_4) could be responsible for the slight increases in the CP contents of the diets. The CP content of 16.92–17.87% were well above the minimum maintenance of 7 % for goats as recommended (NRC, 1981). The CP values of 16.92–17.87 % were higher than the minimum requirement of 7–8 % necessary to provide the minimum ammonia required by rumen microbes to support optimum rumen activity (Norton, 2003). The CP values obtained herein is higher than 12.87–15.62 % by Jiwuba et al. (2021a, b) for WAD goats fed four phytogenic feed additives and lower than 19.03–20.55 % by Fajemisin et al. (2018) for WAD fed Myrianthus arboreus leaf meal but comparable with 16.09–18.92 % by Ukanwoko and Okehielem (2016) for WAD goats fed Gmelina (Gmelina arborea) leaf meal. The EE was similar to the range of 3.25–4.19 % reported by Jiwuba et al. (2016) for WAD goats fed Moringa oleifera leaf meal. The ash was similar to the range of 9.48–13.62 % reported by Jiwuba et al. (2020) for WAD goats fed Annona muricata leaf meal. The NDF, ADF and ADL values of the experimental diets ranged from 30.78–32.18 %, 20.55–22.49 % and 9.99–11.31 %, respectively. These values are comparable with 29.31–31.56 %, 23.71–25.53 % and 9.18–11.58 % for NDF, ADF and ADL, respectively, reported by Jiwuba et al. (2021a, b) for WAD goats fed four phytogenic feed additives. Nouala et al. (2006) outlined that the environmental conditions of the rumen are normally in favour of the fibrolytic microorganisms that aid in the degradation of high fibre diets in contrast to the negative effects of concentrate diets, which are high in carbohydrates. The low to moderate fibre fraction values reported herein are lower than the values reported for low quality roughages, which ruminants can successfully degrade (Arigbede and Tarawali, 1997). The low to moderate fibre fraction values of the diets may indicate high nutritive value since fibre plays an important role in voluntary intake and utilization. This may further imply that the diets have the potentials to support intestinal movement and proper rumen function. The gross energy values were similar to the range of values reported by Jiwuba et al. (2016) and Jiwuba et al. (2020) for WAD goats fed *Moringa oleifera* leaf meal and Annona muricata leaf meal, respectively. The superiority of the energy value could be attributed to the ability of the diet to conform to the recommended energy value for goat diets (6–13 MJ/kg/DM) (Steele, 2006).

The increased SDMI for the treatment groups may be attributed to the greater palatability of the diets conferred on the diets by *Nauclea latifolia* leaf meal. This is in agreement with earlier report of Jiwuba et al. (2021b) who reported significant higher SDMI among goats fed *Nauclea latifolia* leaf meal. The significantly low basal DMI obtained in the treatment groups may be due to significant higher supplement intake observed for the respective treatments as the rumen may have been filled with the supplemental diets. The goats fed T_1 had lower DMI (g/day) and metabolic DMI ($Wkg^{0.75}$) than those fed the treatment diets, which appear to suggest that low crude protein lead to reduced DMI (g/day) in goats, while those with high crude protein promoted high DMI. The observed improved DMI among goats fed NLLM is in consonance with earlier reports of Okah and Antia (2017) and Jiwuba et al. (2021b). Incorporation of browse plant leaf meal into concentrate diets fed to goats is believed to stimulate feed intake or higher DM consumption. This may be attributed to the enhanced palatability conferred on the diets by the phytogenic feed additive. The poor intake of T1 may be attributed to higher level of palm kernel cake in the diet; this is in agreement with earlier report of Fereira et al. (2012) who attributed poor feed intake of cattle fed high palm kernel cake to lower palatability and higher fibre content of the palm kernel cake. Metabolic weight dry matter intake ($g/kgW^{0.75}$) reported in this study (69.46–88.71 $g/kgW^{0.75}$) were above the voluntary DMI of 58 $g/kgW^{0.75}$ recommended as maintenance requirement for goats in Nigeria by Akinsoyinu (1985) and 68 $g/kgW^{0.75}$ recommended by Kearl (1982) for goat breeds commonly found in developing countries. The higher voluntary DMI $g/kgW^{0.75}$ above the recommended values for maintenance maybe responsible for the positive weight gain obtained in this study. The increasing levels of NLLM in the diets may possibly have supported nutrient balance in the diets, with the best synchronization of available nutrients at 10 to 30 % NLLM diets. The values for all the treatments (3.21–4.95 %) are in according with the values of 2.8–4.0 %, which are recommended daily DMI % BW requirements for meat type goats in the tropics Nuru (1985). The results generally indicated that goats on the various treatment diets showed positive DMI status as evidenced by a general positive performance of the goats. The CP intake values for all the treatments were within the range of protein required for goats in the tropics recommended by Devendra and McLeroy (1982). It is worthy to note that the crude protein intake of the goats were higher than the minimum 41.50 g/day recommended by NRC (1981) for goats. The CP intake obtained in this study is in agreement with the CP requirements suggested by Kearl (1982), NRC (1985) and Paul et al. (2003). The high ether extract intakes (10.69–19.31 g/d and 5.92–9.21 $g/kgW^{0.75}$) obtained for all the goats in this study may be responsible for the lustrous smooth hair of the goats. The range of 27.44–47.45 g/d ash intake reported in this present study fell within the range of 45.16–61.70 g/d reported by Jiwuba et al. (2021b) for WAD goats fed four phytogenic browse plant leaf meals. The relatively high among of ash for the treatment groups may have been responsible

for high intakes occasioned by high vitality, which may have increased appetite among the goats fed the respective diets. Ruminants generally require adequate coarse insoluble fibre for normal rumen function, which is associated with adequate rumination and fibre digestion. The NDF values in the diets is below the range suggested as the limit above which intake of tropical feeds by ruminant would be limited (Van Soest et al., 1991). Moderate fibre levels have been reported by Klopfenstein et al. (2001) to aid colonization of ingesta by rumen microorganism, which in turn might induce higher fermentation rates, therefore improving digestibility, intake and overall performance of the animal. Hemicellulose and cellulose intakes are reliant on the intake of NDF, ADF and ADL and the percentage of each in the diets. The high NDF, ADF and ADL intakes observed among the treatment groups may be attributed to the high dry matter intakes of the respective treatments. Similarly, the higher fibre intakes are therefore expected from dried materials.

The improved weight gains of the animals on the *Nauclea latifolia* leaf meal diets could be related to the CP component of the diets, DM and CP intakes of the animals. The result of the present study agrees with significant weight gain reported by Jiwuba et al. (2021b) for goats fed diets containing 20 % each of *Gmelina arborea*, *Mangifera indica* and *Nauclea latifolia*. To overcome the protein-binding effects of tannins, Gilboa et al. (2000) revealed that when supplementing or substituting forage legumes as protein sources, a higher level of CP must be provided. The possible presence of tannins at low level in the control diet may likely resulted in increased ruminal breakdown of CP, which could explain the lower growth rate of goats on the control diet in comparison with the treatment groups. However, protein-binding proved ineffective at larger degrees of inclusion, resulted to significant higher growth rates among the goats. As a result, the higher growth rates and lower feed conversion ratio suggested superior goat performance in terms of weight gain when *Nauclea latifolia* leaf meal diets were fed.

The PCV range of 26.04 to 33.55 % obtained in this current study perhaps fell within the normal physiological range of 21–35 % reported by Daramola et al. (2005) for apparently healthy WAD goats. The normal PCV values indicated that the diets were nutritionally adequate to maintain good health of the animals. The Hb concentration of 8.11 to 11.17 g/dl obtained in this current study fell within the normal physiological range of 7–15 g/dl reported by Daramola et al. (2005) for apparently healthy WAD goats. The within normal physiological range of Hb concentration indicated the potential of the experimental diets in supporting high oxygen carrying ability of blood among the goats. The RBC values in this present study ranged from 10.05–12.97 $\times 10^6$/µl). The RBC range of values reported for the goats fell within the physiological range of 9.2–3.5 $\times 10^6$/µl reported for apparently healthy WAD goats (Daramola et al., 2005). The higher RBC and Hb values reported among the diets containing *Nauclea latifolia* leaf meal gave a clear indication of absence or tolerable level of anti-nutritional factors especially tannin in the diets. This may indicate that the utilization of the experimental diets ensured effective transport of haemoglobin through the red blood cells of the goats. Significant higher RBC count was recorded for the treatment groups, which also corresponded with significant higher PCV values; this may suggest the superiority of the respective diets in terms of their capability of supporting high oxygen carrying capacity of the blood and absence of anaemia-related diseases, which might be due to iron deficiency. The WBC plays a prominent role in disease resistance especially with respect to the generation of antibodies. The WBC counts were within the physiological range of 6.8–20.1 ×103 µl reported by Daramola et al. (2005) for WAD goats and also comparable with 13.1 $\times 10^3$ µl and 15.7 $\times 10^3$ µl reported by Taiwo and Ogunsami (2003) and Obua et al. (2012) for apparently healthy WAD goats. The significantly higher values, but within the physiological range, reported for the *Nauclea latifolia* leaf meal diets implied that goats on these diets remained clinically healthy and able to fight more against any pathogen in the circulatory system. *Nauclea latifolia* leaf meal containing diets maintained significantly higher values than the control diet. The values (59.66–66.65 %) and (22.76–47.44 %) obtained for lymphocyte and neutrophil respectively fell within the physiological range of 47–82 % and 17–52 % reported by Daramola et al. (2005) for lymphocyte and neutrophil respectively. These values are suggestive of a well-developed immune system among the WAD goats with such number of immune cells to proffer good health. The result also implied that *Nauclea latifolia* leaf meal is not deleterious and hence promoted the immunity of WAD goats up to 30 % level of inclusion.

The globulin values showed significant higher values among the treatments and fell within the normal range (27.0–41.0 g/l) reported by Kaneko et al. (2008), which is indicative of high immunity and good resistance to disease among the goats. This perhaps highlighted the ethno-veterinary properties of *Nauclea latifolia* as reported by Nworgu et al. (2008) and corroborated by Okwori et al. (2008). The serum cholesterol concentration ranged between 2.16 and 3.35 mmol/l with the goats on T4 showing lower value as against the T1 group with the highest cholesterol value. The concentration of serum cholesterol fell within the physiological range of 2.07–3.37 mmol/l for clinically healthy goats as stated by Kaneko et al. (2008). The significant lower cholesterol concentration reported for WAD goats fed *Nauclea latifolia* leaf meal containing diets indicated the capacity of *Nauclea latifolia* leaf meal in the treatment and management of heart diseases connected with elevated cholesterol in the blood. This finding may further eliminate the possibilities of the goats suffering myocardial infractions usually associated with high serum cholesterol concentration and

leanness due to low serum cholesterol value. However, the values of 76.83–91.47 µmol/l, fell within the physiological range of 88.4–159 µmol/l reported by Kaneko et al. (2008). The within reference range herein may indicate absence of any factor in the feed to portray its poor quality which may deleteriously affect the stability and normal functioning of the kidney. Serum creatinine concentration is a valuable marker of glomerular filtration in the kidney; thus, normal clinical value indicated that the animals are not in a catabolism condition and kidney functions are improved. This result is an indication that the goats were in good nutritional plane that supported the proper functioning of the kidneys hence feeding *Nauclea latifolia* leaf meal were not deleterious to goat kidneys. The significantly decreased but within reference range of blood enzymes reported herein could indicate that the test diets had similar effects on enzyme secretion mechanisms. The results of AST and ALT are within normal ranges of 43–132 U/L and 7–24 U/sL, respectively, by Sirois (1995). The liver is the centre of various digestive, metabolic, and productive processes, and as such, it is vulnerable to chemical and biological damage to varying degrees. Serum levels of particular enzymes originating from the liver reveal such damage. These enzymes can cause biological activities to be disrupted, resulting in poor health and production performances, depending on their concentrations. Activities in the blood are biomarkers for liver function and injury. Increased levels of these enzymes have been linked to damage to the liver and muscles as a result of stress response of the body. In this investigation, the values of these enzymes were significantly lower in the treatment groups than in the control group. It was observed that induced liver damage using aflatoxin led to an increase in serum ALT (Fernandez et al., 1997). As a result, the significant decrease in AST and ALT caused by *Nauclea latifolia* leaf meal can be interpreted as a sign of improved liver function. The results of this study, however, implied that *Nauclea latifolia* leaf meal has potential in goat feeding, validating Ekpenyong and Biobaku (1986) conclusion that liver enzymes are found to be high in the blood when the level of nutrition is poor.

CONCLUSION

The results suggested that up to 30% inclusion of *Nauclea latifolia* leaf meal yielded positive effect in feeding of goats without any adverse influence. It is therefore overbearing that *Nauclea latifolia* leaf meal promoted nutrient intake, weight gain, haematological and serum biochemical indices in West African dwarf goats.

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Vpliv dodatka različnih količin moke iz listov afriške breskve (*Nauclea latifolia*) na proizvodnost zahodnoafriških pritlikavih koz

POVZETEK

Potreba po povečanju vnosa živalskih beljakovin in promociji varnega mesa je sprožila zanimanje za uporabo naravnih in potrošniku sprejemljivih fitogenih krmnih dodatkov. Podatkov o uporabi moke iz listov *Nauclea latifolia* (NLLM) kot fitogenega krmnega dodatka v kozjereji je malo. Iz tega razloga je bil cilj te raziskave ugotoviti učinek NLLM na vnos hranilni snovi, rastnost, hematologijo in serumsko biokemijo pri zahodnoafriških pritlikavih kozah. Štiriindvajset koz, starih 10–12 mesecev, je bilo naključno razdeljenih v štiri skupine po šest živali. Pripravljeni so bili štirje poskusni obroki, ki so vsebovali 0, 10, 20 in 30% prehranskega dodatka NLLM. Skupine koz so bile popolnoma naključno dodeljene štirim poskusnim obrokom (T1, T2, T3 in T4) za 105 dni. Količina zaužite suhe snovi (SS) dodatka se je znatno povečala ($p < 0,05$) v poskusnih skupinah (T2, T3 in T4). Količina SS osnovne krme je bila značilno ($p < 0,05$) višja v skupini T1. Skupna količina SS obroka (izražena kot g/dan ali g/metabolno težo) se je v poskusnih skupinah znatno povečala ($p < 0,05$). Pri količini SS dodatka, izraženi kot odstotek telesne mase (SS % TM), skupni količini SS, izraženi kot % TM in skupni količini SS, izraženi kot % TM (g/metabolno težo) je bil ugotovljen značilen vpliv dodatka NLLM ($p < 0,05$), pri čemer je imela skupina T1 nižjo vrednost v primerjavi z drugimi skupinami. Vnos surovih beljakovin, etrskega ekstrakta, pepela, v nevtralnem detergentu netopnih vlaken, v kislem detergentu netopnih vlaken in v kislem detergentu netopnega lignina je bil značilno višji ($p < 0,05$) pri poskusnih skupinah. Prirast telesne mase in konverzija krme sta se znatno izboljšala ($p < 0,05$) v poskusnih skupinah. Krvni parametri so pokazali značilne ($p < 0,05$) razlike za volumen celic, hemoglobin, rdeče in bele krvne celice, limfocite, nevtrofilce, globulin, holesterol, kreatinin, aspartat aminotransferazo in alanin aminotransferazo. Na osnovi rezultatov lahko zaključimo, da je dopolnjevanje obroka zahodnoafriških pritlikavih koz z NLLM povečalo vnos hranil in telesno maso ter izboljšalo hematološke in serumske biokemične parametre. Rezultati kažejo, da lahko v obroke za koze vključimo do 30 % NLLM brez kakršnihkoli škodljivih učinkov.

Ključne besede: *Nauclea latifolia*, Afriška breskev, fitogeni krmni dodatki, listna moka, krvni indeksi, zahodnoafriške pritlikave koze