Nigerian J. Anim. Sci. 2023, 25 (2): 178-199

Sphenostylis stenocarpa (African Yam Bean) based diet improves physical condition and blood parameters of West African Dwarf breeding does

Jesuyon, Oluwatosin M. A. [A, D], Adejoro, F. A. [A], Boluwaji, O. V. [A], Ewuola, E. O. [B], Ajayi, D. O. [A] and Sanni, T. A. [C]

[A]*Animal Production and Health Department, Federal University P. M. B. 373, Oye-Ekiti, 371104, Ikole Campus, Ekiti State, Nigeria.*
[B]*Animal Physiology and Bioclimatology Unit, Animal Science Department, University of Ibadan, Nigeria.*
[C]*Department of Food Science and Technology, Federal University, Oye-Ekiti, Ekiti State, Nigeria.*

[D]***Corresponding Author**: dr.oluwatosinjesuyon14@gmail.com; **Phone Number**: +234-806-431-0337*

Target Audience: *Extension workers, Livestock Farmers, Corporate Ruminant Farms, Livestock policy makers, Farm animal Researchers*

Abstract

Underutilized legumes could provide nutrition to indigenous goats vulnerable to inadequate nutrition during the breeding season in Africa. The study evaluated dry matter intake, average daily gain (ADG), feed conversion efficiency (FCE), body condition score (BCS), hematological parameters, serum hormones and urea nitrogen production in West African Dwarf (WAD) does supplemented with soaked African yam bean (AYB)-based concentrates. Forty WAD does were randomly allotted in a complete randomized design into each of four diets AYB-0, 1, 2 and 3 with 0, 12.5, 25.0 and 37.5% AYB inclusion levels as replacement for soybean meal in the concentrate. Animals were fed Guinea grass (Megathyrsus maximus Jacq.) ad-libitum. Data on daily feed intake, body weight and BCS were collected weekly, while blood samples were obtained from the jugular vein for evaluation of haematological, serum hormones and urea nitrogen concentrations of does at initial and 56 days. Increasing the level of soaked-AYB in the diet from 12.5 to 37.5% reduced ADG, FCE and BCS; while cost/daily gain increased significantly (P<0.05). Neutrophil-lymphocyte ratio decreased (P<0.05) indicating improved welfare of pregnant does in the first trimester. Findings support feeding of WAD does with soaked AYB-1 during the dry season to ameliorate feed and nutritional stress.

Keywords: *Average daily gain; Hematological profile; Health status; Neutrophil-lymphocyte ratio; Serum hormones.*

Description of Problem

Goats are a major source of livelihood and sustainability to many smallholders and emerging farming households across various agroecology in Africa (1). Reproductive and growth potential of West African Dwarf (WAD) goats can be improved with nutritional supplements or concentrate feed (2). Inadequate nutrition results in abortion, low birth weight and delay in returning to estrous in does. Above scenario justifies strategic supplemental feeding (3) especially when forage quality and quantity is low. Economic implication of supplemental feeding makes neglected and underutilized legumes a potential source for formulating rations for goats and sheep, as they do not present strong competition between humans and animals. Their production is often adapted to the mixed crop-livestock systems typical among emerging and smallholder farmers across Africa. African yam bean (AYB, Sphenostylis stenocarpa), is an underutilized legume with edible seeds and tubers, consumed by humans and animals (4). It is easily available in the crop-livestock mixed farming areas, and unit price is cheaper than most other common pulses in the open markets especially soyabean. It is adjudged to be rich in nutrients and phytochemicals which could enhance growth and performance in farm animals (5). The nutritional profile is comparable to pigeon pea and cowpea in protein and carbohydrate (4, 5). According to (5), crude protein, total carbohydrates, and neutral detergent fibre concentration of crude AYB was 190, 633, and 324 g/kg DM respectively. Although, AYB contains some phytochemicals such as flavonoids, protease inhibitors, phytate, saponins, oxalate and tannins, simple processing techniques reduce their concentrations to tolerable levels (6). Soaking for 48 hrs significantly reduced total phenol, total tannin, oxalate and phytate concentration to tolerable levels but did not affect anti-trypsin inhibitors concentration (5). Furthermore, in vivo trials are required to establish optimum inclusion levels, and determine the effect of different inclusion levels of processed AYB on feed intake, growth and health status of various animal categories. A fast means of assessing clinical and nutritional effects of feeding trials is through blood analysis (7).

Serum leptin levels can be used to determine feed intake and body energy status of individuals. Blood urea nitrogen is an indication of protein fermentation from rumen, while higher dietary protein content of diets is often associated with increase in urea level (8). Although, toxicity of raw AYB is acknowledged, the effect of residual antinutritional factors in processed AYB on animal intake, rumen fermentation and health indicators of ruminants is unknown. Similarly, information on the haematological and hormonal profile of WAD does fed soaked AYB is also limiting in literature. The study aimed to evaluate effect of different diets based on soaked AYB meal on intake, daily gain, blood and serum metabolites profile of WAD does. It was hypothesized that the best diet shall improve feed utilization efficiency without negative effect on hematology and serum profile.

Materials and methods

The study was conducted at the Teaching and Research Farm, Federal University Oye-Ekiti, Nigeria, located on 7.8°N, 5.2°E. Harvested and sundried AYB seeds were soaked in clean water for 24 hours, drained and sundried for seven days to constant weight. Thereafter, seeds were crushed in a hammer mill through 5 mm screen size to obtain sundried, soaked AYB meal. The seeds of AYB were thus treated to reduce the anti-nutritional factors therein to tolerable levels. Four concentrate diets were formulated with 0 (control), 12.5, 25.0 and 37.5% AYB as replacement for soybean meal as main protein source. The ingredients and chemical composition of experimental concentrate diets are shown in Table 1.

Animal housing and experimental procedure

Forty (40) breeding WAD does with average body weight of 11.4±3.49 kg and aged 2-3 years old, tagged and given routine prophylactic treatments and Pestes des petits ruminants (PPR) vaccination individually was used for the trial. These were synchronized with Prostaglandin F2α (Estrumate) injection at 1 ml /doe, repeated at 7-day interval. That is, on days 1 and 8, serviced by natural mating from day-21 onward, and successful conception confirmed by pregnancy strip test and introduction of Bucks at day-35. Thus, the experiment started with does in their first trimester stage from day 1 to 56th day. Does were ranked and grouped by weight. From each weight group, individuals were randomly allocated to each of four dietary treatments in a completely randomized design: i) control concentrate diet ii) concentrate with 12.5% AYB inclusion, iii) concentrate with 25.0% AYB inclusion, and iv) concentrate with 37.5% AYB inclusion. Each experimental treatment group contained 10 animals. Each doe was housed individually in roofed-crib with open area for roaming. The average room temperature and humidity range were 21.7-30.5^{0}C and 72–78%. All animals consumed wilted guinea grass (Megathyrsus maximus Jacq.) ad-libitum while concentrate portion was offered once a day in separate feeding troughs at 260 g/day per animal at 08h00. Portable water was always available. Experimental period lasted for 56 days.

Table 1: Ingredient composition and chemical analysis, (g/kg DM), of guinea grass forage and concentrate diets fed to West African Dwarf does

		Diets			
Ingredients	Guinea grass	Control/AYB-0	AYB-1	AYB-2	AYB-3
Dried Cassava Peels (g/kg)		500	500	500	375
Yellow Maize (g/kg)		195	195	195	195
Soyabean meal (g/kg)		250	125	0.0	0.0
African Yam Bean (g/kg)		0	125	250	375
Urea (g/kg)		12.5	12.5	12.5	12.5
Salt (g/kg)		12.5	12.5	12.5	12.5
Dicalcium phosphate (g/kg)		25.0	25.0	25.0	25.0
Vitamin-MineralPremix[1] (g/kg)		5.0	5.0	5.0	5.0
Total		1000	1000	1000	1000
Analyzed nutrient composition (g/kg DM)					
Dry matter	260	867	868	867	867
Crude protein	94	144.5	119.0	93.5	118.8
Neutral Detergent Fibre	600	236.4	263.7	291	291.7
Acid Detergent Fibre	380	138.0	165.1	192.0	204.9
Calcium	5.60	85.4	85.1	84.9	66.2
Phosphorus	25.10	12.0	11.3	10.6	9.2
ME (Kcal/kg DM)	1938.75	2,341.0	2,039.0	1,737.0	1,469.2

[1]Masterfeeds goat premix contains (g/kg): Calcium, 180 g; Phosphorus, 60 g; Magnesium, 45 g; Sulphur, 5.6 g; Sodium, 0.93 g; Potassium, 23 mg; Iodine, 45 mg; Iron, 2370 mg; Copper, 500 mg, Manganese, 2,500 mg; Zinc, 3000 mg; Cobalt, 18 mg; Fluorine, 500 mg; Vitamin A, 400,000 IU; Vitamin D, 80,000 IU; and Vitamin E, 1,600 IU. AYB: African yam bean diets 1, 2 and 3 at inclusion levels 12.5, 25.0 and 37.5 %; ME: Metabolizable Energy. Calcium, Phosphorus and ME were calculated.

Data collection

These included feed intake, body weight, body condition score (BCS), hematological and serum (insulin, leptin, IGF-1 and urea) parameters. Both grass and concentrate diets offered, and left-over feeds were recorded daily, and were used to derive average daily feed intake (DFI, g) per animal. The body weight of does were weighed weekly in kg. These two traits were used to derive the average daily gain (ADG, g) of each animal. The feed conversion efficiency (FCE, %) was derived from ADG and DFI. The body condition of does were scored (BCS) weekly based on the 5-point scale for goats namely; 1: too thin/very thin, 2: thin, 3: satisfactory/good, 4: satisfactory but tending towards fat, and 5: too fat/obese (9).

Table 2: Total Intake (g DM/d), average daily gain (d), feed conversion (%) and body condition score in West African Dwarf does supplemented with African yam beans-based diets

	Diets					
Parameters	Control/ AYB-0	AYB-1	AYB-2	AYB-3	SED	P-values
Concentrate intake (DMC g/d)	190	252	250	211	13.10	0.2433
Forage intake (DMF g/d)	284	378	374	317	19.70	0.3253
Total DM intake (TDM g/d)	474	630	624	528	32.50	0.1383
Crude protein intake (CPI g/d)	49.7	69.5	64.2	75.9	5.580	0.1394
Neutral detergent fibre intake (NDF g /d)	277.0	382.0	356.0	365.3	23.30	0.3842
Acid detergent fibre intake (ADF g/d)	180	252	241	255	17.60	0.1452
Initial body weight (kg)	12.0	13.5	12.5	13.6	0.41	0.4413
Final body weight (kg)	12.9	15.1	14.0	14.7	0.46	0.3511
Average daily gain (ADG g)	16.7[c]	28.6[a]	26.8[a]	19.6[b]	2.07	0.0184
Feed conversion efficiency (FCE %)	3.39[b]	4.54[a]	4.29[a]	3.72[ab]	0.86	<0.0500
Body Condition Score (BCS)	2.16[d]	3.30[a]	3.10[b]	2.90[c]	0.13	0.0178
Cost of Feed Intake /day (₦/kg)	83.20[c]	130.90[ab]	149.70[a]	142.20[a]	12.94	<0.0500
Cost/daily gain (₦/kg)	5.18[b]	4.58[c]	5.59[b]	7.24[a]	0.49	<0.0500

[a, b, c] Means in the same row with different superscripts differ significantly ($P < 0.05$). AYB-1, AYB-2 and AYB-3, inclusion of 12.5, 25.0 and 37.5%, respectively, of soaked-AYB as replacement of soybean meal.

Sampling and analytical procedures

Diet samples across days were pooled, mixed and sub-sampled for analysis. These were analyzed for dry matter (ID, 934.01), crude protein (ID, 968.06) according to AOAC (10, 2000) procedures. Neutral detergent fibre (NDF) and acid detergent fibre (ADF) concentrations were analyzed according to (11). Before the experimental feeding and at the end of the 56-day trial period, 5 mL blood samples were collected from the jugular vein of each doe, separated into two labeled-bottles (red-cover: haematology; blue-cover: serum) for each doe. These were stored in the refrigerator and transported in cooled boxes to Public-Private-Partnership laboratory of the University College Hospital, Ibadan, Nigeria for laboratory-analysis. Red-covered samples containing ethylene-diamine-tetra-acetic acid (EDTA) were used. These samples were prepared with special blood lysing buffer for goat hematology (Concentrated Lysing Reagent, SEAC, Florence, Italy) in the CELL-DYN 3700 analyzer within 45 minutes (12). Samples collected into blue-covered empty vacutainer bottles were analyzed for insulin, insulin-like growth factor-1 (IGF-1) and leptin concentrations by the enzyme-linked immunosorbent assay (ELISA) technology - kits calibrated for goat, supplied by Bioassay Technology Laboratory, Shangai, China (13). The serum urea nitrogen concentration was determined from the blue-covered samples using the Cobas C-311 automated analyzer developed by Roche (Germany).

Table 3: Hematological and serum biochemical parameters of West African Dwarf does fed concentrate diets containing soaked African yam bean

		Diets					
Parameters	[1]Baseline	Control/ AYB-0	AYB-1	AYB-2	AYB-3	SED	P-value
Packed cell volume (%)	23.8	23.0	24.6	26.0	25.8	0.57	0.6283
Haemoglobin (g/dl)	7.17	7.75	7.31	8.70	8.12	0.20	0.1721
Red Blood Cell ($x10^{12}$/L)	4.29	4.16	3.43	3.89	4.25	0.13	0.3637
Mean Corpuscular Volume (fL)	5.80	5.52	8.03	7.05	6.24	0.31	0.1766
Mean Corpuscular Haemoglobin (pg)	1.73	1.86	2.37	2.35	1.97	0.09	0.0886
Mean Corpuscular Haemoglobin Concentration (g/L)	302	337	301	338	317	5.95	0.1920
White blood cells ($x10^9$/L)	14.9	13.6	13.6	13.6	14.0	0.63	0.9240
Neutrophils (%)	38.0	39.0	42.0	43.5	36.8	1.64	0.8466
Lymphocytes (%)	46.4	46.7	39.6	40.5	47.6	1.76	0.6859
Neutrophil-lymphocyte ratio (NLR)	0.93	0.98^{ab}	2.53^{a}	1.14^{ab}	0.78^{b}	0.20	0.0500
Monocytes (%)	11.6	10.0	14.4	9.00	9.60	1.37	0.8956
Eosinophils (%)	5.78	3.00	2.80	6.00	5.20	0.50	0.3020
Basophils (%)	1.53	2.00	2.00	2.00	2.00	0.09	0.1405
Urea (mg/dL)	40.9	46.5	35.8	44.2	45.4	1.73	0.3585
Insulin (ng/mL)	12.3	8.39^{b}	5.77^{c}	4.19^{c}	15.1^{a}	1.18	0.0243
Insulin-like growth factor-1 (ng/mL)	128	158^{ab}	128^{ab}	107^{b}	313^{a}	27.81	0.0500
Leptin (ng/mL)	41.3	30.7^{a}	18.3^{b}	15.3^{b}	14.3^{a}	3.33	0.0500

[1]Baseline: Jesuyon et al. 2022. AYB-1, AYB-2 and AYB-3, inclusion of 12.5, 25.0 and 37.5%, respectively, of soaked-AYB as replacement of soybean meal in concentrate. [a, b, c] Means in the same row with different superscripts differ significantly (P <0.05).

Experimental design and data analysis

Design adopted was completely randomized design. The research statistical model was: $Y_{ij} = \mu + D_i + \varepsilon_j$; where, Y_{ij}= individual observations on ith diet, μ = general mean, D_i = effect of ith diet and ε_j= random error. Data were analyzed using GLM procedures, means were separated using Duncan Multiple range test procedure $_{\alpha<0.05}$ (DMRT) of SAS v9.3 (14); while standardized regression (reg_s) procedures investigated causal relationships among serum metabolites, in relation to ADG, FCE and BCS within diets (14). The Regression equation model was of the form: $Y=bX_1+cX_2+dX_3+eX_4$: where Y represent ADG, FCE and BCS; b, c, d, and e, represent the coefficients of relationship; and X_1, X_2, X_3 and X_4 represent insulin, leptin, IGF-1 and urea concentrations in the serum.

Ethics approval. The manuscript does not contain clinical studies or patient data. The experimental procedures of this work were approved by FUOYE Research and development /TETFUND Research Committee. Procedures complied with the ARRIVE guidelines 2019 for reporting animal research and EU standards for the protection of animals used for scientific purposes.

Table 4: Standardized regression relationship of ADG (g/d), FCE (%) and BCS on serum metabolites in West African dwarf does fed with soya bean and African yam bean meal supplements.

Trait (Y)	Diet	Insulin (ng/ml)	Leptin (ng/ml)	IGF-1 (ng/ml)	Urea (mg/dl)	R^2
ADG (g/d)	AYB-0	0.58	- 0.02	- 0.31	0.10	0.12
	AYB-1	0.39	0.42	- 0.46	- 0.02	0.08
	AYB-2	- 0.22	0.15	0.00	0.05	-0.27
	AYB-3	0.48	- 0.35	- 0.14	0.45	0.01
FCE (%)	AYB-0	- 0.02	- 0.21	0.04	0.42	0.06
	AYB-1	0.19	0.48	- 0.50	0.09	0.06
	AYB-2	- 0.20	- 0.04	- 0.13	- 0.08	-0.22
	AYB-3	0.54	- 0.07	- 0.23	- 0.38	0.23
BCS	AYB-0	- 0.72	0.90	0.10	- 0.33	0.22
	AYB-1	- 0.59	0.31	- 0.18	0.37	0.04
	AYB-2	0.61	- 0.94	0.67	0.27	0.77
	AYB-3	0.17	- 0.90	0.32	- 0.29	0.16

ADG: Average daily gain, FCE: Feed conversion efficiency, BCS: Body condition score, R^2: Coefficient of multiple determination

Results

Total dry matter intake (TDM), crude protein intake (CPI), neutral detergent fibre (NDF) and acid detergent fibre (ADF) intakes (g/d, DM) among the treatment groups were statistically (P>0.05) similar (Table 2). Average daily gain (ADG) increased (P <0.05) with higher inclusion levels of soaked AYB from 12.5 % to 25.0%, animals on AYB-3 had lower ADG while control diet recorded the lowest ADG value. Similarly, FCE (P <0.05) was significantly different among treatment groups, as values increased with increased AYB content in test diets. All AYB diets had higher values than the control diet. The body condition score (BCS) of does on test diets differ statistically (P <0.05) and were higher than BCS on the control diet. The BCS of does on the test diets decreased (P <0.05) with higher levels of AYB in diet. In cost per daily gain (₦/g), all diets differ statistically (P <0.05) as cost per daily gain on diet increased with higher levels of AYB.

Increased inclusion levels of AYB in the diet did not affect the hematological

parameters considered (P >0.05, Table 3). The PCV, Hb, MCV, MCH, MCHC and basophils values for control, AYB-1, -2, -3 diets were numerically higher than the baseline values. In contrast, at 37.5% AYB inclusion, neutrophil-lymphocyte ratio (NLR) was lower than those obtained on all other diets. Serum insulin, IGF-1 and leptin concentrations were also influenced ($P < 0.05$) by increasing AYB inclusion levels in the diet, but serum urea nitrogen (SUN) concentration was similar ($P > 0.05$) across dietary treatments and not statistically affected by higher inclusion level of AYB. Table 4 reveals the standardized relationship of ADG, FCE and BCS on serum metabolites in experimental does fed with control soya bean and African yam bean supplemented diets. ADG varied in relationship with insulin, leptin, IGF-1 and urea (R^2 = -0.27 - 0.12) among diets. FCE was negatively related with all tested metabolites in AYB-2 diet (R^2 = -0.22); but negatively related with leptin, IGF-1 and urea in AYB-3 (R^2 =0.23). The BCS varied in relationship with above metabolites among diets (R^2 = 0.16 - 0.77) but its relationship with insulin, leptin, IGF-1 and urea was important and predictable only in AYB-2 diet (R^2 = 0.77).

Discussion

The lack of significant differences in TDM could be attributed to the similarity in CPI, NDF and ADF intake values among diets. With similar nutrient intake, other factors such as palatability could have influenced the numerically higher TDM on the AYB test diets than on control diet. High daily dry matter intake of animals has a positive and direct effect on average weight changes (15). The apparently decreased TDM (630 - 528 g/day), with increased level of AYB in diet, might be due to effect of increased residual anti-nutritional factors in soaked AYB fraction in diet - saponin (6.75 m/100gm), tannin (2.06 mg/100g) determined in earlier study (5); protease inhibitors - (16, 17) and reduced tolerance for higher quantity of AYB in the diet. Saponins are naturally occurring foam-producing steroidal glycosides that reduce uptake of certain nutrients, glucose and cholesterol with various biological effects due to structural differences in their sapogenic fractions (16). Tannin also decreases feed consumption, palatability, nutrient digestibility and reduce growth in animals due to its ability to form strong H-bonds with nutrients, interfering with digestion and absorption of nutrients in the gastro-intestinal tract, thus inhibiting digestive enzymes and rumen microbial activity (18, 19). Consequently, with increased tannin content in diet, these effects increase, as concentrations >7% have been found to reduce nutrient utilization (16). Similarly, protease inhibitors affect dietary protein digestion negatively by blocking the activity of trypsin and chymotrypsin in the gastrointestinal system (20). Observed TDM on soaked AYB diets 1 and 2 were superior to 557.27 - 594.44 g/day TDM on Korean native goats fed with total mixed ration and NDF-feeds (21), and the daily DMI of 29.00 – 38.44 g/day on WAD does fed with maize cob diets (22). It has been shown that as NDF digestibility increases (45-56%), dry matter digestibility increases in young female goats fed with concentrate (64%) compared to Palm Kernel Cake (56%) supplemented group (23).

Average daily gain (ADG, g/day) was better on AYB diets than on control diet~~s~~. This suggested better profile of AYB diet at 12.5% inclusion level for daily gain, body development and welfare in gestating WAD does. The increased ADG with higher inclusion level of AYB could be attributed to higher voluntary TDM, and maximal IGF-1 metabolism revealed through regression analysis on treatment group. The ADG obtained on study were lower than 99-115 g/day on grower Alpine and Nubian goats (24) because experimental WAD does were gestating and were generally of lower body weight than their Alpine and Nubian counterparts. Furthermore, WAD goat is a slow growing breed in its natural unselected state with pre-weaning growth rate of 35.78 g/day (25) and post weaning growth rate of 21.43 - 29.26 g/day in tropical breeds (26, 27, 28). The ADG obtained presently were comparable to above reports.

IGF-1 mediates postnatal growth through regulation of cell proliferation, differentiation and reproduction (29). The higher metabolism and utilization level of leptin on AYB diets (observed on ADG: 0.42, 0.15, vs -0.35, Table 4; leptin concentration: 18.3, 15.3 vs 13.3, Table 3; and on ME Kcal/kg: 2,039, 1,737 vs 1,469, Table 1) revealed does with decreasing body reserves to control diet. Body condition score (BCS) assesses amount of fat accumulation and muscle covering the bones, and it is critical for examination of nutritional status of animals. Decreasing leptin metabolism could lower energy homeostasis, nutrient partitioning between tissues and energy metabolism (30).

The high FCE on AYB than on control diet by goats meant better nutrients efficiency on AYB. The increased BCS (4.5 – 3.7) of does on test diets were considered ‘good and satisfactory’ as AYB content increased in diets. The control diet revealed a BCS value which classified does as ‘thin’. BCS trend on diets revealed higher BCS on AYB-1 diet, with highest energy storage among test diets. Body condition score describes the relative fat reserve or energy balance and assesses the amount of fat and muscle covering the bones of a domestic animal. The positive BCS/urea relationship (0.37 – 0.27; R^2 = 0.04 - 0.77) on AYB-1 and -2 diets signified excess urea in the serum, while the negative BCS/leptin relationship (-0.29, R^2= 0.16) revealed a decreased quantity of urea in the serum, and relatively higher protein in the presence of low energy on AYB-3 diet. The leaner does (BCS =2.16) on the control soyabean diet was probably due to reduced fat storage and energy utilization in body tissues, leading to low ADG. Under-nutrition has been associated with BCS $\leq$ 2.0, low levels of serum glucose, insulin, IGF-1 and urea, while over-nutrition was predicated upon high serum insulin, glucagon and urea levels in goat (31). Thus, AYB-1 and -2 diets could be offered to gestating does for daily nutrition and steaming-up of body reserve for parturition. The unit cost of production per gram gain separated the diets economically, thus making AYB-1 diet most economically efficient at ₦4.60/gram daily gain.

Most hematological values obtained fell within normal ranges reported by Cornell (32). The simultaneously high PCV and Hb trends presented by test diets signified their adequacy for improved blood profile compared to the control. NLR is a basic inflammatory ratio determined from blood count. It has been reported as a predictive marker in reflecting a systemic inflammatory load as neutrophils and lymphocytes are thought to be significant in tumor immunology and inflammation (33). As a marker of inflammation, NLR has been found to be elevated in various diseases and complications that affect gestation outcome. Gestational complications, such as preeclampsia and gestational diabetes, ectopic pregnancies, pregnancy-associated intrahepatic cholestasis and other illnesses have been associated with an increased NLR, but little is known on their direct causal relationship. It thus could be an accessible predictor of common maternal associated morbidities and complications of pregnancy (34, 35). Mohammed et al. (36) submitted that NLR was always significantly higher in non-pregnant cows compared to pregnant cows. The NLR in the peripheral blood reflects the balance between systemic inflammation and immunity and it is an important prognostic biomarker for diseases. An NLR value above the range 0.78 - 3.53 may predispose animals to low heath status due to tumor and inflammatory development processes (37). Pregnant normal goats were found to have lower average NLR (0.19) compared to lactating goats (0.47) due to secretion of progesterone which serve to maintains pregnancy and stimulate the CNS to produce anti-stress that tend to reduce NLR. Low NLR in pregnant does is further influenced by increased lymphocyte value until the lymphoid organs are fully formed and the neonate is born (38). The strong statistical differences of NLR on AYB diets suggested its importance for evaluating health status of the gestating does and could effectively assist in treatment decisions. The NLR values of AYB diet groups decreased (2.53, 1.14, 0.78) as AYB content increased from 12.5 to 37.5 % indicating that values were within normal range and probably indicated improving gestational health on diet. These values were higher than 0.37-1.03 (calculated) from the work of (39) on vaccinated and unvaccinated mixed-sex WAD goats under same tropical environment. These decreasing NLR values thus foreclose the possibility of tumor and inflammatory development processes or physiological abnormalities in foetal development of gestating does since these conditions develop at values above the normal NLR range (37).

Dietary protein is degraded to ruminal ammonia-nitrogen in ruminants, while urea and urinary nitrogen arise largely from excess ammonia (40). Urea formation is quantitatively the most important end-product of nitrogen metabolism in goats (41). The SUN concentration of control and test diets revealed similarity in urea metabolism and nitrogen utilization for metabolic processes. The lack of real differences in serum urea nitrogen (SUN, 36-45 mg/dL) concentration among AYB diets could mean that dietary protein content adequately met nutritional demand of does, and possibly had positive effects on rumen ammonia-nitrogen concentration. Present SUN findings were higher than 7.99-11.23 mg/dL on WAD goats fed with urea-treated sugarcane waste and kolanut husk supplement (42) in the same environment, 3.55-4.16 mg/dL on WAD goat fed with fed groundnut haulms and cowpea husk supplemented with brewers' dried grain (43), blood urea nitrogen (BUN) values of 20.90-25.66 mg/dL reported on 0-45% DM Licury cake fed to Boer goats by (44); and 6.29-7.31 mg/dL obtained on 12-14.8% CP diet fed to growing goat kids (40).

Insulin modulates peripheral satiety signals and targets the central nervous system to inhibit food intake especially energy and protein. Both IGF-1 and insulin display both growth-related and anabolic actions (45). There was a similar trend between groups of does on insulin, IGF-1, and leptin. Insulin level decreased from control diet, to AYB-1 and AYB-2 diets hereby improving TDM on AYB-1 and AYB-2 while AYB-3 diet which displayed maximum insulin level reflected decreased TDM ($P > 0.05$). Present insulin levels on control, AYB-1 and AYB-2 are within the range of 1.85-7.44 ng/ml reported (46) in goats fed with 0-20% dietary crude glycerin. Insulin hormone regulates carbohydrate metabolism while abnormally high insulin levels could be associated with diabetes mellitus (47).

The IGF-1 stimulates anabolic early cell growth, differentiation and body development. The higher IGF-1 concentration of AYB-3 diet offered better prospect for development of the foetus in pregnant does and confirmed reports that its concentration peaks around puberty, but decreases with aging (48), and plays anabolic effects in adults. All diets posted IGF-1 values above the critical lower limit of 80ng/ml, and therefore foreclosed any detrimental effect due to metabolic abnormality and diabetes or hypoglycaemia (48) in experimental animals. AYB-1 and AYB-2 diets displayed higher ability to produce leptin and store fat, than does on AYB-3. The AYB-1 and -2 diets could support steaming-up in gestating does at late trimester stage.

Regression analyses unearthed that WAD does on control/AYB-0 and AYB-1 diets utilized more insulin (-0.72, -0.59) in the presence of leptin and urea for body conditioning, while AYB-2 and -3 utilized more leptin (-0.94, -0.90) in the presence of insulin and IGF for same. AYB-1 does utilized IGF-1 (-0.18 to -0.46) for daily gains in the presence of leptin and urea, while the control does utilized IGF-1 (-0.31) in the presence of insulin for daily gains. Urea (-0.38) was basically utilized in AYB-3 does in the presence of insulin for FCE, while same was utilized (-0.33) in the presence of leptin for body conditioning in the control does. The does on AYB-3 diet demonstrated highest propensity for utilization of leptin, urea and IGF-1; AYB-2 does utilized more of leptin, insulin and IGF-1; while AYB-1 does utilized more of insulin, IGF-1 and urea for daily gains and body conditioning. It thus seemed that does on different dietary treatments demonstrated different modes of metabolism of diets.

Conclusion and Applications

1. Soaked African Yam bean at 12.5% in concentrate diet produced highest average daily gain, feed conversion efficiency and body condition score.
2. Economically, AYB-1 diet was the cheapest at N4.60/gram of daily gain.
3. It could be adopted to feed West African Dwarf does due to absence of noticeable adverse effects on hematology and serum metabolites.

Declaration of funding

This research was funded by TETFund Abuja, Nigeria; with grant number: TETFUND/DESS/UNI/OYE-EKITI/2017/ RP/Vol.1/3.

Data Availability Statement

Data underlining this study are available on request from the Corresponding Author.

Conflicts of interest

The authors declare no conflicts of interest.

Acknowledgements: We express sincere gratitude to Mrs Justina Kehinde Odumboni for the technical services rendered in the laboratory during the research work.

References

1. Agossou, J., Dougba, T. and Koluman-Darcan, N. (2017). Recent developments in goat farming and perspectives for a sustainable production in Western Africa. International Journal of Environment, Agriculture and Biotechnology, 2 (4): 2047-2051. DOI:2047-2051.10.22161/ijeab/2.4.62.
2. Udo, M. D., Ekpo, U. and Ahamefule, F. O. (2015). Effect of processing on the nutrient composition of rubber seed meal. Journal of the Saudi Society of Agricultural Sciences. 17 (3): 297–301.
3. Razzaq, M., Islam, M., Ann Rischkowsky, B., Louhaichi, M. and

Ibrahim M. N. M. (2016). Small ruminants supplemental feeding regimes in arid agro-pastoral systems in Pakistan. Proceedings. First International conference on tropical animal science and production (TASP). July 26-29, 2016. Ambassador Hotel, Bangkok, Thailand. Volume II, pages 185-188.

4. Baiyeri, S. O., Uguru, M. I., Ogbonna, P. E., Samuel-Baiyeri, C. C. A., Okechukwu, R., Kumaga, F. K. and Amoatey, C. (2018). Evaluation of the nutritional composition of the seeds of some selected African yam bean (Sphenostylis stenocarpa Hochst ex. A. Rich. (Harms)) accessions. Agro-Science 17: 37-44. https://doi.org/10.4314/as.v17i2.5.
5. Sanni, T. A., Jesuyon, O. M. A., Adejoro, F. A., Baiyeri, S. O., Boluwaji, O. V., Akanmu, A. M., and Hassen, A. (2020). Influence of supplementing guinea grass with differently processed African yam bean on gas production and in vitro digestibility. Brazilian Journal of Animal Sciences. 49:e20200029, https://doi.org/10.37496/ rbz4920200029.
6. Ihemeje, A., Nwanekezi, E.C., Odimegwu, E. N. and Ekwe, C. C. (2018). Effect of Processing methods of toasting, soaking, boiling, sprouting on dietary fibre and antinutrient contents of African yam bean and red kidney bean flour. European Journal of Food Science and Technology, 6 (1): 40-48.
7. Ewuola, E. O., Sokunbi, O. A., Sanni, K. M., Oyedemi, O. M. and Lawal, T. T. (2015). Haematological and serum biochemical responses of rabbit does to crude Moringa oleifera leaf extract at gestation and lactation. Tropical Animal Health and Production. 47: 637-642.
8. Aliyu, I. D., Maigandi, S. A., Muhammad, I. R. and Garba, Y. (2012). Haematological indices and blood urea nitrogen of Yankasa ram lambs fed urea, poultry droppings and/or urea treated Pennisetum pedicellatum (Kyasuwa grass). Nigerian Journal of Basic and Applied Science, 20 (1): 39-43.
9. Ockert, K. (2015). Body condition scoring in goats. Michigan State University, MSU Extension. htpps://www.canr.msu.edu/news/
10. AOAC, Association of Official Analytical Chemists. (2000) Official methods of analysis. 17th ed. Association of Official Analytical Chemists, Arlington, VA, USA.
11. Van Soest, P. J., Robertson, J. B., and Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science, 74: 3583-3597, https://doi.org/10.3168/jds. S0022-0302(91)78551-2.
12. Al-Bulushi, S., Shawaf, T., and d Al-Hasani, A. (2017). Some hematological and biochemical parameters of different goat breeds in Sultanate of Oman "A preliminary study". Veterinary World, 10 (4): 461-466, DOI: 10.14202/vetworld. 2017.461-466.
13. Alhaji, M., and Farhana, A. (2021). Immunosorbent Assay. In: StatPearls (Internet). Treasure Island (FL): StatPearls Publishing 2021 January.
14. SAS (2011). SAS/STAT Statistical Analytical Systems software, Version 9.3, SAS Institute Incorporated, Carry, NC., USA.

15. Jiwuba, P. C., Ahamefule, F. O., Okechukwu, O. S. and Ikwunze, K. (2016). Feed intake, body weight changes and haematology of West African Dwarf goats fed dietary levels of Moringa Oleifera leaf meal. Agricultura, 13 (1-2): 71-77. DOI: 10.1515/agricultura-2017-0009.
16. Yacout, H. (2016). Anti-nutritional factors and its role in animal nutrition. MOJ Food Processing & Technology. 4 (1): 237 – 239.
17. Ajibola, G. O. and Olapade, A. A. (2016). Physical, proximate and anti-nutritional composition of African yam bean (Sphenostylis stenocarpa) seed varieties. Journal of Food Research, 5 (2): 67-72. DOI:10.5539/jfr.v5n2p67.
18. Frutos, P., Hervás, G., Giráldez, F. J. and Mantecón, A. R. (2004). Tannins and ruminant nutrition – Review. Spanish Journal of Agricultural Research, 2 (2): 191-202.
19. Onuoha, C. H., Harry, B. J. and Eze, S. O. (2017). Evaluation of nutrients and anti-nutritional factors of different species of African yam bean (Sphenostylis stenocarpa). European Journal of Basic and Applied Sciences. 4 (1): 1-8.
20. Kårlund, A., Paukkonen, I., Gómez-Gallego, C. and Kolehmainen, M. (2021). Intestinal Exposure to Food-Derived Protease Inhibitors: Digestion Physiology- and Gut Health-Related Effects. Healthcare. 9: 1002. https://doi.org/10.3390/ healthcare9081002.
21. Jang, S. Y., Kim, E. K., Park, J. H., Oh, M. R., Tang, Y. J., Ding, Y. L., Seong, H. J., Kim, W. H., Yun, Y. S. and Moon, S. H. (2017). Effects of physically effective neutral detergent fiber content on dry matter intake, digestibility, and chewing activity in Korean native goats (Capra hircuscoreanae) fed with total mixed ration. Asian-Australas Journal of Animal Science, 30 (10): 1405-1409. https://doi.org/10. 5713/ajas. 16.0868.
22. Ibhaze, G. A., and Fajemisin, A. N. (2015). Feed intake and nitrogen metabolism by West African Dwarf does fed naturally fermented maize cob-based diets. World Journal of Animal Science and Research, 3 (2): 1 – 8.
23. Rahman, M. M., Abdullah, R. B., Wan Khadijah, W. E., Nakagawa, T. and Akashi, R. (2013). Feed intake, digestibility and growth performance of goats offered Napier grass supplemented with molasses protected palm kernel cake and soya waste. Journal of Animal and Veterinary Advances, 8 (3): 527 – 534.
24. Lu, C. D. and Potchoiba, M. J. (1990). Feed intake and weight gain of growing goats fed diets of various energy and protein levels. Journal of Animal Science 68 (6): 1751-1759. DOI: 10.2527/1990.6861751x.
25. Ayizanga, R. A., Tecku, P. K. M. and Obese, F. Y. (2018). Growth and reproductive performance of West African dwarf goats at the Animal Research Institute, Katamanso station. Ghana Journal of Agricultural Science, 52: 43-53.
26. Birteeb, P. T., Danquah, B. A. and Salifu, A. S. (2015). Growth performance of West African dwarf goats reared in the transitional zone of Ghana. Asian Journal of Animal Sciences, 9: 370-378. DOI: 10.3923/ajas.2015.370.378.
27. Deribe, B. and Taye, M. (2013). Evaluation of growth performance of Abergele goats under traditional

management systems in Sekota district, Ethiopia. Pakistan Journal of Biological Sciences, 16: 692-696.

28. Asaolu, V., Binuomote, R., Akinlade, J., Aderinola, O. and Oyelami, O. (2012). Intake and growth performance of West African dwarf goats fed Moringa olifera, Gliciridia sepium and Leucaena leucocephala dried leaves as supplements to cassava peels. Journal of Biology, Agriculture and Healthcare, 2 (10): 76 - 88.
29. Naicy, T., Venkatachalapathy, R. T., Aravindakshan, T. V. and Kurian, E. (2017) Association of a CacI polymorphism in the IGF-1 gene with growth traits in Indian goats. Journal of Genetic Engineering and Biotechnology 15: 7-11.
30. Avondo, M., Di Trana, A., Valenti, B., Criscione, A., Bordonaro, S., De Angelis, A., Giorgio, D. and Di Gregorio, P. (2019). Leptin gene polymorphism in goats fed with diet at different energy level: Effect on feed intake, milk traits, milk fatty acids composition, and metabolic state. Animals, 9: 424. DOI: 10.3390/ani9070424.
31. Caldeira, R. M., Belo, A. T., Santos, C. C., Vazques, M. I. and Portugal, A. U. (2005). The effect of body condition score on blood metabolites and hormonal profiles in ewes. Small Ruminant Research, 68 (3): 233-241. DOI: 10.1016/j.small rumres.2005.08.027.
32. Cornell (2020). Hematology Advia-2120: Caprine reference values. Routine hemogram reference intervals. Animal Health Diagnostic Centre. Cornell University College of veterinary medicine. https://www.vet.cornell.edu/animal-health-diagnostic-center/laboratories/clinical-pathology/reference-intervals/ chemistry.
33. Guragac, A. and Demierer, Z. (2016). The neutrophil-to-lymphocyte ratio in clinical practice. Canadian Urological Association, 10 (3-4): 141-142. DOI:10. 5489/cuaj.3587.
34. Christoforaki, V., Zafeiriou, Z., Daskalakis, G., Katasos, T. and Siristatidis, C. (2020). First trimester neutrophil to lymphocyte ratio (NLR) and pregnancy outcome. Journal of Obstetrics and Gynaecology, 40 (1): 59-64. https://doi.org /10.1080/01443615.2019.1606171.
35. Biswas, M., Belle, V. S., Maripini, N. and Prabhu, K. (2021). Neutrophil-lymphocyte ratio in pregnancy-associated maternal complications: A review. Asian Pacific Journal of Reproduction, 10 (6): 252-261. DOI:10.4103/2305-0500.331 262.
36. Mohammed, S., Aarti, K., Kalyan, A., Alhussien, M. N., Manjari, P., Yadav, M. L., Sheikh, A. A., De, S., Mohanty, A. K. and Dang, A. K. (2017). Fluctuation in the number, type and activity of blood neutrophils in cows exhibiting successful and unsuccessful completion of gestation cycle. Biological Rhythm Research, DOI: 10.1080/09291016.2017.1311984.
37. Forget, P., Khalifa, C., Defour, J., Latinne, D., Van Pel, M. and De Kock, M. (2017). What is the normal value of the neutrophil‑to-lymphocyte ratio? BMC Research Notes, 10 (12): DOI: 10.1186/s13104-016-2335-5.
38. Nareswari, A., Winarsih, S., Hana, A., Anggraeni, D., Widiyono, I., and Sarmin (2021). Neutrophil and Lymphocyte (N/L) Ratio of Gestation and Lactation Sapera Goats at Kambing Farm, Sukoharjo, Ngaglik,

Sleman. Web of Conferences 33, 06015.

39. Aikhuomobhogbe, P. U. and Orheruata, A. M. (2006). Haematological and blood biochemical indices of West African dwarf goats vaccinated against Pestes des petit ruminants. African Journal of Biotechnology, 5 (9): 743-748.
40. Zhu, W., Xu, W., Wei, C., Zhang, Z., Jiang, C. and Chen, X. (2020). Effects of decreasing dietary crude protein level on growth performance, nutrient digestion, serum metabolites, and nitrogen utilization in growing goat kids (Capra. hircus). Animals, 10 (151). DOI:10.3390/ani10010151.
41. Harmeyer, J. and Martens, H. (1980). Aspects of urea metabolism in ruminants with reference to the goat. Journal of Dairy Science, 63 (10): 1707 – 1728.
42. Okoruwa, M. I. and Amuda, A. J. (2019). Blood profile and nitrogen losses in goats fed urea-treated sugarcane waste and kolanut husk as supplements to poor quality forage. Nigerian Journal Animal Science 21 (1):126-134.
43. Babale, D. M., Millam, J. J. and Gworgwor, Z. (2019). Blood profile and carcass characteristics of West African Dwarf goats fed groundnut haulms and cowpea husk supplemented with brewers' dried grain. Biomed Journal of Scientific and Technical Research 16:1-2019.BJSTR. MS.ID.002789.
44. Borja, M. S., Oliveira, R. L., Bagaldo, A. R., Pereira, M. L., Portela, A., Barbosa, R. W., Ribeiro, A. M. C., Vaz Di, M. and Carvalho, G. G. P. (2014). Microbial protein and blood parameters of goats fed with licury cake. Seminar: Ciências Agrárias, Londrina, 35 (1): 519-530. DOI: 10.5433/1679-0359.2014v35n1p519.
45. Magistrelli, D., Valli, A. and Rosi, F. (2005). Insulin and IGF-1 in goat milk: Influence of the diet. Italian Journal of Animal Science, 4: sup2, 386-388. https://doi.org/10.4081/ijas.2005.2s.386.
46. Chanjula, P., Pakdeechanuan, P. and Wattanasit, S. (2014). Effects of dietary crude glycerin supplementation on nutritive digestibility, ruminal fermentation, blood metabolites and nitrogen balance of goats. Asian-Australas Journal of Animal Science, 27 (3): 365-374. DOI:10.5713/ajas.2013.13494.
47. Shen, Y., Prinyawiwatkul, W. and Xu, Z. (2019). Insulin: a review of analytical methods. DOI: 10.1039/c9an00112c.
48. Li, J., Wang, C., Chen, J., Feng, Z. and Ma, H. (2004). Expression of liver insulin-like growth factor-1 gene and its serum level in rats with diabetes. World Journal of Gastroenterology, 10 (2): 255–259. DOI: 10.3748/wjg. v10. i2.255.