



Soursop Leaf and Pumpkin Pulp Diets Concerning Performance, Nutrient Utilization and Blood Profile of Goats

M. I. Okoruwa ^{a*}, E. O. Aidelomon ^b and I. Ikhimioya ^a

^a Department of Animal Science, Ambrose Alli University, P.M.B. 14, Ekpoma, Edo State, Nigeria.

^b Department of Animal Husbandry Sciences, University of South Bohemia, Ceske Budejovice, Czech Republic.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Assessed growth performance, nutrient utilization and blood constituents of goats fed diets containing fluted pumpkin pulp and different proportions of soursop leaf powder. We used twenty-four West African dwarf female goats of about 7 to 8 months old and 7.00 ± 0.15 kg. They were randomly allotted to four dietary treatments with three replicates of two goats. The compared diets contained; 6% dried fluted pumpkin pulp without soursop leaf powder (control, PPM₁), 6% dried fluted pumpkin pulp with 2% soursop leaf powder (SLP₂), 6% dried fluted pumpkin pulp with 2.5% soursop leaf powder (SLO₃) and 6% dried fluted pumpkin pulp with 3% soursop leaf powder (SLW₄). The results showed that diet PPM₁ was significantly ($P < 0.05$) higher in feed conversion ratio, digestibility of ether extract, gross energy intake, total nitrogen and energy output, creatinine, urea, serum enzymes, total cholesterol and low-density lipoprotein. SLO₃ revealed significantly ($P < 0.05$) better in final, total & daily body weight gain, dry matter, crude protein and crude fiber digestibility, nitrogen retention, digestible and metabolizable energy, packed cell volume, haemoglobin, red and white blood cells, serum total protein, albumin, glucose, and high-density

*Corresponding author: E-mail: odionokos@yahoo.com, okosmich@gmail.com;

lipoprotein. Feed and nitrogen intake as well as triglycerides indicated significant ($P<0.05$) higher values in SLW₄. Using 6% dried fluted pumpkin pulp with 2.5 or 3% soursop leaf powder in diets enhanced nutrient utilization for better performance and health status of goats.

Keywords: Blood; goats; performance; pumpkin-pulp; soursop leaf.

1. INTRODUCTION

Goats have been identified to play a crucial role in nutritional security for supporting mankind in increasing animal protein availability for human sustainability. Their biological values and domestic demand as the choicest milk and meat for consumers have been ranked higher than sheep and cattle [1]. Therefore, the need to increase goat production is a consequence of its capacity to generate income and improve the living standards of rural subsistence-farming communities [2]. The degree to which goats survive to marketable age is one of the key indicators for their efficient productivity. However, nutritional constraints remain a concern, because they limit; animal digestion and growth rate and weaken animals against parasitic and infectious diseases that bring about high mortality. Tropics experience seasonal dry periods that decrease the quantity and quality of available forages for ruminant livestock. Goats raised in this tropical region are predominantly faced with nutritional stress, due to a decrease in the quality of grazing pastures [3]. Conventional feeds that supplement poor forages are expensive as a result of high grain prices and less diversified animal feeds. One possible way to mitigate this incessant challenge ravaging ruminant livestock production is to explore alternate feed resources that are not consumed by man but can be used as feeds for livestock.

Fluted pumpkin (*Telfairia occidentalis*) belongs to the genus *Cucurbita* and the family of *Cucurbitaceae*. The pulp is a by-product of the pumpkin seed which is relatively abundant, most especially in areas where they are produced. The fluted pumpkin pulp is beneficial and economical as a feed resource for animals that provide considerable benefits to goat farmers [4]. However, the inclusion of natural additives to poor quality feeds is currently used by most rural farmers to improve better sustainability of goat farming in Nigeria. They have valuable potentials that are profitable in the aspect of boosting the immune system, biodegradable and biocompatible [5].

Soursop (*Annona muricata*) belongs to the family of *Annonaceae*. It is a herb plant that has good

natural multiple nutritive values with secondary metabolites that justify its application as phyto-additive [6]. It also possesses great potential as anti-microbial and anti-inflammations with bioactive components that modulate rumen to regulate micro-flora for better digestion and inhibition of lipids [7]. However, there is relatively little information regarding the effect of soursop leaf powder supplementation on feed utilization and performance of goats. Thus, the study was designed to determine the effect of soursop leaf powder on growth, nutrient retention and blood constituents of goats-fed diets containing dried fluted pumpkin pulp.

2. MATERIALS AND METHODS

2.1 Location of Study

The study was conducted at the Small Ruminant Unit of the Livestock Teaching and Research Farm of Ambrose Alli University, Ekpoma. The area lies on longitude 6.09°E and latitude 6.42°N within the humid climatic zone of Nigeria. The average annual rainfall and temperature of the region are about 1556mm and 31°C respectively, while the relative humidity of the lactation is about 78% on average.

2.2 Experimental Diets

Green matured soursop leaf was obtained from their naturally growing plant within the Teaching and Research Farm environment. They were air-dried under a well-ventilated shed until the leaves were crispy to the touch, while retaining their greenish coloration. Thereafter, they were milled to pass through a 0.15mm sieve to obtain soursop leaf powder and stored in airtight bags at room temperature. Matured harvested fluted pumpkin fruits were cut open and seeds and pulp were separately removed before pulp was sun-dried and crushed into a fluted pumpkin pulp meal. However, soursop leaf powder and fluted pumpkin pulp meal with other feed ingredients were used to prepare the supplementary diets as shown in Table, 1. Succulent elephant grass obtained within the farm was chopped to small lengths of about 4 to 5cm and served as a basal diet. The basal and supplementary diets were

offered in a ratio of 60: 40 to the animals respectively. The prepared supplementary diets were composed as follows; PPM₁(6% dried fluted pumpkin pulp without soursop leaf powder and served as the control group), SLP₂(6% dried fluted pumpkin pulp with 2% soursop leaf powder), SLO₃ (6% dried fluted pumpkin pulp with 2.5% soursop leaf powder) and SLW₄(6% dried fluted pumpkin pulp with 3% soursop leaf powder) were the inclusion levels in different treatment diets.

2.3 Animals and Management

Twenty-four West African dwarf female goats of about 7 to 8 months old and 7.00 ± 0.15 kg were used. On their arrival, they were confined for a preliminary period of fourteen days to allow them to adapt to the environment and dewormed against internal and external parasites. After the quarantine period, goats were randomly allocated to the four treatment diets giving six animals per treatment. Thus, each treatment was replicated three times with two goats per replicate in a completely randomized design. They were housed in individual semi-open partitioned pens, equipped with feeders, water troughs and saw dust that were changed twice weekly. Diets that were offered to each goat twice daily (8:00-am and 4:00-pm) were calculated based on 5% dry matter of their body weight. The ratio of the basal diet of elephant grass to each of the supplementary diets was used to determine the proportion of each diet that was offered to the goat. The amount of diet supplied to each animal was adjusted daily based on the voluntary intake of the animal with an estimated leftover of 15%. They also had free access to drinking water and the duration of the experiment was 90 days exclusive of the 14 days of acclimation.

2.4 Experimental Procedures and Measurements

2.4.1 Growth performance

The average daily feed intake was determined by the difference between the amount of feed offered and leftovers. The initial body weight of goats was weighed and recorded at the onset of the experiment. Subsequently, weekly weights using the measuretech® hanging scale. Weekly weights were taken before morning feeding to estimate change in body weight. Total body weight was obtained by the difference between the final and initial body weight. The average

daily weight gain was calculated from the weekly weight of individual goats over the entire period of the trial. However, daily feed intake with body weight gain was used to calculate the feed conversion ratio.

2.4.2 Nutrient digestibility, nitrogen retention, and energy metabolism

The growth study was preceded by a 14-day metabolic trial to determine the apparent nutrient digestion of the diets. Three goats with similar body weights were randomly chosen from each treatment group and housed separately in individual metabolic cages designed for feeding, and watering with separate collections of feces and urine. Feed offered, leftover, voided feces and urine were collected and recorded daily for 14 days, which includes 7 days of total collection after a 7-day adaption period. Thereafter, a sub-sample of about 10% of the total fecal output was bulked, properly mixed and pooled for each animal before being stored in a plastic container in the freezer (-20%) for later analysis. Urine from each animal was also collected in a plastic container containing 100 ml of 3.6 mol/L H₂SO₄. The collected urine was strained through a layer of grass wool to remove detached hair fragments and other solid contaminants. The volume was measured and then diluted to 5 L using tap water and a sample of 20 ml was collected and pooled for each animal to prevent loss of nitrogen due to volatilization before being stored at -20°C for total nitrogen determination. Nutrient Digestibility (ND) of the diet was calculated for dry matter, crude protein, crude fiber, ether extract, ash, and nitrogen-free extract from each treatment diet using the equation proposed by McDonald et al. [8].

$$\text{ND \%} = \frac{\text{Total amount of nutrients in feed} - \text{Total amount of nutrients in feces}}{\text{Total amount of nutrients in feeds}} \times 100$$

Nitrogen and energy retention were calculated by standard procedures outlined for direct estimation of animal digestion [8]. Nitrogen balance was determined as the differences between nitrogen intake and nitrogen excreted from feces and urine. The nitrogen retention percentage was estimated from the nitrogen balance expressed as a percentage of nitrogen intake.

The gross energy (GE) of the diets, feces and urine were measured using an adiabatic bomb calorimeter (C200, IKA Works Inc. Staufen,

Germany). The GE intake was calculated as the GE of the feed in dry matter multiplied by the dry matter (DM) of the feed intake, while fecal energy (FE) output was determined as the GE of the feces in DM multiplied by the quantity of the feces in DM. Urine energy (UE) output was determined as the GE of the urine in DM multiplied by the quantity of the urine in DM. Digestible energy (DE) intake was calculated as the difference between GE intake and FE output divided by GE intake expressed as a percentage.

Metabolizable energy (ME) was determined by 82% of DE intakes as reported by National Research Council [9]. The metabolizability (qm) was calculated as ME/GE for each treatment diet [10]

2.4.3 Blood collection and analysis

After the metabolic trial, 10ml of blood sample was collected from each goat the following day through jugular venipuncture, using disposable heparinized syringes into sterilized evacuated collection tubes before morning feeding. Sub-samples of 5ml were drawn into labeled sterilized universal bottles containing ethylene diamine tetra-acetic acid (EDTA) as an anti-coagulant to determine hematological traits. Packed cell volume (PCV) was determined with Wintrobe's micro-hematocrit while red blood cell (RBC) and white blood cell (WBC) were determined with improved Neubauer hemocytometer while differential counts of the WBC such as lymphocytes, eosinophils, neutrophils, monocytes, and basophils were determined by making differential smear using wright stain and percentage. The hemoglobin concentration (Hb) was determined using the cyanomethaemoglobin method. The erythrocytic indices, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean

corpuscular hemoglobin concentration (MCHC) were computed as described by Jain [11].

The other 5ml sub-samples were transferred into anti-coagulant-free plastic tubes and gently inverted a couple of times, kept in an ice box to allow coagulation at room temperature. They were later centrifuged for 15 minutes at 890xg at 4°C and maintained for 8 hours in the refrigerator at 4°C before biochemical analysis and separation of supernatant serum. The plasma was also transferred to a storage tube labeled with the date and animal identification and stored at -20°C until analysis.

The biochemical constituents of the serum samples estimated included total protein and albumin that were analyzed by using commercial kits (Biuret method, Chemelex, SA Barcelona), but globulin was calculated by subtracting albumin from total protein serum. Urea in serum sample was estimated using the diacetylmonoxime method, creatinine was determined by the Jaffe reaction method and blood glucose was obtained by enzymatic colorimetric test. All analyses followed the procedures described by Chen et al. [12] Serum glutamate oxaloacetate transaminase (SGOT), Serum glutamate pyruvate transaminase (SGPT), Alanine aminotransferase (ALT), Aspartate aminotransferase (AST), total cholesterol, high-density lipoprotein (HDL) and triglyceride concentrations were measured using procedures given by Green Cross MS in Korea as described by Kim et al. [13]. The low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL) were calculated using equations below as presented by Fredlund et al. [14].

$$\text{LDL} = \text{Total cholesterol} - (\text{HDL} + \text{VLDL})$$

$$\text{VLDL} = \text{Triglycerides} / 5.$$

Table 1. Gross composition (%DM) of the supplementary diets

Ingredients	Treatment Diets			
	PPM ₁	SLP ₂	SLO ₃	SLW ₄
Wheat offal	47.00	44.00	41.00	38.00
Dried brewers grain	33.00	32.50	32.00	31.50
Rice bran	5.00	8.00	11.00	14.00
Dried fluted pumpkin pulp	6.00	6.00	6.00	6.00
Broken bean /husk	5.50	4.00	4.00	4.00
Soursop leaf powder	-	2.00	2.50	3.00
Bone meal	2.00	2.00	2.00	2.00
Vitamin premix	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00

2.5 Chemical Analysis

Dry matter was determined by drying the fluted pumpkin pulp, soursop leaf, feed, orts, and fecal samples in an air-forced oven at 135°C for 2 h [15]; crude ash content was measured by placing the samples into a muffle furnace at 550 °C for 24h. Nitrogen was determined using the Kjeldahl method, using selenium as a catalyst [15], and crude protein was calculated using the formula 6.25 x N. The ether extract was measured by calculating the weight loss of the dry matter on extraction with diethyl ether using the soxhlet extraction apparatus for 8 h [15]. Crude fiber was determined using Tecator Line (FT122 Fibertee TM). The concentration of phytate was determined according to Fredlund *et al.* (1997). Total tannin was determined colorimetrically as described in [15] while total saponin and oxalates were also quantified using colorimetry [15].

2.6 Statistical Analysis

Data generated from growth, digestibility, nitrogen and energy retention as well as blood constituents were subjected to analysis of variance using the general linear model (GLM) procedure [16] to determine the effects of the treatment diets on parameters. Where significant difference occurs, means were separated by Duncan's multiple range tests [17].

3.RESULTS

In the feed ingredients examined (Table 2), soursop leaf powder (SL) recorded a higher content of crude protein, ether extract and nitrogen-free extract but relatively lower ash

values as compared with dried fluted pumpkin pulp (FPP) and elephant grass(EG). However, FPP recorded higher values in dry matter and ash while EG had the highest crude fiber content than other feed ingredients. All treatment diets were variable according to types and varying levels of feed ingredients used. Treatment diets SLP₂, SLO₃ and SLW₄ had higher and similar values for dry matter, crude protein, ether extract and nitrogen-free extract than PPM₁. On the other hand, crude fiber and ash were relatively higher in diet PPM₁. Above all, oxalate and phytate showed no remarkable difference among feed ingredients and treatment diets. However, diet PPM₁ had the lowest content of tannin and saponin.

There were noticeable significant ($p < 0.05$) differences in mean values for feed intake of goats on the treatment diets (Table 3). Diet SLW₄ appeared higher in value, followed by SLO₃ and SLP₂ compared to PPM₁. However, an initial body weight did not show any significant differences ($P > 0.05$) among diets. The addition of 2.5 and 3% soursop leaf powder in diets indicated higher significant values ($P < 0.05$) in the final body weight of goats. The inclusion of test ingredients in diets consequently improved the total body weight gain of goats significantly ($P < 0.05$), with the highest value recorded in SLO₃ and the lowest in PPM₁. Daily weight gain was significantly ($P < 0.05$) increased with a progressive increase in levels of soursop leaf powder in the experimental diets, but the feed conversion ratio showed fairly high values in goats on the control diet as compared with diets with soursop leaf powder.

Table 2. Proximate and phytogetic composition (%DM) of dried fluted pumpkin pulp meal, soursop leaf powder, elephant grass and treatment diets of goats

	Feed ingredients			Treatment diets			
	FPP	SL	EG	PPM ₁	SLP ₂	SLO ₃	SLW ₄
Dry matter	90.67	87.46	85.04	69.8	75.9	77.8	79.3
Crude protein	3.05	13.98	8.62	10.5	11.2	11.4	11.9
Ether extract	2.03	2.10	1.09	1.78	2.21	2.01	2.46
Crude fibre	19.49	7.53	31.04	33.0	31.9	32.4	30.1
Ash	9.36	5.79	7.41	6.98	5.59	5.19	4.92
Nitrogen free extract	54.74	58.06	35.88	48.1	49.3	48.9	50.1
Phytogetic components							
Tannin	0.68	0.82	0.76	0.87	1.32	1.71	1.56
Saponin	0.79	0.94	0.72	0.49	0.81	0.85	0.89
Oxalate	0.23	0.19	0.58	0.66	0.66	0.53	0.75
Phytate	0.19	0.30	0.51	0.54	0.59	0.67	0.73

FPP = Fluted pumpkin pulp, SL = Soursop leaf, EG = Elephant-grass

Table 3. Effect of soursop leaf powder on growth and nutrient digestibility of goats fed diets Containing fluted pumpkin pulp meal

Parameters	Diets				SEM ±
	PPM ₁	SLP ₂	SLO ₃	SLW ₄	
Feed intake(g/day)	239.01 ^c	252.64 ^b	254.00 ^b	265.02 ^a	1.02
Initial body weight (kg)	7.20	7.14	7.09	7.18	0.09
Final body weight (kg)	9.14 ^b	9.89 ^b	10.11 ^a	10.01 ^a	0.15
Total weight gain (kg)	1.94 ^c	2.75 ^b	3.02 ^a	2.83 ^b	0.03
Daily weight gain (g/day)	27.71 ^c	39.29 ^b	43.14 ^a	40.43 ^a	0.58
Feed conversion ratio	8.63 ^a	6.43 ^b	5.89 ^c	6.56 ^b	0.07
Nutrient Digestibility (%)					
Dry matter	68.94 ^b	71.82 ^a	73.05 ^a	72.28 ^a	0.57
Crude protein	67.75 ^b	70.93 ^a	71.72 ^a	70.96 ^a	0.64
Crude fiber	60.97 ^c	67.44 ^b	70.03 ^a	69.95 ^b	0.59
Ether extract	63.58 ^a	54.44 ^b	51.43 ^b	50.77 ^b	0.48
Ash	55.22 ^c	60.23 ^b	67.56 ^a	66.02 ^a	0.61
Nitrogen-free extract	65.47 ^c	69.14 ^b	74.52 ^a	72.38 ^a	0.79

^{a,b,c} Means in the same row with varying superscripts differ significantly ($P < 0.05$).

Dry matter digestibility was significantly ($P < 0.05$) higher in values observed for goats on test diets (SLP₂, SLO₃ and SLW₄) than the control diet (PPM₁). Goats placed on diets SLO₃ and SLW₄ had higher crude protein digestibility as compared with those on diets PPM₁ and SLP₂ which showed similar and lower significant ($P < 0.05$) values. Digestibility of crude fiber was significantly ($P < 0.05$) highest in SLO₃ followed by diets SLW₄ and SLP₂ compared with diet PPM₁ which recorded the lowest value. The control diet had a higher significant ($P < 0.05$) value in ether extract digestibility. Digestibility of ash varied significantly ($P < 0.05$) in goats on different treatment diets, with test diets being higher in values. However, nitrogen-free extract values

that ranged between 65.47 and 74.52% followed the same pattern of variation as noticed in the digestibility of ash.

The inclusion of soursop leaf powder in diets affected nitrogen retention in goats (Table 4). Nitrogen intake was relatively higher in goats on test diets and significantly ($P < 0.05$) lower in the control diet. Nitrogen excreted in feces and urine (g/day) was significantly ($P < 0.05$) lower in goats who consumed soursop leaf powder. Total nitrogen output was highest significantly ($P < 0.05$) in diet PPM₁, followed by SLP₂ and lowest in SLO₃ and SLW₄. Furthermore, nitrogen balance (g/day) and retention (%) were found to be significantly ($P < 0.05$) higher in goats that consumed SLO₃ and SLW₄.

Table 4. Nitrogen retention and energy utilization of goats fed diets containing different inclusion levels of soursop leaf powder

Parameters	Diets				SEM ±
	PPM ₁	SLP ₂	SLO ₃	SLW ₄	
Nitrogen (N) intake (g/day)	10.50 ^b	11.2 ^a	11.4 ^a	11.7 ^a	0.11
Fecal N-output (g/day)	3.00 ^a	2.35 ^b	2.01 ^b	2.24 ^b	0.03
Urinary N-output (g/day)	1.01 ^a	0.94 ^b	0.56 ^b	0.74 ^b	0.02
Total N-output (g/day)	4.01 ^a	3.29 ^b	2.57 ^c	2.98 ^c	0.04
N- balance (g/day)	6.49 ^c	7.91 ^b	8.83 ^a	8.72 ^a	0.06
N-retention of intake (%)	61.81 ^c	70.63 ^b	77.46 ^a	74.53 ^a	0.98
Energy ((MJ/g/day/DM)					
Gross energy	3948.25 ^a	3686.54 ^b	3299.79 ^c	3169.48 ^c	1.20
Fecal energy	979.84 ^a	799.92 ^b	696.42 ^c	701.55 ^{bc}	0.87
Urinary energy	216.43 ^a	168.49 ^b	102.55 ^c	134.22 ^c	1.05
Total energy output	1196.27 ^a	968.41 ^b	798.97 ^c	835.77 ^c	0.92
Digestible energy	1353.29 ^c	1566.03 ^b	1972.38 ^a	1790.91 ^a	1.73
Metabolizable energy	1109.70 ^c	1284.15 ^b	1617.35 ^a	1468.55 ^{ab}	0.99
Metabolizability (qm)	0.28	0.35	0.49	0.46	0.24

^{a,b,c} Means in the same row with varying superscripts differ significantly ($P < 0.05$).

Energy utilization was also influenced by different proportion of soursop leaf powder in diets (Table,4). Differences were registered significantly ($P<0.05$) in gross energy intake in goats among treatment diets. Higher values were recorded for PPM₁, followed by SLP₂ before SLO₃ and SLW₄ which had lower values. However, a remarkable difference was also pronounced significantly ($P<0.05$) for fecal energy output in goats placed on diet PPM₁. Urinary energy was considerably lower in goats fed diets SLO₃ and SLW₄. Total energy output values followed the same trends as fecal and urinary energy, although their values were not strictly comparable. Digestible and metabolizable energy intake values appeared higher significantly ($P<0.05$) in goats on test diets (SLP₂, SLO₃ and SLW₄) than goats placed on control group (PPM₁) that had lower value. Metabolizability indicated no significant difference between values.

Hematological parameters of goats were significantly ($P<0.05$) influenced by treatment diets except for eosinophils, monocytes, basophils and mean corpuscular volume that were not affected as pointed out in Table 5.

However, packed cell volume haemoglobin and red blood cell values appeared to be higher in goats on test diets SLP₂, SLO₃ and SLW₄. Goats on diets SLP₂, SLO₃, and SLW₄ had higher values of white blood cells, Lymphocyte and neutrophil values were highest in diets SLO₃ and SLW₄, followed by SLP₂ and PPM₁ which had the lowest values. Mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration values were found to be improved in goats on diets with soursop leaf than those on diet without soursop leaf powder.

Significant ($P<0.05$) differences were observed in all serum biochemical indices of goats except globulin which was unaffected by the treatment diets. Total protein and albumin values registered for goats on diets with soursop leaf powder were significantly ($P<0.05$) better. Glucose and triglyceride values were highest in animals placed on diets SLO₃ and SLW₄, followed by SLP₂ before PPM₁ which appeared to be the lowest. There were significant ($P<0.05$) variations in creatinine and urea among treatment diets, these variations were higher in the control group than those that were offered test diets.

Table 5. Mean values for haematological and serum biochemical indices of goats fed experimental diets

Parameters	Diets				SEM ±
	PPM ₁	SLP ₂	SLO ₃	SLW ₄	
Hematological indices					
Packed cell volume (%)	27.01 ^b	29.45 ^a	31.01 ^a	30.98 ^a	0.64
Hemoglobin (g/dl)	5.01 ^b	6.79 ^a	7.02 ^a	6.95 ^a	0.05
Red blood cell (x10 ⁶ /ml)	5.47 ^b	6.04 ^a	6.10 ^a	6.08 ^a	0.07
White blood cell (x10 ⁶ /ml)	5.98 ^c	7.98 ^b	8.62 ^a	8.43 ^a	0.09
Lymphocytes (%)	43.67 ^c	50.62 ^b	54.96 ^a	52.87 ^{ab}	0.76
Eosinophils (%)	2.19	2.35	2.08	2.31	0.08
Neutrophils (%)	40.01 ^c	45.96 ^b	49.55 ^a	47.02 ^a	0.93
Monocytes (%)	0.25	0.42	0.61	0.58	0.03
Basophils (%)	0.30	0.37	0.41	0.45	0.02
MCV (fl)	34.01	34.58	34.95	34.70	0.67
MCH (pg)	7.99 ^c	9.98 ^{ab}	10.16 ^a	10.07 ^a	0.55
MCHC (%)	30.89 ^b	31.95 ^a	32.07 ^a	32.01 ^a	0.86
Serum biochemical indices					
Total protein (g/dl)	6.52 ^b	6.89 ^{ab}	7.39 ^a	7.06 ^a	0.05
Albumin (g/dl)	2.79 ^b	3.45 ^a	3.65 ^a	3.40 ^a	0.03
Globulin (g/dl)	3.55	3.44	3.74	3.66	0.04
Glucose (mg/dl)	62.49 ^c	68.72 ^b	72.01 ^a	70.11 ^a	0.79
Triglyceride (mg/dl)	20.23 ^b	22.57 ^{ab}	22.90 ^a	22.99 ^a	0.62
Creatinine (mg/dl)	1.07 ^a	0.86 ^b	0.73 ^b	0.70 ^b	0.01
Urea (mg/dl)	12.75 ^a	8.62 ^b	7.85 ^c	7.09 ^c	0.45

^{a,b,c} Means in the same row with varying superscripts differ significantly ($P < 0.05$), MCV= Mean corpuscular volume, MCH = Mean corpuscular hemoglobin, MCHC = Mean corpuscular hemoglobin concentration.

As indicated in Table 6, are results for serum enzymes and lipid profile of goats fed diets containing soursop leaf powder and fluted pumpkin pulp. Animals placed on diets with test ingredient systemically decreased significantly ($P < 0.05$) in mean values for serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT). Alanine aminotransferase (ALT) and aspartate aminotransferase (AST) followed the same pattern of variation as observed for SGOT and SGPT.

Total cholesterol values recorded for goats in this study were significantly ($P < 0.05$) varied by treatment effect, goats on diets with 2.50% (SLO₃) and 3.00% (SLW₄) soursop leaf powder inclusion were significantly ($P < 0.05$) lower than goats on diets without soursop leaf powder (PPM₁) and 2% inclusion of soursop leaf powder (SLP₂). However, high-density lipoprotein (HDL) was increased significantly ($P < 0.05$) across treatment diets as soursop leaf powder inclusion levels were increasing progressively in test diets. On the other hand, low-density lipoprotein (LDL) values decreased significantly ($P < 0.05$) as the addition of soursop leaf powder increased in the treatment diets of goats. Very low-density lipoprotein (VLDL) values were not significantly influenced by treatment diets in this study.

4. DISCUSSION

Proximate composition and anti-nutritional factors of fluted pumpkin pulp, soursop leaf powder and elephant grass were comparable with range values reported in literature by

Adebayo et al. [4] Ogbonna et al. [7] Osakwe and Udeogu [18] respectively. The phytochemical levels in these plant species were considered low and safe with regards to phytochemical poisoning critical values of 7.3–9.0mg/g noted by Akomolafe and Ajayi [19]. Variations observed in the nutrient content of treatment diets could probably be due to the reflection of different feed components that supplied nutrients to diets. However, it was interesting to know that crude protein values recorded in diets were above the 8% CP minimum value required for goat maintenance [20].

The test ingredient seems beneficial as it was able to reduce the level of anti-nutritional factors and possibly increase the ability of the animals to properly modify and improve feed efficiency for better nutrient supply, absorption and utilization by animals. This resulted in higher significant final, total, and average daily weight gain in animals on the test diets. This inference was consistent with the earlier report by Osakwe and Udeogu [18] that efficient feed utilization by animals supplies an adequate balance of nutrient requirements at the site of metabolism for heavy weight gain. Daily weight gain values recorded in the work was comparable with the mean value (38.64g/day) reported by Ayandiran et al. [21]. Obvious variation in daily feed intake at similar growth stage of the animals could be related to the type as well as physical nature of diet components, length of time spent on diet and acceptability with other unknown contributing factors of the feeds. It is worth mentioning that the feed conversion ratio (FCR) which measures

Table 6. Effect of soursop leaf powder inclusion on serum metabolites and lipid profile of goats fed diets containing fluted pumpkin pulp

Parameters	Diets				SEM ±
	PPM ₁	SLP ₂	SLO ₃	SLW ₄	
Blood serum enzymes					
SGOT (U/L)	45.04 ^a	32.83 ^b	32.01 ^b	31.03 ^b	0.87
SGPT (U/L)	20.21 ^a	16.32 ^b	15.95 ^b	15.28 ^b	0.39
ALT (U/L)	25.99 ^a	20.85 ^b	19.93 ^b	19.67 ^b	0.46
AST (U/L)	69.83 ^a	62.53 ^b	60.47 ^c	60.01 ^c	0.74
Lipid profile					
Total cholesterol (mg/dl)	70.03 ^a	65.27 ^b	62.13 ^c	61.99 ^c	0.96
HDL (mg/dl)	30.96 ^c	33.57 ^b	35.72 ^a	36.01 ^a	0.85
LDL (mg/dl)	35.02 ^a	27.21 ^b	21.58 ^c	21.32 ^c	0.45
VLDL (mg/dl)	4.05	4.51	4.58	4.60	0.07

^{a,b,c} Means in the same row with varying superscript differ significantly ($P < 0.05$). SGOT = Serum glutamate oxaloacetate transaminase, SGPT = Serum glutamate pyruvate transaminase, ALT = Alanine aminotransferase, AST = Aspartate aminotransferase, HDL = High-density lipoprotein, LDL = Low-density lipoprotein, VLDL = Very low-density lipoprotein

feed intake per unit weight gain was lowest in diet SLOP₃, indicating better feed efficiency. However, the higher weight gain and FCR recorded in diets with test ingredients attest to the superiority of the diets.

Following the previous findings, digestibility in goats is governed by many factors that include the nature and quality of feeds, level of feed intake, salivary secretion, manner of rumen fermentation, and flow rate in gastro-intestine [18]. The improvement obtained in dry matter digestibility might be channeled to unlimited nutrient from greater proportion of forage grass that was compensated with appreciable percentage of supplement diet. This nutrient availability could have possibly stimulated the activity of cellulolytic rumen flora for better feed ingested and digestibility. The higher crude protein digestibility in test diets showed that phytochemical bioactive components in the test ingredient did not cause harmful effects on the activities of rumen bacteria but improved digestibility. This is in harmony with a previous study by Ayandiran et al. [21] who observed that secondary components in diets suppress rumen degradation to enhance appreciable quantity of protein availability in post-rumen digestion. Likewise fiber digestion in test diets could be linked to the modulation effect that appeared to favor the proper functioning of rumen ecology for high fermentable cell wall fractions and digestibility of fiber. This was earlier observed by Okoruwa and Ikhimiya [20], who stated that easily digestible features in feeds increase the activity of rumen-degrading microbes that break fiber feed constituents to provide energy for themselves and host animals. Interestingly, it was apparent that the addition of soursop leaf powder to diets was inversely proportional to the digestibility of ether extract. The reason for this inconsistency could presumably depend on the bioactive ingredients in the diets that could have disrupted the activity of enzyme reaction in the rumen by forming an indigestible complex for oil-degrading components. Notwithstanding, there was a considerable increase in the digestibility of ash and nitrogen-free extract in goats on test diets. This observation further affirmed the positive interaction effect of the feed components that were found to enhance nutrient availability for effective digestion. The low digestion in almost all nutrients in the control diet could be traced to an inhibition of digestive enzyme activity by anti-nutritional factors in fluted pumpkin pulp and their interactions with fibre which adversely reduced cell wall carbohydrates

as demonstrated in goats on diet with no soursop leaf powder.

The discrepancy noticed in values of nitrogen intake could mainly be attributed to the difference in contributory effects of the dietary components that tend to increase the protein content of test diets. However, the high numerical values of fecal, urinary, and total nitrogen excreted in the control group could be a result of rapid breakdown of dietary protein to ammonia which increased nitrogenous excretion [8]. It is worth pointing out that all diets in the study had positive nitrogen balance, explaining treatment diets were tolerated with the provision of adequate protein requirement for the animals. The higher nitrogen retention noticed in diets with 2.5 and 3% soursop leaf powder inclusion, could be connected to the presence of optimum anti-microbial effects that delay rumen protein degradation by suppressing bacteria population and making denatured protein absorbed and utilized in the intestine by animals for maintenance and production purposes [22]. Nitrogen retention values obtained in this work were within the reference values reported by Okoruwa and Edoror [23].

The observed increment in gross energy (GE) intake in the control diet could perhaps be linked with the ingestion of the feed components that had a measurable effect on energy concentration. This possibly explains the excessive amount of GE intake by the animal to meet with energy requirements for their body's physiological activities. The higher fecal, urinary, and total energy output noted in the control diet, further buttressed the imbalanced level of energy catabolism that was associated with poor energy utilization in the diet. The improved digestible energy values in animals on test diets showed that the phytochemical components in the feeds were active to make nutrient available for efficient feed utilization and reduced fecal energy. Metabolizable energy (ME) is often used as a sensitive yardstick for the determination of the overall energy intake of feed and measures the metabolic sum of the process of digestion, absorption, and utilization of feed in energy unit [24]. Thus, the efficiency with which higher ME was retained and utilized for growth in animals on test diets was influenced by low energy loss as heat. This low heat increment was a function of nutrient adequacy in feeds that gave better ME which was expressed in higher weight gain. However, this depends on the interaction of two principal factors; the nature of

the chemical compounds in which ME was contained and the purpose for which these compounds were used by the animals. The similar values of metabolizability (qm) have laid credence to the work reported by Ahamefule and Udo [25] who noted that qm of complete feed is relatively constant and equivalent to about 0.96 MJ/g/day DM.

Blood examination is a scientific way of screening and assessing the nutritional and health status of an animal. Thus, hematology provides an opportunity to clinically investigate the presence of several metabolic needs and other constituents in the body of animals [26]. Packed cell volume (PCV) is an indicator of blood volume or blood dilution that may result from the toxic substance, while hemoglobin (Hb) and red blood cell (RBC) measure the ability to withstand some levels of respiratory stress and oxygen carrying capacity. The positive comparative values of these indices showed that animals were in normal healthy condition and not anaemic. Mean corpuscular volume, mean corpuscular hemoglobin and mean corpuscular hemoglobin concentration values that explain the bone marrow capacity for blood cell production and diagnosis of anemia were correlated with PCV, Hb, and RBC obtained in this study. This further explains the quality of the balanced feeds that had no adverse effect on blood and health status. White blood cell (WBC) improves the immune system, antibody production, and disease-fighting ability of the animal. The immune response of animals in this study was not negatively affected by test feeds as showed in their values that tallies with average value ($7.68 \times 10^3/m^3$) for goats as reported by Okoruwa et al. [26]. The results of neutrophils and lymphocytes for white blood differential counts imply that goats on these diets tended not being susceptible to microbial infection or disease condition. Low values of monocytes, eosinophils, and basophils were indications that their immune system was not challenged by toxic substances present in the test feeds. However, their values showed good resistance to diseases and did not portend any danger, since they fell within the normal range values of 10-50% neutrophils, 40-75% lymphocytes, 1-5% monocytes, 1-8% eosinophils and 0-3% basophils [11].

The higher serum total protein and albumin concentration obtained in animals on diets with soursop leaf powder could be traceable to low content of secondary compounds and availability of better nutrient utilization that were able to

supply an adequate digestible amount of protein needed to make nitrogen available for rumen microbes. Consequently, this increased protein absorption in the intestine which is responsible for maintaining normal serum protein levels in animals. However, total protein and albumin values obtained in this study, were in line with average range values of 7.02 and 3.18 g/dl respectively, earlier noted by Okoruwa and Edoror [23]. This indicates that anti-nutritional factors in test diets could not reduce nutrient absorption but proposed intact health hepatic cellular functions. The constant globulin values observed, could probably be due to the goats adaptation to stress which made them disease-free and caused excessive production of antibodies through gamma globulin production [12]. It might be logical to say that the favourable role of test feeds gave way to increased soluble carbohydrate for metabolic efficiency in the stomach which modulated nutritional metabolism. This might probably be translated to the improvement in serum glucose and triglyceride that was linked to the increment in body weight gain of the animals. The low creatinine levels in serum, suggest no muscle or tissue wastage and animals did not survive at the expense of their body reserves. This is proportional to the low urea levels with positive nitrogen balance observed in animals on test diets, reflecting the superiority of the dietary protein that was efficiently utilized and did not cause excessive protein catabolism that is associated with protein deficiency. The Almeida et al. [27] noted in the literature that urea tests measure the amount of nitrogen in the serum and high serum urea level is an indication of kidney dysfunction because protein intake and kidney functioning are affected by the quantity of blood urea nitrogen.

Serum enzymes are found in practically every tissue of the animal body, inducing red blood cells that are highly concentrated in cardiac muscle and liver intermediate in skeletal muscle and kidney but much lower concentration in other tissues [28]. Their measurements are helpful for diagnosis and following cases of myocardial malfunction, hepato-cellular disease and skeletal muscle disorders. They are excellent markers of hepatic liver damage caused by exposure to toxic substances [22]. The reference values of SGOT (14.0 to 123 U/L), SGPT (15 to 44 U/L), ALT (10.3 to 53.3 U/L) and AST (43 to 230 U/L) reported by Adebayo et al. [4] Chen et al. [12] for goats were within the recorded values obtained in this study. These normal physiological serum enzyme levels imply that the phytogetic

bioactive components in the test diets had no debilitating effect on the liver of the animals [13], asserted that the clinically significant risk of serum enzyme activities above normal range is an aberration and indication that animals may suffer from liver diseases. Moreover, the clear low values of serum enzymes, creatinine and cholesterol in conjunction with urea observed in this study could be conventionally used as tools to show that the test ingredients did not interfere with renal and hepatic functions, explaining the absence of damage in the liver and myocardial.

The residual effect of tannin and saponin in the test diets could be responsible for the scavenging effect of free radicals in the blood that suppressed serum as expressed in low cholesterol [22], observed that a cholesterol level of 180mg/dl and below may not result in arteriosclerosis, hence the values registered in this work suggest a safe concentration for good animal health. The increased levels of high-density lipoprotein cholesterol noted in animals on test diets further attest to the good effect of the feeds that could prevent peripheral artery disease and arteriosclerosis [28], found that low and very low-density lipoproteins are considered bad cholesterol because their high levels can cause a build-up of cholesterol in arteries. However, the reduction of their concentration levels in the test diets could be attributed to high dietary fiber utilization and the presence of secondary metabolites which could depress hepatic activities of lipoemic and cholesterol enzymes.

5. CONCLUSION

The study discovered that feeding dried fluted pumpkin pulp with different proportions of soursop leaf powder as a dietary supplement to goats can serve as a potential alternative feed that will provide a more practical approach to their feeding regime. Thus, it is expected that this alternative feed can go a long way in making animal protein available at affordable prices to an average Nigerian and also reduce competition between man and ruminant livestock for feeds, most especially during the dry season.

The efficacy of processing fluted pumpkin pulp and soursop leaf powder in the study diets reduced anti-nutritional factors and provided phytochemical components. This increases nutrient utilization as demonstrated in greater feed ingestion capacity with nutrient digestibility that consequently improved health status and body

tissue build-up as seen in growth performance without any negative effect in goats. However, the response in terms of goat improvement was more pronounced in diets that contained 6% dried fluted pumpkin pulp with 2.5 or 3% soursop leaf powder (SLO₃ and SLW₄)

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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