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Full Length Research

Evaluation of growth, carcass and meat sensory characteristics of West African Dwarf bucks fed dietary *Enterolobium cyclocarpum* leaves

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ABSTRACT: The leaves of *Enterolobium cyclocarpum* contain secondary metabolites which have beneficial and detrimental effects on the animals consuming them. This experiment was thus designed to investigate these effects on the growth performance, carcass, and meat sensory characteristics of WAD bucks fed concentrate diets containing varying levels of *Enterolobium cyclocarpum* leaves. Harvested leaves of *Enterolobium cyclocarpum* (EC) were wilted for 12 to 36 hours, shredded, and incorporated into concentrate diets. Diet 1 contained no EC (0%), while Diets 2, 3 and 4 contained 7.50, 15.00 and 22.50% EC leave, respectively. The crude protein content of the diets ranged from 16.45 to 17.50% and differed significantly (p<0.05). The concentration of tannin (24.02, 28.93 and 29.71 mg/100g) and oxalate (113.15, 96.64 and 142.55 mg/100g) in diets 2 to 4 differed significantly (p<0.05) across dietary treatments. Bucks fed dietary 15% EC leaves (Diet 3) had the highest final live weight of 8.83kg which was statistically similar (p>0.05) to the final weight of bucks fed the control diet (7.73kg; Diet 1), 7.50% EC leave diet (7.33kg; Diet 2) but higher than (p<0.05) 22.50% EC leaves diet (5.65kg; Diet 4). Some internal organs (kidney, heart, and diaphragm) had significant changes in their relative weight across the treatments with diet 3 (15% EC leaves) recording the lowest values. The kidney weight of bucks fed diet 3 (0.64%) compared favourably with the control (0.61%), while the heart and diaphragm weight of bucks fed diet 3 (0.99 and 0.61%) were quite lower than those fed the control diet (1.05 and 0.67). Similarly, meat from bucks fed diet 3 was significantly (p<0.05) adjudged the most preferred, possessing the best aroma, flavor, juiciness, and tenderness. Thus, dietary EC leaves for WAD goats should not exceed 15% for better growth performance, carcass yield, and sensory characteristics.

Keywords: Antinutritional factors, carcass, *Enterolobium cyclocarpum*, growth performance, proximate composition, West African Dwarf goats.

INTRODUCTION

Browse plants are available all year round, less expensive but have high nutritive value. One of such introduced browses is the ear pod tree, *Enterolobium cyclocarpum* (EC). This tree also commonly known as Guanacaste or caro-caro is naturally found in humid and sub humid regions including Nigeria (Andreu *et al*., 2015). Arboretum of EC plants are established in South Western States (Ayuk *et al*., 2014) and some campuses of Nigerian Universities, such as the University of Uyo, South - South, tropical rainforest zone of Nigeria. The utilization of these natural resources such as EC in a rational and sustainable way is a viable option for obtaining profits in agricultural activities (FAO, 2012). Furthermore, the utilization of forage trees as feed ingredients helps to improve the animal diet and reduce the use of concentrates in ruminant diets (Isah *et al*., 2011; Delgado *et al*., 2014; Ekanem *et al*., 2020a).

However, like many other browse plants, EC contains secondary metabolites (anti-nutritional factors) which have beneficial and detrimental effects on the plants and on animals consuming them (Babayemi, 2006; Crozier *et al*., 2006; Ekanem *et al*., 2020a; Ekanem *et al.*, 2020b). Some of these anti-nutritional factors (ANFs) affect the activities of microbes in the rumen, increasing bacterial proteins and overall nutrients flow and digestibility to the duodenum for subsequent absorption by the ruminant (Koenig *et al*., 2007; Isah *et al*., 2011; Idowu *et al*., 2013). Some of these ANFs have defaunation qualities while some have bactericidal or bacteriostatic properties (Isah *et al*., 2011; Galindo *et al*., 2014). These plant bioactive compounds possess antimicrobial activity which can be used as alternative additives to reduce methanogen population in the rumen (Kamra *et al*., 2012). Herbal extracted products have a prominent effect on rumen microbiota either directly changing the methanogens or indirectly affecting protozoa (Karri *et al*., 2015). Based on the aforementioned, browses such as EC may or may not be readily accepted by livestock. Fortunately, the leaves, seeds and other parts of *Enterolobium cyclocarpum* have been efficiently utilized in ruminant nutrition studies with exciting results in animal preference, growth performance and carcass characteristics (Isah *et al*., 2011; Idowu *et al*., 2013; Ayuk *et al*., 2014; Ukanwoko and Okpechi, 2016; Udoh *et al*., 2020; Ekanem *et al*., 2020a),

In an earlier preference studies in our station (Ekanem *et al*., 2020a), West African Dwarf (WAD) bucks preferred the fresh EC leaves to the ensiled (silage), sundried (hay) or silage: hay leaves. The authors concluded that the high acceptability of fresh EC leaves by WAD bucks was due to the high crude protein of the leaves and their previous experience in consuming fresh leaves (Ekanem *et al*., 2020a). This form the basis for choosing fresh EC leaves for further investigation. The main objective therefore of this experiment was to assess the influence of the antinutritional factors present in *Enterolobium cyclocarpum* leaves on the growth performance, carcass characteristics and meat sensory parameters of West African Dwarf bucks.

MATERIALS AND METHODS

Experimental site

The study was carried out at the Teaching and Research Farms, University of Uyo, Uyo, Akwa Ibom State, Nigeria. Uyo is located between latitudes 4˚59´ and 5˚04´ N and longitudes 7˚52´ and 8˚00´ E. Uyo is located within the tropical rainforest zone which characterizes the South-South agro-ecological zone of Nigeria. The annual rainfall in Uyo ranges from 800 to 3,200 mm per annum. Rains begin in March and continue till October with peaks in June and September and two weeks of break in August (August break), then followed by dry season from November till February. Annual temperature varies between 23 and 28˚C. Average relative humidity 80% (74 to 85%), average rainfall of 252.7 mm per day (2 to 536 mm/day) with a total amount of rainfall of 3027mm per annum and average temperature of 26˚C (23 to 28˚C) (The Meteorological Station, University of Uyo, 2016).

Experimental animals and diets

A total of sixteen (16) bucks aged between 6 to 9 months of average 6.33 ± 0.01 kg were randomly allotted to four (4) dietary leaf meal. There were four animals per treatment, with each animal in a treatment serving as a replicate. The goats (bucks) were weighed at the start of the experiment and subsequently every week during the 14-week experimentation period including 2 weeks of diet acclamation. Fresh EC leaves was partly wilted for 12 to 36 hours under shade, shredded/chopped into smaller sizes and mixed in concentrates diets containing brewers' dried grain, wheat offal, palm kernel cake, bone meal, salt and vitamin/trace mineral premix. The ingredients composition of the experimental diets is as shown on Table 1.

Weighed but *ad libitum* quantity of the experimental diets were offered as the basal diets. The bucks' diets were supplemented with 300 g of mixed forages consisting mostly of *Panicum maximum*. Feed offered and total feed intake were recorded. Clean water was supplied *ad libitum*. Data were obtained on initial body weight, final body weight, body weight changes and feed intake while feed conversion ratio was calculated. The experimental design was a Completely Randomized Design (CRD). The model for the design is:

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

Where: Y_{ij} = individual observation, μ = overall mean, α_i = effect of the treatment and e_{ij}= random error (iind0σ).

The experimental diets were analyzed for their chemical composition. Proximate compositions were analyzed following the method of AOAC (1990). The fibre fractions – neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) - were determined using the procedures of Van Soest *et al*. (1991). Cellulose was calculated as the difference between ADF and ADL while hemicellulose was calculated as the difference between

Table 1. Ingredients composition (%) of experimental diets fed WAD bucks.

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4
Enterolobium cyclocarpum leaves	0.00	7.50	15.00	22.50
Wheat offal	60.00	60.00	60.00	60.00
Brewers' dried grain	10.00	10.00	10.00	10.00
Palm kernel cake	27.00	19.50	12.00	4.50
Bone meal	2.00	2.00	2.00	2.00
Salt	0.50	0.50	0.50	0.50
Vitamins/trace minerals premix	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00
Calculated composition				
% Crude protein	14.75	14.82	14.89	14.97

NDF and ADF. Tannins were determined by the Folin-Dennis Spectrophotometric method (Pearson, 1976). The saponin content of the diets were determined by the Double Solvent Extraction Gravimetrical Method (Harborne, 1973). Phytate was analyzed by the procedure of McCance and Widdowson (1953) while Ammonia nitrogen (NH_3N) was determined by the Nessler's Colorimeter Method (AOAC, 1990).

At the end of the feeding trial, 3 bucks per treatment were fasted for 18 hours but allowed access to water. Weights of the animals were taken before they were slaughtered by severing the jugular and carotid veins with a sharp knife. After slaughtering, carcasses were flayed and eviscerated. Carcasses were dissected into two equal halves and weighed. The left half was divided into primal cuts. Primal cuts (shoulder, leg, rack, brisket, neck, flank, and loin). The internal organs (liver, lung, heart, spleen, kidney, and diaphragm) and external offal (head, skin, testes, foreshank, and hind shank) were weighed separately. Parameters considered were: live weight (fasted), slaughter weight, hot carcass weight, dressing percentage, meat-to-bone ratio, meat-to-fat ratio, chilling weight/loss, standardized wholesale cuts, and weights of organs and offal (Kadim *et al*., 1989; Odoemelam *et al*., 2014). The experimental design was a completely randomized design. To determine chilling loss, the other half cut of the carcass was chilled at 2˚C for 24 hours. The chilling loss was determined as the difference between the warm carcass weight and the chilled carcass weight (Omojola, 2007).

For the sensory evaluation, meat samples were obtained from the loin muscle and cooked to an internal temperature of 72˚C. Cooked meat samples were cut into equal bite sizes, replicated thrice and served to a 16-person semi-trained sensory panelist in odourless breakable plates far away from the cooking area. Samples were coded to reduce bias. The judges were offered water and cracker biscuits for them to rinse their mouth of any carryover flavour from previously evaluated meat samples. Meat samples from the four treatments were evaluate on a 9-point hedonic scale (1 = dislike extremely to 9 = like extremely) as described by Omojola (2007) and Larmond (1977) for aroma, colour, flavour, juiciness and tenderness.

Data obtained were subjected to analysis of variance using SAS (2000) statistical software. Significant means were separated using Duncan Multiple Range Test of the same Statistical package.

RESULTS AND DISCUSSION

Chemical composition of the experimental diets

The proximate composition of the concentrate diets containing 0, 7.50, 15.00, and 22.50% wilted EC leaves and the mixed forage fed the goats are shown in Table 2. The mixed forage was made up of more than 90% *Panicum maximum*. There were significant differences ($p<0.05$) in all the proximate composition across the diets. The crude protein content (14.00 to 17.50%) of the concentrate diets and the mixed forages (14.00%) were far above the minimum CP value (8%) required for effective rumen function (Norton, 1998) and were also above the minimum protein requirement of 10 to 12% for ruminant animals (ARC, 1984).

The fibre fractions of the control diet (0%) EC leaves and other diets containing 7.50, 15.00 and 22.50% levels of shredded EC leaves are shown in Table 3. Apart from the content of acid detergent lignin (ADL) and hemicellulose, there were significant differences ($p<0.05$) in the concentrations of other fibre fractions. The NDF content differed significantly ($p<0.05$) among the treatment diets and was highest in the 22.50% EC diet followed by the 7.50% EC diet, then (0% EC) diet and the least value in the 15.0% EC diet with values ranging from 58.77 to 61.34%. The ADF followed the same pattern as the NDF with the values ranging from 42.85 to 48.75%. Low ADL values (16.38 to 17.38%) were obtained across dietary treatments. The high NDF and low ADL will make the feed

Table 2. Proximate composition (%) of concentrate diet containing graded levels of *E*nterolobium *cyclocarpum* leaves and mixed forage fed to WAD bucks.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	MF	SEM
Dry matter	85.55[a]	82.80[b]	81.35[c]	78.14[d]	33.48[e]	5.22
Crude protein	17.15[b]	16.80[c]	16.45[d]	17.50[a]	14.00[e]	0.33
Crude fibre	5.24[d]	4.89[e]	6.59[a]	6.23[c]	6.36[b]	0.18
Ether extract	6.89[b]	10.05[a]	6.75[c]	6.58[d]	3.48[e]	0.56
Ash	6.29[d]	5.74[e]	8.38[b]	7.77[c]	9.54[a]	0.37
Nitrogen free extract	64.43[b]	62.52[c]	61.87[e]	61.92[d]	66.62[a]	0.49

[a – e] Means on the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean. MF = Mixed forages.

Table 3. Fibre fractions (%) of concentrate diet containing graded levels of *Enterolobium cyclocarpum* leaves fed to WAD bucks.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Neutral Detergent Fibre	61.18[c]	61.25[b]	58.77[d]	61.34[a]	0.33
Acid Detergent Fibre	48.68[c]	48.72[b]	42.85[d]	48.75[a]	0.77
Acid Detergent Lignin	17.29	17.35	16.38	17.38	0.13
Hemicellulose	12.50	12.54	13.92	12.59	0.28
Cellulose	31.39[a]	31.37[a]	26.47[b]	31.37[a]	0.64

[a – d] Means on the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Table 4. Anti-nutritional factors (mg/100g) of concentrate diet containing graded levels of *Enterolobium cyclocarpum* leaves.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Tannin	13.73[d]	24.02[c]	28.93[b]	29.71[a]	1.92
Saponin	4.48[a]	2.85[c]	3.96[b]	2.32[d]	0.26
Oxalate	150.36[a]	113.15[c]	96.64[d]	142.55[b]	6.76
Phytate	6.60[d]	6.99[b]	6.95[c]	7.49[a]	0.96
HCN	8.01[d]	11.55[b]	14.83[a]	10.37[c]	0.74

[a – d] Means on the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

easily digestible (Ekanem *et al*., 2020b).

Table 4 shows the anti-nutritional factors (mg/100g) of concentrate diet containing graded levels of *Enterolobium cyclocarpum* leaves fed the WAD goats. There were significant differences (p<0.05) across dietary treatments in the composition of plant secondary metabolites (tannin, saponin, oxalate, phytate and HCN). Tannin contents were lowest (13.73 mg/100g) in the control diet and increased (24.02, 28.93 and 29.71 mg/100g) significantly (p<0.05) in diets 2, 3 and 4, respectively with increased EC leaves in the diet. Tannic contents obtained in this study were higher than the range of 3.11 to 10.31 mg/100g reported by Bassey *et al*. (2014) for *Rauvolfia vomitoria*>*Palisota hirsute*>*Manniophytonfulvum*>*Spondiasmombin* but lower than the 93.40 mg/100g reported by Ekanem *et al*. (2020b) for fresh EC leaves. High contents of tannin obtained in this study corroborates the high concentration (+++) of tannins reported by Galindo *et al*. (2014) for *Enterolobium cyclocarpum* leaves. Saponin concentration ranged from 2.32 mg/100g in diet 4 to 4.48 mg/100g in diet 1. Bassey *et al*. (2014) reported the absence (-) of saponins in the leaves of *Palisota hirsute,* moderate (++) concentration in the leaves of *Spondias mombin* and *Manniophyton fulvum* and strongly present (+++) in the leaves of *Rauvolfia vomitoria* found in Akwa Ibom State, Nigeria. Moderate (++) concentrations of saponins were reported by Galindo *et al*. (2014) for *Enterolobium cyclocarpum* leaves. Concentration of oxalic acids in the diets were, 96.64, 113.15, 142.55 and 150.36 mg/100g in diets 3, 2, 4 and 1, respectively and were significantly different ($p<0.05$) across dietary treatment. Values for oxalate obtained in this study were lower than the range of 202.40 to 598.40 mg/100 reported for *Rauvolfia vomitoria*>*Palisota hirsute*>*Manniophyton fulvum*>*Spondias mombin* found in Akwa Ibom State. Similarly, concentration of oxalic acid in the diet were lower than the value of 450.21 mg/100g reported by Ekanem *et al*. (2020b) for fresh EC leaves. Phytic acid concentration obtained in this study ranged from 6.60 to 7.49 mg/100g. These values were lower, compared to the range of 27.59 to 45.27 reported by Bassey *et al*. (2014) for browse plants in Akwa Ibom State, Nigeria. Concentration of hydrocyanic acid (HCN) ranged from 8.01 mg/100g in the control diet to 14.83 mg/100g in diet 3 (15% EC leaves). The range of HCN content in these diets were lower than the value of 21 mg/100g or 0.021% reported by Isah *et al*. (2011) for EC leaves. Variations in contents of anti-nutritional factors may be due to level of inclusion in the diets, ecological zone, soil type and season of the year. Reduced anti-nutrients in the diets as obtained in this study favoured increased feed preference and intake (Ekanem *et al*., 2020a).

Growth performance of bucks fed the experimental diets

Table 5 shows the growth performance of WAD bucks fed concentrate diets containing graded levels of EC leaves. There were significant differences ($p<0.05$) in the average feed intake of the diets. The average final body weight of bucks fed diet 3 (15% EC leaves inclusion) was the highest (8.83kg) and was significantly different ($p<0.05$) from the average final body weight (5.65kg) of bucks fed diet 4 (22.50% EC) which recorded the least average final body weight. The range of the average initial (6.25 to 6.43 kg) and final (5.65 to 8.83 kg) body weight obtained in this study was within the range of initial body weight (6.29 to 6.40 kg) and final body weight (8.08 to 8.38 kg) for WAD goats fed *Gliricidia sepium*, cassava and *Leucaena leucocephala* leaf meal in a cassava peel-based diets (Ukanwoko and Okpechi, 2016).

There were significant differences ($p<0.05$) in the average daily weight changes and feed conversion ratio of the bucks fed the experimental diets. Bucks fed the control diet had the highest average daily weight gain (20.00 g/d) and least feed conversion ratio (14.58). Comparing the EC diet to the control, bucks fed diet 3 had the highest daily weight gain (17.86 g/d) and least feed conversion ratio (FCR) of 20.36 compared to diets 2 and 4. Diet 4 with 22.50% EC leaves adversely affected the growth of the animals as they were rather losing weight and probably living on their body reserve. When Idowu *et al*. (2013) fed graded levels (0, 10, 20, and 30%) of toasted *Enterolobium cyclocarpum* seeds to WAD rams to assess their growth performance, it was rams fed the 10% toasted *Enterolobium cyclocarpum* seeds diet that had the best result in growth performance.

Carcass characteristics of bucks fed the EC leaves containing diets

The carcass characteristics of WAD bucks fed diets containing 0, 7.50, 15 and 22.50% EC leaves is shown in Table 6. There were significant differences ($p<0.05$) in fasted body weight (8.13; 5.40 kg), bled weight (7.83; 5.10 kg) and empty body weight (5.55; 3.28 kg) of bucks fed diet 3 and those fed diet 4, respectively. Average fasted body weight (6.97 kg) of bucks fed diet 2 (7.5% EC leaves) did not differ significantly ($p>0.05$) from the weight (7.40 kg) of bucks fed the control diet without EC leaves. The range of fasted body weight (5.40 to 8.13 kg) obtained in this study was within the range of fasted body weight (7.85 to 8.22 kg) reported by Ukanwoko and Okpechi (2016) for WAD goats fed *Gliricidia sepium*, cassava and *Leucaena leucocephala* leaf meals in a cassava peel-based diet. The 8.13 kg fasted body weight of bucks fed 15% EC leaves (diet 3) compared favourably with the 8.12 kg reported by Odoemelam *et al*. (2014) for WAD goats fed 20% Bambara nut meal. Bucks fed 15% EC leaves had highest values of fasted body weight (8.13 kg), bled weight (7.83 kg), empty body weight (5.55 kg) but similar to those of bucks fed the control and diet 2. Hot carcass weight, chilled carcass weight and dressing percentage did not differ ($p>0.05$) among the treatment means.

The dressing percentage obtained in this study was higher than the range of 40.56 to 43.28% reported by Odoemelam *et al*. (2014) for WAD goats fed 0, 10, 20 and 30% Bambara nut meal. The range of values for dressing percentage (46.97 to 48.23%) obtained in this study was however lower than but closer to the reported value of 51.29% for WAD goats by Ajayi *et al*. (2017) when they assessed the conventional and non-conventional estimation of live weight, carcass characteristics and dressing percentage of three breeds (WAD, Sahel and Maradi) of Nigerian goats. Higher dressing percentage of 53.12 to 55.35 was reported by Ukanwoko and Okpechi (2016) for WAD goats fed *Gliricidia sepium*, cassava and *Leucaena leucocephala* leaf meals in a cassava peel-based diet. Similarly, higher dressing percentage of 55.99 to 57.66 which was higher than what was obtained in this study was reported by Okpanachi *et al*. (2016) for WAD goats fed sun-dried yellow cashew pulp-based diets. Bucks fed Diet 4 had the least gut fill and the highest dressing percentage. This corroborated earlier reports by Talton (2011), McGregory (2012) and Ajayi *et al*. (2017) who reported that the lower the gut fill, the higher the dressing percentage (or vice versa). Generally, bucks fed

Table 5. Growth performance characteristics of WAD bucks fed concentrate diets containing *Enterolobium cyclocarpum* leaves.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Average Initial body weight (kg)	6.30	6.43	6.33	6.25	0.45
Average Final body weight (kg)	7.73^{ab}	7.33^{ab}	8.83^{a}	5.65^{b}	0.50
Average Daily feed intake (g)	291.65^{c}	338.14^{b}	363.61^{a}	245.52^{d}	6.79
Average Daily weight changes (g/d)	20.00^{a}	11.07^{c}	17.86^{b}	-7.14^{d}	1.56
Feed Conversion Ratio	14.58^{c}	30.55^{a}	20.36^{b}	-34.39^{d}	7.54

$^{a-d}$ Means on the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Table 6. Carcass characteristics (relative to live weight) of WAD bucks fed concentrate diets containing *Enterolobium cyclocarpum* leaves.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Fasted body weight (kg)	7.40^{ab}	6.97^{ab}	8.13^{a}	5.40^{b}	0.44
Bled weight (kg)	7.10^{ab}	6.67^{ab}	7.83^{a}	5.10^{b}	0.43
Empty body weight (kg)	4.78^{ab}	4.62^{ab}	5.55^{a}	3.28^{b}	0.34
Hot carcass weight (kg)	3.57	3.33	3.82	2.60	0.22
Dressing percentage (%)	47.82	48.09	46.97	48.23	0.73
Chilled carcass weight (kg)	1.68	1.70	1.93	1.30	0.11
Chilling loss (%)	11.67	10.00	11.67	8.33	0.96

^{a,b} Means on the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Table 7. Primal cuts (expressed as percentage of hot carcass weight) of WAD bucks fed concentrate diets containing *Enterolobium cyclocarpum* leaves.

Parameters (%)	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Shoulder	18.73	21.93	20.78	20.54	0.63
Leg	26.72	29.54	28.28	30.13	0.33
Rack	10.31	12.13	12.82	12.74	0.49
Brisket	10.66	8.27	9.42	8.37	0.44
Neck	11.08	11.50	9.77	12.23	0.75
Flank	7.94^{a}	6.21^{ab}	6.68^{ab}	5.01^{b}	0.44
Loin	8.60	7.19	10.04	7.54	0.50

^{a,b} Means on the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

diet 3 (15% EC leaves) recorded the best values for carcass characteristics.

Table 7 shows the primal cuts of WAD bucks fed concentrate diets containing 0, 7.50, 15 and 22.50% of EC leaves. Except for the weight of flank, there were no significant differences (p>0.05) in the weight of other primal cuts. The shoulder, leg and rack weight ranged from 18.73 to 21.93, 26.72 to 30.13 and 10.31 to 12.82%, respectively. Bucks fed the control (0% EC leaves) diet had heavier (p<0.05) flank weight than bucks fed the 22.50% EC leaves containing diet but similar (p>0.05) to those fed 7.50 and 15.00% EC leaves diets.

The distribution of tissues (expressed as percentage of hot carcass weight) of WAD bucks fed concentrate diets with or without *Enterolobium cyclocarpum* leaves is presented on Table 8. The tissue distribution values were

Table 8. Distribution of tissues (expressed as percentage of hot carcass weight) of WAD bucks fed concentrate diets containing *Enterolobium cyclocarpum* leaves.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Meat (%)	29.37	30.07	28.96	27.61	0.46
Bone (%)	12.64^{b}	9.48^{c}	12.68^{b}	15.10^{a}	0.64
Fat (%)	0.67	0.38	0.54	0.03	0.11
Meat: Bone	2.27^{b}	3.21^{a}	2.29^{b}	1.83^{b}	0.17
Semitendinosus muscle (%)	1.32	1.15	1.15	1.09	0.05
Semimembranosus muscle (%)	3.52	3.62	3.12	3.60	0.14

$^{a-c}$ Means on the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Table 9. Internal organs (expressed as percentage of empty body weight) of WAD bucks fed concentrate diets containing *Enterolobium* cyclocarpum leaves.

Parameters (%)	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Liver	3.46	3.40	3.48	4.23	0.15
Kidney	0.61^{b}	0.68^{ab}	0.64^{a}	0.83^{a}	0.03
Heart	1.05^{ab}	1.07^{ab}	0.99^{b}	1.26^{a}	0.04
Spleen	0.24	0.27	0.26	0.32	0.02
Lungs	1.74	1.84	1.79	2.12	0.08
Diaphragm	0.67^{b}	0.89^{ab}	0.61^{b}	1.14^{a}	0.09

^{a,b} Mean in the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

meat (29.37, 30.07, 28.96 and 27.61%), bone (12.64, 9.48, 12.68 and 15.10%), fat (0.67, 0.38, 0.54 and 0.03%), semitendinosus muscle (1.32, 1.15, 1.15 and 1.09%) and semimembranosus muscle (3.52, 3.62, 3.12 and 3.60%) for bucks fed diet 1, 2, 3 and 4, respectively. There was no significant difference (p>0.05) in the yield of meat of the bucks fed the diets. There was significant difference (p<0.05) in the meat-to-bone ratio with bucks fed diet 2 yielding the highest ratio of 3.21. The meat–to-bone ratio of bucks fed diets 3 and 4 did not differ significantly (p>0.05) with the control. There was no significant difference (p>0.05) in the weight of semitendinosus muscle and semimembranosus muscle of the bucks.

Table 9 shows the internal organs (expressed as percentage of empty body weight) of WAD bucks fed concentrate diets containing *Enterolobium cyclocarpum* leaves. There were no significant differences (p>0.05) in the weight of liver (3.46, 3.40, 3.48 and 4.23%), spleen (0.24, 0.27, 0.26 and 0.32%) and lungs (1.74, 1.84, 1.79 and 2.12%) of bucks fed the four experimental diets. Significant differences (p<0.05) were observed in the weight of the kidney (0.61, 0.68, 0.64 and 0.83), heart (1.05, 1.07, 0.99 and 1.26%) and diaphragm (0.67, 0.89, 0.61 and 1.14%) of bucks fed diets 1, 2, 3 and 4, respectively. Generally, bucks fed diet 4 had higher weight of kidney and diaphragm than those fed the control diet. The internal organ weights appeared to be better for bucks fed diet 3 (22.50% EC leaves).The increases in weight of the internal organs must likely be due to toxicity caused by the plant secondary metabolites (PSM) present in EC leaves. The presence of these PSM led to increased metabolic activities of the organs in an attempt for these organs to reduce these toxic PSM to non-toxic forms. This confirmed earlier published reports by Bone (1979), Ahamefule (2005), Odoemelam *et al*. (2014) and Ukanwoko and Okpechi (2016).

The external offal (expressed as percentage of empty body weight) of WAD bucks fed concentrate diets containing graded levels of *Enterolobium cyclocarpum* leaves are shown on Table 10. The weight of the heads (15.62, 15.76 and 12.91%) of bucks fed diets 1, 2 and 3, respectively did not differ significantly (p>0.05). The weight of head (17.86%) for bucks fed diet 4 was similar (p>0.05) to those of diets 1 and 2 but higher (p<0.05) than the 12.91% obtained from diet 3 group. The weight of skin ranged from 15.85 to 14.04% and was significantly higher for bucks fed diet 1 than those fed diets 2, 3 and 4. The fore shank and hind shank weights ranged from 2.62 to 3.51% and 2.93 to 3.79%, respectively with diet 4 having the highest (p<0.05) values of 3.51 and 3.79%, respectively. There was no significant difference (p>0.05) in the weight of the right (0.55, 0.63, 0.58 and 0.62%) and

Table 10. External offal (expressed as percentage of empty body weight) of WAD bucks fed concentrate diets containing graded levels of *Enterolobium cyclocarpum* leaves.

Parameters (%)	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Head	15.62[ab]	15.76[ab]	12.91[b]	17.86[a]	0.69
Skin	15.85[a]	14.22[b]	14.05[b]	14.54[b]	0.27
Right testis	0.55	0.63	0.58	0.62	0.04
Left testis	0.56	0.64	0.61	0.65	0.04
Fore shank	2.79[b]	2.84[b]	2.62[b]	3.51[a]	0.12
Hind shank	2.93[b]	2.94[b]	3.02[b]	3.97[a]	0.15

[a, b] Mean in the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Table 11. Internal offal (expressed as percentage of empty body weight) of WAD bucks fed concentrate diets containing graded levels of *Enterolobium cyclocarpum* leaves.

Parameters (%)	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Trachea	0.32[b]	0.41[ab]	0.39[ab]	0.51[a]	0.03
Rumen	4.20[ab]	4.52[ab]	3.63[b]	4.93[a]	0.21
Reticulum	0.66[bc]	0.72[ab]	0.52[c]	0.89[a]	0.05
Omasum	0.77	0.78	0.65	0.82	0.04
Abomasum	0.93[b]	1.15[b]	1.16[b]	1.82[a]	0.12
Esophagus	0.42	0.36	0.44	0.55	0.03

[a,b,c] Mean in the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

Table 12. Sensory characteristics of buck loin meat (chevon) fed graded levels of *Enterolobium cyclocarpum* leaves.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	SEM
Aroma	4.13[a]	3.32[ab]	3.70[a]	2.60[b]	0.21
Colour	5.53	5.15	4.83	3.50	0.40
Flavour	5.37[a]	4.06[bc]	4.67[ab]	3.65[c]	0.23
Juiciness	5.17[ab]	5.37[ab]	6.07[a]	4.00[b]	0.34
Tenderness	5.20[ab]	5.68[ab]	6.03[a]	4.20[b]	0.29
Overall acceptability	6.13	5.88	5.83	5.15	0.17

[a,b,c] Mean in the same row with different superscripts are significantly different (p<0.05). Diet 1 = 0% *Enterolobium cyclocarpum* (EC) leaves inclusion concentrate diet. Diet 2 = 7.50% EC leaves inclusion concentrate diet. Diet 3 = 15% EC leaves inclusion concentrate diet. Diet 4 = 22.50% EC leaves inclusion concentrate diet. SEM = Standard error of mean.

left (0.56, 0.64, 0.61, 0.65%) testes of the bucks.

Table 11 shows the internal offal (expressed as percentage of empty body weight) of WAD bucks fed concentrate diets containing graded levels of *Enterolobium cyclocarpum* leaves. Significant differences (p<0.05) were obtained in the trachea (0.32, 0.41, 0.39 and 0.51%), rumen (4.20, 4.52, 3.63 and 4.93%), reticulum (0.66, 0.72, 0.52 and 0.89%) and abomasum (0.93, 1.15, 1.16 and 1.82%) weight of bucks fed diets 1, 2, 3 and 4, respectively. The internal offal weight of bucks fed diet 3 (15% EC leaves) were lower than or in the same weight range with bucks fed the control diet. Higher internal offal weights signifying higher metabolic activities were recorded for bucks fed diet 4 (Odoemelam *et al*., 2014; Ukanwoko and Okpechi, 2016).

The sensory characteristics (aroma, colour, flavour, juiciness, tenderness and overall acceptability) of buck loin meat fed graded levels of *Enterolobium cyclocarpum* leaves are shown on Table 12. While there were significant differences (p<0.05) in aroma (4.13, 3.32, 3.70 and 2.60), flavour (5.37, 4.06, 4.67 and 3.65), juiciness (5.17, 5.37, 6.07 and 4.00) and tenderness (5.20, 5.68, 6.03 and 4.20) of the meat of bucks fed diets 1, 2, 3 and 4, respectively, there were no significant differences (p>0.05) in the colour and overall acceptability of the meat. The meat of bucks fed diet 3 was adjudged best in most of the sensory parameters (aroma, flavor, juiciness and tenderness) assessed.

Conclusion

The diets were rich in protein, nitrogen free extract and neutral detergent fibre, but low in acid detergent lignin and anti-nutritional factors. Bucks fed concentrate diet containing 15% EC leaves (diet 3) performed better in terms of average final body weight, fasted weight, hot and chilled carcass weight. Reduced internal organs weight comparable with those fed the control diets were observed in bucks fed 15% EC leaves diet (diet 3). Meat from bucks fed diet 3 was also adjudged the best with regard to aroma, flavor, juiciness and tenderness. Therefore, dietary EC leaves for WAD goats should not exceed 15% for better growth performance, carcass yield and sensory characteristics.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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