Nigerian J. Anim. Sci. 2021, 23 (3): 244-257

Performance, carcass and meat traits of grasscutters (Thryonomys swinderianus) fed diets of different protein sources in captivity

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Target Audience:

Abstract

The study investigated the effects of supplementing Soybean meal (SBM), Locust bean meal (LBM) and Melon seed meal (MSM) which are protein sources on performance, carcass and meat traits of grasscutters in captivity. A total of 30 grasscutters – 6 families of 24 females and 6 males weaners of age between 3 and 4 months of 600 to 680g weight range were used for this study. They were quarantined and raised in cages partitioned with wire mesh and necessary medications were given. Three iso-proteinous diets were prepared from fermented SBM, LBM and MSM with Basal diet as control and mixed with chopped cassava tubers dried to 12% moisture content and pelleted. The grasscutters were randomly allocated into 3 treatments diets and the control thus; T0 = Control, T1 = Diet with SB, T2 = Diet with LB and T3 = Diet with MS. They were fed for 124days with 150g of feed for 2 months and was increased to 250g for last four months, water was given ad-libitum. 12 animals were randomly selected, slaughtered and fabricated, meat samples were excised from leg cut for meat analysis. Data were analysed with ANOVA in a completely randomized experiment, significant means were separated at ($p<0.05$) with Duncan multiple range test. Performance, body morphometric, carcass profile, primal cuts, offals, meat physical, proximate and sensory characteristics values were higher ($p<0.05$) in T2 followed by T1 and least ($p<0.05$) in T3. Therefore, LBM was recommended for supplementing diets as a source of protein furnishing higher performance in grasscutters.

***Key words:** Captivity, carcass and meat, diet protein sources, grasscutters, performance.*

Description of Problem

Several attempts have been made to increase the production of existing breeds of ruminants with fairly significant progress. One major factor contributing to this is the nature or types of breed of animals raised in sub-saharan Africa, as tropical animals are characterised by small birth weights, slow growth rates and relatively small maturing weights (1). Another factor according to (2) hindering the production of livestock in sub-saharan Africa is nutrition. The most critical livestock feed stuffs are those that supply protein and energy. This is because the cereal grains and legumes that are used as livestock feeds serve as staple food for most population of the world (3). Grasscutter is being developed as micro-livestock species for meat production in most West African Countries as it is found to be hardy, highly prolific and eats a wide range of feedstuffs (4). Many researchers had attempted to determine the protein requirement of grasscutter which included (5) who reported that a dietary protein of 4.6% was adequate to meet maintenance requirements of grasscutter while (6) suggested a supplementary ration of concentrate with crude protein of 17% for proper grasscutter growth. There is the need to prepare complete diets with known crude protein level and caloric value from available feedstuff that can supply protein which when fed to grasscutter would help to determine the correct level of protein needed for optimum growth and performance such as locust beans (Pakiabiglobosa) with a protein level of 30% (7), Melon (Citrullus lamatus) with 23.4% crude protein (8) and Soybeans (Glycine max.) with 37.5% protein according to (9). This study therefore, aimed at evaluating the body measurements, performance, carcass and meat traits of grasscutters (Thryonomysswinderianus) in captivity fed diets prepared from soybeans, locust beans and melon seeds as sources of protein.

Materials and Methods

This study was carried out at the Teaching and Research Farm of the Olabisi Onabanjo University, Ayetoro Campus, Ogun State.

Experimental animals

A total of 30 grasscutters (6 families) consisting of 24 females and 6 males weaners of age between 3 and 4 months with weight between 600 and 680grams.They were purchased from a Shonghai farm in Cotonou, Benin Republic and transported to the Research Farm. They were quarantined and raised in cages partitioned with wire mesh and necessary medications were given them. Six cages were constructed each containing four females and one male.

Experimental diets

Three iso-proteinous diets were prepared from fermented Soybean (SB), Locust Beans (LB) and Melon Seeds (MS) following the procedures described by (10), while the fourth diet was basal diet (control). Each of the test protein meal was mixed with chopped and milled cassava tubers dried to 12% moisture content and compounded into pellets form.

Experimental procedure

Seven grasscutters were randomly allocated into 4 treatment diets of T0 = Control, T1 = Diet with Soybean Meal (SBM), T2 = Diet with Locust Bean Meal (LBM), T3 = Diet with Melon Seed Meal (MSM) as shown in Table 1.

One-week preliminary feeding trial was conducted to introduce the grasscutters to the dietary treatments, while the actual experimental period lasted for 124days. The grasscutters were fed twice each day 07hours GMT and 17hours GMT Nigerian time. One hundred and fifty grams (150g) were fed to each of the grasscutter each day for the first 2 months supplemented with Panicum maximum and was increased to two hundred and fifty grams (250g) for third and fourth months, while water was supplied ad-libitum throughout the experimental period.

Data Collection

1. Performance characteristics

The performance traits of experimental grasscutters measured included the initial and final body weight, total weight gain, average forage and concentrate intake, total feed intake and Feed Conversion Ratio (FCR) following the procedures of (6).

2. Morphometric profile of experimental grasscutters

The body morphometric measurements taken included: The lengths of head, trunk, tail, the entire body length, the length of fore limb, hind limb, ear and width of ear height at wither and height at girth following the procedures of (12).

3. Slaughter of animals and fabrication of Carcasses

At the end of the feeding trial (124days) 3 animals; 2 females and 1 male on each of the diet totalling 12 were randomly selected and fasted for 16 hours, slaughtered and the carcasses fabricated to primal cuts – Leg, loin, shoulder, breast, rack and flank and their weights measured following the procedures of (11).

(a) Carcass slaughter offals and organ profile of grasscutters
The carcass profile of the grasscutters measured were the bled weight dressed carcass weight, dressing percentage or yield, chilled carcass weight, chilling loss and carcass length while the offals included the external and internal offals and organs according to (13).

(b) Primal cuts of grasscutters
The primal cuts measured were the thigh weight and length, loin weight and length, shoulder weight and length, rack weight and length, the breast weight and length and flank weight and length following the methods of (11).

4. Physical Properties of Meat

(a) Cooking loss
This was carried out by boiling 10 g and 6 cm of meat samples from Leg was boiled for 20 minutes at 72°C at the geometric centre of the meat and were allowed to cool and reweighed according to (14) thus cooking loss was calculated as:

$$\frac{\mathrm{Mwt}_1 - \mathrm{Mwt}_2}{\mathrm{Mwt}_1} \times 100$$

Where: Mwt_1 = Initial Weight of Meat
Mwt_2 = Final Weight of Meat

(b) Cooking Yield
Cooking yield was calculated according to (15) as 100 – Cooking Loss (%)

(c) Drip Loss
The drip loss of meat was determined according to the procedures of (16). 10g of meat samples from the loin were wrapped and suspended in polythene bags and hung in a refrigerator at 4°Cfor 48hours for the juice to drain and were reweighed. Drip loss was calculated thus:

$$\frac{(\mathrm{Wp}+\mathrm{j})-(\mathrm{Wp})}{(\mathrm{Wp}+\mathrm{m})-(\mathrm{Wp})} \text{ x } 100$$

Where: Wp + j = Weight of Pack + Juice
Wp = Weight of Pack
Wp + m = Weight of Pack + Meat

d. Thermal shortening
This meat variable was determined using the same meat samples for cooking loss according to (13). The meat samples with initial length of 6cm were remeasured after boiling and the thermal shortening calculated thus:

$$\frac{\mathrm{ML}_1 - \mathrm{ML}_2}{\mathrm{ML}_1}\ x\ 100$$

Where: ML_1 = Meat Initial Length
ML_2 = Meat Final Length

e. Cold shortening
This variable was determined according to (17) by placing 6cm long meat samples from the loin into a deep freezer at -180°C for 48 hours and the percentage reduction in length was calculated as done for thermal shortening.

$$\frac{\mathrm{ML}_1 - \mathrm{ML}_2}{\mathrm{ML1}}\ x\ 100$$

f. Water Holding Capacity (WHC)
This was determined as expressible juice following the method prescribed by (18). Approximately 1g of meat sample was placed between two pre-weighed 9cm Whitman No. 1 filter papers (Model C, Caver Inc. Wabash USA). The meat sample and the filter papers were pressed between two 10.2 x 10.2cm^2 plexiglass at about 32.5kg/cm^2 absolute pressure for 1minute

with a vice. The wet filter papers were reweighed and WHC was calculated thus:

$$\frac{\text{Wwp}-\text{Wdp}}{\text{Wdp}} x100$$

Where: Wwp = Weight of Wet Papers(g)
Wdp = Weight of Dry Papers(g)

g. Shear Force Value of Meat

The meat samples shear force values were determined following the procedures of (14) and (19). 10g of meat samples were arranged in polythene bags and boiled for 20minutes in a pressure pot on a PITCO Japan Electric hot plate (Model No ECP 202) to an internal temperature of 72^{o}C. The meat samples were cooled to room temperature (26.7^{o}C) and not reweighed, were wrapped in polythene bags and chilled at 4^{o}Cfor 18 hours. They were removed and allowed to equilibrate to room temperature (26.7^{o}C) and 1.25cm diameter cores parallel of muscle fibre orientation made and were sheared at three locations with WarnerBratzler V-Notch blade shearing instrument and the average shear values were recorded for each treatment.

h. Proximate Composition of Meat

The proximate composition of meat samples was determined following the procedures described by (20). Moisture content of meat was determined by drying 2g of meat sample from each treatment in an oven at 100 – 105^{o}C until constant weight was achieved. Crude protein was determined through Khjedahl methods which included: Digestion, distillation and titration of the distillates. The value of protein was derived by converting Nitrogen (N %) content of the distillation with a constant (6.25) thus, protein values were obtained as (6.25 x N %). Meat fat (Ether Extract) was determined with Soxhlet extraction method using Petroleum ether. The meat samples were dried in an oven for 4hours at 105^{o} and fat was extracted with soxhlet apparatus. Ash content of meat samples was determined by igniting dried meat in a muffle furnace at 550 – 600^{o}C for 24hours until ashes were formed. The Nitrogen free extract values were obtained by mathematical computation. The total values of moisture, crude protein, ether extract and ash were subtracted from 100% (100 – proximate value). The meat pH was determined by homogenizing 10g of meat sample for 5minutes with 90ml of distilled water using a laboratory blender (Plate 5mm Model 242, Nakai, Japan). The pH of meat was measured with a pH meter model H-18424 micro-computer, Havana Instruments, Romania following the procedures of (21).

Organoleptic Properties of Meat

The organoleptic characteristics of rabbit meat were determined using a 10-member semi-trained taste panel according to (22). The taste panellists were drawn from students and staff in the Department of Animal Production, Olabisi Onabanjo University, Ayetoro Campus of age ranging between 19 and 45 years with partial organoleptic measurement experience. They were provided with unsalted biscuits and water for use in between tasting of meat samples during the sessions. Meat samples were coded and boiled at 107^{o}C for 20 minutes. The meat samples were cooled and served to the panellist on clean saucer and were evaluated independently of the other on a 9-point hedonic scale on which 1 = disliked extremely and 9 = liked extremely for colour, flavour, tenderness, juiciness, texture and overall acceptability of the meat.

Experimental design and statistical analysis

This study was conducted based on Completely Randomized Design (CRD) and all the data collected were analysed with analysis of variance (ANOVA) at ($p<0.05$) using (23) and significant means were separated with Duncan multiple test of the same software.

Results and Discussion

Table 1 shows the ingredient composition of the experimental diets fed to the grasscutters. The protein and energy components of the diets were shown in the table.

Table 1: Ingredients composition of experimental diets

	Treatment Diets			
Ingredients	T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)
Cassava Flour Meal	80	70	70	70
Soybean Meal	-	10	-	-
Locust bean Meal	-	-	10	-
Melon Seed Meal	-	-	-	10
Palm Kernel Cake	15	15	15	15
Vitamin Premix	0.5	0.5	0.5	0.5
Bone Meal	2.0	2.0	2.0	2.0
Urea	2.0	2.0	2.0	2.0
Salt	0.5	0.5	0.5	0.5
Total	100.0	100.0	100.0	100.0
Calculated Values				
Moisture	9.31	9.33	9.32	9.18
Crude Protein	9.93	18.50	16.18	14.58
Ether Extract	0.92	1.34	1.61	1.18
Ash	6.59	6.86	5.11	6.47
Crude Fibre	9.93	12.28	9.31	11.16
Energy (Mj/kg ME)	11.32	11.45	12.14	12.04
*Protein Energy Ratio	0.9:1	1.6:1	1.3:1	1.2:1

*Premix to supply Vitamin A, D, E, K and B_{12}, Pantothenic acid Niacin, Folic Acid, Biotin, 0.36mg. Chloride, 120mg. Antioxidant, Manganese, 24mg. Zinc, 96mg. Cobalt, 0.4mg. Iron, 48mg. Copper, 60mg. Chlortetracycline, 48mg. Iodine, 1.8mg. and Selenium

SBM = Soybean Meal, LBM = Locust Bean Meal, MSM = Melon Seed Meal

Performance characteristics of grasscutter

Table 2 shows the results of the performance of the grasscutter fed diets of different protein sources. The final body weight, total weight gain, average forage, concentrate and total feed intake were higher ($p<0.05$) in grasscutter fed LBM based diet followed by those fed control diet (T0), while those fed diet T3 had the least ($p<0.05$) performance characteristic values.

Table 2: Performance characteristics of grasscutters fed diets of different protein sources

Variable	Treatment Diets T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)	SEM
Initial Body wt. (g)	615.00	620.00	620.00	618.00	25.16
Final Body wt. (g)	1335.00^{b}	1083.00^{c}	1430.00^{a}	1025.00^{d}	46.09
Total wt. gain(g)	715.00^{b}	568.00^{c}	810.00^{a}	457.00^{d}	24.8b
Ave. Forage Intake(g)	297.37^{b}	265.41^{c}	302.38^{a}	252.16^{d}	0.16
Ave Conc. Intake(g)	76.51^{b}	74.45^{c}	78.57^{a}	64.39^{d}	9.53
Total Feed intake(g)	373.88^{b}	340.25^{c}	380.95^{a}	307.05^{d}	0.16
Feed Conversion Ratio	1.38	1.92	2.13	1.32	0.02

Means on the same row with different superscripts are statistically significant ($p<0.05$)
SBM = Soybean Meal, LBM = Locust Bean Meal, MSM = Melon Seed Meal, Ave. Conc. Intake = Average Concentration Intake

It was obvious that the grasscutters fed diet T2 elicited higher performance in all the variables measured. This could be due to the fact that they consumed more of the diet than other diets as shown on Table 2. Locust beans are known to be palatable when well processed and Soybean has a slightly bitter taste while melon seeds are not sweet in taste. These could be responsible for lower total feed intake recorded for animals fed diets T1 and T3. These results were in agreement with the findings of (6) who reported the effect of protein supplementation on live weight gains in captive grasscutters.

Body morphometric values of grasscutters

The results of body morphometric values of grasscutters are presented in Table 3. All the body parts of grasscutters measured were higher ($p<0.05$) in grasscutters fed diet T2 except, the head, limbs, and the ears that had values similar to those of grasscutters on control diet (T0) while those on diet T3 had almost the least ($p<0.05$) values in body, tail and trunk lengths.

Table 3: Body morphometric values of grasscutters fed diets of different protein sources

Variable	Treatment Diets T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)	SEM
Head Length (cm)	9.01^{a}	8.01^{b}	9.54^{a}	8.37^{b}	0.03
Body Length (cm)	44.45^{b}	44.56^{b}	48.31^{a}	40.23^{c}	0.03
Tail Length (cm)	13.08^{ab}	12.61^{b}	13.61^{a}	11.54^{c}	0.04
Trunk Length (cm)	22.55^{b}	22.55^{b}	25.02^{a}	20.32^{c}	0.04
Heart Girth (cm)	22.79^{b}	23.76^{b}	27.42^{a}	22.07^{b}	0.68
Height at Wither (cm)	11.37^{a}	11.48^{b}	12.95^{a}	9.77^{b}	0.02
Fore Limb (cm)	13.11^{a}	12.29^{b}	13.28^{a}	12.14^{b}	0.04
Hind Limb (cm)	15.41^{a}	14.32^{b}	15.63^{a}	14.22^{b}	0.03
Ear Length (cm)	3.00	3.01	3.00	2.41	0.04
Ear Width (cm)	2.34	2.32	2.29	2.00	0.02

Means on the same row with different superscripts are statistically Significant ($p<0.05$)
SBM = Soybeans Meal, LBM = Locust Beans Meal, MSM = Melon Seeds Meal

Morphometric studies are very important for determining or predicting the amount of meat or meatiness in any particular animal. In this study, the grasscutters fed diet containing locust bean meal (T2) had highest body morphometric values closely followed by those fed Soybean and control diets, while those fed melon seed meal differed at body, tail and trunk lengths but had the same values statistically with those of grasscutters fed other diets. However, grasscutters fed control diet had the same values of hind and fore limbs with those fed locust bean diet but there were no significant differences in the values of ear length and width of grasscutters across all the tested diets. The values obtained in this study on morphological traits of grasscutters were very close to those reported by other previous workers that heart girth and body length were the best predictors of body weight (24;12;25;26).

Carcass profile of grasscutters

The results of carcass profile of grasscutters fed diets of different protein sources are shown on Table 4. Grasscutters fed T2 had higher ($p<0.05$) live, bled, dresses and chilled weight values as well as carcass length except the chilling loss that was significant ($p>0.05$) across the animals put on different diets. Those animals put on T3 recorded the least ($p<0.05$) carcass profile followed by those fed diet T1.

Table 4: Carcass profile of grasscutters fed diets of different protein Sources

	Treatment Diets				
Variable	T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)	SEM
Live wt. (g)	1,361.00^{b}	1,107.00^{c}	1,458.00^{a}	1,048.00^{d}	51.64
Bled wt. (g)	1,307.30^{b}	1,058.30^{c}	1,408.30^{a}	1,001.00^{d}	41.68
Dressed Carcass wt. (g)	762.70^{b}	600.00^{c}	925.00^{a}	553.30^{d}	1.09
Dressing Percentage (%)	57.38^{b}	55.40^{c}	64.69^{a}	44.22^{d}	8.10
Chilled Carcass wt. (g)	747.70^{b}	587.00^{c}	907.00^{a}	475.30^{d}	25.00
Chilling Loss (%)	1.97	2.17	1.85	2.42	0.01
Carcass Length (cm)	26.33^{b}	25.27^{c}	28.46^{a}	23.07^{d}	0.13

Means on the same row with different superscripts are statistically Significant ($p<0.05$)
SBM = Soybeans Meal, LBM = Locust Beans Meal, MSM = Melon Seeds Meal

The carcass profile of an animal is related to the morphometric values of the animal, because the meat composition of the carcass is a result of the degree of morphometric development of the animal's body. Table 4 shows the results of carcass profile of grasscutters fed diets of different protein sources. Grasscutter fed diet (T2) developed highest carcass profile followed by those fed control diet (T0) than those fed diets T1 and T3. This could be that they consumed more of diet because the flavour of the diet was higher than others as a result of high nutrient digestibility of diet T2 and consequently due to high feed intake. It had been reported that crude protein of a diet has effect on nutrients' digestibility (27). The dressing percentage reported in this study was relatively close to that reported by (28); (29) and (30).

Offals and organs characteristics of grasscutters

Table 5 presents the result of offals and organs characteristics of grasscutters fed diets of different protein sources. The animals fed diet T3 elicited the least (p<0.05) offals and organs characteristics, while those fed diet T2 had highest (p<0.05) offals and organs values followed by those fed control diet (T0).

Table 5: Offals/organs characteristics of grasscutter fed diet of different protein sources

Ingredients	Treatment Diets T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)	SEM
External Offals					
Head(g)	117.32[b]	112.27[c]	132.35[a]	105.55[d]	0.06
Tail(g)	10.24[b]	9.18[c]	13.45[a]	8.24[c]	0.01
Hind feed(g)	14.85[b]	13.78[c]	18.89[a]	11.52[d]	0.03
Fore feet(g)	4.79[b]	3.26[c]	5.86[a]	3.14[c]	0.01
Skin(g)	21.34[b]	18.25[c]	24.42[a]	15.12[d]	0.10
Internal Offals					
Liver(g)	24.76[b]	23.70[c]	25.83[a]	21.08[d]	0.01
Kidney(g)	5.18[b]	5.30[b]	7.47[a]	4.11[c]	0.01
Heart(g)	6.29[b]	5.20[c]	7.94[a]	4.16[d]	0.00
Lungs(g)	8.64[b]	6.32[c]	10.80[a]	5.23[d]	0.00
Spleen(g)	1.29	1.53	1.96	1.03	0.02
Full GIT(g)	200.75[b]	185.71[c]	300.14[a]	150.74[d]	0.16
Full LI(g)	175.20[b]	150.90[c]	250.10[a]	145.10[d]	0.12
Empty LI(g)	30.39[b]	27.11[c]	32.59[a]	26.43[d]	0.01
Full SI(g)	16.92[b]	15.40[c]	18.96[a]	14.05[d]	0.01
Empty SI (g)	11.75[b]	10.29[c]	12.91[a]	9.09[d]	0.24

Means on the same row with different superscripts are statistically Significant (p<0.05)
GIT = Gastro-Intestinal Tract, LI = Large Intestine, SI = Small Intestine

Table 6: Primal cuts of grasscutters fed experimental diets from different protein sources

Ingredients	Treatment Diets T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)	SEM
Thigh weight(g)	200.11[b]	195.20[c]	230.10[a]	125.01[d]	0.00
Thigh Length(cm)	10.23[b]	9.10[c]	11.37[a]	7.03[d]	0.33
Loin weight(g)	225.19[b]	200.12[c]	250.65[a]	150.66[d]	0.12
Loin Length(cm)	15.25[b]	13.12[c]	17.73[a]	10.07[d]	0.17
Shoulder weight(g)	105.64[b]	95.24[c]	125.11[a]	78.64[d]	0.03
Shoulder length(g)	11.10[b]	9.60[c]	12.17[a]	8.45[d]	0.22
Rack weight(g)	110.12[b]	100.30[c]	115.21[a]	96.15[d]	1.52
Rack Length(cm)	13.17[b]	12.10[c]	15.20[a]	10.13[d]	1.20
Breast weight(g)	61.23[b]	50.15[c]	75.26[a]	47.10[d]	0.16
Breast length(cm)	9.47[b]	7.52[c]	12.40[a]	5.53[d]	0.05
Flank Weight(g)	50.57[b]	45.07[c]	65.12[a]	41.01[d]	0.03
Flank Length(cm)	8.70[b]	6.56[c]	9.83[a]	5.30[d]	0.22

Means on the same row with different superscripts are statistically significant (p<0.05)
SBM = Soybean Meal, LBM = Locust Beans Meal, MSM = Melon Seeds Meal

It was obvious that both external and internal offal values were higher in grasscutters fed diet T2 followed that those fed control diet (T0) and were least in those fed dietT3. The results could be that animals consumed more of diets T2 and T3 which culminated in high nutrient digestibility of diets T2 and T3 as it was obtained in carcass profile results. The results recorded in this study were very similar to those reported by (27).

Primal cuts of grasscutters

The same pattern of results in Table 5 were obtained in the results of grasscutters primal cuts in Table 6. Those animals fed diet T2 recorded highest ($p<0.05$) primal cuts, followed by those fed control diet, while those fed diet T3 had the least ($p<0.05$) primal cut values.

The primal cuts weights of grasscutters fed diets containing different protein sources followed the similar pattern recorded for carcass profile (Table 6). The primal cuts' values of grasscutters fed diet T2 were significantly higher than those in other treatments, simply because the animals fed diet T2 recorded higher feed intake which resulted in high nutrient intake and higher body size hence, higher muscle development in the animals (30). Thigh cut had highest weight followed by loin cut, while flank had the least value, but loin cut was longest, in all the cuts, while flank had shortest length. The weight of primal cuts determines the level of premium placed on the cuts. Most consumers placed higher premium on the loin cut as the muscle therein is relatively tender than those found in other wholesale cuts and in this study, the value of loin cut weight and length were higher in grasscutters fed diet T2 compared to loin cuts of other grasscutters' carcasses. Similar results were reported by (31).

Meat physical characteristics of grasscutters

Table 7 shows the results of physical properties of grasscutters meat. Meat from animals fed control diets showed the most ($p<0.05$) detrimental characteristics, followed by meat from those fed diet T3, while meat from animals fed diet T2 furnished the most ($p<0.05$) advantageous characteristics having highest ($p<0.05$) cooking yield (87.76%) and Water Holding Capacity (WHC) (67.21%).

Table 7: Meat physical characteristics of grasscutters fed diets of different protein sources

	Treatment Diets				
Variable	T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)	SEM
Cooking loss(%)	16.43^{a}	14.36^{c}	12.24^{d}	15.37^{b}	0.03
Cooking yield(%)	83.57^{d}	85.64^{b}	87.76^{a}	84.63^{c}	1.87
Drip Loss(%)	21.35^{a}	19.16^{c}	16.22^{d}	20.25^{b}	1.68
Thermal Shortening(%)	22.67^{a}	20.00^{c}	15.01^{d}	21.00^{b}	0.00
Cold Shortening(%)	18.32^{a}	16.27^{c}	14.03^{d}	17.37^{b}	0.07
WHC (%)	60.20^{c}	61.50^{b}	67.21^{a}	52.53^{d}	
Shear Force (kgcm^3)	5.45^{a}	4.10^{b}	3.00^{c}	4.31^{b}	0.24

Means on the same row with different superscripts are statistically significantly ($p<0.05$)
SBM= Soybean Meal, LBM = Locus Bean Meal, MSM = Melon Seed Meal, WHC = Water Holding Capacity

The cooking yield of meat from grasscutters fed dietT2 was very high probably due to the fact that the cooking and drip losses, thermal and cold shortening were relatively lower than in meat of other treatments also, the Water Holding Capacity (WHC) was higher in meat from grasscutters fed diet T2, which could have contributed to the higher value of cooking yield obtained for treatment 2. The shear force value was also very low compared to the values obtained for shearforce in other treatments. Since cookingand drip losses, thermal and cold shortening were low in the meat of grasscutters fed locust bean meal, that could result in tougher meat, more so, the WHC was relatively higher in the meat as the juice retained in it greatly enhanced the tenderness of the meat. Similar result was recorded by (32) who worked on the effect of feeding graded levels of palm kernel meal diets on performance carcass quality and organ characteristics of pigs.

Meat proximate composition of grasscutters

The results of the proximate composition of meat from grasscutters fed diets of different protein sources are presented in Table 8. The moisture content was highest ($p<0.05$) in meat from animals fed control and T3 diets (71.15%) and (71.10%), while meat from animals fed T1 and T2 had similar ($p<0.05$) moisture content (70.00%). Crude protein was higher ($p<0.05$) in meat from animals fed diet T1 and T2 with 23.33% and 23.27% respectively; while meat from animals fed diet T3 had highest ($p<0.05$) fat (5.73%). Nitrogen Free Extract (NFE) was high and similar ($p>0.05$) in meat from animals fed control and T2 diets, while meat from those fed diet T3 had the least ($p<0.05$) NFE and no significant ($p>0.05$) difference in the pH of meat across the meat of animals on different treatment diets.

Table 8: Meat proximate composition and pH of grasscutters fed diets of different protein sources

	Treatment Diets				
Variable	T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)	SEM
Moisture(%)	71.15^{a}	70.00^{b}	70.00^{b}	71.10^{a}	0.28
Crude Protein(%)	20.37^{c}	23.33^{a}	23.27^{a}	21.42^{b}	0.79
Ether Extract(%)	4.60^{b}	3.50^{c}	3.20^{c}	5.73^{a}	0.22
Ash(%)	1.20	1.60	1.23	1.63	0.27
NFE	2.68^{a}	1.57^{b}	2.30^{a}	0.12^{c}	0.04
pH	5.70	5.50	5.50	5.70	0.01

Means on the same row with different superscripts are statistically significantly ($p<0.05$)
SBM= Soybean Meal, LBM = Locus Bean Meal, MSM = Melon Seed Meal, NFE = Nitrogen Free Extract

Crude protein values were higher and similar in meat from both grasscutters fed diets T1 and T2 followed by those fed with diet T3 and least in those fed control diet (T0), this could be because moisture content in the meat of grasscutter fed diets T1 and T2 were lower but compared favourably with what was obtained in treatments 0 and 3. The relationships between moisture of protein in meats is inversely related (17) therefore, the results obtained from this study showed similar relationship according to (33) who reported that high level of moisture content in meat was an indication of tenderness and the range of moisture 70.00 to 71.15% showed that grasscutter meat would tender.

The moisture content of grasscutter meat observed in this study were higher than that of Yankasa rams according to (34). The fat content of grasscutter meat is low while the protein content is high especially in the meat of grasscutters fed diets T1 and T2 probably because the protein levels in the diets T1 and T2 were very high which agreed with the report of (27) which stipulated that the differences in crude protein of raw meat of animals of the same species could be attributed to age of the animals and the type of diet fed to them. The crude protein content of grasscutter meat is high which compared favourably with other conventional livestock which indicates that if grasscutter rearing is fully integrated into the mainstream of animal production, it would boost protein consumption (35).

The pH level of grasscutter meat ranged between 5.50 to 5.70 with grasscutter fed diets T1 and T2 meats having 5.50 which compared well with normal meat pH (5.4 – 6.3) according to (36) who reported that pH range of 5.4 to 6.4 is normal and regarded as ultimate pH which indicates the cessation of glycolysis and production of Adenosine Triphosphate (ATP) and the onset of rigour mortis. The pH level of grasscutter meat suggests that the meat could be kept for a relatively longer periods that is, long shelf-life, because the rate of microbial growth and action in meat reduces with decreasing pH level.

Meat organoleptic characteristics of grasscutters

Table 9 shows the results of organoleptic characteristics of meat from grasscutters fed diets of different protein sources. Cooked rabbit meat colour was highest ($p<0.05$) in meat from animals fed control, T1 and T3 diets, while it was lower ($p<0.05$) in meat from animals fed diet T2. The meat flavour, juiciness, texture and overall acceptability scores were higher ($p<0.05$) in meat from animals fed diet T2, while tenderness score was highest ($p<0.05$) in meat of animals fed diet T3, while texture and overall acceptability were lower ($p<0.05$) in both meat of animals fed control diets and T3 respectively.

Table 9: Meat organoleptic characteristics of grasscutters fed diets of different protein sources

	Treatment Diets				
Variable	T0 (Control)	T1 (SBM)	T2 (LBM)	T3 (MSM)	SEM
Colour	7.67^{a}	7.63^{a}	6.59^{b}	7.67^{a}	0.13
Flavour	6.27^{b}	5.40^{c}	7.65^{a}	6.53^{b}	0.34
Tenderness	6.10^{c}	6.42^{c}	7.10^{b}	8.10^{a}	0.15
Juiciness	6.17^{b}	6.53^{b}	7.70^{a}	6.40^{b}	0.19
Texture	6.20^{c}	7.27^{b}	8.30^{a}	6.27^{c}	0.18
OA	7.53^{b}	7.50^{b}	8.73^{a}	6.45^{c}	0.18

Means on the same row with different superscripts are statistically significantly ($p<0.05$)
SBM= Soybean Meal, LBM = Locus Bean Meal, MSM = Melon Seed Meal, OA = Overall Acceptability

The taste panel scores for grasscutter meat showed that meat from grasscutters fed locust bean meal (dietT2) furnished higher sensory properties with exception of colour and tenderness (Table 9) which were also very close to the highest score in meat from diet T3 and compare with the control treatment (T0). The higher score obtained for meat from grasscutters fed diet T2 on overall acceptability might have been based on the totality of contribution of other eating factors such as colour that was relatively high,flavour, juiciness and texture as well as the relatively high tenderness which might have been brought about by high protein, water holding capacity and moisture contributed to the flavour and juiciness of the meat (37). Also, colour or appearance contributes immensely to acceptability of meat because it really beckons to the consumers to purchase the meat if the colour is intensive or not to purchase the meat when the colour is absolutely dull or unattractive (13).

Conclusion and Applications

1. The results of this study showed that supplementation of cassava flour meal with 10% locust bean meal furnished higher performance, carcass and meat characteristics in grasscutter than supplementing cassava meal with either Soybean or Melon seeds with same percentage.
2. Therefore, locust bean meal is recommended for use in grasscuttter diets.

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