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Carcass characteristics and body linear measurements of Yankasa rams fed a mixed ration of Cowpea husk (*Vigna unguiculata* l. Walp) and Tiger nut (*Cyperus esculentum*) residue

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ABSTRACT

The carcass characteristics, body linear measurements, and cost-benefit analysis for Yankasa rams fed varying levels of cowpea husk and tiger nuts residue were investigated in an experiment that lasted for 91 days. Thirty (30) rams with an initial average weight of 14.0±1.5 kg were randomly assigned to five (5) treatments in a completely randomised design with six (6) animals per treatment. Significant ($p<0.05$) differences were observed in the carcass characteristics and body linear measurements of Yankasa rams fed the mixed ration. Optimum carcass characteristics was observed in Yankasa rams fed 20% tiger nuts residue and 20% cowpea husk mixed rations, hence it is recommended that farmers should include 20% cowpea husk and 20% tiger nuts residue in diet formulation for fattening rams for good profitability.

Keywords: Yankasa rams, carcass, body linear measurement, cowpea husk, tiger nuts residue, cost-benefit

1. INTRODUCTION

Meat production is based on the growth production of the animal which depends on environmental factors and management practices (Akinleye et al., 2019). The carcass composition of various breeds differs considerably in terms of carcass weight, fat, muscle, and bone (Islam et al., 2019). Similarly, the non-carcass component which comprises all the internal organs, the gastrointestinal system, the skin, the feet, and the head has also gotten little to no attention as a significant factor in the amount of animal protein consumed, particularly by rural residents (Omojola and Attah, 2006). In Nigeria, where livestock farming is a significant contributor to the agricultural sector, the Yankasa sheep breed holds a prominent position due to its adaptability and suitability for diverse ecological zones. Lambs grow very rapidly during the few months of life and may reach slaughter weight in less than half the time they were in the uterus.

The growth performance of sheep is influenced by breed, type of birth, sex, age, or parity of the dam, month or season of parturition, disease incidence, and management practices such as mortality, nutrition, and husbandry practice (Hassan, 2014). The proper utilization of feed resources is crucial in optimizing the productivity and profitability of Yankasa sheep farming (Sen et al., 2011). As the Nigerian livestock industry seeks sustainable practices and improved animal production, understanding the implications of utilizing unconventional feed resources is essential (Akinleye et al., 2019). One such potential feed source in Nigeria is the combination of cowpea husk and tiger nut residue, which offers an opportunity to enhance the overall performance of these animals. This therefore necessitated this study to gain insight into the effect of feeding Yankasa rams a mixed ration of cowpea husk and tiger nut residue on carcass characteristics, body linear measurements, and cost-benefit analysis.

2. MATERIALS AND METHODS

Experimental Site

The study was conducted at the small ruminant experimental unit of the National Open University of Nigeria (NOUN), Kaduna farm located at Latitude 10.61362 N10036147.692`` Longitude 7.46852 E 7028123.667`` at an altitude of 612.65 meters. The climate is tropical wet and dry, classified as Koppen Aw. The wet season lasts from April through to mid-October with a peak in August; while the dry season extends from mid-October of one calendar year to April the next year (Abaje et al., 2018). The spatial and temporal distribution varies, decreasing from an average of about 1,203 mm. The highest average air temperature occurs in April (28.90C) and the lowest in December (22.90C) through January (23.10C) (Abaje et al., 2016). The mean atmospheric relative humidity ranges between 70% – 90% and 25% – 30 % for the rainy and dry seasons respectively (Abaje et al., 2018).

Collection and Preparation of experimental diets

Tiger nuts residue was collected from women who process and make a local drink termed '*kunu aya*' and dried under shade to ensure that the moisture content is reduced. Dry cowpea husks were procured from the farmer's previous harvest and used to compound the experimental diets.

Experimental animals and their management

Thirty growing Yankasa rams between eight and ten months of age with an initial mean body weight of 14.0±1.5 kg were used for the study. The animals were obtained from an open livestock market in Makarfi Local Government Area of Kaduna State. The experimental pens and surroundings were cleaned and disinfected two weeks before the arrival of the animals. Upon arrival, the animals were given a prophylactic treatment consisting of intramuscular injection of a long-acting antibiotic, Oxytetracycline 20% LA at 1mL/10kg body weight, and subcutaneous injection of Ivermectin injection at 0.3ml/10kg body weight.

The animals were also vaccinated against *Peste des petits* ruminants (PPR) which was administered at 1ml/ram. The animals were housed individually in cages and allowed to adapt to the experimental environment for 14 days before the commencement of the experiment. The growing rams were randomized into five dietary treatments of six replicates per treatment to get a homogenous unit. A basal total mixed ration was formulated to meet the nutrient requirements of growing rams according to recommendations by.

Experimental Design and Treatments

All thirty (30) rams were weighed and randomly assigned to the five treatment diets while balancing their weight with six animals per treatment in a completely randomised design (CRD). The rams were housed in pens which were cleaned and disinfected with Septol.

Feeding trial

The complete diet was formulated with a fixed quantity of some ingredients based on values from the literature. After the feed formulation of the complete diets, the proximate analysis was carried out to determine the proximate composition of each treatment diet. The ingredient composition of the feeding trial diets is presented in (Table 1). A daily allowance of a complete diet was offered to the Yankasa Rams twice daily (in the morning and afternoon). Fresh and clean water was given *ad libitum*.

Intake and Performance

Daily feed intake was taken throughout the experiment by weighing the feed offered each day and the leftovers (orts) on the following day. Daily intake of the diets was estimated for each animal by subtracting the leftovers from the quantity served to the animal. The experiment lasted for 91 days. The weight of individual animals was measured at the onset of the trial and subsequently at weekly intervals (Mondays) between 8:00 am – 10:00 am throughout the feeding trial. Bodyweight (BW) was taken using the Salter hanging spring-type scale and measured to the nearest 0.5 kg. Heart girth (HG) was measured by taking the circumference of the chest using a tailor's tape calibrated in cm, taken as the circumference of the body immediately behind the shoulder blades in a vertical plane, perpendicular to the long axis of the body.

A rigid tape measure was used to determine, the body measurements, Corpus length (CL), measured as the distance from the point at the top behind the scapular to the base of the tail, height at withers (HW), measured as the distance from the ground to the withers, and height at rump (RH), measured as the distance from the ground to the rump. Chest girth (CG), head length, head width, and pin bone (PB).

Weight gain was determined by subtracting the initial weight from the final weight within the period.

Weight gain = Final weight – initial weight (Kg)

$$\text{Average daily weight gain (ADG)} = \frac{\text{weight gain}}{\text{number of days}}$$

The feed conversion ratio was determined by dividing feed intake by weight gain.

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed intake}}{\text{Weight gain}}$$

Carcass analysis

Three rams were randomly selected from each of the treatment groups following the termination of the feeding trial. The rams were starved of feed and water overnight to reduce the volume of gut contents before slaughter hence reducing the risk of contamination of the carcass during dressing. The animals were weighed before slaughtering to determine the slaughter weight. After slaughtering and evisceration, the animals were weighed to determine hot carcass weight. External offals such as head, tail, and skin were removed and weighed separately after slaughter. Following evisceration, the internal offals (liver, lung, heart, and spleen) were removed and weighed separately. The gastrointestinal tracts (GITs) were also measured. Total weight and meat composition were determined. The dressing percentage was determined using the method of.

$$\text{Dressing percentage} = \frac{\text{carcass weight}}{\text{Slaughter weight}} \times 100$$

Table 1 Ingredient composition (%) of the total mixed basal diet

Ingredient (%)	Treatment diets				
	T1	T2	T3	T4	T5
Cowpea husk	40.00	30.00	20.00	10.00	0.00
Tiger nut	0.00	10.00	20.00	30.00	40.00
Sorghum Stover	25.00	25.00	25.00	25.00	25.00
Wheat bran	24.00	24.00	24.00	24.00	24.00
Groundnut cake	10.00	10.00	10.00	10.00	10.00
Salt	0.50	0.50	0.50	0.50	0.50
Premix	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00

3. RESULTS AND DISCUSSION

Carcass characteristics of Yankasa Rams fed a mixed ration of cowpea husk and tiger nut residue

Significant differences ($p<0.05$) were observed in the carcass characteristics of Yankasa rams fed a mixed ration of cowpea husk and tiger nut residue (Table 2). The highest body condition score (BCS) was observed in Treatment 2 (3.00) and lowest in Treatment 3 (1.50). the highest starved live weight of 29.00kg was observed in Treatment 2 and the lowest in Treatment 3 (16.50kg). Similarly, the empty body weight was higher in Treatment 2 (19.20kg) and lowest in Treatment 5 (10.20kg). Carcass weight was highest in Treatment 2 (12.50kg) and least in Treatment 5 (7.00kg). The highest slaughter weight of 28.00kg was observed in Treatment 2, and the least in Treatment 3 (15.50kg). Treatment 2 (11.50kg) had the highest Visceral weight, and the lowest observed in Treatment 5 (7.50kg). The highest weight of carcass with visceral was observed in Treatment 2 (24.00kg) and lowest in Treatment 5 (14.00kg). The highest dressing percentage was observed in Treatment 4 (45.00) and the least in Treatment 5 (41.00).

The highest lean meat was observed in Treatment 2 (6.83kg) and the lowest observed in Treatment 3 (2.27kg). Bone was highest in Treatment 2 (3.94kg) and lowest in Treatment 3 (2.47kg). Lean to bone ration was highest in Treatment 1 (1.74) and lowest in Treatment 5 (0.90), while the highest lean to fat ration was highest in Treatment 3 (12.80) and least in Treatment 1 (7.30). Body condition scoring (BCS) proves to be a practical and easily acquired technique, rendering it an ideal tool for management purposes. Its superiority over live weight measurement lies in its independence from specialized equipment. Additionally, compared to live weight, BCS overcomes challenges related to skeletal size variations among and within breeds, as well as factors such as physiological state, gut fill, or the length and moisture content of the fleece (Kenyon et al., 2014). The body condition score from this study indicates that the animals used were growing rams.

Starved live weight, empty body weight, carcass weight, slaughter body weight, and dressing percentage obtained from this study were lower compared to the findings of Akinleye et al., (2019) who used matured rams. The variation between this study and the report of Akinleye et al., (2019) could be attributed to the age of the rams used in the current study. Lean-to-bone and lean-to-fat ratios from this study were also lower than the range of 3.47 to 5.52 and 5.30 to 10.22 respectively reported by Akinleye et al., (2019). Lean-to-bone ratio indicates that lean meat is nearly twice as bone, while the lean-to-fat ratio indicates that there were little fat deposits in rams used for this study. Muscle development in animals follows a distinct pattern compared to fat deposition. While muscle tissue exhibits steady growth throughout the animal's life, fat depots develop later and in a specific order: Internal fat first, followed by intermuscular, subcutaneous, and finally intramuscular fat. This sequential development translates to an increasing fat percentage and muscle-to-bone ratio as the animal matures.

As body weight increases, the proportion of muscle in the carcass decreases, while the proportion of fat increases. Furthermore, tissue composition changes with age. Muscle tissue accumulates lipids and loses water as the animal matures (Prache et al., 2022). The dressing percentage obtained from this study is higher than the range between 25.80% to 37.10% reported by Njidda et al., (2018) in red Sokoto goats. It is important to note that besides feed other factors could influence dressing percentage, for example, an animal that is weighed “fully fed” versus fasted for a day can dress up to 5 percent lower, heavier muscled and fatter animals will in general, have higher dressing percentage than lighter muscled and leaner animals respectively, amount and length of hair may also influence dressing percentage (Akinleye et al., 2019).

Other factors that affect carcass characteristics include breed, age and weight at slaughter, sex of the animal, nutritional and environmental factors, pre-slaughter handling, and stress (Oral, 2014). The carcass characteristics for Yankasa rams fed a mixed ration of 30% cowpea husk and 10% tiger nut residue was highest compared to other ration groups (Treatments). In general, animals that are heavier-muscled have a higher dressing percentage than lighter-muscled animals. Additionally, as the fat thickness on the outside of a carcass increases, the dressing percentage also increases. Other factors that can negatively influence dressing percent are mud or manure on the hide, gut fill, amount of bone, unshorn wool, horns, abscesses, or bruises.

Table 2 Carcass Characteristics of Yankasa Rams fed a mixed ration of cowpea husk and Tiger nuts residue.

	Treatment					
Parameter	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**
Body condition score	2.50b	3.00a	1.50c	2.50b	2.00bc	0.26
Starved live weight (kg)	24.50b	29.00a	16.50c	19.00c	17.00c	2.41
Empty Body weight (kg)	15.70b	19.20a	9.60d	12.70c	10.20d	1.80
Carcass weight (kg)	10.50b	12.50a	6.50d	8.50c	7.00d	1.12
Slaughter weight (kg)	23.00b	28.00a	15.50c	18.00c	16.00c	2.38
Visceral (kg)	8.50b	11.50a	8.50b	8.00b	7.50b	0.70
Carcass with visceral (Kg)	20.00b	24.00a	12.00c	15.00c	14.00c	2.19
Dressing percentage (%)	43.00a	43.00a	39.00b	45.00a	41.00ab	0.04
Lean meat (kg)	5.40a	6.83a	2.27c	3.43b	2.31c	0.90
Bone (kg)	3.10b	3.94a	2.47c	2.78bc	2.60c	0.27
Lean:Bone	1.74a	1.73a	0.92c	1.23b	0.90c	0.19
Lean:Fat	7.30b	7.70b	12.80a	9.10ab	11.00a	4.85

a, b, c, d Means within the same rows with different superscripts differed significantly ($p<0.05$); SEM = Standard Error of Mean

Non-carcass components and abdominal fat of Yankasa rams fed a mixed ration of cowpea husk and tiger nuts residue

The non-carcass components and abdominal fat content of the growing Yankasa rams fed a mixed ration of cowpea husk and tiger nuts residue differed significantly ($p<0.05$) as shown in (Table 3). Treatment 1 had the highest head weight of 1.68kg while Treatment 3 had the lowest head weight (0.97kg). Feet from Treatment 1 had the highest weight (0.59kg) and Treatment 5 had the least weight of 0.40kg. The tail weight was highest in Treatment 1 (68.00g), and lowest in Treatment 3 (19g). The skin observed from Treatment 2 was the highest (1.81kg) and least in Treatment 3 (0.79kg). The neck weight was observed to be highest in Treatment 2 (1.05kg) and the lowest in Treatments 3 and 5 (0.5kg). Ribcage was highest in treatment 2 (2.06kg) and lowest in Treatment 3 (0.78kg). The Loin was highest in Treatment 1 (0.81kg) and least in Treatment 3 (0.32kg). Hindlimb from Treatment 2 was observed to be highest (3.60kg) and lowest in Treatment 3 (1.73kg). Forelimb was highest in Treatment 2 (3.07kg) and lowest in Treatment 3 (1.34kg). for fat, the highest kidney fat was observed in Treatment 2 (265.00g) and lowest in treatment 5 (26.00g).

Similarly, omental fat was observed to be high in Treatment 2 (349.00g) and low in Treatment 5 (31.00g) and absent in Treatment 3 (0.00g). Mesenteric fat was highest in Treatment 1 (305.00g), low in Treatment 5 (152.00g) and absent in Treatment 3 (0.00g). The total fat was highest in Treatment 2 (892.00g) and least in Treatment 3 (69.00g). The weights of non-carcass components such as head, skin, feet, hindlimb, and forelimb, from this study, were lower than the findings of who obtained a range between 1.80kg-2.50kg for the head, 1.50-2.20kg (skin), and 0.70kg-0.88kg (feet), but higher than the findings of Njidda et al., (2018) in red Sokoto goats who reported range of 0.15 kg to 1.12 kg (head), 0.80 kg to 1.05kg (skin), 0.18kg to 0.30 kg (hindlimb), and 0.20kg to 0.30kg (forelimb). Similarly, the weight of the kidney fat, omental fat, mesenteric, and total fat from this study was higher than the findings of Njidda et al., (2018) who reported 0.05g to 0.08 (kidney fat), 0.03 g to 0.2 g (omental fat), and (0.001 g to 0.02 g) mesenteric fat.

Total edible non-carcass components are useful qualities not only for evaluating the yield of the breed of ruminants and production practices but are highly consumed in Nigeria and other developing countries (Omojola and Attah, 2006). The differences in weights of some of the internal organs could be attributed to high dry matter intake and different rates of development. The weights of non-carcass components, organs, and viscera are generally higher for animals fed *ad libitum* (Akinleye et al., 2019).

Table 3 Non-carcass components and abdominal fat of Yankasa Rams fed a mixed ration of cowpea husk and Tiger nuts residue.

	Treatment					
Parameter	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**
Head (kg)	1.68a	1.62a	0.97c	1.32b	1.03c	0.15
Feet (kg)	0.59a	0.56a	0.42b	0.43b	0.40b	0.40
Tail (g)	68.00a	61.00a	19.00c	54.00b	44.00b	8.53
Skin (kg)	1.75a	1.81a	0.79c	1.03b	0.83c	0.22
Neck (kg)	0.95a	1.05a	0.50c	0.80b	0.50c	0.12
Ribcage (kg)	1.40b	2.06a	0.78c	1.04b	0.93b	0.24
Loin (kg)	0.81a	0.78a	0.32c	0.47b	0.42b	0.10
Hindlimb (kg)	2.75b	3.60a	1.73d	2.28c	1.75d	0.40
Forelimb (kg)	2.48b	3.07a	1.34d	1.90c	1.40d	0.33
Kidney fat (g)	157.00b	265.00a	69.00c	82.00c	26.00d	42.00
Omental fat (g)	276.00b	349.00a	0.00e	133.00c	31.00d	67.87
Mesenteric fat (g)	305.00a	278.00b	0.00d	162.00c	152.00c	54.19
Total fat (g)	738.00a	892.00a	69.00c	377.00b	209.00b	155.99

a, b, c, d Means within the same rows with different superscripts differed significantly ($p<0.05$); SEM = Standard Error of Mean

Effect of cowpea husk and Tiger nuts residue on organ weights and offals of Yankasa Rams.

The mixed ration of Cowpea husk and Tiger nuts residue had significant difference ($p<0.05$) on organ weights and offals of Yankasa Rams (Table 4). It was observed that the liver from Treatment 2 was higher (488.00g) and the lowest was obtained from Treatment 5 (287.00g). Similarly, Treatment 2 had the highest heart weight of 142.00g and the lowest observed in Treatment 5 (73.00g). Lungs from Treatment 1 weighed the highest (345.00g) and least from Treatment 2 (138.00g). The Kidney from Treatment 2 had the highest weight (72.00g) and the least observed in Treatment 3 (50.00g). The Spleen weighed higher in Treatment 5 (59.00g) and lowest in Treatment 3 (26.00g). The weight of the reticulum was highest in Treatment 2 (120.00g) and least in Treatment 5 (59.00g). Trachea was observed to weigh 187.00g in Treatment 2 (as the highest) and 95.00g in Treatment 5 (lowest). The highest rumen weight of 731.00g was obtained from Treatment 2 while Treatment 4 had the lowest rumen weight (302.00g).

Intestinal weight was highest in Treatment 2 (643.00g) and least in Treatment 5 (329.00g). The longest intestinal length was from Treatment 2 (24.80m) while the shortest was from Treatment 4 (17.49m). The pluck weight was highest in Treatment 2 (1.30kg) and least in Treatment 3 (0.76kg). Gut content from Treatment 2 was highest (1.10kg) and least from Treatments 4 and 5 (0.56kg). The Omasum weighed more in Treatment 2 (90.00g and least in Treatment 4 (54.00g) while the abomasum from Treatment 2 had the highest weight (158.00g) and the lowest weight of 105.00g was obtained from Treatment 3. All organ weights obtained from this study were lower than the findings of, who reported between 2.15 kg to 3.33 kg for rumen content, 1.05 kg - 1.45kg (intestine weight), 350 g – 575 g (liver), 129 g – 174 g (heart), lungs (320-400g), kidney (82-96g), and 61-76g (spleen). Njidda et al., (2018) reported lower weights for liver (10 g to 50 g), heart (10 g to 100 g), lungs (100 g to 350 g), kidney (50 g to 70 g), and spleen (10 g to 50 g).

The observed variations in the weights of these organs might be attributed to differences in the type of animals used, and their physiological activities, potentially caused by the varying levels of tiger nuts residue utilised in this study. Yankasa ram lambs were used by, Red Sokoto goats were used by Njidda et al., (2018), and growing Yankasa rams were used in the present study. The effect of feed on organ weights of rams indicates that various dietary factors, including protein and energy balance, fibre content, mineral and vitamin supplementation, and feeding regimen, play significant roles in influencing organ development and weight. Studies have demonstrated that the protein and energy balance in the diet can impact the size and development of organs such as the liver, kidneys, and heart in rams. Diets with differing levels of protein and energy content have been found to influence organ development, highlighting the importance of balanced nutrition for optimal organ health. Furthermore, the fibre content of the diet has been shown to affect organ development, particularly the size and function of the rumen in ruminants like rams.

High-fibre diets, typically containing forages, promote larger rumen sizes and greater development of rumen papillae, which are essential for nutrient absorption and digestion. Conversely, low-fibre diets may lead to reduced rumen size and function, impacting overall digestive efficiency (Firkins et al., 2007). Additionally, mineral and vitamin supplementation has been identified as crucial for supporting organ health and function in rams. Certain minerals and vitamins are involved in metabolic processes and immune function, influencing the development and activity of organs involved in these functions (McDowell, 2003). Feeding regimen, including factors such as meal frequency and timing, also plays a role in determining organ weights in rams. Restricted feeding regimens, for instance, may result in changes in organ size and metabolic activity compared to ad libitum feeding, highlighting the importance of considering feeding practices in conjunction with diet composition. By examining the body organs, valuable information about the general body condition and overall health of farm animals could be ascertained.

Table 4 Effect of cowpea husk and Tiger nuts residue in a mix ration on organ weights and offals of Yankasa Rams

	Treatment					
Parameter	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**
Liver (g)	383.00b	488.00a	310.00c	290.00c	287.00c	38.27
Heart (g)	96.00b	142.00a	99.00b	81.00c	73.00c	11.95
Lungs (g)	345.00a	138.00c	169.00c	212.00b	184.00bc	35.90
Kidney (g)	52.00c	72.00a	50.00c	52.00c	58.00b	4.03
Spleen (g)	36.00b	34.00b	26.00c	28.00c	59.00a	5.90
Reticulum (g)	60.00c	120.00a	60.00c	96.00b	59.00c	12.43
Trachea (g)	97.00b	187.00a	104.00b	102.00b	95.00b	17.58
Rumen weight (g)	555.00b	731.00a	344.00c	302.00c	315.00c	84.07
Intestinal weight (g)	542.00b	643.00a	430.00c	410.00c	329.00d	54.86
Intestinal length (m)	22.32ab	24.80a	24.59a	17.94b	20.77b	1.28
Pluck weight (kg)	1.05b	1.30a	0.76c	0.79c	0.76c	0.11
Gut content (kg)	0.85b	1.10a	0.57c	0.56c	0.56c	0.11
Omasum (g)	84.00a	90.00a	56.00b	54.00b	62.00b	7.45
Abomasum (g)	154.00a	158.00a	105.00c	106.00c	128.00b	11.32

a, b, c, d Means within the same rows with different superscripts differed significantly ($p<0.05$); SEM = Standard Error of Mean

Body Measurements of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk.

Significant differences were observed in the body measurements for Yankasa rams fed a mixed ration of Tiger nuts residue and cowpea husk (Table 5). Treatment 3 had the highest body length of 65.80cm (initial) and 67.80cm (final) while the lowest body length was observed in Treatment 2 with 59.90cm (initial) and 62.60cm (final). The highest initial rump height was observed in Treatment 4 with 67.20cm (initial) and 69.40cm (final), while Treatment 2 had the lowest initial (63.30cm) and final (65.50cm) rump height. The highest head width of 65.50 cm (initial) and 67.20 (final) was observed in Treatment 3, and the lowest initial head width observed in Treatment 2 (63.40cm) and the final value of 65.00cm. Initial and final Neck gait was highest in Treatment 1 (32.70cm and 33.80cm), lowest initial at Treatment 4 (27.60cm), and lowest final value of 29.60cm (Treatment 5). Pin bone was highest at the initial phase in Treatment 1 (9.70cm) and final in Treatment 3 (12.70cm), while the lowest initial and final values were recorded in Treatment 4 (8.50cm) and Treatment 2 (10.40cm) respectively.

Hearth girth was highest in Treatment 3 (initial - 63.90cm and final – 70.80cm), and lowest in Treatment 2 (initial – 62.30cm and final - 63.80cm). Scrotal length was highest in Treatment 1 (initial – 14.80cm, final – 16.90cm) and the lowest in Treatment 5 (initial – 12.70cm, and 14.80cm). The initial and final scrotal circumference was highest in Treatment 1 (19.20 and 24.20cm) and the lowest in Treatment 2 (16.30cm and 18.00cm) respectively. The increase in linear body measurements confirmed that growing Yankasa rams were used for this study. Linear body measurement is a more dependable index for estimating the changes in growth and live weight of animals. Values for body linear measurements from this study were higher than reports from (Njidda et al., 2018). Variation is attributed to the age and type of animals, growing Yankasa rams between 8 to 10 months were used for this study, while Njidda et al., (2018) used Red Sokoto bucks between 5 to 7 months of age.

Table 5 Body measurement of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk.

	Treatment					
Parameter	**T1**	**T2**	**T3**	**T4**	**T5**	**SEM**
Body Length (cm) Initial	62.60	59.90	65.80	62.60	61.60	0.11
Final	64.60b	62.60c	67.80a	64.40b	64.40b	
Rump Height (cm) Initial	64.40	63.30	66.70	67.20	66.00	0.05
Final	66.90c	65.50d	68.80b	69.40a	68.80b	
Head width (cm) Initial	64.50	63.40	65.50	65.50	64.10	0.13
Final	65.20c	65.00c	67.20a	66.50b	65.50c	
Neck Gaith (cm) Initial	32.70	29.50	28.40	27.60	29.40	0.31
Final	33.80a	30.80c	31.50b	31.50b	29.60d	
Pin Bone (cm) Initial	9.70	9.10	8.70	8.50	9.20	0.19
Final	12.30b	10.40d	12.70a	12.30b	11.50c	
Heart Girth (cm) Initial	63.90	62.30	63.90	63.10	63.90	0.43
Final	67.60b	63.80e	70.80a	68.60c	67.00d	
Scrotal length (cm) Initial	14.80	14.80	13.10	13.60	12.70	0.16
Final	16.90a	15.80b	16.30a	15.30b	14.80c	
Scrotal circumference (cm) Initial	19.20	16.30	18.60	18.30	19.00	0.36
Final	24.20a	18.00c	24.30a	24.30a	22.70b	

a, b, c, d, e Means within the same rows with different superscripts differed significantly ($p<0.05$); SEM = Standard Error of Mean

Feed composition significantly influences body linear measurements in rams, reflecting the crucial role of nutrition in their growth and development. Adequate protein and energy intake in the diet have been associated with larger body size and linear measurements in rams. Additionally, mineral supplementation, particularly calcium, phosphorus, zinc, and copper, supports bone development and overall body growth. Vitamin supplementation has also shown positive effects on body linear measurements by promoting overall health and metabolic functions (Heffernan et al., 2019). While most studies focus on macronutrients and micronutrients, the fibre content of the diet indirectly influences body measurements by affecting nutrient intake and digestive efficiency (Sileshi et al., 2021). Optimizing feed composition, including protein, energy, minerals, vitamins, and fibre, is essential for achieving desired body size and linear measurements in rams, contributing to their growth, development, and overall well-being.

Correlation between Body weight and other morphological characteristics of Yankasa rams fed cowpea husk and tiger nuts residue.

There was a significant ($p<0.05$) positive correlation between body weight and neck gait, pin bone, and heart girth (Table 6). Similarly, rump height was positive and significantly ($p<0.05$) correlated with neck gait, heart girth, and scrotal circumference. Neck gait was significantly ($p<0.05$) correlated with pin bone and heart gait strongly and positively, likewise the pin bone and heart girth. Scrotal length and scrotal circumference were positive and strongly correlated significantly ($p<0.05$). Body weight is a very important characteristic in animal husbandry due to selection criteria and economic profit (Cam et al., 2010). It might be affected by different management, environment, and enterprise feeding conditions. The results of the correlation between body weight and other morphological characteristics of Yankasa rams agree with the recommendations of Olafadehan et al., (2017) who stated that heart girth is a very reliable indicator of body weight.

The positive and strong correlation between body weight and neck girth, heart girth and pin bone, and between scrotal length and scrotal circumference indicates that these morphological characteristics (neck girth, heart girth, and pin bone) could be used to assess and estimate body weight in growing rams. Correlation stands as a frequently used and highly valuable statistical measure, depicting the extent of association between two variables. Correlation is one of the most common and most useful statistics that describes the degree of relationship between two variables. Scientists attempt to predict the accuracy of body weight from body measurements by making use of this characteristic of correlations. The accurate estimation of live weight from live animals' simple body measurements is making a fortune for rural livestock enterprises especially without cooperate characteristics. Due to profitable aims a producer can measure all the body measurements easily from a live animal and can determine body weight approximately (Cam et al., 2010).

Table 6 Correlation between Body weight and other morphological characteristics of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk

	Weight	*Body Length*	*Rump Height*	*Head width*	*Neck Gaith*	*Pin Bone*	*Heart Girth*	*Scrotal length*	*Scrotal circumference*
Weight (Kg)	1	-	-	-	-	-	-	-	-
Body Length (cm)	- 0.193	1	-	-	-	-	-	-	-
Rump Height (cm)	039ns	0.078*	1	-	-	-	-	-	-
Head width (cm)	- 0.032	-0.133ns	-0.180	1	-	-	-	-	-
Neck Gaith (cm)	0.654*	-0.387ns	0.295*	-0.045	1	-	-	-	-
Pin Bone (cm)	0.489*	-0.257ns	0.072ns	-0.097	0.701*	1	-	-	-
Heart Girth (cm)	0.602*	-0.335ns	0.116*	0.128ns	0.680*	0.694*	1	-	-
Scrotal length (cm)	040ns	-0.091ns	-0.022	0.032ns	0.099ns	0.149ns	0.032ns	1	-
Scrotal circumference (cm)	.060ns	-0.124ns	0.140*	-0.198	0.381ns	0.220ns	0.173ns	0.699*	1

*=p<0.05, ns=not significant

Correlation between body condition score and carcass weights of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk

Table 7 presents the correlation results between body condition score and carcass weights for Yankasa rams fed Cowpea husk and tiger nuts residue. There were significant ($p<0.05$), positive, and strong correlations between the body condition score and starved live weight, empty body weight, carcass weight, slaughter weight, visceral weight, and carcass with visceral weights. There are different methods for estimating body energy reserves, some of them under controlled conditions, however, body weight (BW) and body condition score (BCS) are preferred under practical conditions (Diaz-Lopez et al., 2017). The BCS has been the preferred method used for estimating energy body reserves and nutritional status in different breeds of ewes (Chay-Canul et al., 2011; Kenyon et al., 2014). The body condition score from this study was positive and strongly correlated with carcass weights which confirms the reliability of the body condition score as an indicator for carcass weights.

Table 7 Correlation between body condition score and carcass weights of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk.

	Body condition score	*Starved live weight (kg)*	*Empty Body weight (kg)*	*Carcass weight (kg)*	*Slaughter weight (kg)*	*Visceral (kg)*	*Carcass with visceral (Kg)*
Body condition score	1	-	-	-	-	-	-
Starved live weight (kg)	0.870*	1	-	-	-	-	-
Empty Body weight (kg)	0.918*	0.993*	1	-	-	-	-
Carcass weight (kg)	0.921*	0.992*	0.999*	1	-	-	-
Slaughter weight (kg)	0.874*	0.999*	0.993*	0.992*	1	-	-
Visceral (kg)	0.644*	0.850*	0.828*	0.815*	0.866*	1	-

Carcass with visceral (Kg)	0.895*	0.994*	0.988*	0.990*	0.993*	0.815*	1

*=p<0.05

Research on the correlation between body condition score (BCS) and carcass weights in rams indicates a positive relationship between these two factors. Studies have consistently shown that rams with higher BCS tend to exhibit higher carcass weights. This positive correlation underscores the importance of assessing body condition as a predictor of carcass composition and overall productivity in sheep production systems. Factors influencing the correlation between BCS, and carcass weights include nutrition, genetics, and management practices. Diets that promote better body condition scores often lead to increased carcass weights, highlighting the importance of optimal nutrition in sheep management. Additionally, genetic factors play a role, with certain breeds or genetic lines showing stronger correlations between BCS and carcass weights (Apple et al., 1999). Management practices such as feeding regimens, grazing conditions, and supplementation strategies also impact both BCS and carcass weights.

Correlation between body weight and body parts of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk

The results of the correlation between body weight and body parts of Yankasa rams indicated a significant (p<0.05), positive, and strong relationship between body weight and body parts between 0.736 and 0.996 (Table 8). Growth is characterized as a rise in tissue mass. Initially, mass expands through hyperplasia in early life, and later through hypertrophy, although hyperplasia of adipose tissue persists throughout an individual's lifetime (Owens et al., 1993). This rise in tissue mass occurs across the entire body of the animal hence a strong and positive correlation was observed between body weight and other body parts in this study. In many animals, including rams, certain body parts tend to grow proportionally with body weight, a term known as Allometric growth. This phenomenon is governed by genetic factors and physiological mechanisms regulating growth and development (Shingleton et al., 2007).

Table 8 Correlation between body weight and body parts of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk.

	Empty Body weight (kg)	*Starved live weight (kg)*	*Head (g)*	*Feet (g)*	*Tail (g)*	*Skin*	*Neck (g)*	*Ribcage (g)*	*Loin (g)*	*Hindlimb*	*Forelimb*
Empty Body weight (kg)	1	-	-	-	-	-	-	-	-	-	-
Starved live weight (kg)	0.993*	1	-	-	-	-	-	-	-	-	-
Head (g)	0.926*	0.907*	1	-	-	-	-	-	-	-	-
Feet (g)	0.879*	0.902*	0.936*	1	-	-	-	-	-	-	-
Tail (g)	0.787*	0.747*	0.902*	0.748*	1	-	-	-	-	-	-
Skin	0.958*	0.967*	0.966*	0.977*	0.815*	1	-	-	-	-	-
Neck (g)	0.980*	0.961*	0.974*	0.906*	0.836*	0.966*	1	-	-	-	-
Ribcage (g)	0.973*	0.982*	0.824*	0.813*	0.688*	0.906*	0.907*	1	-	-	-
Loin (g)	0.921*	0.928*	0.969*	0.966*	0.879*	0.986*	0.937*	0.861*	1	-	-
Hindlimb	0.996*	0.988*	0.891*	0.845*	0.736*	0.932*	0.966*	0.980*	0.882*	1	-
Forelimb	0.999*	0.993*	0.933*	0.890*	0.787*	0.963*	0.984*	0.968*	0.926*	0.994*	1

Correlation between body weight and body fats of Yankasa rams fed a mixed ration of Tiger nuts residue and cowpea husk.

Table 9 shows the results of the correlation between body weight and body fats of Yankasa Rams fed a mixed ration of Tiger nuts residue and cowpea husk. A significant (p<0.05), strong, and positive correlation exists between body weight and body fats (kidney fat, omental fat, mesenteric fat, and total fat). Though body weights are best predicted with other parameters aside from body fats, there is a likelihood that the level of body fats affects the weight of an animal. Body fats are not a reliable quality to estimate body weight and are not an advisable method to predict body weight (Frutos et al., 1997). Body weight often reflects energy reserves stored in adipose tissue.

Table 9 Correlation between body weight and body fats of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk.

	Starved live weight (kg)	*Slaughter weight (kg)*	*Kidney fat (g)*	*Omental fat (g)*	*Mesenteric fat (g)*	*Total fat*
Starved live weight (kg)	1	-	-	-	-	-
Slaughter weight (kg)	0.999*	1	-	-	-	-
Kidney fat (g)	0.973*	0.977*	1	-	-	-
Omental fat (g)	0.981*	0.976*	0.930*	1	-	-
Mesenteric fat (g)	0.834*	0.821*	0.688*	0.896*	1	-
Total fat	0.979*	0.973*	0.913*	0.997*	0.923*	1

Animals with higher body weights typically have greater fat deposits, influencing body composition and certain body measurements such as chest girth and abdominal circumference (Duren et al., 2008). The relationship between fat and body weight in rams is influenced by genetics, nutrition, age, and physiological status. Body weight includes fat as a component of overall body composition, and an increase in body weight may signify an increase in fat mass. Factors such as high-energy diets, genetic predispositions, and physiological conditions like maturity and reproductive status can affect fat deposition and body weight in rams.

Correction between body weight and intake of Yankasa rams fed a mixed ration of Tiger nuts residue and cowpea husk

Results of the correlation between body weight and intake indicate there is a significant (p<0.05), positive, and strong correlation between final body weight and total weight gain, total dry matter intake, metabolic dry matter intake and daily weight gain (Table 10). A negative and non-significant correlation was observed between initial weight and all other intake parameters. As animals consume feed, they utilize the nutrients from the feed for growth and development. Body weight increases with the intake of good-quality feed, especially in young animals (Yakubu, 2010).

Table 10 Correlation between body weight and intake of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk.

	Initial weight	*Final weight*	*Total weight gain*	*Total dry matter intake*	*Daily dry matter intake*	*Feed conversion ratio*	*Dry matter Intake* **(W0.75)**	*Daily weight gain* **(W0.75)**
Initial weight	1	-	-	-	-	-	-	-
Final weight	-0.585ns	1	-	-	-	-	-	-
Total weight gain	-0.671ns	0.994*	1	-	-	-	-	-
Total dry matter intake	-0.216ns	0.898*	0.851*	1	-	-	-	-
Daily dry matter intake	-0.216ns	0.898*	0.810*	1	1	-	-	-
Feed conversion ratio	-0.677ns	-0.282ns	-0.990ns	0.849ns	0.849ns	1	-	-
Dry matter Intake	-0.216ns	0.898*	0.851*	0.999*	0.999*	0.849ns	1	-

(W0.75)								
Daily weight gain (W0.75)	-0.369ns	0.994*	0.999*	0.854*	0.854*	0.992*	0.854*	1

The correlation between body weight and feed intake in rams reflects the intricate interplay of metabolic, physiological, genetic, and environmental factors. As rams grow and gain weight, their metabolic rate increases, necessitating higher energy and nutrient intake to support basic physiological functions and tissue development. Larger rams have higher growth requirements, requiring increased feed intake to meet their energy and nutrient needs. This relationship is further influenced by genetic factors, with breeds or genetic lines exhibiting different growth potentials and metabolic efficiencies. Environmental conditions, such as temperature and forage availability, also impact feed intake in rams, as animals may adjust their intake in response to external stressors (Roba et al., 2022).

Correlation between body weight and body measurements of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk

Body weight significantly ($p<0.05$) had a positive and strong correlation with the longissimus dorsi muscle, testicular circumference, testicular length, and testicular weights. The correlation ranged from 0.814 to 0.994, as presented in (Table 11). The positive and strong correlations observed between body weight and body measurements indicate that growth occurs across all body parts as the animal develops to maturity. Understanding the correlation between body weight and body linear measurements has practical implications for sheep management, breeding programs, and selection criteria. Breeders may use body linear measurements as indicators of growth potential, body conformation, and overall productivity in rams (Worku, 2019).

Table 11 Correlation between body weight and body measurements of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk.

	Empty Body weight	*Starved live weight*	*Longissimus Dorsi Muscle*	*Testicular circumference before carcass*	*Testicular circumference After carcass*	*Testicular length before carcass*	*Testicular length after carcass*
Empty Body weight	1	-	-	-	-	-	-
Starved live weight	0.992*	1	-	-	-	-	-
Longissimus Dorsi Muscle	0.973*	0.992*	1	-	-	-	-
Testicular circumference before the carcass	0.845*	0.869*	0.843*	1	-	-	-
Testicular circumference after carcass	0.814*	0.809*	0.766*	0.948*	1	-	-
Testicular length before the carcass	0.898*	0.899*	0.857*	0.981*	0.965*	1	-
Testicular length after carcass	0.865*	0.871*	0.823*	0.974*	0.919*	0.985*	1
Right	0.887*	0.900*	0.870*	0.995*	0.962*	0.994*	0.977*

testicular weight							
Left testicular weight	0.836*	0.854*	0.826*	0.994*	0.973*	0.982*	0.960*

Research has consistently shown a positive correlation between body weight and various body linear measurements in rams. As rams grow and gain weight, they typically exhibit increased body dimensions such as height, body length, chest girth, and hip width. The strength of the correlation between body weight and body linear measurements can vary depending on genetic factors, breed characteristics, and environmental conditions. Different breeds may exhibit distinct growth patterns and body proportions, influencing the relationship between body weight and linear measurements (Lallias et al., 2017).

Correlation between body weight and organ weights of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk

The correlation between body weight and organ weights were significant ($p<0.05$), strong, and positive with all the organs except the lungs and spleen (Table 12). There was a negative and non-significant correlation between the spleen and reticulum, trachea, rumen weight, intestinal weight, pluck weight, gut content. Body organs are obtained after the slaughter of animals. From this study, it can be established that every organ contributes to the overall live weight of the animal except for the spleen which had a negative but weak correlation with body weight. The correlation between body weight and organ weights in rams reflects the complex relationship between metabolic demands, growth patterns, and physiological function. As rams grow and gain weight, their organs undergo proportional development to meet increased metabolic needs associated with growth and development.

Table 12 Correlation between body weight and organ weights of Yankasa Rams fed a mixed ration of Tiger nuts residue and Cowpea husk.

	Starved live weight (kg)	*Slaughter weight (kg)*	*Liver (g)*	*Heart (g)*	*Lungs (g)*	*Kidney (g)*	*Spleen (g)*	*Reticulum (g)*	*Trachea (g)*	*Rumen weight (g)*	*Intestinal weight (g)*	*Intestinal length (cm)*	*Pluck weight (g)*	*Gut content (g)*	*Omasum*	*Abomasum*
Starved live weight (kg)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slaughter weight (kg)	0.999*	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Liver (g)	0.959*	0.963*	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Heart (g)	0.823*	0.836*	0.936	1	-	-	-	-	-	-	-	-	-	-	-	-
Lungs (g)	0.105ns	0.067ns	-0.084	-0.334	1	-	-	-	-	-	-	-	-	-	-	-
Kidney (g)	0.721*	0.744*	0.786	0.751*	-0.520ns	1	-	-	-	-	-	-	-	-	-	-
Spleen (g)	-0.167ns	-0.169ns	-0.188ns	-0.382	-0.014ns	0.218ns	1	-	-	-	-	-	-	-	-	-
Reticulum (g)	0.655*	0.680*	0.634	0.685*	-0.469ns	0.736ns	-0.333ns	1	-	-	-	-	-	-	-	-
Trachea (g)	0.786*	0.809*	0.878*	0.932*	-0.528ns	0.913ns	-0.191ns	0.842*	1	-	-	-	-	-	-	-
Rumen weight (g)	0.969*	0.969*	0.993*	0.893*	0.025ns	0.743ns	-0.143ns	0.561ns	0.817*	1	-	-	-	-	-	-
Intestinal	0.945*	0.944*					-				1	-	-	-	-	-

weight (g)			0.960*	0.913*	0.062ns	0.605ns	0.419ns	0.607ns	0.788*	0.958*						
Intestinal length (cm)	0.403*	0.407	0.628*	0.737*	-0.262ns	0.402ns	-0.183ns	0.048ns	0.543*	0.612*	0.586*	1	-	-	-	-
Pluck weight (g)	0.989*	0.991*	0.989*	0.883*	0.002ns	0.778*	-0.145ns	0.648*	0.843*	0.991*	0.952*	0.519*	1	-	-	-
Gut content (g)	0.981*	0.982*	0.992*	0.883*	0.010ns	0.773*	-0.119ns	0.605*	0.832*	0.997*	0.949*	0.559*	0.998*	1	-	-
Omasum	0.938*	0.930*	0.922*	0.737*	0.224ns	0.665ns	0.053ns	0.382ns	0.656ns	0.960*	0.871*	0.522*	0.945*	0.958*	1	-
Abomasum	0.872*	0.862*	0.833*	0.598*	0.277ns	0.650ns	0.254ns	0.284ns	0.555ns	0.886*	0.748*	0.419*	0.873*	0.890*	0.977*	1

This correlation underscores the functional capacity of organs in supporting physiological processes necessary for maintaining homeostasis and overall health (Underwood et al., 2015). Factors such as breed characteristics, genetic factors, nutrition, and environmental conditions may influence the strength of this correlation. Understanding the relationship between body weight and organ weights in rams provides valuable insights into growth dynamics, metabolic efficiency, and overall health status (Balasundaram et al., 2023).

Cost-benefit Analysis of Feeding Cowpea Husk and Tiger nuts residue on Yankasa rams.

The highest cost of feed per kilogram was in T1 (₦50.75) and the least from T5 (₦30.75). Similarly, the total cost of feed was highest in T1 (₦3,378.43) and the least in T5 (₦1,980.82). The accruable income from the study was highest in Treatment 2 (₦32,260.00) and least in Treatment 5 (₦17,490.00). The apparent profit recorded was highest in T3 (₦29,299.69) and lowest in T5 (₦15,509.18) (Table 13). The results of the economic analysis of growing lambs fed the experimental diets indicated that rams on 20% cowpea husk and 20% tiger nuts residue had the highest total weight gain followed by those fed 10% cowpea husk and 30% tiger nut residue which affirms that a mix of both cowpea husk and tiger nut residue will give an optimum accruable income and profit. Though the inclusion of Tiger nuts reduced the cost of feed, feed intake also influenced the growth of Yankasa rams. There is scanty information on the effect of a ration mix of cowpea husk and Tiger nut residue on the cost-benefit analysis of feeding Yankasa rams.

Table 13 Cost-benefit analysis of fattening Yankasa rams fed a mix ration of Cowpea husk and tiger nuts residue.

Parameters	**Treatment**				
	T1	**T2**	**T3**	**T4**	**T5**
Initial weight (Kg)	16.17	15.50	15.50	15.50	15.75
Final weight (Kg)	23.00	25.92	26.17	23.67	21.58
Total weight gain (Kg)	6.83	10.42	10.67	8.17	5.83
Total feed intake (kg)	66.57	67.67	67.17	65.83	64.42
Cost of feed/kg (₦)	50.75	45.60	40.35	35.80	30.75
Total cost of feed (₦)	3378.43	3085.75	2710.31	2356.71	1980.82
Income accruable* (₦)	20490.00	31260.00	32010.00	24510.00	17490.00
Apparent profit (₦)	17111.57	28174.25	29299.69	22153.29	15509.18

*Calculated based on the prevailing price of 3,000NGN/kg of mutton after the feeding trial

5. CONCLUSION

Carcass characteristics in Yankasa rams fed 20% tiger nuts residue and 20% cowpea husk mixed rations had a better performance, hence it is recommended that farmers should include 20% cowpea husk and 20% tiger nuts residue in diet formulation for fattening rams for optimum profitability.

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All authors have read and agreed to the published version of the manuscript.

Ethical approval

The Animal ethical guidelines are followed in the study for species observation & identification.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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Data and materials availability

All data associated with this study are present in the paper.

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