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RESEARCH ARTICLE

Physiological and Linear Body Measurement of West African Dwarf Goats Fed Cocoa Pod, Cassava Pulp and Acacia Leaf Silage

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ABSTRACT

This study was conducted in Teaching and Research farm, Landmark University, Kwara State, Nigeria, to determine the effects of cocoa-based diets on body length and eleven (11) morphometric parameters. Twenty-eight (28) West African dwarf bucks, aged between 4 to 5 months with average body weight of 7.00±0.2kg were used for the study. The control groups (T1 and T7) were fed (0:60:40) and (60:0:40) of cocoa pod, cassava pulp and acacia leaf respectively for experimental period of fortyfive (45d). The measurements were taken in the morning (08:00h) fortnightly. Data generated were subjected to descriptive statistics using analysis of variance. Results obtained showed that diets had significant effect (P< 0.05) on the body traits. The mean BL, WG, CD, HG, SC, NC, FL, HL, HW, EL and RT were 51.00±4.08-57.50±5.74cm, 24.50±1.73-31.50±3.11cm; 44.00±1.63-48.75±1.71cm; 42.25±2.87-44.75±2.06cm; 11.00±1.83-14.25±3.30cm; 20.25±0.95-23.00±2.45cm; 12.25±1.70-14.50±1.73cm; 2.00±0.00-3.75±1.25cm; 10.25±1.25-10.75±1.25cm; 8.75±0.50-9.50±1.29cm and 38.13±0.25-39.10±0.350C respectively. The results showed that as the body length increased, other body traits also increased. As cocoa pod decrease, the animals consumed the diets and their body measurements increased. The correlation coefficients showed that there was high positive and significant relationship among the variables. It was concluded that the body linear measurement was subjected to the diet given. Therefore, the study revealed that feed had effect on most of the linear body measurements physiologically.

Contents

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1. Introduction

Ruminants play an important role in the livelihood of farmers in the tropics, they provide meat, milk and fertilizer [1]. Small ruminants especially goats have been reported to have a unique position among other domestic animals reared by man especially in the rural areas [2]. A number of agriculture by-products have potential as alternative feeds due to their abundance and availabilities throughout the year. Unfortunately, agricultural by-products are usually characterized by low nutritional quality; occasioned by high fibre and low protein contents. Such characteristics often require that the by-products be treated, either physically or chemically prior to feeding to animals [3]. In Nigeria, for example, cocoa pod and cassava pulp are regarded as wastes and they are usually left to rot away or burnt to create space for the accumulation of yet more waste heaps. The heaps emit carbondioxide and produce a powerful offensive smell. In order to prevent environmental impacts arising from the huge waste streams generated during cocoa and cassava processing, it was suggested that various waste should be gathered and converted to useful products including fuel ethanol [4]. Cassava pulp offers an alternative to high-starch grains and can be used as an energy source in ruminant diets. It comprised of 15.8–23.4% dry matter with 1.2–2.8% crude protein and 17.9–24.0% crude fibre [5]. Acacia *Senegalia brevispica* is considered promising as the foliage, pods and seeds are readily eaten by goats.

Table 1 Dietary Composition of combinations of cocoa pod, cassava pulp and Acacia leaf to West African Dwarf Goats (%)

	Control						Control
	T1	T2	T3	T4	T5	T6	T7
Cocoa pod	0.00	10.00	20.00	30.00	40.00	50.00	60.00
Cassava pulp	60.00	50.00	40.00	30.00	20.00	10.00	0.00
Acacia leaf	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Body weight is the commonly known trait that measure the size of the animal while growth rate measures the improvement of the meat [6]. Therefore, the assessments of the powers of body measurements in the estimation of weights and the accuracy of body weights in the estimation of size have been reported [7]. Body measurements play an important role in determining several characteristics of the farm animals which could be influenced by the feeds taken. Live weight prediction using linear measurement is practical, faster, easier and cheaper in the rural areas where weighing scales are not available [8]. Researches on the prediction of body weight of goats using linear body measurements have been conducted in many parts of the country like United State of American (USA), African and Europe [9]. Several researches have stated positive effect of chosen predictor variables in body measurements of the animals [10]. Body lengths, width at shoulder, heart girth were significant predictors of linear measurement [11]. Hence, heart girth and body weight can be varied depending on the breeds, feed and management of the animals [12]. Sexual dimorphism in body weight and other body linear measurements favoured does than bucks in goats [13]. Although, morphological characterization of the West African Dwarf (WAD) goat has been undertaken in a number of studies [14]. Thus, information on the effects of diets on morphometric traits are still scanty. Evaluation of influence of feeds and morphometric characteristics of West African Dwarf goats (WAD) are important for a number of reasons, (i) They indicate the growth trends of the animal during the period of high growth rate.

(ii) They enable more accurate prediction of linear body values due to feeds taken [15]. With this background, the present study was designed to evaluate the relationship between live weight and some body measurements in West African Dwarf (WAD) goats fed ensiled combinations of cocoa pod, cassava pulp and Acacia leaves. We hypothesized that feeding West African Dwarf (WAD) goats ensiled combinations of cocoa pod, cassava pulp and *Acacia Senegalia brevispica* leaves influenced the relationship between live weight and some body measurements.

2. Materials and Methods

2.1. Ethical Statement

This study was performed in accordance with the recommendations of the Animal Ethics Committee guidelines of the University of Ilorin, Kwara State, Nigeria. The UERC Approval Number given was UERC/ASN/2018/1143.

2.2. Experimental Site

The study was carried out at the Teaching and Research farm of the Department of Animal Science, Landmark University, Omu-Aran, Kwara State, Nigeria.

2.3. Experimental Design

Twenty-eight (28) West African dwarf male, aged between 4 to 5 months with average body weight of 7.00±0.2kg was sourced from livestock market at Otun Ekiti, Nigeria. After 14 days of acclimatization the animals were allotted to seven dietary treatments in a completely randomized design with 4 animals per treatment in an intensive system of management.

2.3.1. Feed Ingredients

The experimental diets comprised combinations of cassava pulp, cocoa pod and Acacia leaf. Previously, the nutritional and microbial properties of thirty samples of silage prepared from cocoa pod, cassava pulp and Acacia leaf mixtures had been evaluated. From the result obtained, the best seven dietary combinations of cocoa pod, cassava pulp and Acacia leaf were chosen for the present experiment.

Each of the animals selected for measurement was restrained and calmed before measurements were taken on them to ensure that they were not unnecessarily stressed. Live weight of each animal was determined by suspending the animal on a spring balance and weight of each animal taken and recorded. The body surface temperature, rump, chest, back and Rectal temperature were measured daily in the morning (08.00 hour) before feeding using infrared thermometer (HTC Instruments, Mumbai, India) with error of ± 0.1^{0}C at forthnightly interval. The body surface temperature (BST) was taken by keeping the infrared thermometer perpendicular to the body from a distance of 10cm. The Rectal temperature was also measured daily in the morning (08.00 hour) before feeding using a digital clinical thermometer (OMRON MC-246, Omron Healthcare Co., Limited, Kyoto, Japan). The thermometer was inserted about 3cm inside the rectum for the measurements of Rectal temperature. While tape rule was used to measure body linear values. The following measurements were also taken:

Body length: This was measured from the tip of the scapula to the pin bone of the tail.

Chest depth: was obtained as the circumference of the body, slightly behind the shoulders.

Wither height: This was measured at the highest point on the dorsum of the animal to the platform at the level of the forelegs while the animal was standing.

Ear length: This was measured from the point where the ear is attached to its tip.

Facial length: This was measured from mid-point of the zygomatic arches to the upper lip.

Neck length: This was measured as the region of the cervical vertebrae.

Horn length: This was measured from the point of its attachment of the horns to the head up to its tip.

Tail length: This was measured as the distance between the beginning of the caudal vertebrae to its tip.

Leg Length: The leg length was measured as the distance from the tip of the hoof to the point where the tarsal is joined to the tibia and fibula.

2.4. Data Collection

Their body linear measurements were evaluated for morphometric characteristics. The following metric characters were measured on each animal (Kid): Body length (BL), Ear length (EL), Neck circumference (NC), Facial length (FL), Head width (HW), Tail Length (TL), Foreleg (FL), Hindleg (HL); Head, Back, Chest, Rump and Rectal temperature. Reference marks used for body measurement were done according to the method of Salako and Ngere [12]. For the correlation parameters.

(a)

(a)

(a)

Figure 1 Goat Pen (a), Cassava pulp waste (b), and Ground cocoa pod (c)

Goat Experimental Pen, Cassava pulp waste and Ground cocoa pod are shown in Figure 1.

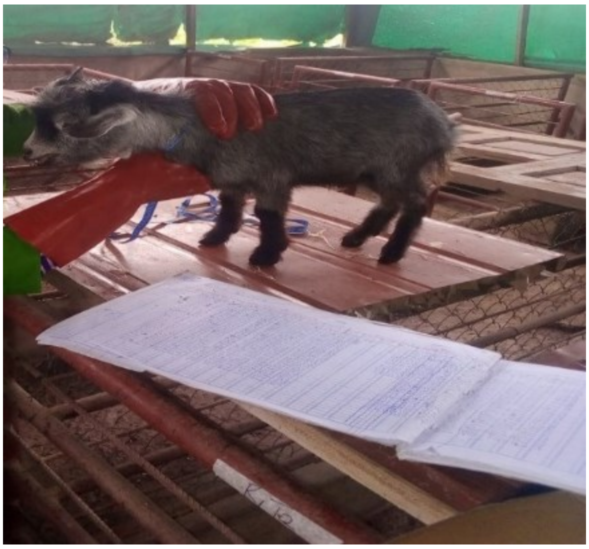

Figure 2 Neck Circumference measurement

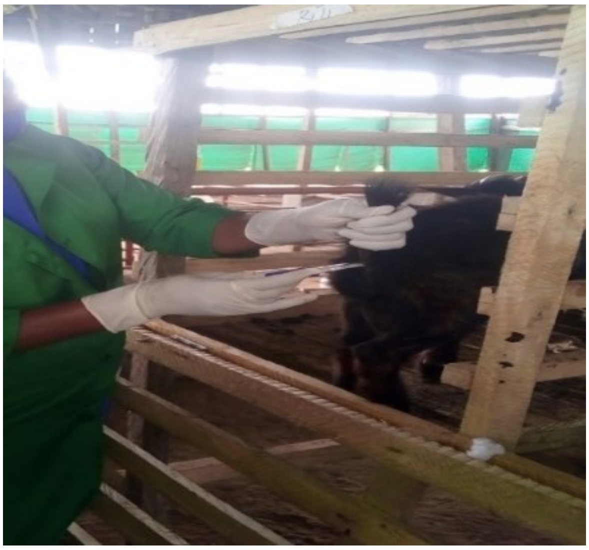

Figure 3 Rectal Temperature measurement

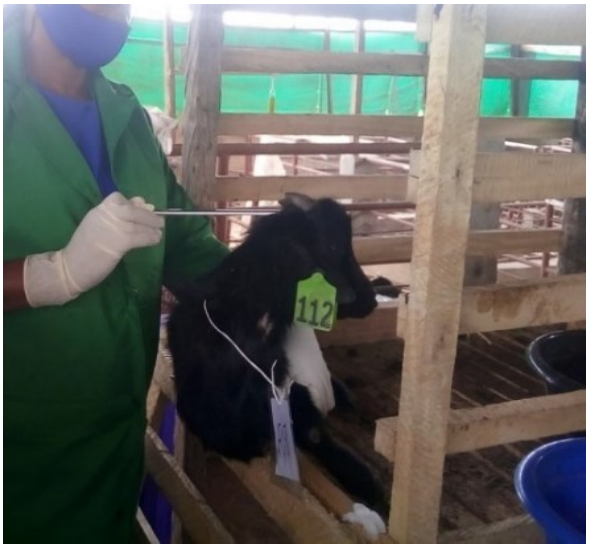

Figure 4 Head Temperature measurement

The photos taken during the measurements of Neck Circumference, Rectal Temperature, Head Temperature, Back Temperature, Chest Temperature, Rump Temperature are given respectively in Figure 2, Figure 3, Figure 4, Figure 5, and Figure 6.

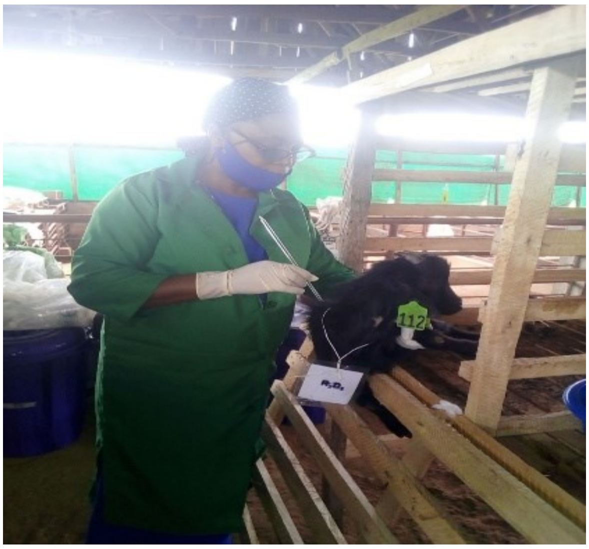

Figure 5 Back Temperature measurement

Figure 6 Chest Temperature measurement

2.5. Statistical analysis

The data obtained were subjected to standard methods of statistical analysis using windows- based SPSS (Version 20.0, 2014, USA). The analysis of variance (ANOVA) test was used and Level of significance was set at $p \leq 0.05$. Duncan multiple range test was used as post hoc test to compare all pair wise mean differences between the groups. The interrelationship between monthly body weights and morphometric traits were obtained by Pearson's correlation analysis using the Statistical Package for Social Sciences [16].

We expressed body weight as a function of some of the variables of interest in this study as follows:

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon_i \quad (1)$$

where y_i is the body weight, X_1 is the body length, X_2 denotes neck circumference, X_3 denotes facial length, X_4 denotes head width, X_5 ear length, X_6 represent tail length, X_7 denotes the foreleg, X_8 denotes hindleg.

ε_i is the error term such that $\varepsilon_i \sim N(0, \sigma^2)$, $\beta_i, i = 0,1, \ldots, 8$ are the regression coefficients. The regression coefficient was estimated using the ordinary least squared estimator. The Ordinary least squared estimator is defined as follows:

$$\hat{\beta} = (X^T X)^{-1} X^T y \quad (2)$$

The ridge estimator is defined as follows:

$$\hat{\beta}_R = (X^T X + kI)^{-1} X^T y \quad (3)$$

where k is the ridge shrinkage parameter and it was obtained as follows:

$$k = \frac{p\hat{\sigma}^2}{\sum_{i=1}^{p} \hat{\beta}_i^2} \quad (4)$$

where $\hat{\sigma}^2$ is the mean squared error, p is the number of estimated regression parameters.

Kibria and Lukman [17] proposed the K-L estimator as an alternative estimator to the ridge regression estimator and concluded that the estimator outperform the ridge regression estimator and the ordinary least squared estimator (OLSE). The K-L estimator is defined as follows:

$$\hat{\beta}_{KL} = (X^T X + kI)^{-1} (X^T X - kI) \hat{\beta} \quad (5)$$

3. Results

3.1. Chemical composition of the experimental feeds

The chemical composition of feeds used in this experiment is shown in Table 2. There were significant (p<0.05) effects on the composition of the combinations of cocoa pod, cassava pulp and Acacia leaf. The crude protein contents of Diet T1 (0:60:40) 12.51% and T2 (10:50:40) 12.42% were high compared with Diet T6 (50:10:40) 9.27% and T7 (60:0:40) 9.01%. The crude fibre in the feeds followed the same trend as the crude protein. The highest crude fibre (CF) content was observed in Diet T7 (60:0:40) 14.90% while the least value was recorded for Diet T1 (0:60:40) 5.03±0.02%. The Diet T7 (60:0:40) had the highest Dry Matter content (85.55%) and decreased with decrease in cocoa pod in the feeds. Ether extract increased progressively with increasing levels of cocoa pod which ranged from 9.43% to 24.00%.

The ash content of the diets increased across the dietary treatments with 10% inclusion levels of ensiled cocoa pod. T1 (0:60:40) had the highest nitrogen free extract 36.23% while diet T7(60:0:40) had the least value of 28.46%. The neutral detergent fiber (NDF) (47.19%) and acid detergent fiber (ADF) (38.68%) contents of T4 (30:30:40) were very low compared to group T1(0:60:40) 52.635% and 45.86% respectively.

Likewise, Calcium and Phosphorus of T1 (0:60:40) 85.80g/kg dry matter (DM) and 66.24g/kg DM; T2 (10:50:40) 90.90±0.28 g/kg DM and 67.33±.26 g/kg DM respectively were higher than the other treatments. The values of chemical composition recorded in this study fell within the normal range standard diets for West Africa Dwarf goats. The study revealed a significant (P<0.05) reduction in theobromine concentration of cocoa pod during fermentation from 0.38g/100gDM to 1.28g/100gDM) as the period of fermentation increased.

Table 2 Chemical composition of combinations of cocoa pod, cassava pulp and Acacia leaves

Parameters	T1	T2	T3	T4	T5	T6	T7
Dry Matter (DM) %	65.71^a	68.85^a	72.48^b	79.38^b	80.39^c	81.67^c	85.55^c
Crude protein (CP) %	12.51^a	12.42^a	10.95^b	10.76^b	9.79^c	9.27^c	9.01^c
Crude fibre (CF) %	5.03^a	7.46^b	7.96^b	10.39^c	11.22^c	12.09^d	14.90^e
Ether extract (EE) %	9.43^a	11.34^b	14.07^c	19.25^d	20.12^d	21.69^d	24.00^e
Ash %	2.53^a	3.64^a	6.05^b	6.42^b	8.38^c	8.95^c	9.18^c
Nitrogen free extract (NFE) %	36.23^a	33.97^b	33.44^b	32.22^b	30.88^c	29.66^c	28.46^c
Neutral detergent fibre % (NDF)	52.63^a	50.19^b	54.46^b	47.19^c	55.15^b	52.87^b	51.28^b
Acid % detergent fibre (ADF)	45.86^a	42.30^a	48.35^b	38.68^d	48.61^b	46.54^c	45.61^c
Calcium(g/kg DM)	85.80^a	90.90^b	84.75^a	76.45^c	80.90^a	84.60^a	56.50^d
Phosphorus(g/kg DM)	66.24^a	67.33^a	58.13^c	56.70^c	60.89^b	55.41^d	55.56^d
Theobromine content (%)	0.00	0.38	0.56	0.74	0.92	1.10	1.28

^{abcde}= means within the same row with different superscripts are significantly (P<0.05) different.

Theobromine content - calculated based on standard method proposed by Odunsi and Longe, (1998).

3.2. Physiological Traits and Body Linear Measurements

The descriptive statistics (mean ± SE) for the physiological traits and body linear measurement of the experimental animals are presented in Table 3. The physiological traits measured were statistically ($p < 0.05$) increased in T1 to T3 compared to T4 to T7 in all the groups.

Table 3 Descriptive statistics of physiological traits and body linear measurements of WAD Goats

Parameters (cm)	TI	T2	T3	T4	T5	T6	T7
Body length	57.50[a]	55.25[b]	54.25[c]	53.00[d]	52.00[e]	52.00[e]	51.00[e]
Wither height	31.50[a]	28.00[b]	26.75[c]	26.00[c]	25.50[d]	25.00[d]	24.50[d]
Chest depth	48.75[a]	47.00[b]	46.25[c]	46.00[c]	46.00[c]	44.50[d]	44.00[d]
Heart girth	44.75[c]	46.75[a]	45.25[b]	45.00[b]	44.50[c]	43.50[d]	42.25[d]
Shark circumference	14.25[a]	13.50[b]	12.00[c]	12.00[c]	11.75[d]	11.25[d]	11.00[d]
Neck circumference	23.00[a]	22.25[b]	22.25[b]	22.00[b]	22.00[b]	21.75[c]	20.25[d]
Facial length	14.50[a]	14.00[a]	13.25[b]	13.25[b]	13.00[c]	13.00[c]	12.25[d]
Horn length	3.75[a]	3.75[a]	3.00[b]	3.00[b]	2.75[c]	2.75[c]	2.00[d]
Head width	10.75[a]	10.75[a]	10.50[b]	10.50[b]	10.50[b]	10.50[b]	10.25[c]
Ear length	9.50[a]	9.50[a]	9.50[a]	9.50[a]	9.25[b]	9.25[b]	8.75[c]
Tail length	11.75[a]	10.75[b]	10.75[b]	10.25[c]	10.00[c]	10.00[c]	9.75[d]

3.3. Rectal and Body Surface Temperature

The rectal temperature (RT) and body surface temperature for different treatments were presented in Table 4. The mean rectal temperature and body surface temperature were significantly ($p < 0.05$) different from each other in groups. So, the body surface temperature (BST) at fore head, rump, chest and back were not influenced by the diets given.

Table 4 The means and standard errors of Rectal and some Body surface temperature

Parameters (0^0C)	T1	T2	T3	T4	T5	T6	T7
Rectal temperature	39.10±0.35	38.75±0.86	38.70±0.51	38.38±0.47	38.35±0.43	38.33±0.39	38.13±0.25
Head temperature	29.50±0.50	27.00±0.50	26.75±0.34	26.00±0.30	28.50±0.25	27.00±0.44	25.50±0.40
Back temperature	30.55±1.61	29.25±1.63	29.75±1.561	29.00±1.35	28.50±1.65	29.75±2.25	30.00±1.38
Chest temperature	30.60±2.06	29.75±2.22	29.25±1.95	30.65±1.82	30.50±1.73	30.85±2.88	32.45±2.87
Rump temperature	28.85±3.30	26.50±4.20	26.00±1.41	28.75±0.82	28.00±1.89	28.25±2.06	29.00±1.83

3.4. Correlation Relationships

between Live Weights and Body Measurements of bucks fed ensiled combinations of cocoa pod, cassava pulp and Acacia leaves

We expressed body weight as a function of some of the variables of interest in this study as follows: The correlation coefficients showed that there was high positive and significant relationship among all the variables. For instance, it was evident that as body weight increased the body length also increased.

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon_i \quad (6)$$

where y_i is the body weight, X_1 is the body length, X_2 denotes neck circumference, X_3 denotes facial length, X_4 denotes head width, X_5 ear length, X_6 represent tail length, X_7 denotes the foreleg, X_8 denotes hindleg.

ε_i is the error term such that $\varepsilon_i \sim N(0, \sigma^2)$, $\beta_i, i = 0,1,\ldots,8$ are the regression coefficients. The regression coefficient was estimated using the ordinary least squared estimator. The Ordinary least squared estimator is defined as follows:

$$\hat{\beta} = (X^T X)^{-1} X^T y \quad (7)$$

The result was provided in Table 5. The coefficient of determination R^2 showed that the body length parameters explained about 98.5% of the variation in body weight. The F-test showed that the overall model fits well to the data (F-statistic=894.831, $p < 0.001$). It was shown that the following parameters contributed to the increase of body weight: body length, neck circumference, facial length, head width, tail length, foreleg, hind leg. Only ear length and foreleg gave a negative coefficient.

Table 5 Correlation relationships between body weights and body measurements of Kids of Goats fed ensiled combinations of cocoa pod, cassava pulp and Acacia leaves

	Body weight	Body Length	Neck Circumf.	Facial Length	Head Width	Ear Length	Tail Length	Foreleg	Hindleg
Body Weight (BW)		0.962**	0.939**	0.948**	0.976**	0.944**	0.810**	0.909**	0.893**
Body Length (BL)	0.962**		0.925**	0.887**	0.950**	0.922**	0.766**	0.907**	0.890**
Neck Circumference (NC)	0.939**	0.925**		0.842**	0.953**	0.962**	0.814**	0.922**	0.922**
Facial Length (FL)	0.922**	0.887**	0.842**		0.928**	0.908**	0.811**	0.875**	0.842**
Head Width (HW)	0.976**	0.950**	0.953**	0.928**		0.971**	0.835**	0.938**	0.908**
Ear Length (EL)	0.944**	0.922**	0.962**	0.908**	0.971**		0.875**	0.960**	0.942**
Tail Length (TL)	0.810**	0.766**	0.814**	0.811**	0.835**	0.875**		0.937**	0.949**
Foreleg (FL)	0.909**	0.907**	0.922**	0.875**	0.938**	0.960**	0.937**		0.950**
Hind leg (HL)	0.893**	0.890**	0.922**	0.842**	0.908**	0.942**	0.949**	0.950**	

**. Correlation is significant at the 0.01 level

Following the performance of this estimator, we employed it to estimate the regression coefficients in model (1) and present the result in Table 6. The K-L regression estimate showed that the variables had a positive sign as against the given result by OLSE. The regression analysis of linear body measurements for goats confirmed that the coefficient of determination R^2 showed that the body length parameters explained about 98.5% of the variation in body weight. The F-test showed that the overall model fits well to the data (F statistic=894.831, p-value=0.000). In terms of the scalar mean squared error, the K-L estimator possessed the minimum mean squared error (MSE_{OLSE}=0.074, MSE_{KL}=0.066).

We assessed if the error term in the model distributed using the Shapiro-Wilk (SW) test. The result showed that the error in the model follows a normal distribution (SW-statistic=0.986, p-value=0.282).

Table 6 Regression result for goats

	Coefficients (OLSE)		t-value	Sig.	VIF	Coefficients using K-L
	B	Std. Error				
$\hat{\beta}_0$	-4.038	.247	-16.36	.000		0.098
$\hat{\beta}_1$	.061	.010	5.952	.000	15.826	2.495
$\hat{\beta}_2$	.117	.018	6.393	.000	22.508	1.402
$\hat{\beta}_3$	.326	.029	11.063	.000	10.316	0.748
$\hat{\beta}_4$	.186	.039	4.712	.000	37.369	0.479
$\hat{\beta}_5$	-.272	.076	-3.560	.001	63.545	0.480
$\hat{\beta}_6$	.043	.062	.688	.493	31.822	0.527
$\hat{\beta}_7$	-.042	.021	-2.011	.047	18.438	1.797
$\hat{\beta}_8$	.011	.022	.512	.610	19.180	1.953

4. Discussion

Chemical composition (%) of the experimental ration fed to West African Dwarf bucks with different levels of Cocoa pod and Cassava pulp, where Acacia leaves were added as complementary ingredients up to 100% was observed in this study. A crude protein content of 8.00 % for sundried cocoa pod husk meal (CPHM) [18] was slightly lower than the value obtained in this study and higher than the values reported by Aregheore [19] (6.20 %) and Adegunloye and Famolu [20] (6.11 %). The dry matter content in cocoa pod found in this study was similar to 87% report of Nguyen et al. [21]on cacao pod shell. Some studies [22] have indicated that cocoa pod could produce feed with high protein value as high as value (12.51%) obtained in this study.

In general, the goats on combinations of 0% cocoa pod, 60% cassava pulp and 40% acacia leaf to combinations of 20% cocoa pod, 40% cassava pulp and 40% acacia leaf consumed the feed more than those on combinations of 30% cocoa pod, 30% cassava pulp and 40% acacia leaf to 60% cocoa pod, 0% cassava pulp and 40% acacia leaf. The findings in this study showed that total feed intake (TFI) decreased as the inclusion levels of cocoa pod increased with decrease in cassava pulp levels in the diets was in agreement with the reports of Aderolu et al. [23] who indicated decrease in feed intake by ruminant livestock have been found to depend on unacceptability, physical characteristics and toxicity of the feed.

However, total intake tended to improve with increasing levels of cassava pulp in the diets. Increased levels of cassava pulp in the diets relatively increased the crude protein content and perhaps the palatability, this might very well explain the relatively high intake observed in favour of the increased cassava pulp diets over increased cocoa pod diets. In a previous study, [24] observed the same trend with cassava peel-based diets containing pigeon pea seed meal. [25] indicated that feed intake is an important factor in the utilization of feed by ruminant livestock and a critical determinant of energy intake, physiological and morphological performance in small ruminants.

The physiological traits of the bucks such as body length, whither height, chest girth, heart girth, shank circumference, neck circumference, facial length, horn length, head length ear length and tail length of the animal were affected by the diets given. This corroborates the findings of Seifemichael et al. [26] who reported that district was found to affect body length, chest girth, whither height, pelvic width, and rump height, while body weight, horn length and ear length of the animal were not affected by district of the goat. Some researchers had also reported the influence of age on physiological traits of the animals such as Fajemilehin and Salako [27], Akpa et al. [28] Tsado and Adama [29], and Su [30].

The Mean rectal temperature was significantly different from each other in groups. The rectal temperature was constant and fell within the normal range for sheep and goats (32.60^{0}C to 39.60^{0}C) was in agreement with the findings of Aye [31]. Moreover, the mean body surface temperature was significantly different from each other but fell within normal range as reported by Patbandha et al. [32].

The correlation coefficients showed that there was high positive and significant relationship among all the variables. For instance, it was evident that as body weight increased the body length also increased. This was in agreement with Agajiye [33] who reported that the correlation relationship between body measurements and the live weights of sheep had positive significant correlation except girth circumference. Neck circumference (NC), abdominal circumference (AC) and length of animal (LA) had highly positive and significant influence on body weights. The works of Afolayan et al. [34] and Otoikhian et al. [35] reconfirmed all these findings. Afolayan et al. [34] in estimating live weight from body dimensions of Yankassa sheep found that live weight was highly correlated with girth circumference at 0.94. Height, length and girth circumference of the animals were directly related to the size of the animals, hence, displayed moderate to very high positive correlations with one another (0.79 and 0.87).

In addition, the study of Otoikhian et al. [35] on correlation of body weight and body dimensions of Uda sheep under extensive management system found that distance between eyes, ear length and ear width, tail length and live weight increased progressively with age of the animal which eventually decreased with age beyond 25 months. They found that positive correlations were found between live weights of the animals and their linear dimension parameters. Hamayun et al. [36] in research to find the relationship between body weights and body linear dimensions found all values of body measurements to be higher in males than females. That body weight had positive and highly significant correlation (P<0.001) with body length (0.49), height at withers (0.75) and heart girth (0.64). The highest and significant correlation existed between live weight and girth circumference which eventually was taken over by body length with advance in age.

The regression results between linear body measurements and prices of animals showed very highly significant relationships between all linear body measurements and prices of goats. All their F-ratios are highly significant, confirming the significance of these variables on the prices of the animals. This necessitated us to diagnose the model for any violation of the assumptions in the linear regression model. According to Lukman and Ayinde [37] and Kibria and Lukman [17], some of the regression coefficients would sometimes exhibit wrong sign when the independent variables are correlated- a situation called multicollinearity. The variance inflation factor (VIF) was employed to assess if the independent variables are correlated. According to Ayinde et al. [38], the independent variables were correlated when the VIF was greater than 10. It was evident from Table 5 that some of the VIF exceeded 10. Thus, we concluded that there was multicollinearity problem in the model. Hoerl and Kennard [39] developed the ridge regression estimator as an alternative method of estimating the regression parameters when there was multicollinearity.

It was observed that the estimation of prices in small ruminants marketing could be influenced by body condition and physiological traits of the animals [40]. That body condition is judged by healthiness of animals, body configuration and average weight according to size and height. Dossa et al. (2015) found that selection criteria for small ruminants in Kano and her environs were health status of animal with body conformation being highly significant. Therefore, important criteria were related to physical appearance consisting of body size, apparent health and body conformation. Agajiye [33] stated that in marketing of small ruminants, smallholders use visual observations and other proxy methods for estimation of weights and prices. By visual observation, they consider body condition and healthiness of the animals. Therefore, small ruminant farmers are encouraged to improve body condition of their animals in order to attract higher premium prices for their animals.

The result in Table 5 showed that the following parameters contributed to the increase of body weight: body length, neck circumference, facial length, head width, tail length, foreleg, hindleg. Only ear length and foreleg gave a negative coefficient. This was in agreement with Otoikhian et al. [35] who reported that sheep showed the R2 value to be 94.8 % with the F-ratio, 16.26 and is highly significant. He reported that the weight of sheep or goat fluctuates as a result of management system, physiological traits, pregnancy, gut fill and lactation.

5. Conclusion

The findings of this study showed that combinations of cocoa pod and cassava pulp with acacia leaves up to the ratio of 20:40:40 levels could influence the growth of the animals and thereby determine the physiological traits of the animal for sustainable and profitable goat production particularly during the dry season. Likewise, the relationship between the body length and linear body traits could enhance genetic improvement of growth rate and overall body size through selection focusing on body length, shank circumference and height at withers as possible selection criteria especially in the field where scales are not usually available.

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Ethics approval

The authors confirm that the ethical policies of the journal, as noted in the journal authors guide lines, have been adhered to. Approval to perform the research and use of animals was obtained from the Ethics Committee of the University of Ilorin, Kwara State, Nigeria.

Authors' Contributions

C.O.R and A.A.A conceived and planned the experiments. All the authors participated in design and coordination. C.O.R performed the experiments, contributed to sample preparation, interpreted the results, and took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analyze, and write the manuscript.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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