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Growth and Linear Body Developments of New Zealand White rabbit bucks fed diets supplemented with *Azanza garckeana* (Goron Tula) fruit meal

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Abstract

Ethno- and traditional medicine have inferred that Azanza garckeana plant products possessed varying phytochemicals and pharmacological properties capable of stimulating muscular growth and cellular development. Thus, this study was conducted to examine the direct and residual effects of Azanza garckeana fruit on the growth, linear body developments and carcass composition of New Zealand White rabbit bucks. Sixty New Zealand White rabbit bucks were randomly assigned to 4 treatments of 15 bucks, replicated three times in a completely randomized design. The experimental diets were formulated and supplemented with Azanza garckeana fruit meal at 0, 100, 200 and 300g/kg respectively, representing T_1, T_2, T_3 and T_4. The study was conducted in two experimental phases, the direct and the residual phase. At the end of each experimental phase, data were collected on the growth, linear body parameters and on the carcass compositions. Results showed that the different supplementation levels of Azanza garckeana fruit up to 300g/kg on the direct phase improved the final weights (T_1 2276.67g to T_4 2446.67g), weight gain (T_1 1295.22g to T_4 1449.89g) and the weights of the skin (T_1 237.00g to T_4 259.00g). It also increased the weight of the forelimb (T_1 199.33g to T_4 258.33g), hindlimb (T_1 255.33g to T_4 292.67g), backcuts (T_1 189.03g to T_4 564.57g), the ear lengths (11.49cm in T_1 to 13.52cm in T_4), heart girts (26.04cm in T_1 to 28.00cm in T_4) and the body length (36.33cm in T_1 to 38.66cm in T_4). On the residual phase, the different supplementation levels of Azanza garckeana fruit reduced the weight gain (T_1 215.33g to T_4 54.65g), dressed weights (from 2110.42g in T_1 to 1936.83g in T_4) and dressed percentages (84.69% in T_1 to 77.44% in T_4); but had no significant ($P>0.05$) effects on the carcass parts and on the linear body development of the rabbit bucks. It is therefore, concluded that the different supplementation levels of Azanza garckeana fruit impacted favourably on the growth of the rabbit bucks, carcass development and on the linear body growth; but had no residual effects on the carcass parts and linear body growth of the rabbit bucks.

Keywords: *Azanza garckeana;* Growth; Linear Body Developments; Internal organs; Rabbits.

Introduction

The domestic rabbit possesses many absolute and comparative advantages when compared to other livestock species. The rabbit has a short gestation length, exhibits early maturity, a high prolificacy efficient reproduction and the ability to be rebred shortly after parturition. These attributes lead to short generation interval (Mmereole, 2009; Ekuma, *et al*., 2017; Amaduruonye, *et al*., 2021). Rabbits are small livestock that are easy to manage either on backyard farm or on a large scale production. They are clean and relatively odourless. Rabbits produce white, palatable, high protein, low fat, low cholesterol and well flavoured meat (Lebas *et al*., 2007). Rabbits have been effectively and extensively used in research (Herbert, *et al*., 2005; Oguike, *et al*., 2019; Emmanuel and Ochefu, 2020; Jiwuba, *et al*., 2021). Rabbits are also raised for shows and as pets. Other advantages of keeping rabbits over other livestock species include limited cost of the housing, feeding, efficient reproductive ability, efficient feed converter, ability to live on forage requires little space compared to other large livestock, especially in areas where there are shortage of agricultural land. They are easy to transport and market (Biobaku and Oguntona, 2007; Brahmantiyo, *et al*., 2021; Nathaniel, *et al*., 2023). Apart from being a good source of white meat, rabbits provides fur, skins, manure and pets. It is the only farm animal which produces meat 10 to 15 times of its weights yearly through progenies (Baruwa, 2014; Cherwon, *et al*., 2020; Babangida, 2021). Rabbit production is an ideal enterprise for young farmers, as it requires limited capital investment for housing and equipment. Today, rabbit as a micro-livestock production is part of food value chain. This results from huge potentials of rabbit production in supplying the much needed animal protein. Furthermore, it is an alternative livestock specie where trypanosomiasis has posed a huge threat to cattle and other livestock production.

Despite all these comparative advantages over other livestock species, the production of meat from rabbits in Nigeria is still low. This may be due to the slow growth rate of rabbits when fed low quality browse and forage plants. Therefore, there is need to stimulate the growth and production of rabbit by harnessing the potentials of the readily available pharmacological plant products, such as *Azanza garckena.*

A*zanza garckeana* is an indigenous fruit shrub with rich sources of proteins, carbohydrates, fat, vitamins, minerals and other trace elements (Michael *et al.,* 2015; Ochokwu, *et al,* 2015; Jacob, *et al*, 2016; Alfred, 2017). Hence, the need to harness the full nutritional, physicochemical and pharmacological potentials of *Azanza garckeana* fruit meal in rabbit production. *Azanza garckeana* has been reported to possess a wide range of pharmacological activities justifying some of its ethno-medicinal uses (Mojeremane and Tshwenyane, 2004; Mutindi, 2014; Ochokwu, *et al.,* 2014). The fruits of *Azanza garckeana* have been documented to possess significant amounts of alkaloids, phytosteroids, tannins, Phenols, Saponins and Cyanogenic glucosides (Nkafamiya *et al*., 2015; Ahmed and ***Hamid***, 2020). Some other researchers have also reported the presence of Terpenoids, triterpenes, Cumarins, Cardiac glycosides, Carotenoids and Flavonoids in *Azanza garckeana* fruit extracts (Idris *et al*., 2015; Ahmed and ***Hamid***, 2020; Dikko *et al*., 2016). These phytosteroids, pharmacological chemical compounds and antinutrients may affect the physiological growths and development of rabbit bucks when *Azanza garckeana* fruit is used in rabbit nutrition. Therefore, this study aimed to examine the *physiological* growth potentials and nutritional impact of *Azanza garckeana fruit on New Zealand white rabbit bucks in the humid tropics.*

Materials and Methods

Experimental site

This research was conducted at the Rabbit Unit of the Teaching and Research Farm of the College of Animal Science and Animal Production, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The area is located in South-East of Nigeria on latitude $5^{0}27^{!}$ North, longitude 7^{0} 32' East, an altitude of 123m above sea level with an annual rainfall of 2177mm, temperature of $22^{0}C$ – $36^{0}C$ and relative humidity of 50 – 90%. It is situated within the humid rain forest zone of West Africa, characterized by long duration of rainy season (March-October) and short period of dry season (November - February). Climatic data were collected from the Meteorological Center of National Root Crop Research Institute, Umudike, Abia State (NRCRI, 2018).

Experimental Animals and Management

A total number of 60 growing New Zealand white rabbit bucks aged 2-3 months were used for this study. The rabbits were purchased from rabbit farms in in Uyo, Akwa Ibom State, and Umuahia, Abia state, Nigeria. Two week pre-experimental period were used to get the rabbits acclimatized to the experimental procedures. Prior to the arrival, hutches were washed and disinfected. A quarantine period of 2 weeks pre- experimental trial were allowed during which the animals were treated against ecto and endo-parasite using Ivomectin and Levamisole (0.1mL/kg body weight), respectively. On arrival, the bucks were weighed. The 60 experimental bucks were divided into 4 treatments groups and replicated 3 times. Care were taken when placing the rabbits into treatment groups in order to balance the groups such that there were no significant differences between the rabbits on the basis of age and weight. The experimental rabbits were house singly in pens of colony hutches for ease of identification throughout the experimental period. The condition of housing and management were similar for all the experimental animals. Experimental diets and clean water were offered to the rabbit bucks *ad-libitum.* All routine management practices were strictly adhered throughout the experimental period. All weight measurements were taken with a 5kg digital weighing scale (Camry EK 5055 Digital Scale) of 0.01 sensitivity. The field work lasted for 16 weeks.

Experimental design

The design for the study was a Completely Randomized Design (CRD) experiment with 4 treatments consisting of T_1, T_2, T_3 and T_4 respectively. T_1 served as the control. Fifteen (15) growing rabbits bucks were randomly assign to each treatment, balanced in weights and replicated 3 times, with 5 rabbits per replicate. The ages of the rabbits were between 2-3 months. The rabbits in T_1 (Control) were given no *Azanza garckeana* ***fruit meal***. Each rabbit in T_2 were given 100g/kg of *Azanza garckeana* fruit meal per kilogram of feed, the rabbits in T_3 were given 200g/kg of *Azanza garckeana* ***fruit*** meal per kilogram of feed, and T_4 rabbits were given 300g/kg of *Azanza garckeana* fruit meal ***per kilogram of feed***. The *Azanza garckeana* ***fruit*** meal were mixed with the feed and offered to the rabbit bucks between 7.00am and 8.00am local time daily.

The experimental model were as follows:

$$\mathbf{Y_{ij} = \mu + Ti + e_{ij}}$$

Where:

$\mathbf{Y_{ij}}$ = individual observation on the rabbit characteristics.

$\boldsymbol{\mu}$ = overall mean

$\mathbf{T_i}$ = treatment effect

$\mathbf{e_{ij}}$ = Experimental error, assumed to be independently, identically and normally distributed with zero means and constant variances.

Nutrient Composition of Azanza garckeana

Table 1: Proximate Composition of *Azanza garckeana* (%)

Plant Part	Moisture content (w/w)	Crude protein (w/w)	Crude fibre (w/w)	Lipid content (w/w)	Total ash (w/w)	Total carbohydrate (w/w)
Fruits	6.50	12.00	45.30	1.10	6.70	28.40
Leaves	5.50	5.60	25.00	0.96	11.00	49.94
Roots	2.70	7.42	11.89	0.68	8.70	70.81
Stem/bark	0.50	4.91	13.75	1.12	7.56	72.16

Source: Nkafamiya, *et al*., (2015). (w/w = weight/weight)

The research was carried out in two (2) phases:

Phase 1: Azanza garckeana fruit meal administration Phase

This experimental phase lasted for 8 weeks. In this phase, the ground *Azanza garckeana* fruit were given between 7.00 and 8.00am local time daily for 8 weeks to the rabbit bucks. The ground *Azanza garckeana* fruit meal were mixed with the feed and offered to the rabbit bucks daily. At the end of this phase, data were collected, evaluated, and analyzed. The compositions of the experimental diets for the direct phase are presented in Table 2.

Table 2: **Gross Composition and Calculated Nutrients of Experimental Diets for Rabbit Bucks in Phase 1**

Ingredients	T_1	T_2	T_3	T_4
Maize	44.94	44.94	44.94	44.94
Soya bean meal	17.31	17.31	17.31	17.31
Rice husk	32.00	32.00	32.00	32.00
Fishmeal	2.00	2.00	2.00	2.00
Bone meal	1.00	1.00	1.00	1.00
Limestone	2.00	2.00	2.00	2.00
Vit/min Premix*	0.25	0.25	0.25	0.25
Common salt	0.50	0.50	0.50	0.50
Total	**100.00**	**100.00**	**100.00**	**100.00**
Ground *Azanza garckeana* (g/kg feed)	0.00	100.00	200.00	300.00
Calculated nutrients:				
Crude Protein (%)	17.00	17.00	17.00	17.00
Metabolizable Energy (ME) (Kcal/kg diet)	2505.42	2505.42	2505.42	2505.42
Crude fiber (%)	11.36	11.36	11.36	11.36
Lysine (%)	0.514	0.514	0.514	0.514
Methionine (%)	0.199	0.199	0.199	0.199

**Premix composition (per kg of diet): vitamin A, 12,500 IU; vitamin D3, 2500 IU; vitamin E, 50.00mg; vitamin K3, 2.50mg; vitamin B1, 3.00mg; vitamin B2, 6.00mg; vitamin B6, 6.00mg; niacin, 40mg; calcium pantothenate, 10mg; biotin, 0.08mg; vitamin B12, 0.25mg; folic acid, 1.00mg; chlorine chloride,300mg; manganese, 100mg; iron, 50mg; zinc, 45mg; copper, 2.00mg; iodine, 1.55mg; cobalt, 0.25mg; selenium, 0.10mg; antioxidant, 200mg.*

Phase 2: Residual phase

This experimental phase lasted for another 8 weeks, which continued immediately after the phase 1 experiment. In this phase, no *Azanza garckeana* fruit meal were supplemented on the diets. The rabbits in each treatment were fed the control diet. This was done to examine for possible side effects or residual effects of *Azanza garckeana* fruit after the first 8 weeks administration. At the end of this phase, data were also collected, evaluated, and analyzed.

Sourcing and Preparation of Azanza garckeana Fruit Meal

The *Azanza garckeana* fruit were sourced from the rural and urban markets in Abia State. The *Azanza garckeana* fruit were dried at room temperature to a constant weight. *A. garckeana fruit* were ground to a fine powder using a mechanical grinding machine to produce *Azanza garckeana* fruit meal. The ground *Azanza garckeana* fruit meal were used as the test ingredients for the experiment. The ground *A. garckeana* fruit meal were mixed with the feed and offered to the rabbit bucks daily between 7.00am and 8.00am local time.

Data Collection

Growth Performance

The rabbit bucks were weighed weekly. Average daily weight gain were determined. Daily weight gain were determined by dividing the total weight gain by the number of the experimental days in each of the experimental phase.

Weight Determination

Initial and final body weights of the rabbit bucks were measured on arrival to the rabbit Farm and at the end of each experimental phase, respectively. Subsequently, body weights and other growth performance parameter were taken at weekly interval throughout the study. All weight measurements were taken with the aid of an electronic weighing scale (Camry EK 5055 Digital Scale) of 0.01 sensitivity. Weight gain were calculated as the difference between the final and the initial weight of the rabbits. *At the end of each experimental phase, 3* rabbit bucks sampled *from each replicate* were *slaughtered* using a captive bolt and allowed to bleed. *The various internal organs and carcass parts* were *collected, measured and recorded.*

Linear Body Developments

The linear body measurement of each rabbit buck were measured in centimeter on the first day of arrival and subsequently at 7 days intervals until the 18th week of the experiment, using a calibrated measuring tape. The parameters measured were: Ear length (cm), Ear width (cm), Length of forelimb (cm), Length of hind-limb (cm), body length (cm), body circumference (cm), Tail length (cm), Heart girth (cm), Head to shoulder (cm) and shoulder to tail drop (cm). The ear length was the length in centimeter measured from the base of the ear to the tip of the ear. The ear width was the length of the broad part of ear taken perpendicularly to the ear length. The length of the forelimb and hindlimb was measured from the shoulder and pelvic joints to the tips of the paws respectively. The body length is the length in centimeters from the nose to the tip of the tail. The body circumference was the circumference of the body in centimeters measured behind the fore limbs. The tail length was the length in centimeters from the base of the tail to the tip of the tail. The Heart girth was the measurement in centimeters of the circumference of the chest area. The head to shoulder is the length in centimeters of the animal taken from the tip of the nose to the base of the shoulder. Shoulder to tail drop was the measurement of the length in centimeters from the shoulder to the base of the tail.

Carcass Evaluation

At the end of each experimental phase, 3 rabbit bucks sampled *from each replicate* were *sacrificed. The internal organs* were *collected, measured and recorded.* The absolute weights of the organs were determined and recorded. The carcass parts were collected measured and recorded. The live weights, dressed weights, dressed percentage, Skin, Singed, Neck, Forelimb, Hind limb, back cut, Loin and Ribs were all weighed in grams and recorded.

Data Analysis

Data collected on the different growths and carcass parameters were subjected to Analysis of Variance (ANOVA) using a software package (SPSS version 23). Significant means were separated using Duncan's Multiple Range Test at 5% level of significance (Duncan, 1955). All statistical analysis were in accordance with the methods of Steel and Torie, (1980).

Results and Discussion

The direct effects of *Azanza garckeana* fruit meal on the growth performance of New Zealand white rabbit bucks are shown in Table 3.

Table 3: Growth Performance of New Zealand White Rabbit Bucks Fed Diets Supplemented with *Azanza garckeana* Fruit Meal

Parameters (g)	T_1 (0.0g/kg)	T_2 (100g/kg)	T_3 (200g/kg)	T_4 (300g/kg)	SEM
Final Weight (g)	2276.67^a	2406.67^b	2366.67^b	2446.67^b	39.51
Initial Weight (g)	981.44	994.44	988.44	996.77	58.21
Weight Gain (g)	1295.22^a	1412.22^b	1378.22^b	1449.89^b	72.10
Average Daily Weight Gain (g)	23.13^a	25.22^b	24.61^b	25.89^b	1.25
Dressed Weight (g)	1489.13	1490.27	1469.85	1596.53	49.82
Dressed Percentage (%)	65.35	61.68	62.01	64.51	1.43

$^{abc:}$ Means with different superscripts along rows are significantly different ($p<0.05$) and SEM: Standard error of treatment means.

The results showed that the supplementations of *Azanza garckeana* fruit meal in the diets of the New Zealand white rabbit bucks did not alter the dressed weights and the dressed percentage of the rabbit bucks. The result further showed that significant differences ($p<0.05$) were observed on the final weights, weight gain and on the average daily weight gain of the rabbit bucks following the supplementation of *Azanza garckeana* fruit meal compared with the control. The supplementation of *Azanza garckeana* fruit meal significantly ($p<0.05$) increased the final weights, weight gain and the average daily weight gain of the rabbit bucks in T2, T3 and T4 respectively; while the dressed weights and the dressed percentage were not significantly affected. The dressed weights and the dressed percentage of the New Zealand white rabbit bucks fed diets supplemented with *Azanza garckeana* fruit meal in T2, T3 and T4 were statistically similar ($p>0.05$) with those on the control group (T1). The final weights of rabbits in T2 (2406.67g), T3 (2366.67g) and T4 (2446.67g) were significantly heavier compared to those of the rabbit bucks in T1 (2276.67g). The highest weight gain were observed in T4 (1449.89g), followed by T2

(1412.22g) and T3 (1378.22g). The least weight gain were observed in T1 (1295.22g). The similar trend were observed on the average daily weight gain of the rabbit bucks. As such, the different supplementations levels of *Azanza garckeana* fruit meal in the diets of the rabbit bucks increased the final weights, weight gain and the daily weight gain of the New Zealand white rabbit bucks in the humid tropics. The significant improvements on the weight gain following the supplementations of *Azanza garckeana* fruit meal may be attributable to the direct impacts of *Azanza garckeana* fruit on tissues growth and muscular developments of the rabbit bucks, resulting from the presence of appreciable amount of amino acid profile with rich nutritional benefits, accompanied by several phytosteroids in *Azanza garckeana* fruit. This may also have resulted from the higher carbohydrate content of diets supplemented with *Azanza garckeana* fruit meal, as *Azanza garckeana* fruit contain appreciable amount of carbohydrates, as observed in Table 1 (Nkafamiya *et al*., 2015). For instance, foods rich in carbohydrates, amino acid profile and steroids respectively, have been proven to enhance growth, weight gain and muscular developments; as such have been used to ameliorate malnutrition in humans (Harika, *et al*., 2017; Johnson, 2021).

The residual effects of *Azanza garckeana* fruit meal on the growth performance of New Zealand white rabbit bucks are shown in Table 4.

Table 4: Residual Effect of *Azanza garckeana* Fruit Meal on the Growth Performance of New Zealand White Rabbit Bucks

Parameters (g)	T_1 (0.0g/kg)	T_2 (100g/kg)	T_3 (200g/kg)	T_4 (300g/kg)	SEM
Final Weight (g)	2492.00	2495.67	2473.67	2501.00	8.47
Initial Weight (g)	2276.67^{a}	2406.67^{c}	2366.67^{b}	2446.67^{c}	19.08
Weight Gain (g)	215.33^{c}	89.44^{a}	107.32^{b}	54.65^{a}	19.76
Average Daily Weight Gai n (g)	3.85^{b}	1.60^{a}	1.92^{a}	0.98^{a}	0.35
Dressed Weight (g)	2110.42^{b}	1912.47^{a}	1924.05^{a}	1936.83^{a}	21.19
Dressed Percentage (%)	84.69^{b}	76.63^{a}	77.78^{a}	77.44^{a}	0.72

[abc:] Means with different superscripts along rows are significantly different ($p<0.05$) and SEM: Standard error of treatment means.

The results showed that significant differences ($p<0.05$) were observed on the weight gain, average daily weight gain, dressed weight and dressed percentage of the rabbit bucks at the residual phase of the experiment. The different weight gains reduced significantly in T2 (89.44g), T3 (107.32g) and T4 (54.65g), with the highest weight gain observed in T1 (215.33g). The average daily weight gain in T4 (0.98g), T3 (1.92g) and T2 (1.60g) significantly reduced compared to those of T1 (3.85g). The significant reduction on the average daily weight gain followed similar trend as observed on the weight gain. The dressed weights in T2 (1912.47g), T3 (1924.05g) and T4 (1936.83g); and the dressed percentage in T2 (76.63%), T3 (77.78%) and T4 (77.44%) respectively reduced significantly, with the highest dressed weights (2110.42g) and dressed percentage (84.69%) observed in T1 respectively. The dressed percentage of the New Zealand white rabbit bucks in T2, T3 and T4 reduced significantly ($p<0.05$) compared to the gains in weight, average daily weight gain,

dressed weights and the dressed percentage respectively of the rabbit bucks in the control group. This significant reduction in weights observed at the residual phase following the withdrawal of *Azanza garckeana* fruit meal may be attributed to the reduction in the nutrient quality and palatability of the new diet, as the diets supplemented with *Azanza garckeana* fruit meal had a better nutritional quality. This may have also resulted from the change in diets of high carbohydrate and amino acid profile to a diets of lower carbohydrates and amino acid profile, as seen in Table 1 (Nkafamiya *et al*., 2015). Moreover, the change to a new diet and subsequent adjustments of the rabbit bucks initially on *Azanza garckeana* fruit meal supplemented diets to a new diet may have reduced the feed intake and weight gain, as sudden change in feed reduces feed intake and weight gain (González, *et al*., 2008). These inferred that the *Azanza garckeana* fruit meal supplemented diets had a better growth performance on the New Zealand white rabbit bucks in the humid tropics.

The direct effects of *Azanza garckeana* fruit meal on the Carcass Characteristics of New Zealand white rabbit bucks are shown in Table 5.

Table 5: Carcass Characteristics of New Zealand White Rabbit Bucks Fed Diets Supplemented with *Azanza garckeana* Fruit Meal

Parameters (g)	T_1 (0.0g/kg)	T_2 (100g/kg)	T_3 (200g/kg)	T_4 (300g/kg)	SEM
Final weight	2276.67^a	2406.67^b	2366.67^b	2446.67^b	39.51
Slaughtered weight	2358.33	2398.33	2266.33	2436.00	39.65
Skin	237.00^a	236.33^a	254.33^b	259.00^b	3.81
Dressed Weight	1469.85	1490.27	1489.13	1596.53	49.83
Forelimb	199.33^a	200.00^a	194.667^a	258.33^b	15.31
Hindlimb	255.33^a	2667.33^a	250.67^a	292.67^b	21.83
Backcut	489.03^a	531.47^b	516.27^b	564.57^c	21.25
Ribs	154.00	155.67	149.00	144.67	3.02
Loin	266.33	264.67	272.67	275.33	3.44
Neck	81.667	77.00	79.67	84.67	1.94
Head	186.67	200.33	152.67	143.00	12.53
Evisceral Weight	430.45	465.43	463.53	428.90	7.20

^{abc}: Means with different superscripts along rows are significantly different ($p<0.05$) and SEM: Standard error of treatment means.

The results showed that only the final weights, skin weight, forelimb, hindlimb and backcuts of the rabbit bucks were significantly different ($p<0.05$) compared to the rabbit bucks in the control group. All the other carcass parameters measured were statistically similar ($p>0.05$) compared with the control group. Furthermore, significant improvements ($p<0.05$) were observed on the final weights, skinned weights, forelimb, hindlimb and backcuts of the rabbit bucks. The skinned weights of the rabbits in T1 (237.00g) and T2 (236.33g) were statistically similar ($p>0.05$) but significantly lower compared to those in T3 (254.33g) and T4 (259.00g). The weights of the forelimb and hindlimb of rabbit bucks in T1, T2 and T3 were statistically similar ($p>0.05$) and significantly ($p<0.05$) lower compared to the forelimb (258.33g) and hindlimb (292.67g) of rabbit bucks in T4. The

backcuts of rabbit bucks in T2 (531.47g), T3 (516.27g) and T4 (564.57g) significantly increased across the treatment groups compared with the backcuts of the rabbits in T1 (489.03g). This results are similar to what was observed in Table 3. Animals with a higher weight gain will produce a heavier carcass parts. The rabbit bucks fed diets supplemented with *Azanza garckeana* fruit meal are heavier and had a better weight gain, thus, producing heavier cut parts. This showed that the supplementations of *Azanza garckeana* fruit meal in the diets of the rabbit bucks significantly increased the skin, forelimb, hindlimb and backcuts of the New Zealand white rabbit bucks.

The residual effects of *Azanza garckeana* fruit meal on the Carcass Characteristics of New Zealand white rabbit bucks are shown in Table 6.

Table 6: Residual Effects of *Azanza garckeana* Fruit Meal on the Carcass Characteristics of New Zealand White Rabbit Bucks

Parameter (g)	T_1 (0.0g/kg)	T_2 (100g/kg)	T_3 (200g/kg)	T_4 (300g/kg)	SEM
Final weight	2492.00	2495.67	2473.67	2501.00	38.52
Slaughtered weight	2483.33	2487.33	2465.00	2492.33	8.55
Skin	280.00	276.00	282.33	283.00	3.03
Dressed Weight	1529.67	1543.67	1550.67	1530.00	12.21
Forelimb	239.00	240.33	243.33	241.67	4.61
Hindlimb	281.67	297.33	285.00	292.00	1.76
Backcut	509.67	512.00	510.00	505.67	2.32
Ribs	154.00	156.33	153.67	142.00	7.94
Loin	279.00	278.00	278.33	281.67	1.21
Neck	80.00	78.00	81.00	76.05	0.93
Head	207.67	203.67	211.67	205.33	1.86
Evisceral Weight	373.92	379.53	396.18	359.83	15.50

SEM: Standard error of treatment means.

The results on the carcass characteristics of the rabbit bucks at the residual phase showed that no significant differences ($p>0.05$) were observed on the different carcass parts of the New Zealand white rabbit bucks compared with the control group. The carcass parts were all statistically similar ($p>0.05$) with those of the control group, following the supplementations of *Azanza garckeana* fruit meal in the diets. Similarly, non-significant differences on the carcass parts were documented by Haruna and Muhammad, (2018) when rabbits were fed yam peel meal. Also, Ibrahim (2019) reported no significant differences on the carcass characteristics of rabbits when fed different forages as supplement. Furthermore, Nathaniel *et al*., (2023) examined the performance and carcass characteristics of rabbit bucks fed diets containing varying levels of tiger nut meal, also reported no significant effects on the carcass characteristics. This results, therefore, indicated that the different supplementation levels of *Azanza garckeana* fruit meal up to 300g/kg in the diets of New Zealand white rabbit bucks in the direct phase did not have any residual effect on the carcass characteristics of the rabbit bucks in the humid tropics.

The direct effects of *Azanza garckeana* fruit meal on the Linear Body Growth of New Zealand white rabbit bucks are shown in Table 7.

Table 7: Linear Body Growths of New Zealand White Rabbit Bucks Fed Diets Supplemented with *Azanza garckeana* Fruit Meal

Parameter (cm)	T_1 (0.0g/kg)	T_2 (100g/kg)	T_3 (200g/kg)	T_4 (300g/kg)	SEM
Ear Length	11.49^a	13.39^b	11.93^a	13.52^b	0.29
Ear Width	5.66	5.70	5.83	5.77	0.12
Length of Forelimb	15.74^a	16.94^b	16.78^b	16.77^b	0.18
Length of Hindlimb	25.53^a	27.80^c	26.71^b	27.93^c	0.32
Tail Length	10.73^a	11.82^b	11.78^b	12.78^c	0.24
Heart Girt	26.04^a	26.08^a	25.99^a	28.00^b	0.29
Body Length	36.33^a	37.96^b	38.34^b	38.66^b	0.32
Head to Shoulder	16.74	15.62	16.07	16.31	0.20
Shoulder To Tail -drop	34.80	35.60	36.00	34.40	0.20
Body Circumference	35.00	34.10	35.80	35.50	0.40

^{abc}: Means with different superscripts along rows are significantly different ($p<0.05$) and SEM: Standard error of treatment means.

The results showed that with the exception of the lengths of the ear width, head to shoulder, shoulder to tail-drop and body circumference, all the other linear body parameters measured were significantly ($p<0.05$) affected by the different supplementations of *Azanza garckeana* fruit meal in the diets of New Zealand white rabbit bucks. The lengths of the ear width, head to shoulder, shoulder to tail-drop and body circumference of the rabbit bucks in T2, T3 and T4 were statistically similar ($p>0.05$) with those in the control groups (T1). Furthermore, the supplementation of the *Azanza garckeana* fruit meal in the diets at 100g/kg, 200g/kg and 300g/kg increased significantly ($p<0.05$) the lengths of forelimb, hindlimb, tail lengths and the body lengths compared with the control group. The ear lengths of T1 (11.49cm) and T3 (11.93cm) were statistically similar ($p>0.05$) but significantly lower ($p<0.05$) compared to those of T2 (13.39cm) and T4 (13.52cm). The heart girts of T1 (26.04cm), T2 (26.08cm) and T3 (25.99cm) were statistically similar ($p>0.05$) but significantly lower ($p<0.05$) compared to those of the rabbit bucks in T4 (28.00cm). These results inferred that the supplementation of *Azanza garckeana* fruit meal at these supplementation levels in the diets of New Zealand white rabbit bucks affected the linear body growths of the rabbits.

The linear body growths, such as the ear length, body length, heart girt, head-to-shoulder and shoulder-to-tail of the rabbit bucks in T2, T3 and T4 are similar with those documented by Abdullah *et al*. (2003) for rabbit bucks under tropical conditions. These observations collaborated with the linear body growths pattern reported by Amaduruonye, *et al*., (2017) for rabbit bucks fed diets supplemented with *Allium sativum in the humid tropics,* thus, indicating that the varying supplementation levels of *Azanza garckeana* fruit meal did not cause abnormal linear body growth of the rabbit bucks**.**

The residual effects of *Azanza garckeana* fruit meal on the Linear Body Growths of New Zealand white rabbit bucks are shown in Table 8.

Table 8: Residual Effects of *Azanza garckeana* Fruit Meal on the Linear Body Growths of New Zealand White Rabbit Bucks

Parameter (cm)	T_1 (0.0g/kg)	T_2 (100g/kg)	T_3 (200g/kg)	T_4 (300g/kg)	SEM
Ear Length	13.10	13.40	13.10	13.50	0.13
Ear Width	6.10	6.70	6.10	6.20	0.05
Length of Forelimb	17.10	17.00	17.30	17.30	0.16
Length of Hindlimb	26.50	27.50	27.70	28.20	0.27
Tail Length	13.10	13.00	12.70	12.40	0.11
Heart Girt	27.20	27.50	26.00	28.00	0.22
Body Length	39.30	38.90	39.10	38.40	0.09
Head to Shoulder	17.20	16.30	16.80	17.00	0.15
Shoulder To Tail -drop	38.50	37.00	38.00	36.50	0.50
Body Circumference	36.20	35.00	37.00	37.50	0.30

SEM: Standard error of treatment means.

The results on the linear body growths of the rabbit bucks at the residual phase showed that no significant differences ($p>0.05$) were also observed on the different carcass parts of the New Zealand white rabbit bucks compared with the control group. The linear body growth parameters measured were all statistically similar ($p>0.05$) with those of the control group. Similarly, Anya *et al.,* (2018) also reported no significant differences on the linear body measurements and growth performance characteristics of rabbits when fed **cocoa bean shell meal - based diets**. These linear body growths as observed in this study are still within the normal range as documented by Abdullah, *et al*. (2003) for healthy rabbit bucks in tropical environmental **conditions.** As such, this inferred that the different supplementation levels of *Azanza garckeana* fruit meal in the diets of the New Zealand white rabbit bucks did not have any residual effect on the linear body growths of the rabbit bucks.

Conclusion

Based on the results and observations from this study, it is concluded that the different supplementation levels of *Azanza garckeana* fruit meal up to 300g/kg in the diets impacted favourably on the growths of the rabbit bucks, carcass developments and on the linear body growths of the rabbit bucks. *Azanza garckeana* fruit had no residual effects on the carcass parts and linear body growths, but residually reduced the weights, dressed weight and dressed percentage of the rabbit bucks.

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