EEFECTS OF *Canarium schweinfurthii* FRUIT CAKE SUPPLEMENTED DIET ON GROWTH CHARACTERISTICS IN MALE WISTAR RATS

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ABSTRACT
Forty male wistar rats were used in a 42-day trial to examine the effect of supplementing different levels of Canarium schweinfurthii fruit cake on growth characteristics of male wistar rats. The rats were randomly distributed into groups of ten (10) using a completely randomized design in four treatment groups with one serving as control. Control group was fed using standard growers mash as diet without fruit cake, while the remaining treatment groups were fed diet supplemented with 2.5%, 5.0%, and 10.0% Canarium schweinfurthii fruit cake. Proximate composition, weekly weight change, mean percentage weight change, cumulative weight change, weekly feed intake, cumulative feed intake, feed efficiency ratio and cumulative feed efficiency ratio were determined. Results indicated that weight change and mean percentage weight change of rats differed significantly (p<0.05). Feed intake also differed significantly (p<0.05) among the rats receiving 10% level of Canarium schweinfurthii fruit cake supplemented diet when compared to the other treatment groups, also proximate analysis revealed high crude fat, crude protein and calcium levels in this particular level of supplemented diet. The findings in this present study suggest that dietary Canarium schweinfurthii fruit cake supplemented diet at the appropriate levels can promote healthy growth.
Keywords: Canarium schweinfurthii; dietary supplementation; weight change, feed efficiency ratio; proximate analysis

INTRODUCTION

One of the most important research areas in the field of nutritional science is to investigate the role of dietary active compounds in human nutrition. Food and diet not only supply the nutrients to the body to perform its functions, but also have several beneficial effects to maintain the health. Several findings have implicated food as a major factor behind majority of the metabolic and degenerative diseases (Hasler, 1998). In recent years, researchers are identifying some of the specific bioactive components in food and assessing their mechanisms, role and effects within the body.

Canarium schweinfurthii is a large forest tree with its crown reaching to the upper canopy of the forest, with a long clean, straight and cylindrical bole exceeding 50 m which has a diameter above the heavy root swellings. The bark on the young tree is fairly smooth and thick, becoming increasingly scaly and fissured with age also the slash is reddish or light brown with turpentine like odour, exuding a heavy, sticky oleoresin that is sulphur yellow. The fruit is a small drupe, bluish-purple, glabrous, 3-4 cm long and 1-2 cm thick. The calyx is persistent and remains attached to the fruit. The fruit contains a hard spindle-shaped stone that eventually splits releasing 3 seeds (Orwa *et al.*, 2009). The slightly greenish pulp of the fruit is edible which can be eaten raw or softened in warm water to improve palatability. The seed kernel is oily and edible and is cooked in Nigeria and prepared into a vegetable butter and eaten as a substitute for Shea-butter (Ajiwe *et al.*, 2000).

Crude *Canarium schweinfurthii* known as "atili" in Hausa, in addition to containing natural flavors, free fatty acids, pigments, moisture, trace element, pro-vitamins, vitamins also contain naturally occurring antioxidants and enzymes. The fruits have served man for centuries as snack and oil from the fruits have served man for domestic, pharmacological and industrial purposes. The study intends to determine the improvement of growth characteristics derived from *Canarium schweinfurthii* fruit cake supplemented diets.

METHODOLOGY
Plant Collection
Canarium schweinfurthii fruit was purchased in Bukuru, Jos, Plateau State, Nigeria. The fruits were identified at the Heberium of the Biological Science department Ahmadu Bello University Zaria, Kaduna State, Nigeria where a Voucher Number 7232 was issued.

Preparation of the Extracts
The fruit was first washed, and then about 1.5 litres of water was boiled at a temperature of 87^0C after which an equal volume of water at room temperature was then added bringing the temperature down to 55^0C and then it was poured into a bucket containing the fruit to make it tender. The fruit pulp was then removed from their seeds, dried outdoors for three (3) days and then milled in a locally made wooden mortar and pestle, after which it was then defatted using the Soxhlet technique adopting the method described by Association of Official Analytical Chemist (1980) using n-hexane. About 1.5 kg of the powdered fruit pulp were packed in muslin cloth, and inserted into the soxhlet extractor and subjected to continuous reflux action for 10 hrs using n-hexane as the solvent. n-hexane was recovered using a rotary evaporator. Exactly 6 kg *Canarium schweinfurthii* fruit was defatted and the fruit cake obtained was then stored in airtight polyethylene bags and refrigerated at 4^0 C until required.

Experimental Design
Forty-eight wistar rats, between 7-8 weeks old and weighing 120 kg were used for the experiment. The animals were housed in standard rat cages and were fed *ad libitum* with growers mash. Wistar rats which made up the normal control were fed with growers mash and comprised group I, group II was made up of wistar rats **f**ed with growers mash and 2.5% *C. schweinfurthii* fruit cake. Group III wistar rats were fed with growers mash and 5% *C. schweinfurthii* fruit cake and Group IV comprised of wistar rats fed with growers mash and 10% *C. schweinfurthii* fruit cake.

Diet Supplementation
Wistar rats in group 1 were fed standard growers mash, however the wistar rats in groups 2-4 were fed growers mash supplemented with varying levels of *Canarium schweinfurthii* fruit cake at 2.5%, 5% and 10% for six weeks. The 2.5% diet supplementation group; 97.5g of growers mash was mixed manually with 2.5% *Canarium schweinfurthii* fruit cake making a total weight of 100g of the diet supplemented feed, for the 5% diet supplementation group; 95g of growers mash was mixed manually with 5% *Canarium schweinfurthii* fruit cake making a total weight of 100g of the diet supplemented feed and for the 10% diet supplementation group; 90g of growers mash was mixed manually with 10% *Canarium schweinfurthii* fruit cake making a total weight of 100g of the diet supplemented feed.

Body Weight and Feed Intake Measurement
Animals in each group were fed with the respective diets every day. Individual daily food consumption record was maintained. The feed that is served to each animal was weighed and recorded. Split and leftover food was weighed everyday to obtain an accurate weight of the food consumed. The change in weight was determined by weighing the rats at the commencement of the feeding trial and thereafter on a weekly basis until termination of the experiment.

Estimation of Feed Efficiency
The data from feed intake and weight gain was used to calculate the cumulative weight gain, average weekly weight gain, cumulative feed efficiency. Feed efficiency was calculated according to the method of Muramatsu *et al.,* (1986). The weight changes of the animals in the respective groups were summed up on weekly basis for the period of the experiment. The weekly feed intakes were calculated for the supplemented and control groups and the feed efficiency was evaluated as:

$$\text{Feed efficiency } = \frac{\text{weight gain (g/rat)}}{\text{Feed intake (g/rat)}}$$

Estimation of feed intake
The feed intake in the various supplemented groups and the control groups was calculated by summing up the feed/characteristics for each group for 6 weeks, Muramatsu *et al.,* (1986). The weight of the rats in their respective groups were also calculated by taking the average of the animal weight for the 6 weeks. The feed intake (g/kg bodyweight) was extrapolated as

$$\text{Feed intake(g/kgbodyweight) } = (\frac{\text{Average feed intake (g)}}{\text{Average Body weight (kg)of rat}} \times 1000)$$

Estimation of body weight change
i. The weekly body weight change was evaluated by subtracting the initial average weight of the animals (IAW) Muramatsu *et al.,* (1986), from the final average weight of the animal (FAW) on weekly basis

Average weekly weight change = FAW − IAW

ii. The average cumulative weight change (ACWC) was evaluated by summing up the result obtained from (FAW-IAW)

iii. % weekly weight change was calculated via deducting the weight of a week to it previous week divided by the weight of the animals multiply by 100.

$$\% \text{ weight change } (\%) = \left(\frac{\text{Body weight 2 (g)} - \text{Body weight 1(g)}}{\text{Body weight 1 (g) of rat}} \times 100\right)$$

Proximate Analysis of *Canarium schweinfurthii* Fruit Cake

Determination of Crude Protein
Protein in the sample was determined by Kjeldahl method described by Chang (2003). Protein in the sample was determined by Kjeldahl method. 0.5-1.0 g of dried samples was taken in digestion flask. 10-15 ml of concentrated H_2SO_4 was added together with 8 g of digestion mixture i.e. K_2SO_4: CuSO (8: 1). The flask was swirled in order to mix the contents thoroughly then placed on a heater to start digestion till the mixture become clear (blue green in color) with the procedure taking 2 hrs to complete. The digest was cooled and transferred to 100 ml volumetric flask and the volume was made up to mark by the addition of distilled water, after which distillation of the digest was performed in Markam Still Distillation Apparatus (Khalil and Manan, 1990). Ten milliliters of digest was introduced in the distillation tube then 10 ml of 0.5 N NaOH was gradually added through the same way and this continued for at least 10 mins and NH3 produced was collected as NH4OH in a conical flask containing 20 ml of 4% boric acid solution with few drops of modified methyl red indicator, which then gave a yellowish color due to NH_4 OH. The distillate was then titrated against standard 0.1 N HCl solution till the appearance of pink color. A blank was also run through all steps as above. Percent crude protein content of the sample was calculated by using the following formula:

% Crude Protein = 6.25* x %N (*. Correction factor)

$$N (g\%) = \frac{(\text{mL 0.1N HCl sample} - \text{mL 0.1N HCl blank}) \times 0.0014 \times N \text{ HCl} \times 100}{\text{Weight of sample}}$$

Where 0.014 = Milli equivalent weight of Nitrogen

Determination of crude fat
The crude fat were determined by solvent extraction method described by Kirk and Sawyer (1980). Sample was blended until homogenous and about 1-5 g of homogeneous sample or 10 mL was weighed in duplicate, into a container (W1) in which some glass beads were placed. The flask was then connected to an air condenser and refluxed with gentle boiling for 30 mins after which the residue was then washed with warm water until the filtrate was deemed free from acid. The filter paper containing the residue was dried in an oven at 60^0C for 6 h or overnight and then transferred into an extraction thimble which was then placed in a reservoir part of a soxhlet apparatus. A round flat bottom flask was then dried in an oven at 100^0C for 1 h and was then cooled in a desiccator and weighed (W2) after which about 50 mL diethyl ether was then added into the pre-weighed round flat bottom flask and placed into the fat extraction system. Sample was extracted in the thimble by immersing it in warmed solvent for 30 min and then the solvent was evaporated in each round flat bottom flask on a water bath in a fume hood. The flask was then dried in an oven at $100^0 C$ for 30 min and cooled in a desiccator and then re-heated and weighed again every 30 min until constant weight was obtained (W3), (Horwitz., 2000).

$$\text{Total Fat (g/100 g)} = \frac{W_3 - W_2}{W_1} \times 100$$

where: W1 = Weight of sample; W2 = Weight of dried extraction cup before fat extraction; W3 = Weight of dried extraction cup after fat extraction

Determination of Crude Fiber
The crude fiber was determined by furnaces incineration gravimetric method described by James (1995). Sample was dried in an oven at 150^oC for 1 h after which the sample was allowed to cool in a desiccator and weighed (W_1) and kept in crucibles in a muffle furnace at 55^oC for 4 hrs after which the samples were then cooled in a desiccator and weighed again (W_2). Calculations were done by using the formula:

$$\% \text{ Crude Fiber} = \frac{W1 - W2}{W_0} \times 100$$

Determination of Total Ash

The total ash was determined by furnaces incineration gravimetric method described by James (1995) and AOAC (1984). Clean empty crucible was placed in a muffle furnace at 600°C for an hour, cooled in desiccator and then the weight of empty crucible was noted (W_1). One gram of each of sample was taken in crucible (W_2) and the sample was ignited over a burner with the help of a blowpipe, until it is charred. Then the crucible was placed in muffle furnace at 550°C for 2-4 h and the appearances of gray white ash indicated complete oxidation of all organic matter in the sample. After ashing furnace was switch off and the crucible was cooled and weighed (W_3). Percent ash was calculated by following formula:

$$\%Ash = \frac{\text{Difference in Wt. of Ash} \times 100}{\text{Wt. of sample}}$$

Determination of Calcium

The digested sample was analyzed for mineral contents by Atomic Absorption Spectrophotometer (Hitachi model 170-10). The equipment was run for standard solution of the mineral before and during determination to check that it is working properly. The dilution factor for calcium was 100, further dilution of the original solution was done by using 0.5 ml original solution and enough distilled water was added to it to make the volume up to 100 ml. About 1.0 ml lithium oxide solution was added to the original solution to unmask Ca from Mg. The concentrations of the mineral was recorded in terms of "ppm" and converted to milligrams (mg) of the mineral by multiplying the ppm with dilution factor and dividing by 1000, as follows:

$$MW = \frac{\text{absorbency (ppm)} \times \text{dry wt.} \times D}{\text{Wt. of sample} \times 1000}$$

Statistical Analysis

The data generated from the study were analyzed using Excel and SPSS 20 applications. All results are expressed as ± standard deviation.

RESULT

The proximate analysis (Fig 3a) of the diet supplemented 10% *C. schweinfurthii* fruit cake differed significantly ($p > 0.05$) with higher values for crude fibre, nitrogen, crude protein and calcium compared to the normal control and the other diet supplemented groups.

Table 3a. Proximate Composition of *Canarium schweinfurthii* Fruit Cake Supplemented diet

Diet Supplementation Level	% Dry matter	% Ash	% Crude fat	% crude fibre	% Nitrogen	% Crude protein	Calcium (mg)
2.5% *Canarium schweinfurthii* supplemented diet	93.69 ± 1.11	4.83 ± 0.93	15.41 ± 1.41	7.20 ± 1.05	3.88 ± 0.05	24.25 ± 1.98	0.19 ± 0.01
5% *Canarium schweinfurthii* supplemented diet	93.75 ± 1.01	4.76 ± 1.02	16.16 ± 1.30	9.45 ± 1.51	3.58 ± 0.64	22.38 ± 1.78	0.20 ± 0.00
10% *Canarium schweinfurthii* supplemented diet	93.80 ± 1.00	4.44 ± 1.20	21.28 ± 0.67	22.41 ± 0.75	3.67 ± 0.55	22.94 ± 1.56	0.21 ± 0.01

Values are expressed as mean ± standard deviation

The body weight change, the mean percentage weight change and feed efficiency data generated during the period of the study are presented below. The weekly weight change (Table 3a) and mean percentage weight change (Fig. 3a) of the 10% *C. scheinfurthii* fruit cake supplemented diet rats was significant ($p < 0.05$) when compared to the normal control and the other supplemented diet groups.

Table 3b. Effects of *C. schweinfurthii* Fruit cake Supplemented diet on Weekly Weight Change in Male Wistar Rats

Weeks	Normal control	2.5% *C. scheinfurthii* fruit cake supplemented diet	5% *C. scheinfurthii* fruit cake supplemented diet	10% *C. scheinfurthii* fruit cake supplemented diet
1	10.50 ± 3.62	23.25 ± 1.38	18.00 ± 1.91	23.25 ± 0.63
2	17.75 ± 3.54	16.00 ± 3.19	20.75 ± 1.11	26.25 ± 2.02
3	14.50 ± 0.87	-2.75 ± 0.48	12.00 ± 1.08	6.50 ± 2.40
4	12.25 ± 1.11	16.25 ± 9.32	17.50 ± 3.97	6.75 ± 1.11
5	11.75 ± 1.32	8.75 ± 3.94	4.50 ± 1.29	14.25 ± 1.11
6	16.25 ± 1.11	7.75 ± 2.87	11.75 ± 1.44	12.50 ± 0.87

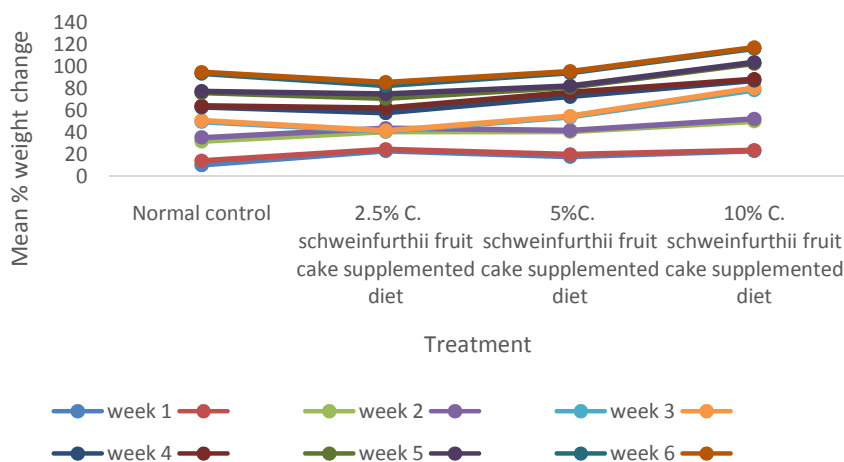Values are expressed as mean ± standard deviation

Figure 3a. Effect of *Canarium schweinfurthii* Fruit Cake Diet Supplemented diet on the Mean Percentage Weight Change of Male Wistar Rats

The weekly feed intake (Table 3c), cumulative feed intake (Fig 3b), feed efficiency ratio (Fig 3c) and cumulative feed efficiency ratio (Fig 3d) for the 10% *C. scheinfurthii* fruit cake supplemented diet rats was significant (p<0.05) when compared to the normal control and the other supplemented diet groups.

Table 3c. Effects of *C. schweinfurthii* Fruit cake Supplemented diet on Weekly Feed intake in Male Wistar Rats

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
Normal control	560±16.89	848±29.67	792±28.34	781±27.82	811±21.44	819±27.82
2.5% *C. schweinfurthii* fruit cake supplemented diet	691±17.33	721±28.78	715±27.11	741±24.35	804±28.77	809±24.35
5% *C. schweinfurthii* fruit cake supplemented diet	737±21.11	701±22.89	666±23.11	876±39.73	874±25.64	867±39.73
10% *C. schweinfurthii* fruit cake supplemented diet	736±22.34	600±25.56	775±30.43	864±37.39	902±35.62	925±37.39

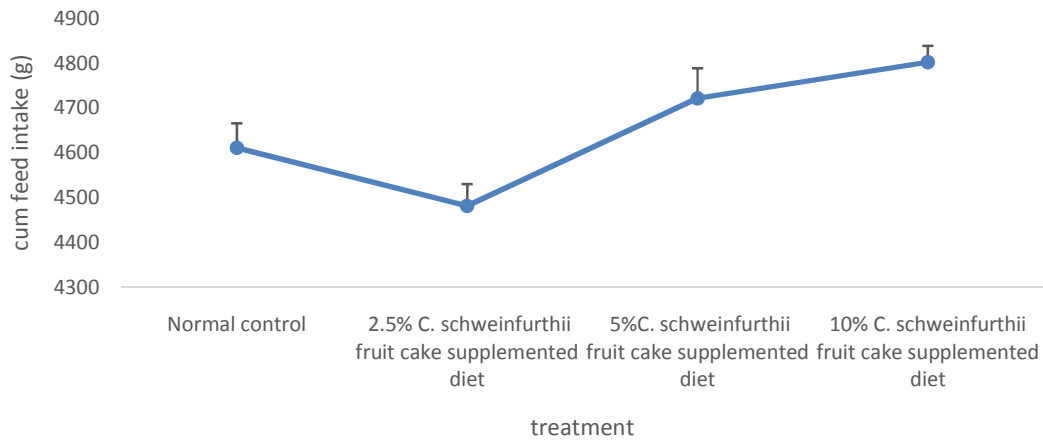Values are expressed as mean ± standard deviation

Figure 3b. Effect of *Canarium schweinfurthii* Fruit Cake Diet Supplemented diet on cumulative feed intake of Male Wistar Rats
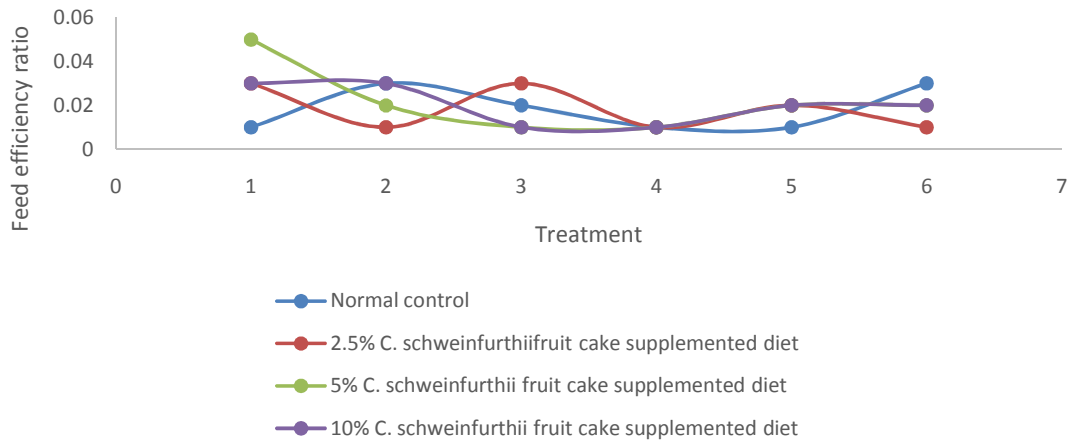

Figure 3c. Effect of *Canarium schweinfurthii* Fruit Cake Diet Supplemented diet on Feed efficiency ratio of Male Wistar Rats
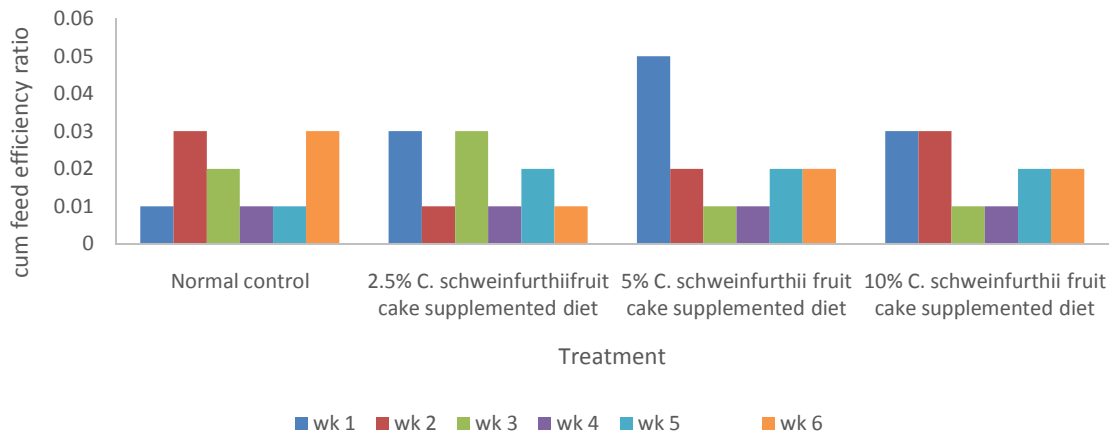

Figure 3d. Effect of *Canarium schweinfurthii* Fruit Cake Diet Supplemented diet on Cumulative Feed efficiency ratio of Male Wistar Rats

DISCUSSION
Weight gain of rats received different dietary levels (%) of *Canarium schwerfurthii* fruit cake is given (Table 3a). Weight gain of rats differed significantly (p<0.05) among the treatments at 2nd week of age. The weight gain of 10% *Canarium schwerfurthii* fruit cake group was higher (p<0.05) than that on 5% dietary fruit cake at 2nd week of age. At the 5th week weight gains of the normal control and 10% fruit cake almost similar. From the results of *Canarium schwerfurthii* fruit cake supplemented diet on weight gain of rats it as clear that supplemented diet up to 5% had considerable non-significant (p>0.05) positive effect on this parameter of the rats. Results also showed that at the 1st week of age of rats, there was no significant effect of fruit cake supplemented diet and it might be the adjustment period in the utilization of fruit cake which perhaps has been minimized to show significant (p<0.05) increasing weight gain of the rats in the subsequent weeks. This result coincides with the findings of Nwoche *et al.* (2013) who found that 10% supplemented diet level of *Canarium schwerfurthii* fruit cake showed the highest (p<0.05) body weight gain. Hake *et al.* (2015) reported that *Canarium schwerfurthii* fruit cake has positive effect on weight of rats. Figure 3b shows that rats fed on different levels of *Canarium schwerfurthii* fruit cake gained cumulative weight similar to 0% fruit cake. The results of this study indicated that weight gain of 0% and 10% dietary *Canarium schwerfurthii* fruit cake group are similar but lower than the rest of the groups.

Differences in feed intake among Normal control, 2.5, 5 and 10% *Canarium schwerfurthii* fruit cake groups were found significant (p<0.05) at 2nd week of age. Rats that received 10% dietary *Canarium schwerfurthii* fruit cake consumed the highest amount of feed compared to others. Highly significant (p<0.01) differences in feed intake among different groups were also found at 4th week of age, but there were no significant differences among different groups at 3 and 5th week of the trial. Cumulative feed intake was (p<0.05) higher on 10% dietary *Canarium schwerfurthii* fruit cake group during 4th week (Fig.3b).

Supplemented diet from *Canarium schwerfurthii* fruit cake gave an interesting result as regards feed intake of rats. At the 1st week, feed intake was similar (p>0.05) in all diet supplementation groups compared with without fruit cake. It is interesting that all other lower levels of supplemented diet (2.5 and 5%) showed lower feed intake than that of the normal control. Among the lower level of supplemented diet, 5% showed the highest feed intake. This result is consistent with the findings of Nwoche *et al.* (2013), who found that feed intake was highest (p<0.05) at 5% supplemented diet level of *Canarium schwerfurthii* fruit cake in rats diet and also observed. Total feed intake of all treated groups was higher than that of the normal control except 10% fruit cake group. This was probably for increased level of energy in the diet as supported by Franco *et al.* (2015). Olorede and Longe (2019) reported that supplemented diet of *Canarium schwerfurthii* fruit cake in rats diet improved feed intake which is relevant to the present study.

Feed efficiency ratio (FER) under different dietary treatments are presented (Fig 3c). The feed efficiency ratio differed significantly (p<.0.05) among the treatments at 2nd week of age. The best weekly FER was observed in 5% dietary *Canarium schwerfurthii* fruit cake diet supplementation group at 1, 2 and 3rd week and rats on 10% *Canarium schwerfurthii* fruit cake had better FER than 2.5% and 5% fruit cake supplemented diet groups at 4 and 5th week of age. However, no significant differences were found throughout the experimental period. The differences observed among the normal control and 2.5, 5 and 10% *Canarium schwerfurthii* fruit cake diets were not significant. Cumulative FER of rats is also given (Fig 3d) showing no significant difference among dietary treatments but it was observed that increasing level of *Canarium schwerfurthii* fruit cake resulted in better FER than the normal control in most of the cases.

The stimulation for efficient utilization of diets supplemented with *Canarium schwerfurthii* fruit cake has been reported by different researchers. *Canarium schwerfurthii* fruit cake promotes the intestinal uptake of amino acids, even when the amino acids are present as a mixture, by modifying the intestinal epithelium for better uptake Abaelu *et al.* (2019). In terms of absorbed amino acids, *Canarium schwerfurthii* fruit cake improves the metabolism of the sulphur containing amino acids Umoh *et al.* (2013). As a result, growth characteristics as well as FER tends to be improved.

CONCLUSION
From this findings we can infer that wistar rats whose diets were supplemented with 10% *Canarium schweinfurthii* fruit cake exhibited high growth characteristics.

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