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GROWTH PERFORMANCE AND NUTRIENT UTILISATION OF AFRICAN GIANT LAND SNAIL (*Archachatina marginata*) FED GROWER MASH PARTIALLY REPLACED WITH CRAB AND KITCHEN WASTES

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ABSTRACT

The objectives of the study were to assess how dietary inclusion of kitchen and crab waste affected the growth performance of juvenile African giant land snails (Archachatina marginata). The study was carried out in the Department of Animal Production's Snailery Unit at Dennis Osadebay University in Asaba, Nigeria. One hundred and forty-four two-month-old snails with an average initial weight of 2.0 g were randomly assigned to four dietary treatments in a completely randomised design, such that each treatment had three replicates of 12 snails per replicate. The control treatment, which is T_1, comprised 100% grower mash. The other treatments, T_2, T_3, and T_4, contain different levels of crab waste and kitchen waste supplemented with bone meal and vitamin premix. The feeding trial was for eight weeks. Final body weight, total weight increase, average daily weight gain, feed intake, feed conversion ratio, shell length, shell breadth, and survival rate were the growth performance characteristics that were assessed. RStudio (version 4.4.3) analysis of variance was used to analyse the data, and Duncan's Multiple Range Test was used to sort the treatment means at the 5% significance level. For the majority of growth measures, the results demonstrated significant differences ($P< 0.05$) between treatments. The highest final body weight (39.15 g), average daily weight growth (0.65 g day^{-1}), total weight gain (36.61 g), feed intake (11.31 g), and survival rate (73.83%) were all found in T_1 snails. All treatments showed effective feed utilisation, with the feed conversion ratio ranging from 0.26-0.29. Growth and survival performances decreased with increasing dietary kitchen waste. From the study, it was concluded that crab waste can be included in balanced snail diets as a cost-effective alternative feed ingredient; however, excessive inclusion of kitchen waste may negatively impact productivity and survivability in A. marginata.

Key words: *Archachatina marginata*, crab waste, kitchen waste, growth performance, alternative feed ingredients, snail production

INTRODUCTION

Particularly in sub-Saharan Africa, snail farming has attracted growing interest lately as a sustainable source of alternative animal protein for human consumption. The African giant land snail (*Archachatina marginata*) is one of the most valuable snail species cultivated because of its delicious flesh, size, and exceptional nutritional profile, which includes high protein, low fat, and important minerals such as calcium and iron (Ahmadu *et al.*, 2021; Ejidike and Adeniji, 2021). According to Kosal (2023) and Obakanurhe *et al*. (2024), snails are a popular alternative to traditional livestock because they require less space and convert feed more efficiently.

Despite the potential economic and nutritional advantages of formulated diets, their scarcity and high cost limit Nigerian snail production. Because commercial feeds are costly and directly compete with human food sources, snail farming is less profitable (Ejidike, 2001; Ade *et al.*, 2023; Ade *et al.*, 2024). Finding inexpensive, locally accessible, and nutritionally sufficient feed ingredients is therefore becoming more and more important in order to promote sustainable snail production. Because of their nutrient density and year-round availability, domestic and agricultural by-products such as fruit peels and kitchen waste, and animal by-products such as crab waste, have demonstrated potential as feed supplements (Abinnusi, 2014).

Crab waste is high in protein, calcium, and chitin, which are byproducts of seafood production and nutrients necessary for snail growth and shell formation. In a similar vein, when appropriately balanced, the energy and organic matter found in kitchen trash can complement feed items high in protein. Recycling organic waste and incorporating these waste products into snail diets lowers feed costs and also improves environmental sanitation (Okon *et al.*, 2012). Although research has shown that snails fed diets comprising animal and plant-based wastes had better development performance and carcass characteristics, there is still a lack of thorough analysis of the addition of both kitchen and crab waste.

Thus, the purpose of this study was to assess the growth response of young *Archachatina marginata* fed diets enriched with kitchen trash and crab waste. The results of this study will provide important insights into the feasibility of using organic waste materials as reasonably priced feed sources for sustainable snail production in Nigeria and other developing and underdeveloped nations.

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MATERIALS AND METHODS

Experimental Site

The study was carried out at the Snailery Unit of the Department of Animal Production, Dennis Osadebay University, Asaba, Nigeria. The experimental site lies within the tropical rainforest zone of Nigeria, with an average temperature ranged between 25 and 30°C, relative humidity in the range of 70-80%, and characterised by an annual rainfall in the range of 1,200-1,500 mm (Ade *et al*., 2024).

Experimental Animals and Management

The study used 144 young African giant land snails (*Archachatina marginata*) that were two months of age and had an average initial live weight of 2.0 g. The snails were purchased from a reliable breeder in Ibadan, Oyo State of Nigeria. They were acclimatised for two weeks in well-ventilated concrete pens. To ensure physiological stability, they were fed pawpaw leaves and clean water.

Experimental Design and Dietary Treatments

The experiment was conducted using a completely randomised design (CRD) comprising four dietary treatments with three replicates of 12 snails each, giving a total of 144 experimental snails. Treatment 1 (T_1) served as the reference (control) diet because it consisted primarily of grower mash, which provided a comparatively balanced nutrient base relative to the other experimental diets formulated with unconventional feed materials.

The experimental diets were formulated to evaluate the response of young *Archachatina marginata* to varying inclusion levels of crab waste and kitchen waste as alternative feed resources. Crab waste was included as a potential protein and calcium source, while kitchen waste served as an alternative energy and organic matter source. Bone meal and vitamin premix were incorporated into the diets to improve mineral and micronutrient supply essential for growth and shell development. The dietary composition of the experimental diets for the African giant land snails is presented in Table 1.

Prior to feeding, all feed ingredients were thoroughly sorted, crushed, properly mixed, and air-dried. Feed and clean water were supplied *ad libitum* once daily in the evening to correspond with the nocturnal feeding behavior of snails. Feed intake was determined by subtracting the weight of leftover feed from the quantity offered daily. Routine cleaning and sanitation of the pens were carried out throughout the experimental period to maintain proper hygiene, minimise microbial contamination, and prevent ant infestation of the pens.

Estimated Proximate Composition of Experimental Diets

The nutrient composition of the experimental diets (Table 2) was estimated using standard feed composition tables and published nutrient values for grower mash, crab waste, kitchen waste, bone meal, and vitamin premix ingredients.

Table 1: Dietary composition of the experimental diets for the African giant land snails

Ingredient	T_1	T_2	T_3	T_4
Grower mash	99.75	72	50	48
Crab waste	0	25	48	25
Kitchen waste	0	0	0	25
Bone meal	0	2	2	2
Vitamin premix	0.25	0.25	0.25	0.25

Table 2: Estimated proximate composition of experimental diets for the African giant land snails

Parameters	T_1	T_2	T_3	T_4
Crude Protein (%)	16.50	13.80	11.60	9.20
Crude Fiber (%)	4.20	5.10	8.40	12.60
Ether Extract (%)	5.10	6.80	5.50	2.90
Ash (%)	9.50	13.40	11.20	7.10
Calcium (%)	2.50	6.60	5.20	4.10
Moisture (%)	8.20	10.80	11.50	12.00
Estimated ME (kCal kg^{-1})	2650	2510	2210	2080

Data Collection

Data were collected weekly for eight weeks on growth traits: body weight (g), shell width (cm), feed intake (g), and shell length (cm). These observable traits were taken using a digital balance and a Vernier caliper, respectively.

Growth Parameters Calculated

First, the following performance indices were computed during the experimental period:

- Weight gain (WG) = final weight − initial weight;
- Average daily weight gain (ADWG) $= \frac{\text{weight gain (g)}}{\text{feeding duration (days)}}$;
- Feed intake (FI) = quantity of feed offered – leftover feed;
- Feed conversion ratio (FCR) $= \frac{\text{Total quantity of feed consumed}}{\text{Total weight gain of the snail}}$;
- Shell length gain (SLG) = final shell length − initial shell length;
- Shell width gain (SWG) = final shell width − initial shell width;
- Percentage mortality $= \frac{\text{number of deaths}}{\text{total number of snails}} \times 100$; and
- Percentage survival rate (SR) $= \frac{\text{NS} - \text{DS}}{\text{NS}} \times 100$, with NS as total snails stocked, and DS as total number of dead snails.

Then, the growth parameters calculated were specific growth rate (SGR) and relative growth rate (RGR), and they were calculated, respectively, as:

$$\text{SGR (\%/day)} = \frac{\ln W_2 - \ln W_1}{T} \times 100; \text{ and}$$

$$\text{RGR (\%)} = \frac{\text{final weight} - \text{initial weight}}{\text{initial weight}} \times 100;$$

where W_1 is initial weight, W_2 is final weight, and T is duration of the experiment in days.

Statistical Analysis

The collected data were subjected to analysis of variance using RStudio (version 4.4.3). The general linear model was used to evaluate treatment effects on growth parameters. When significant ($p < 0.05$) differences were found among treatments, mean separation was done using Duncan's Multiple Range Test (DMRT) with the Agricolae package.

RESULTS AND DISCUSSION

In most growth indicators, including final body weight (39.15 g), total weight gain (36.61 g), average daily weight gain (0.65 g day^{-1}), feed intake (11.31 g), and survival rate (73.83%), snails fed the experimental diet of T_1 performed better than the rest, while T_4 consistently showed the lowest growth response

(Table 3). These findings show that incorporating grower mash with crab waste provided a more balanced nutrient profile that gave better growth and survivability of *Archachatina marginata*. Similar observations were made by Adeniji *et al.* (2014) and Genodepa and Apines-Amar (2024). These authors reported that marine-based protein sources such as fishmeal and crab shell meal improved the final body weight (32.14-40.22 g) of snails.

Although T_1 showed the highest final body weight and body weight gain, relative growth indices such as specific growth rate (SGR) and relative growth rate (RGR) were computed because the treatments differed significantly in initial body weights. The relatively higher SGR and RGR values indicated in T_4 were largely influenced by its lower initial body weight rather than superior dietary performance. Therefore, absolute growth indices and survival parameters indicated that T_1 was the most effective dietary treatment for promoting snail growth and productivity.

The lower final body weight observed in T_4 agrees with the findings of Aribisala (2023), who reported that nutrient limitations in kitchen-waste-based diets restricted snail growth to 28.40-31.20 g. Likewise, Jimoh *et al*. (2020) observed improved weight gain (33.50-37.80 g) in snails fed diets fortified with animal protein sources. The trend observed in total weight gain closely followed feed intake patterns, indicating that nutrient intake played a major role in growth performance. Tchowan *et al.* (2024) further explained that crab-derived feed ingredients contain essential amino acids and minerals necessary for tissue accretion and shell development, thereby supporting the superior performance observed in T_1 and T_2.

Feed intake progressively reduced as the proportion of kitchen waste increased in the diets, probably due to lower palatability and reduced nutrient density. Similar findings were reported by Omole *et al.* (2011) and Emelue and Omonzogbe (2018), who noted that snails perform better on diets containing balanced protein and mineral sources that improve feed acceptability and shell formation. The feed conversion ratio values (0.28-0.31) obtained in this study showed efficient feed utilisation among treatments, with the better feed conversion observed in T_2. These values fall within the acceptable range (0.25-0.35) earlier reported by Jimoh *et al.* (2020) for *A. marginata*.

Survival rate decreased progressively from T_1 (73.83%) to T_4 (63.45%), indicating that exclusive feeding on kitchen waste negatively affected snail viability. A similar observation was made by Oyeagu *et al*. (2018), who reported survival rates of 70-80% in snails fed balanced animal-plant protein diets. Similarly, Aribisala (2023) documented reduced survival rates (55-65%) in snails fed household waste diets, supporting the present findings that nutritionally imbalanced kitchen-waste diets compromise survivability and overall productivity in *Archachatina marginata*.

The feeding treatments had a major impact on the shell and carcass growth performance of *Archachatina marginata* (Figure 2). Since there were no significant changes ($p > 0.05$) between treatments in the first shell measurements, the snails began the trial with similar sizes. This implies that disparities in growth were subsequently caused by diet rather than initial body size. Ani *et al.* (2014) found that snails had uniform initial shell measurements before feeding, which is in line with this conclusion.

Table 3: Growth performance of African giant land snail (*A. marginata*) fed diets containing experimental diet

Parameters	T1	T2	T3	T4
Average initial body weight (g)	2.54 ± 0.21^{a}	2.27 ± 0.29^{ab}	2.11 ± 0.30^{b}	1.66 ± 0.39^{c}
Average final body weight (g)	39.15 ± 0.81^{a}	36.32 ± 0.19^{b}	34.27 ± 0.31^{c}	29.57 ± 0.54^{d}
Total weight gain (g)	36.61 ± 0.11^{a}	34.05 ± 0.10^{b}	32.16 ± 0.01^{c}	27.91 ± 0.15^{d}
Average daily weight gain (g/day)	0.65 ± 0.01^{a}	0.61 ± 0.01^{b}	0.57 ± 0.01^{c}	0.50 ± 0.01^{d}
Specific growth rate (%/day)	4.88 ± 0.02^{b}	4.95 ± 0.01^{ab}	4.98 ± 0.01^{ab}	5.14 ± 0.02^{a}
Relative growth rate (%)	1441.34 ± 5.11^{d}	1500.00 ± 4.32^{c}	1524.17 ± 3.88^{b}	1681.33 ± 4.05^{a}
Average feed intake (g)	11.31 ± 0.06^{a}	9.53 ± 0.08^{b}	9.39 ± 0.09^{b}	8.72 ± 0.08^{c}
Feed conversion ratio	0.31 ± 0.02^{a}	0.28 ± 0.01^{b}	0.29 ± 0.01^{ab}	0.31 ± 0.02^{a}
Survival rate (%)	73.83 ± 6.75^{a}	70.37 ± 4.06^{ab}	66.91 ± 6.26^{b}	63.45 ± 6.12^{c}

^{abc}means within the same row bearing different superscripts, the differences are significant ($p < 0.05$).

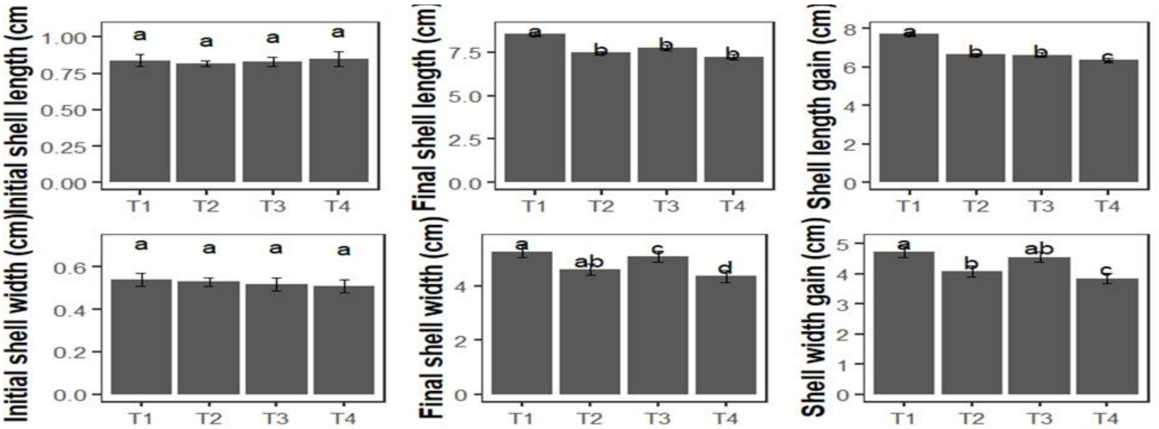

Figure 1: Shell characteristics of African giant land snail (*A. marginata*) fed diets containing experimental diet

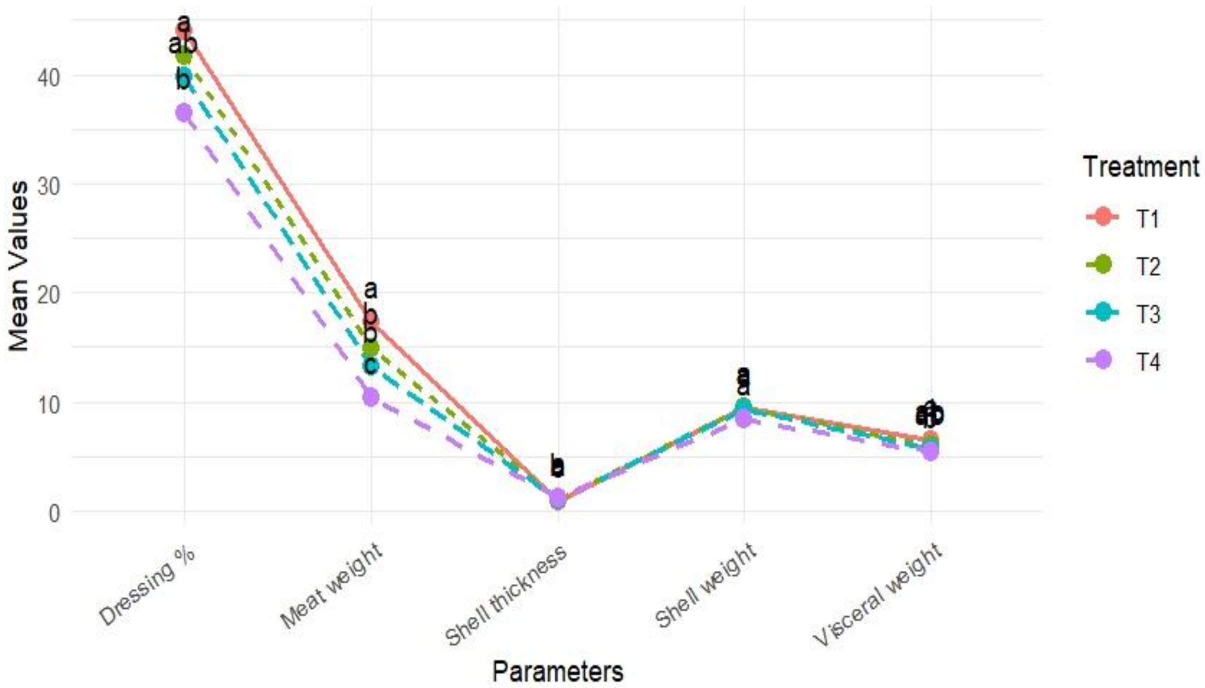

Figure 2: Carcass characteristics of African giant land snail (*A. marginata*) fed experimental diets

Shell Growth Performance

With the highest final shell length (8.56 cm) and width (5.28 cm), as well as the largest increases (7.72 cm length; 4.74 cm width), snails fed T_1 had a better shell growth. These values differed considerably ($p < 0.05$) from those of other treatment groups. The improved performance under T_1 indicates that the combination of sufficient calcium synthesis and high-quality protein from grower mash and crab waste stimulated shell mineralisation and linear development. The final shell length (7.21 cm) and width (4.36 cm) of the snails given 100% kitchen waste (T_4) were the lowest, implying a lack of nutrients such as calcium and essential amino acids needed for shell deposition. In contrast, snails fed T_3 and T_2 performed moderately. These results are in line with those of Omole *et al*. (2011), Tuncha *et al*. (2021), and Aribisala (2023), who found that snails fed diets rich in animal by-product minerals had better shell elongation and width than those provided diets based on plant and kitchen waste.

Carcass Traits

The nutritional amendments also had a significant impact on carcass traits. The meat weight (17.39 g) and dressing percentage (44.01%) of snails fed T1 were the highest, while those fed T4 produced the lowest (36.52% and 10.45 g, respectively). This indicates that, whereas exclusive kitchen trash diets offer inadequate protein quality, nutrient-balanced diets promote improved muscle growth and carcass production. These findings support those of Akinola *et al.* (2017) and Popoola *et al.* (2023), who reported that snail diets containing marine by-products like crab meal produced better carcass deposition.

According to Oyeagu *et al.* (2018), the modest results in T_2 and T_3 validate the minerals' bioavailability in crab waste for better carcass formation. Nonetheless, T_4's lower levels are consistent with Aribisala's (2023) findings, suggesting that diets high in kitchen waste restrict the amount of carcass produced economically.

Figure 2 shows the effect of dietary treatment on the traits of the carcass and shell of *Archachatina marginata.* With better dressing percentage (44.01%), meat weight (17.39 g), and visceral weight (6.45 g), snails fed with the T_1 diet showed superior carcass performance. This clearly indicates that protein utilisation, overall development efficiency, and tissue accretion are better with a balanced combination of nutrients derived from plants and animal sources. This finding in this study is consistent with Popoola *et al.* (2023), who found that snail meat weights under balanced animal-protein diets ranged from 15.8 to 18.2 g. Also, in a similar report by Kehinde *et al.* (2020) found that adding 50% crab shell increased snail meat weights (16.5 g), while snails given poorer-quality diets had far lower values of 8.51 g.

In contrast, snails fed (T_4) showed the lower carcass performance, with the poorest dressing percentage (36.52%) and meat weight (10.45 g). The high-fiber, low-protein nature of kitchen waste likely hindered nutrient absorption and muscle deposition. Jimoh *et al.* (2020) similarly observed reduced meat growth (10-12 g) in snails under nutritionally imbalanced diets. The poor carcass attributes in T_4 show that kitchen waste alone is inadequate to provide optimum production in *A. marginata.*

Visceral weight

Visceral weight ranged from 5.39 g (T_4) to 6.45 g (T_1), with T_1, T_2 and T_3 being similar ($p > 0.05$). The slightly higher visceral weight in T_1 shows improved metabolic organ development tied to better feed conversion. Comparable ranges (6.0-6.7 g) were recorded by Alikwe *et al.* (2014) in snails fed animal by-product-based feeds, while Aribisala (2023) reported lower values (5.1-5.4 g) in snails raised on kitchen-waste diets, consistent with the T_4 group.

Shell weight

Shell weight did not significantly ($p > 0.05$) differ among dietary treatments, although T_1 (9.44 g) revealed a slight improvement over T_4 (8.40 g), implying that minimum calcium requirements were met among diets. This agrees with Ejidike and Adeniji (2021), who reported 8.5-9.8 g shell weight under calcium-inclusive feeding studies. However, reduced shell weight in T_4 showed that exclusive kitchen waste may not support sufficient mineral balance for optimal shell formation.

Shell thickness

Shell thickness revealed an opposite trend to carcass yield. Thickness increased progressively from T_1 (0.92 cm) to T_4 (1.15 cm), with significantly higher values ($p < 0.05$) in the low-protein diets (T_3 and T_4). This shows that when dietary protein is not enough for muscle development, snails may divert mineral deposition to the shell. Badmos *et al.* (2016) and Dhiman and Pant (2021) similarly reported thicker shells (1.10-1.20 cm) in nutritionally stressed snails as a survival mechanism rather than a sign of healthy growth. Therefore, while higher shell thickness may improve durability, it is negatively linked with productive traits such as meat yield.

CONCLUSION

The study showed that dietary inclusion of crab waste and kitchen waste significantly influenced the growth performance, shell development, carcass traits, and survival rate of young *Archachatina marginata*. Snails fed the reference diet (T_1), which consisted mainly of grower mash, recorded superior body weight gain, feed intake, shell growth, carcass yield, and survival rate compared with snails fed diets containing higher levels of kitchen waste.

The findings indicate that crab waste can serve as a useful alternative feed ingredient due to its protein and calcium content, which are essential for tissue growth and shell formation. Moderate inclusion of crab waste supported satisfactory growth performance and feed utilisation in the snails.

However, increased inclusion of kitchen waste negatively affected growth and survival performance, likely due to its lower nutrient quality and energy content. Therefore, crab waste may be incorporated into balanced snail diets as a cost-effective and sustainable feed resource, while excessive dependence on kitchen waste alone is not recommended.

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