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Growth Performance and Proximate Composition of *Archachatina marginata* Snail Fed with Formulated Diets Using Pawpaw (*Carcia papaya*) Leaf Meal and Poultry Droppings Meal as Protein Sources

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Authors' contributions

This work was carried out in collaboration between both authors. Author NOI designed the study, reviewed the literature searches and managed the experimental process and performed statistical analyses of the experiment. Author OOA performed the experimental process and analysis, wrote the first draft of manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

The combined effect of pawpaw leaf meal (PLM) and poultry droppings meal (PDM) as protein sources in snail feed on the performance of *Archachatina marginata* (Giant African Land Snail) snail was investigated in the Department of Science Laboratory Technology, Federal Polytechnic Ilaro, Ogun State, Nigeria. One hundred and twenty-six (126), six (6) weeks old snails and average weight 10.34 g were used for a 12 weeks experiment in a completely randomised feeding trial. Five experimental snail diets (Diets II-VI) containing at least 20% crude protein were prepared using PLM and PDM in ratios 4:0, 3:1, 2:2, 1:3, and 0:4), respectively. The diet I is modified Cobbinah;s snail feed concentrate, and diet VII is fresh pawpaw leaf (control diet). Proximate composition, the progression in weight, feed intake, and shell dimensions of the snails were determined. The

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maximum weight increase was obtained in snail fed with the diet I while minimum weight increase recorded for snails on diet IV. The feed conversion ratio (FCR) ranged from 1.45 to 2.21, with snails on diet II recording the highest FCR. The feed intake and shell length gain of the snail on diet II are significantly higher than those on other diets. The highest shell width increase was recorded in snails that consumed diet VII. The meat of snails which fed on diet I have the highest protein value. Snails which fed on diet IV gave maximum ash content, while those fed on diet III have the least value. The result of the present study showed that highest growth performance and feed utilisation for *A. marginata* snail was favored by diet I. The compounded diets consisting of PLM and PDM as protein sources were efficiently utilised by *A. marginata* snail more than the control diet (fresh pawpaw leaf).

Keywords: Pawpaw leaf meal; poultry droppings meal; Archachatina marginata; protein sources.

1. INTRODUCTION

A. marginata is an example of a land snail. The incorporation of animal meat as a source of protein in the human diet cannot be overemphasised. The expensive nature and inadequacy of animal protein for human demands have compelled the necessity for intensive rearing of some non-conventional livestock such as the snail hitherto hunted from the wild [1]. Heliculture, the farming of snails, has become an important commercial activity in Nigeria in recent times in a renewed trust to improved animal protein production [2]. Snail rearing is a good source of income and less capital is used in setting it up compared to other livestock species such as poultry, fish farming, cattle and goat production, etc [3]. Snail rearing is eco-friendly and required little skill and cash [3, 4]. Snail meat is a rich source of protein, iron, calcium but low in fat and cholesterol when compared to other animal protein sources like pork and chicken [5,6].

Snails belong to a group of invertebrate and are mainly herbivores, feeding on green vegetation including fruits and vegetables like groundnuts, black-eyed peas, cucumber, melons, and dry unpeeled sweet potatoes, pawpaw leaf and fruit, cocoyam tubers and mango fruits [7,8]. One more major challenge of domestication is the ability to mimic perfectly the conditions in the wild so as to maximise the growth and reproductive potentials of the snails. Ademolu et al. [9] reported that much still has to be done to achieve this task as a great gap exists between snails in the wild and those reared in captivity.

Various studies have used different feed options to determine which one will give optimal performance Omole et al. [10] investigated on the potential of peels of mango, plantain, cocoyam and pawpaw as diets for growing snails; Okonta, [8] studied effect of Selected Diets on the Performance Of *A. Marginata*; Ademolu et al. [4] assessed feeding snails with different nitrogen sources on the Performance, proximate and mineral content *A. marginata*; Ejidike, and Afolayan [11] determined the effects of natural and compounded rations on the growth performance of African Giant Land Snail *A. marginata; etc.* Similarly, non-compounded materials, poultry droppings, and pineapple peel are also consumed by snails [8] Ademolu et al. [4] used poultry droppings and pawpaw leaves as separate diets to feed *Archachatina marginata* snails. They found out that snails fed with poultry droppings had a higher protein content and growth performance compared to those fed with pawpaw leaves. An intensive production of snail requires the use of compounded feed instead of the already existing traditional ones [12].

The result of these several studies on growth performance and nutrient content of land snails reared on different plant food materials cannot be directly equated with those fed formulated diets because of its high protein and energy contents [13]. Compounded diets have been shown to give more favourable results compared to single diets [14]. Due to numerous functional roles of protein such as growth maintenance, hormonal and enzymatic activities in animals' well-being, special attention is given to it, when formulating and preparing nutritionally balanced snail's diets in order to achieve sustainable production of snails [4]. Commercial protein sources are very expensive and may be beyond the reach of small scale farmers, It has been shown that poultry litter/dropping can serve as potential source of protein because of its non-protein nitrogen (NPN) that can be easily converted to protein by animal [15,16] Most poultry droppings contain about 25% Dry matter (%DM).

Studies have been carried out using pawpaw leaves and poultry droppings separately and reported their influence on the growth performance of snail [4], but there is no information on the use of diets comprisingpawpaw leaves and poultry droppings together. The aim of this work was therefore, to investigate the possibilities of enhancing the growth performance and proximate composition of *A. marginata* snails with diets consisting of combined pawpaw leaves and poultry droppings as nitrogen sources.

2. MATERIALS AND METHODS

2.1 Location and Source of Materials

The experiment was carried out in the Department of Science Laboratory Technology, Federal Polytechnic Ilaro, Ogun state, Nigeria. Ilaro is a small city in Nigeria, situated at 6.89° North latitude, 3.02° East longitude and 68 m elevation above the sea level. The daily temperature in Ilaro ranges between an average minimum of 23°C to a maximum of 34.2°C. The paw-paw (*Carica papaya,* Linn.) leaves were collected from pawpaw trees around the Polytechnic premises in Ilaro in the month of February. The pawpaw leaves were removed from the stalk, cleaned, chopped and sun-dried to crispiness for five days, without losing the green colour. The crispy leaves were ground into fine powder in a hammer mill to produce pawpaw leaf meal (PLM) of 2 mm particle size. The poultry litter used for this work was the droppings of caged layers collected from a commercial poultry farm in Ilaro. It was spread and sun-dried for one week while raking at intervals. Stones and other foreign materials were removed. When dried, the litter was ground into fine powder using a hammer mill to produce poultry droppings meal (PDM) of 2 mm particle size. The proximate composition of PLM and PDM were determined using standard methods of Association of Official Analytical Chemists (AOAC) [15,17].

2.2 Experimental Diets

The PLM and PDM were used in different ratios as protein sources to compound 5 experimental snail diets (Diets II-VI) containing at least 20% crude protein using slightly modified Cobbinah et al, snail feed formulation [18] (Table 1). Diet I was the modified Cobbinah et al snail feed [18], while diet VII was fresh pawpaw leaf which served as the control diet.

2.3 Experimental Snails and Treatments

One hundred and twenty-six (126), six-week-old snails, and average weight of 10.34g were purchased from a snail farm in Ilaro, the snails were randomly allotted to seven treatments in a completely randomized design. Each treatment was in triplicate, having six sails each. The treatments were different diets compounded with different ratios of poultry dropping meal and pawpaw leaf meal (Table 1) fresh pawpaw leaves served as control. The snails were reared in the plastic basket of 0.5 x0.5x 0.3M dimensions with adequate perforations to enhance the easy flow of air and proper drainage. The bottom of the baskets were filled with heated loamy soil to a depth of 10 cm. The baskets were placed on a wooden platform of 1.0 M high, which legs were dipped inside a container filled with water and used engine oil to prevent insect infestation, the soil was

Table 1. Composition of experimental diets

Ingredients	Diet I	Diet II	Diet III	Diet IV	Diet V	Diet VI	Diet VII
Fresh pawpaw leaf	0	0	0	0	0	0	100
pawpaw leaf meal	0	0	16.25	32.5	48.75	65	
poultry droppings meal	0	65	48.75	32.5	16.25	0	
Maize(yellow)	31.30	31.30	31.30	31.30	31.30	31.30	
wheat offals	16.00	0.00	0.00	0.00	0.00	0.00	
soya bean meal	25.00	0.00	0.00	0.00	0.00	0.00	
Groundnut cake	10.00	0.00	0.00	0.00	0.00	0.00	
Palm kernel meal	10.00	0.00	0.00	0.00	0.00	0.00	
fish meal	4.00	0.00	0.00	0.00	0.00	0.00	
bone meal	1.20	1.20	1.20	1.20	1.20	1.20	
limestone	2.25	2.25	2.25	2.25	2.25	2.25	
Premix	0.25	0.25	0.25	0.25	0.25	0.25	
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

sprinkled with water twice daily to keep the internal environment moist. Plastic feeding troughs were used to provide feeds and water to the snails *ad libitum*. Since snails are nocturnal animals and feed mostly at night [4], they were fed with the diets every evening between 4.00 and 6.00 p.m. for 12 weeks. (84 days). The baskets were cleared of leftover feed and excreta of the snails every day to prevent the buildup of pathogens. The daily feed intake was determined by subtracting the weight of leftover feed from its previous weight before feeding the snails.

2.4 Data Collection

Three snails each per replicate in a treatment were marked for data collection. The growth performance of the snails was determined by measuring the following parameters every week: body weight was taken using a weighing balance (Camry electronic kitchen scale model EK 5350. O.1g), shell length and shell width were measured with Vernier calipers, and feed conversion ratio was calculated. The nine marked snails from each treatment were picked, sacrificed and processed into a powder prior to analysis. Proximate analysis was carried out on the experimental diets and powdered snail flesh using standard AOAC methods [17]. One-way Analysis of variance (ANOVA) was used to analyse data collected and significant differences were separated by Duncan Multiple Range Test. using the SPSS 16.0 statistical package [19].

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of PLM and PDM

The results of the proximate analysis of the PLM and PDM as indicated in Table 2 showed that there were a significant difference (P>0.05) in their composition. The PLM is higher in crude protein (CP), ether extract (EE), and gross energy, but lower in dry matter, (DM) crude fiber (CF), and ash content than PDM. There is agreement in the protein content (30.89 %DM) of the PLM with those reported by other researchers who worked on the same leaf CP 30.12% DM 30.12% DM, [20] CP 29.89% DM, [21] and CP 28.20% DM, [22].

The CF content of PLM was 6.54% DM which was also close to 5.0% DM reported by Onyomonyi and Onu [20] Also, the proximate composition of pawpaw leaf on fresh basis is comparable with values reported by Omole et al. [10] CP 23.9%, CF 10.5%, EE 0.38% Ash 7.61%, and NFE 36%. This variation may have resulted from differences in soil, cultivars/varieties, stage of growth and time of harvest, and geographical location [23,24] The composition of the PDM (Table 2) is similar to the values reported by Onimisi and Omage [25] for CP 20.3% DM, EE 2.5% DM, Ash 17.5% DM, NFE 40.5% DM except for CF 19.2 %DM. The reason for this high crude fiber is because they used poultry droppings from a deep litter broiler pen resulting from the use of sawdust as bedding material.

3.2 Proximate Composition of the Experimental Diets

The result of the proximate composition of the experimental diets (Table 3) revealed that there was no significant difference (P<0.05) in all their percentage moisture contents except that of fresh pawpaw leaf. However, a significant difference (P<0.05) exist in all other nutrients of the diets. The modified snail feed concentrates [15] has the highest percent crude protein and energy value closely followed by that of diet VI (100% PLM). Diet II (100% PDM) has the least percent protein and energy. The results also showed that materials used as a source of protein in this study have a translational impact on the nutrient content of formulated diets which likely influenced the differences in their utilisation by the snails.

Table 2. Proximate composition of pawpaw leaf meal (PLM) and poultry droppings meal (PDM)

Proximate composition	PLM	PDM	±SEM**
Dry matter (DM) %	75.68^{a*}	90.35^{b}	±4.76
Crude protein, %	30.89^{b}	19.14^{a}	±1,03
Crude fiber, %	6.54^{a}	9.67^{b}	±1.43
Ether extract, %	5.36^{b}	3.64^{a}	± 0.69
Ash, %	11.22^{a}	20.31^{b}	± 1.89
Nitrogen-free extract (NFE), %	45.99^{a}	47.24^{a}	± 2.84
gross energy Kcal/kg	3557.60^{b}	2982.90^{a}	± 48.63

**Means bearing the different superscripts on the same row are significantly different (P<0.05);*
*** Standard error of mean*

Table 3. Proximate composition of experimental diets %DM and pawpaw leaf %WM

Proximate composition	Diet I	Diet II	Diet III	Diet IV	Diet V	Diet VI	Diet VII	±SEM**
Moisture	9.45^{a}	11.2^{a*}	10.56^{a}	10.34^{a}	9.78^{a}	10.12^{a}	24.32^{b}	±3.45
Crude protein (%DM)	25.28^{f}	20.23^{a}	21.03^{b}	21.93^{c}	22.49^{d}	23.19^{e}	23.38^{e}	±1.53
Ether extract (%DM)	$3.93b^{c}$	2.39^{a}	2.67^{ab}	2.97^{bc}	3.21^{c}	3.84^{d}	4.95^{e}	±0.35
Crude fibre (%DM)	$5.95d^{e}$	6.79^{f}	6.08^{e}	5.65^{d}	5.05^{c}	4.55^{b}	4.06^{a}	±0.23
Ash (%DM)	7.89^{a}	15.2^{g}	13.75^{f}	12.4^{e}	10.75^{d}	9.29^{c}	8.49^{b}	±0.96
NFE (%DM)	56.95^{d}	44.19^{b}	45.95^{bc}	46.71^{cd}	48.72^{d}	49.01^{d}	34.80^{a}	±2,13
Energy (%DM)	3824.7^{g}	2791.9^{b}	2919.9^{c}	3013.7^{d}	3137.3^{e}	3233.2^{f}	2692.39^{a}	±35.63

Means bearing the different superscripts on the same row are significantly different (P<0.05);
***Standard error of mean*

Table 4. Growth response and nutrient utilisation of snail fed experimental diets

Parameters / Diets	Diet I	Diet II	Diet III	Diet IV	Diet V	Diet VI	Diet VII	±SEM**
Initial mean weight	11.03^{b*}	9.92^{a}	9.86^{a}	10.53^{b}	10.21^{ab}	10.34^{b}	10.47^{b}	.±0.46
Final mean weight	63.37^{e}	63.16^{e}	59.74^{c}	59.69^{c}	58.77^{b}	57.52^{a}	62.42^{d}	±1.35
Mean total weight gain	54.84^{f}	53.24^{e}	49.8^{c}	49.16^{bc}	48.56^{b}	47.18^{a}	51.95^{d}	±0.67
Mean daily weight gain	0.65^{cd}	0.63^{c}	0.59^{bc}	0.59^{bc}	0.58^{b}	0.56^{a}	0.62^{c}	±0.03
Initial mean Shell Length (cm)	3.02^{a}	3.11^{b}	2.99^{a}	3.06^{ab}	3.05^{ab}	2.97^{a}	3.13^{b}	±0.09
Final mean Shell Length (cm)	5.58^{c}	4.78^{a}	4.81^{a}	4.97^{ab}	5.14^{b}	5.2^{b}	5.75^{c}	±0.12
Mean Shell Length gain (cm)	2.56^{d}	1.67^{a}	1.82^{ab}	1.91^{b}	2.09^{c}	2.23^{c}	2.62^{d}	±0.07
Initial mean shell width (cm)	2.72^{a}	2.8^{b}	2.7^{a}	2.71^{a}	2.69^{a}	2.69^{a}	2.74^{a}	±0.03
Final mean shell width (cm)	4.59^{c}	4.78^{d}	4.58^{c}	4.51^{c}	4.4^{b}	4.33^{a}	4.36^{a}	±0.08
Mean shell width gain(cm)	1.87^{d}	1.98^{e}	1.88^{d}	1.8^{c}	1.71^{b}	1.64^{a}	1.62^{a}	±0.02
Mean Feed intake (g)	80.60^{a}	118.32^{g}	107.09^{f}	100.43^{e}	92.91^{c}	87.81^{b}	95.56^{d}	±2.76
Food conversion ratio (FCR)	1.45^{a}	2.21^{e}	2.14^{d}	2.04^{c}	1.89^{b}	1.86^{b}	1.83^{ab}	±0.14
Survival rate(%)	100^{a}	100^{a}	94^{a}	94^{a}	94^{a}	100^{a}	100^{a}	±0.24

Means bearing the different superscripts on the same row are significantly different (P<0.05);
***Standard error of mean*

Table 5. Proximate analysis of the snail flesh (% WM)

Proximate composition	Diet I	Diet II	Diet III	Diet IV	Diet V	Diet VI	Diet VII	±SEM**
Moisture	69.6[a*]	71.92[b]	72.7[b]	72.37[b]	75.4[c]	75.39[c]	76.44[c]	±3.16
Crude protein (%WM)	21.68[c]	20.88[c]	20.03[bc]	19.93[b]	17.49[a]	16.85[a]	16.19[a]	±1.02
Ether extract (%WM)	2.93[bc]	2.24[a]	2.89[b]	3.04[c]	2.69[b]	3.09[c]	3.1[c]	±0.06
Crude fibre (%WM)	0.95[c]	0.26[a]	0.57[b]	0.12[a]	0.97[c]	0.62[b]	0.97[c]	±0.01
Ash (%WM)	2.89[c]	2.86[c]	2.12[a]	2.97[d]	2.16[a]	2.55[b]	2.22[a]	±0.33
Nitrogen-free extract (%M)	1.95[e]	1.84[d]	1.69[cd]	1.57[c]	1.29[b]	1.5[c]	1.08[a]	±0.04
Energy	604.45[d]	555.2[c]	564.45[cd]	566.8[cd]	496.6[ab]	506.06[bc]	489.9[a]	±16.54

**Means bearing the different superscripts on the same row are significantly different (P<0.05);*
***Standard error of mean*

3.3 Growth Performance of Snail

Table 4 depicts the survival rate, appreciation in growth indices (weight, shell length, and shell width), and feed conversion of snail (*A. marginata*) reared on different experimental diets. The recorded changes in weight of snails fed on the diets differ significantly (p<0,05).

This is in conformity with the report of [7] that there was significant weight difference (P<0.05) between snail fed on plant leaves (green papaw leaves) and those fed broiler grower's mash. Diet I being a formulated feed concentrate which has the highest nutrient composition and expected to have a better balance of nutrient gave the highest daily and total weight gain. This is in agreement with the claim of other researchers that weight gain and feed efficiency were improved with a higher amount of dietary protein and energy [26,27,28]. The results of the study revealed the utilisation of the experimental diets by snails varied significantly (P<0.05). The lowest FCR recorded by the snails on the diet I (concentrate diet) over the snails on other diets, (Table 4), even the control (fresh pawpaw leaf) though with acceptable low FCR indicates that African giant land snail utilised the nutrients available in the diets more efficiently. Comparatively, compounded diets have a good role to play in the farming of the snail all year round without facing scarcity of food during the dry period as against plant [11].

The increments in weight, shell length and shell width observed among snails fed on the experimental diet could be attributed to the enhanced growth performance of snails on these diets and the pawpaw leaf (Diet VII) gave highest shell length while largest shell width was observed in snail fed on Diet II. This result corroborates the findings of [4] that PLM increases shell length of the snail while PDM causes an increase in the snail shell width. A positive correlation between live weight gain, shell length gain, and shell width gain had been established in snails [27,29]. Ademolu et al. [6] reported that diet based on100% poultry droppings gave a stronger positive correlation between live weight gain and shell width than shell length. The observed nigh weight gain in snail reared on Diet VII could be attributed to the fact that larger shell circumference will accommodate more snail flesh the longer shell length. The observation agreed with the finding of Ademolu et al. [4,6]. These increases in the body weight and all the morphological parameters of the snail in all the experimental diets indicate that compounded diets have the potential of sustaining snail farming especially during the scarcity of snail's natural plant food [11].

The morphological parameters of the snails (shell length and shell width in all the treatments were observed to differ significantly (P>0.05) as the ratio of PLM and PDM varies in the Diets. Shell length increased proportionally to increase in PLM proportion in the diets, while increasing the amount of PDM in the diet caused increase in the width of the shell of snails (Table 4).

3.4 Proximate Composition of the Snail Flesh

Proximate analysis of the snail flesh as presented in Table 5 revealed that the crude protein content of the snail flesh fed different experimental Diets were significantly different (p< 0.05).The values ranged from 21.68 % WM for Diet I to 16.19 % WM for Diet VII, crude protein values obtained decrease with the diet from I to VII The ash content was significantly different from one another with Diet IV having the highest value of 2.97 % WM and Diet III with the lowest value of 2.12 % WM.

There was also a significant difference in the fat content with Diet VII having the highest value of 3.1% WM and Diet II with the least value of 2.24% WM. The moisture content is highest in Diet VII 76.44% WM and lowest in Diet L 69.6% WM. There was also a significant difference (p<0.05) in the gross energy ranging from 604.45 kcal/kg for Diet I to 489.9 kcal/kg for Diet VII. The snails fed with Diet I was more nutritious than those fed with other Diets because they contain higher crude protein and gross energy. This observation is similar to the work of Awa [30] that diets with high crude protein and crude fat contents increase total body weight gained by animals. This is also in line with the findings of Adeyemo and Borire [31] that reported significant differences in the body weight gain of snails fed with different levels of yam peel; Comparing the result of the proximate analysis of the snail fed with diets comprising of PLM and PDM in different ratio (Diet II to Diet VI) also showed that snails fed diet II had the highest crude protein Studies have shown that poultry dropping has a moderate nitrogen content, which could be utilised by animals [32], and snails, thus, have the ability to convert animal waste into body protein [4]. This could probably explain the high daily weight gain and total weight gain of the snail fed with Diet I despite its low protein content (20.23% DM).

4. CONCLUSION

In conclusion, the results obtained in this study indicated that *A. marginata* Snails respond positively to all diets used in this study. Best performance in terms of growth response, nutrient composition of edible meat, and feed conversion ratio was obtained in *A. marginata s*nails fed with diet I (snail feed concentrate), closely followed by Diet II. The compounded diets consisting of PLM and PDM as protein sources were efficiently utilised by *A. marginata* snails more than the control diet (fresh pawpaw leaf), Therefore, the use of PLM and PDM in the formulation of feed for *A. marginata* will positively affect the performance and the nutritive value of *s*nails, however, snails reared on 100% PDM based diet performed better than the rest experimental snails and there was gradual decline in the performance with an increase in the quantity of PLM in the snail ration. Apart from the good performances of snails when fed with the formulated diets, it was considered to be easily accessible and available all the year round to the farmers. and can be stored for a longer period of time when compared with direct agricultural feed such as pawpaw leaves. Since PLM and PDM can be obtained at little or no cost, their inclusion in snail feeds will considerably decrease the costs of snail production.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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