EFFECTS OF DIFFERENT PROTEIN SOURCES ON GROWTH AND CARCASS CHARACTERISTICS OF AFRICAN GIANT LAND SNAIL (*ARCHACHATINA MARGINATA*) IN CAPTIVITY

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ABSTRACT

This study evaluated the effect of replacing groundnut cake with Moringa oleifera, Leucaena leucocephala and Gliricidia sepium leaf meal on growth performance and carcass characteristics of giant African land snails. One hundred and twenty (120) growing snails (Archachatina marginata) of 150 – 170 g, aged 5 – 6 months were randomly assigned to four different treatments with three replicates and ten snails per replicate. M. oleifera, L. leucocephala and G. sepium leaves were harvested, shed dried and milled to obtain M. oleifera leaf meal (MOLM), L. leucocephala leaf meal (LLLM) and G. sepium leaf meal (GSLM). Snails in Treatment 1 were given groundnut cake (GNCD), treatment 2 snails had GSLM, treatment 3 snails had MOLM and treatment 4 snails were given LLLM as the protein source in a 13 week feeding trial. Feed intake, live weight gain, shell changes and carcass characteristics were measured using standard procedures. The result showed that weight gain and final weight of snails fed GNCD, MOLM, and LLLM were statistically (p>0.05) similar but significantly (p<0.05) higher than snails fed GSLM. Dressing percentage and percentage visceral weight of snails fed MOLM was highest across treatments. Percentage shell weight was highest among snails fed GNCD, whereas percentage haemolymph weight was highest among snails fed LLLM. Inclusion of M. oleifera and L. leucocephala leaf meals as protein sources in concentrate rations for snails was beneficial for growth and carcass characteristics of growing snails.

Keywords: Carcass traits, Dressing percentage, Foot weight, Leaf protein, Leguminous forages

INTRODUCTION

In Africa, the human protein requirement has not been met due to scarcity and the high cost of meat. This led to diversification and rearing of non-conventional livestock such as the snail. The giant African land snails are a wildlife dietary protein source in Nigeria and some other parts of Africa (Alikwe *et al.,* 2014). Snail meat is tender and tastes good. It is highly nutritious and serves as a delicacy in native African dishes. Nutritious benefits of snail meat include being particularly rich in protein, iron, calcium and phosphorous and low in fat, saturated fatty acids and cholesterol when compared with beef, goat meat, mutton, pork, broiler meat and fish (Babalola, 2015).

In spite of the stated nutritional value of snail meat, snail production has not reached large-scale production and commercialization as compared with other livestock like cattle, goat, sheep and poultry. Its demand is met by hunting the animals from their habitat in the wild. In recent years, wild snail populations have declined considerably, primarily because of the impact of human activities such as deforestation, pesticide use, slash-and-burn agriculture, spontaneous bushfires, and the collection of immature snails (Oyeagu *et al.,* 2018). Commercial snail production is necessary to conserve this important resource, meet the animal protein demand, and to optimize nutritional and medicinal qualities of the snail meat. There is an increasing interest in the rearing of snails to make them available in commercial quantities for marketing at all seasons of the year (Eze *et al.,* 2010).

Snails are territorial and will stay in their own area if sufficient food is available. Limitations of rearing snails include their very slow growth rate and seasonal breeding pattern, severely limiting their productivity (Eze *et al*., 2010). Snails are traditionally fed on roughages and household wastes, thus they don't optimise their productivity in subsistence level. Therefore to meet the snail meat demand and commercialisation drive, balanced ration must be provided to meet the production requirement of the animals. Concentrate feeds have the advantage of being balanced in terms of macro and micronutrients and can thus optimize productivity. Snails, like other animals, need basic nutrients (energy, protein, fats, amino acids, vitamins and minerals) for optimal metabolism and growth, shell formation and reproduction (Eze *et al.,* 2010).

Snail are traditionally fed cheaply available roughages, thus to reduce cost of concentrate ration, alternative feedstuffs must be considered. For the formulation of balanced and cheaper rations, alternative feed sources should be studied, particularly those that are not involved in competition for consumption by humans and livestock such as leaf meals. Leaf meals do not only serve as a protein source but also provide some necessary vitamins and minerals (Chadd *et al*., 2002). Hence locally available leaf meals are gaining acceptance as feedstuff in an animal diets. Multipurpose trees have the ability to provide large quantities of high-quality forage material all-year-round. Despite the availability and abundance of *Moringa oleifera, Leucaena leucocephala, Gliricidia sepium*, there is little information on the use of these plants as feed resources in snail diets. This research therefore aimed at determining the effect of replacing groundnut cake with *M. oleifera, L. leucocephala* and *G. sepium* leaf meal diet on growth performance and carcass characteristics of snails.

MATERIALS AND METHODS

Experimental Site: The study was conducted at the Snail Research Unit of Teaching and Research Farm, Department of Agricultural Technology, Federal Polytechnic, Ado-Ekiti, Nigeria. The study area is located between latitudes 07°03′07″N and 07°07′12″N and longitudes 5°04′11″E and 5° 09′31″E measured using Global Positioning System.

Experimental Animals, Design and Management: This research was undertaken with approval from the institutional ethics committee of the Department of Agricultural Technology, Federal Polytechnic, Ado-Ekiti. The National Institutes of Health guide for the care and use of Laboratory animals were followed, and appropriate measures were taken to minimize pain or discomfort on the animals (NRC, 2011). A total of 120 growing snails (*Archachatina marginata*) aged 5 – 6 months and of 150 – 170 g, live weight were purchased from a farm in Ibadan, Oyo State, Nigeria. Snails were kept in twelve wooden cages with dimension 30 x 40 x 24 cm^3. Feed and water were provided *ad libitum. M. oleifera, L. leucocephala* and *G. sepium* leaves were obtained from a pasture and forage field within the teaching and research farm premises, identified and authenticated by a plant taxonomist in Forest Herbarium, Ibadan, where the voucher specimens were deposited. The harvested leaves were shed dried until they were crispy to touch while retaining their greenish colouration, these done to reduce the anti-nutritional factors of the leaves (Soetan and Oyewole, 2009; Soetan and Aiyelaagbe, 2016) and optimise phyto-nutrient profile and its utilisation by the animals (Olatunji, 2019). The leaves were then milled to obtain a product herein referred to as *M. oleifera* leaf meal (MOLM), *L. leucocephala* leaf meal (LLLM), and

G. sepium leaf meal (GSLM). In the formulation of snail ration, the leaf meals were incorporated in different treatments at 16.5% which is not toxic to the animals (Coelho da Silva *et al.,* 2013; Abd El-Hack *et al.,* 2018) in replacement for groundnut cake, the diets were formulated with other ingredients with groundnut cake (GNCD) in Treatment 1, treatment 2 GSLM, treatment 3 MOLM and treatment 4 LLLM as the protein source in snail diet. The meals were analyzed for their nutrient composition as described by AOAC (1990) as shown in Table 1.

The 120 snails were randomly assigned to the 4 treatments with 3 replicates of 10 snails per replicate in a completely randomised design. The cages, drinkers, and feeders were cleaned before the arrival of the snails. The first two weeks served acclimatization of the snails before the experiment commenced. The snails were weighed individually at the start of the experiment, thereafter at the end of each week to determine the weekly live weight gain for each animal. The snails were fed *ad libitum*, feed and clean water were offered twice daily for 13 weeks.

Daily feed intake was determined by quantifying the difference between the amount of feed supplied and the leftover feed for each replicate and was expressed on dry matter basis. Body weight and body weight gain were measured to know the cumulative differences between the final and initial body weights. Feed conversion efficiency (FCE) was calculated from the ratio of body weight gain to feed intake during the experimental period.

At the end of the feeding trial, 12 snails were randomly selected from each treatment (four snails per replicate) for carcass and organ analysis. The snails were euthanized by fast-freezing them at -20°C for 30 minutes (Gilbertson and Wyatt, 2016). The foot (edible portion), the shell and the visceral mass were weighed separately. Organs such as intestine, kidney, salivary gland were separated and weighed using an analytical balance with a sensitivity of 0.01 g. Shells were measured with a vernier calliper. Dressing percentage, percentage shell weight, percentage visceral weight and percentage haemolymph weight was calculated by expressing the individual weights relative to live weight of the snails.

Statistical Analysis: Data obtained in this study were subjected to analysis of variance (ANOVA) to detect significant effects with a confidence level of 95 %. New Duncan's multiple range test was used to separate means. The statistical model is as follow: $Y_{ijl} = \mu + B_i + e_{ijl}$, where Y_{ijl} represents the values of growth traits, carcass merit in the l^{th} animal; μ is the overall mean for each character; B_i is the fixed effect of the protein sources i.e. GNCD, GSLM, MOLM, LLLM and e_{ijl} is the random residual effect. All analyses were done using IBM SPSS version 25.

RESULTS

The performance of snails fed different protein sources indicated that the final weight and weight gain were significantly ($p<0.05$) affected by the dietary treatments (Table 2). The weight gain and final weight of snails on GNCD, MOLM and LLLM were statistically similar ($p>0.05$) but significantly higher ($p<0.05$) than that of snails fed diet containing GSLM. The average feed intake, changes in shell length, shell width and survival rate were statistically similar ($p>0.05$) across the treatments. The feed conversion efficiency of snails on leaf meal containing diets was lower than that of snails fed diet containing GNCD. The carcass characteristics of snails fed different leaf protein sources indicated that the live weight, carcass weight, edible weight, kidney weight, salivary gland weight, fluid weight and intestine length were significantly ($p<0.05$) affected by dietary treatment (Table 3). Shell weight, visceral weight, intestinal weight, shell length and width were not affected ($p>0.05$) by the protein sources incorporated in their diets. The shell weights of snails fed diet containing GNCD and LLLM were highest ($p<0.05$), while snails fed GSLM and MOLM treatment diets had similar values ($p>0.05$). The edible weight of snails fed MOLM treatment diet was highest ($p<0.05$). However, snails fed leaf meal based diets had similar edible weights as snails fed diet containing GNCD.

Table 1: Gross composition of the experimental diets fed to *Archachatina marginata*

Variable	Treatment 1 (GNCD Control diet)	Treatment 2 (GSLM)	Treatment 3 (MOLM)	Treatment 4 (LLLM)
Maize	50	50	50	50
Wheat offal	27.5	27.5	27.5	27.5
Groundnut cake	16.5	-	-	-
Gliricidia	-	16.5	-	-
Moringa	-	-	16.5	-
Leucaena	-	-	-	16.5
Bone meal	3	3	3	3
Oyster shell	3	3	3	3
Total	100	100	100	100
Nutrient composition				
Dry matter (%)	83.46	74.17	72.02	72.78
Crude protein (%)	17.10	13.70	14.58	14.82
Metabolizable Energy (kcal/kg)	2666.85	2303.03	2298.74	2231.25
Ether extract (%)	3.95	3.78	5.17	3.72
Crude fibre (%)	4.16	7.15	4.17	7.01
Calcium (%)	2.23	2.35	2.40	2.51
Phosphorus (%)	0.61	0.63	0.75	0.62

Table 2: Performance of captive snails fed different protein sources

Variable	GNCD	GSLM	MOLM	LLLM
Final weight (g)	259.29 8.10 ± 8.41^{b}	240.87 ± 4.35^{a}	254.34 ± 3.37^{b}	258.18 ± 4.57^{b}
Initial weight (g)	155.53 ± 0.78	156.33 ± 1.20	151.27 ± 0.98	154.53 ± 1.23
Daily feed intake (g/snail)	3.76 ± 0.03	3.75 ± 0.12	3.72 ± 0.29	3.73 ± 0.10
Daily weight gain (g/snail)	1.24 ± 0.08^{b}	1.01 ± 0.31^{a}	1.25 ± 0.11^{b}	1.25 ± 0.09^{b}
Shell length changes (cm)	1.29 ± 0.34	1.26 ± 0.53	1.52 ± 0.49	1.19 ± 0.65
Shell width changes (cm)	1.01 ± 0.23^{a}	0.84 ± 0.20^{b}	0.80 ± 0.15^{b}	0.96 ± 0.10^{a}
Feed conversion efficiency	0.33 ± 0.15	0.27 ± 0.11	0.34 ± 0.08	0.34 ± 0.06
Survival rate (%)	100	100	100	100

abc: In a row, means with different superscripts are significantly different (P<0.05), GNCD: Groundnut cake based diet, MOLM: Moringa oleifera leaf meal, LLLM: Leucaena leucocephala leaf meal, GSLM: Gliricidia sepium leaf meal

Table 3: Carcass characteristics of captive snails fed different protein sources

Variable	GNCD	GSLM	MOLM	LLLM
Live weight (g)	259.29 ± 8.41^{b}	240.87 ± 4.35^{a}	254.34 ± 3.37^{b}	258.18 ± 4.57^{b}
Shell weight (g)	49.98 ± 1.02	41.76 ± 0.88	46.48 ± 1.10	41.68 ± 0.81
Carcass weight (g)	138.29 ± 0.65^{b}	126.40 ± 0.42^{a}	127.75 ± 0.59^{a}	137.58 ± 0.47^{b}
Edible weight (g)	87.03 ± 6.05^{ab}	80.90 ± 3.98^{a}	95.35 ± 6.03^{b}	81.46 ± 5.82^{a}
Visceral organ weight (g)	71.02 ± 11.02	72.71 ± 10.68	83.11 ± 6.34	78.92 ± 9.56
Haemolymph weight (g)	51.26 ± 5.40^{b}	45.50 ± 8.00^{b}	29.40 ± 3.63^{a}	56.12 ± 5.08^{b}
Kidney weight (g)	1.57 ± 0.11^{a}	2.61 ± 0.17^{b}	2.52 ± 0.07^{b}	3.91 ± 0.11^{c}
Salivary gland (g)	0.85 ± 0.02^{a}	0.99 ± 0.23^{a}	2.11 ± 0.15^{b}	0.61 ± 0.14^{a}
Intestine weight (g)	37.59 ± 1.29	40.00 ± 2.34	43.66 ± 1.94	41.88 ± 2.07
Intestine length (cm)	28.92 ± 1.23^{b}	29.13 ± 1.98^{b}	26.66 ± 2.00^{b}	18.62 ± 5.33^{a}
Shell length (cm)	11.88 ± 3.47	11.49 ± 2.95	11.65 ± 3.54	11.88 ± 2.64
Shell width (cm)	6.65 ± 0.95^{b}	6.34 ± 0.55^{a}	6.47 ± 0.07^{a}	6.48 ± 0.35^{a}

abc: In a row, means with different superscripts are significantly different (P<0.05), GNCD: Groundnut cake based diet, MOLM: Moringa oleifera leaf meal, LLLM: Leucaena leucocephala leaf meal, GSLM: Gliricidia sepium leaf meal

The kidney weight of snails fed diet containing LLLM was highest (p>0.05), while that of snails fed diet containing GNCD was lowest. The salivary gland weight of snails fed diet containing MOLM was higher (p<0.05) than that of snails fed other treatment diets. The intestine weight of snails fed diet containing GSLM was the highest (p<0.05) while snails fed other treatments diets had similar values (p>0.05). The haemolymph weight of snails fed diet containing MOLM was higher (p<0.05) than those fed other treatments diets.

The relative weight of carcass traits for snails fed different leaf protein sources indicated that parameters assessed had statistically similar ($p>0.05$) values across treatments except dressing percentage and haemolymph/live weight (Table 4). However, dressing percentage of snails fed diet containing MOLM was significantly highest ($p>0.05$) across the different treatments, whereas percentage shell weight was apparently highest ($p>0.05$) for snails fed diet containing GNCD and percentage haemolymph weight was significantly least ($p>0.05$) for snails fed diet containing MOLM.

DISCUSSION

The inclusion of different leaf protein sources in the snails' diet revealed that snails, being herbivores, performed well on leaf-based diets as reported by Oyeagu *et al.* (2018). Weight gain and final weight of snails fed diet containing GNCD, MOLM and LLLM were similar and better than that of snails fed diet containing GSLM. This indicated that snails fed diet containing MOLM and LLLM performed favourably in comparison with snails fed diet containing GNCD. The average feed intake, changes in shell length and width and survival rate compared favourably across the treatments. However, the feed conversion efficiency of snails fed diet containing GSLM was lower than those of snails fed diet containing GNCD. These results were in line with the findings of Ejidike (2001) and Akinnusi (2002) that a higher protein level of diets resulted in better feed utilization efficiency and improved growth performance in snails. This may be explained by the fact that increasing the level of protein in the feed stimulates appetite in growing snails, resulting in higher weight gain (Tchowan *et al.*, 2018). Olomu (1995) reported that protein functions mainly in tissue growth of animals. Considering the protein levels in GNCD, MOLM and LLLM diets were slightly higher than GSLM diet. The snails performances in diet containing MOLM and LLLM corroborated the report of Oyeagu *et al.* (2018) that snails did better when higher levels of leaf proteins are included in the diet. Alikwe *et al.* (2013) and Oyeagu *et al.* (2018) reported that supplementation or inclusion of herbs and leaves to concentrate formulations of snail diets improved growth in *A. marginata*. However, proteins solely may not responsible for the observed growth performances (Tchowan *et al.*, 2018). It is essential to note the synergistic action of organic matter (proteins, carbohydrates and lipids) and all the mineral and vitamin elements in growth metabolism (Cobbinah *et al.*, 2008). Omole *et al.* (2004) reported that snails can be fed solely on compounded rations without any adverse effect on health. This explained the high survival rate and performance of the snails in this study. Ani *et al.* (2014) reported that performance of snails was optimized when 20 % of *M. oleifera* leaf meal was incorporated into a snail concentrate ration. This was in line with the rate of inclusion of MOLM (16.5 %) in this study and the high performance obtained from this treatment. In contrast, Ogagaoghene (2015) indicated that concentrate feeds may be more useful only as supplements for extra mineral and energy source in snail feeding.

The result of this study that changes in shell length and width were statistically similar across the treatments was in agreement with Ejidike and Afolayan (2010), and suggested that the mineral requirement for shell growth were met in the diets. Positive correlation between live weight gain, shell length gain, and shell width gain was reported in growing snails (Ani *et al.*, 2013).

The edible weight of snails fed diets containing MOLM compared favourably with the control, a very important trait for commercial meat production. The total weight gained by snails is of utmost importance as this will translate into edible protein (Babalola *et al.*, 2015). Snails fed LLLM and GSLM based diets produced high haemolymph content which is valued for its therapeutic properties in cardiovascular diseases (Olagbende-Dada, 2015). The high kidney weight in leaf protein based diets in comparison to GNCD might be attributed to increased kidney activity for the elimination of plant secondary metabolites and/or anti-nutritional factors present in the leaves (Ewuola *et al.,* 2012).

Table 4: Relative weights of carcass traits in captive snails fed different protein sources

Variable	GNCD	GSLM	MOLM	LLLM
Dressing percentage (%)	33.56 ± 3.26[a]	33.59 ± 2.74[a]	37.49 ± 1.45[b]	31.55 ± 1.32[a]
Shell weight / live weight (%)	19.28 ± 2.91	17.34 ± 3.01	18.27 ± 2.99	16.14 ± 4.28
Visceral weight / live weight (%)	27.39 ± 2.23	30.19 ± 3.00	32.68 ± 1.93	30.57 ± 1.50
Haemolymph weight / live weight (%)	19.77 ± 5.09[b]	18.89 ± 4.52[b]	11.56 ± 4.31[a]	21.74 ± 6.34[b]

GNCD: Groundnut cake based diet, MOLM: Moringa oleifera leaf meal, LLLM: Leucaena leucocephala leaf meal, GSLM: Gliricidia sepium leaf meal

However, at present inclusion levels, this did not have a deleterious effect on the animals as judged from the high survival rates.

Babalola *et al.* (2015) reported that bone meal as a calcium supplement in the diet of snails fed *Euphorbia heterophylla* led to 40 % mortality and had the poorest performance when *E. heterophylla* was supplemented with three different calcium sources (eggshell, oyster shell and bone meal). The report of this study negates this claim (100 % survival rate), despite having combined oyster shell and bone meal in the concentrate ration. In comparison with this study, it shows the inherent benefit of balanced ration as contained in concentrate formulation, compared to nutrient toxicity, antagonism, and the deficiency that arise from imbalanced nutrition which could result in disease conditions and mortality. Bone meal has unquestionably been used as mineral (calcium and phosphorus) feedstuff in livestock and poultry diets for decades. It is essential to note the synergistic action of organic matter (proteins and lipids) and all the mineral elements being important for growth metabolism (Cobbinah *et al*., 2008), a good example of which is magnesium which is essential for the assimilation of vitamin B2 (thiamine) and the synthesis of proteins (Tchowan *et al*., 2018). The high survival rate in this study was in agreement with Ejidike and Afolayan (2010) and Nyameasem and Borketey-La (2014) when snails are fed concentrate diets. This affirmed the nutritional advantage of balanced ration formulation over roughages and herbal feedstuffs. Oluokun *et al.* (2005) and Nyameasem and Borketey-La (2014) reported that snails are hardy and therefore, have a relatively low mortality rate if proper management is observed compared to other conventional livestock.

Dressing percentage and percentage visceral weight of snails fed diet containing MOLM was the significantly highest across the different treatments. The values obtained were in line with the dressing percentages of *A. marginata* snails of 37 – 43 % (Oluokun *et al*., 2005; Okpeze *et al*., 2007; Babalola and Akinsoyinu, 2009; Eze *et al*., 2010; Babalola *et al.,* 2015). Dressing percentage and relative shell weight obtained in this study were similar to the range obtained by Ani *et al*. (2014) in snails fed *M. oleifera* based concentrate. The inclusion of MOLM was reported to be beneficial up to 20% inclusion in concentrate diet for snails. However, the percentage haemolymph weight was similar in both studies, probably due to their common plant origin inclusion in snail diet. Plant or herbs inclusion in snail diet has been reported to favour haemolymph production. The highest percentage of haemolymph in snails on GSLM based diet agrees with the report that herbages in snail diet result in higher haemolymph in the snail, which is of pharmaceutical importance in the treatment of cardiovascular diseases (Eze *et al*., 2010).

Conclusions: The inclusion of leaf meals as protein sources in concentrate rations for snails was beneficial to growth and carcass traits of growing snails. *M. oleifera* leaf meal and *L. leucocephala* leaf meal compare favourably with groundnut cake as a protein source in snail diet in growth-enhancing capacities. These leaves have the ability to reduce the cost of feed because they are abundant and at little or no cost to the farmers. It is recommended that *M. oleifera* leaf meal and *L. leucocephala* leaf meal be incorporated in snail diets as protein sources for commercial snail farming for optimal productivity.

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