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Growth Response of African Giant Land Snails (Archachatina marginata) to Varying Dietary Levels of Moringa Oleifera Leaf Meal

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Abstract
The effects of varying dietary levels of *Moringa oleifera* leaf meal (MOLM) on growth performance of *Archachatina marginata* snails was investigated using 180 *A. marginata* snailets weighing between 20.05-21.45g (P>0.05). The snails were randomly divided into six treatments (30 snailets each) and three replicates per treatment (10 snailets each) in a completely randomized design (CRD). The treatments were assigned to one of six caloric (2.78 - 3.13 Mcal/kg ME) and nitrogenous (23.82 - 24.05 % crude protein, CP) diets containing 0, 5, 10, 15, 20 and 25% MOLM, respectively. Feed and water were supplied *ad libitum* to the snails throughout the 10 weeks experimental period. The response parameters evaluated were body weight (BWT), body weight gain (BWG), feed intake (FI), feed conversion ratio (FCR), daily protein intake (DPI), protein efficiency ratio (PER), shell length (SL) and width (SW), carcass yield (CY) and cost of feed per kg weight gain (CPWG). Results showed that dietary inclusion of *Moringa oleifera* leaf meal had significant (P<0.05) effects on FI, BWT, BWG, SL and SW, FCR, PI, PER and CPWG. Body weight, BWG and PER were significantly (P<0.05) increased as the level of MOLM in the diets increased from 0 to 20 %, beyond which there was significant (P<0.05) reduction in growth performance. There was significant (P<0.05) reduction in CPWG with increases in MOLM inclusion level. There was significant (P<0.05) reduction in live weight, weight of edible portion and dressing percentage as the level of MOLM in the diets increased beyond 20%. It was concluded that up to 20% MOLM can be included in the diet of growing snails without any adverse effect on growth performance and carcass yield of the snails.
Keywords: *Moringa oleifera* leaf meal, *Archachatina marginata*, diet, growth performance, carcass yield.

1. Introduction

Heliculture, the farming of snails, has become an important economic activity in Nigeria in recent times in a renewed trust to increased animal protein production (Ugwuowo and Ani, 2011). Snail farming is environment-friendly and can be done with little skill and cash (NRC, 1991; Robert, 2012; Akinnusi, 2004). Snails are accepted nationwide and in all cultures in Nigeria. Snail meat is regarded as a delicacy. It is very palatable, nutritious, rich in protein and iron as well as calcium and phosphorus. It is a major source of essential amino acids (lysine, leucine, isoleucine, arginine, tryptophan, and phenylalanine; Kalio and Etela, 2011). Snail meat provides more lysine and arginine than whole egg and it is perhaps for these amino acid contents that snail meat is recommended for convalescing patients (Okonkwo *et al.,* 2000). It is low in sodium, fat, and cholesterol, so useful for the treatment of anaemia, asthma, high blood pressure, arteriosclerosis, and similar ailments (Okonkwo *et al.,* 2000) while its shell can be incorporated into animal feeds or used in liming to reduce soil acidity. Micro animals like snails require and consume less feed. Heliculture thus encourages cheap and affordable animal products. Snail meat costs less compared to other livestock meats.

The nutritional quality of snail meat would depend on the quality of the feed they consume. *Moringa oleifera* leaf is a rich source of vitamins, amino acids and minerals (Mekkar and Bekkar, 1999; Francis *et al.,* 2005). The incorporation of *Moringa oleifera* leaf meal in the diet of growing snails may be of help in meeting the nutritional and health requirement of snails as well as enhance their growth performance, thereby enabling them to attain maturity and market weight within a shorter period of time. This study was therefore conducted to determine the growth and cost implications of feeding graded levels of *Moringa oleifera* leaf meal to *Acharchatina maginata* snailets.

2. Materials and methods

Location of the Study: The study was conducted at the Snail Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka. Nsukka lies in the derived savannah region, and is located on longitude $6^{o}45^{1}$E and 7^{o1}E and latitude 7^{o} 12.5^{1}N and altitude 447m above sea level (Breinholt *et al.*, 1981). The climate of the study area is typically tropical, with relative humidity ranging from 65-80%. Average diurnal minimum temperature ranges from 22-24.7^{o}C while the average maximum temperature ranges from 33-

37^{o}C. Annual rainfall ranges from 1680-1700mm (Energy centre, UNN, 2008, unpublished).

2.1 Experimental diets

Six caloric (2.78-3.13 Mcal/kg ME) and nitrogenous (23.82-24.05% crude protein) diets containing 0, 5, 10, 15, 20 and 25% *Moringa oleifera* leaf (MOLM) were formulated for the experiment. Other feed ingredients included maize, wheat offal, groundnut cake, soyabean meal, fish meal, palm kernel cake, limestone, bone meal, and vitamin premix (Table 1).

2.2 Experimental animals

One hundred and eighty (180) *Archachatina marginata* snailets with initial average weight of 20.05-21.45g (P>0.05) were used for the study. The snails were randomly divided into six groups of 30 snails each in a completely randomized design (CRD) and assigned to one of the six caloric (2.78 - 3.13 Mcal/kg ME) and nitrogenous (23.82 - 24.05% crude protein) diets. Each treatment was replicated thrice with 10 snailets per replicate. Each replicate was housed in a plastic basket measuring 30cm in diameter and 13cm in height with proper perforations to enhance easy flow of air and proper drainage. Each basket was filled with loamy soil treated with hot water to 5cm depth. The soil was watered two times daily from tap water to keep the soil moistened to prevent the snails from aestivating. The baskets were placed on a raced wooden platform with the legs dipped in a container filled with spent engine oil for protection from ants and other predators. Feed and water were provided *ad libitum* throughout the period of the study which lasted for 10 weeks. The feed was moistened before supply to allow for easy ingestion and to prevent respiratory problems. Plastic feeding troughs were used for feeding the snails. Since snails are nocturnal animals and feed mostly at night, they were fed in the evenings, between 16:00 and 18:00 h. Fresh feed was given to the snails daily. Left over feed was removed daily from the feeding trough. The quantity of feed that was offered to the snails daily was weighed before introduction and the leftover were dried and then weighed to determine daily feed intake. The feeding and watering containers were washed every day. Other sanitary measures included scooping out the faeces of the snails daily to prevent the buildup of pathogens.

2.3 Data collection

The initial body weight of the snails was measured on the first day and subsequent weights were taken every week till the end of the experiment using a sensitive weighing balance (Harvard trip balance). The shell length and shell width of the snails were measured with venier callipers on weekly basis. Other parameters measured were feed intake, shell length, shell width, carcass yield and mortality. Feed conversion ratio (FCR) was calculated as feed: gain; protein intake was calculated from feed intake values while protein efficiency ratio (PER) was calculated as weight gain divided by protein intake. Feed cost per kg weight gain was calculated as feed cost per kg multiplied by feed conversion ratio.

2.3.1 *Proximate and Data analyses***:** Feed samples were assayed for proximate composition by the method of AOAC (2005). Data collected were subjected to analysis of variance (ANOVA) for completely randomized design (CRD) using the Statistical Package for Social Sciences (2007) (SPSS in corporate, Chicago, USA). Significantly different means were separated using Duncan's New Multiple Range Test option in SPSS.

3. Results

3.1 Proximate compositions of *Moringa oleifera* leaf meal and experimental diets

The percentage compositions of the experimental diets are presented in Table 1 while Table 2 shows the proximate compositions of *Moringa oleifera* leaf meal and experimental diets. The *Moringa oleifera* leaf meal used in the present study contained 80.5% DM, 32.7% CP, 0.7% EE, 5.7% ash, 7.9% CF and 33.5% NFE. The crude fiber content of the diets increased as the percentage of *Moringa oleifera* leaf meal increased in the diets.

3.2 Effect of *Moringa oleifera* leaf meal on growth performance and feed intake of *A. marginata* snails

Table 3 shows the growth performance of African giant land snails (*Archachatina marginata*) fed varying dietary levels of *Moringa oleifera* leaf meal (MOLM). There were significant differences (P<0.05) among treatments in average daily feed intake (ADFI), final body weight (FBW), average daily weight gain (ADWG), total weight gain (TWG), feed conversion ratio (FCR), shell length (SL), shell width (SW), daily protein intake (DPI), protein efficiency ratio (PER) and percent mortality. Snails on 10 and 20% MOLM diets had comparable (P>0.05) ADFI values and these were significantly (P<0.05) higher than the ADFI values of snails on other treatments. Snails on 0, 5, 20, and 25% MOLM diets did not differ significantly (P>0.05) in their average daily feed intake values. The final body weight of the snails was significantly (P<0.05) affected by the treatments. Snails on 20% MOLM had the highest (P<0.05) FBW values followed by those of the control while snails fed 10, and 15% MOLM surpassed those of 25% in FBW. Snails fed 5 and 25% MOLM had equivalent FBW values. Average daily weight gain was statistically the same for snails fed 20 and 0% MOLM but was significantly (P<0.05) lowest in snails fed 25% MOLM. Snails fed 5, 10 and 15% MOLM diets had statistically similar ADWG. Snails fed 20% MOLM diet (treatment 5) had the highest (P<0.05) total weight gain followed by snails fed 0, 5, and 10% MOLM which in turn surpassed those fed 25% MOLM in total weight gain. Snails on 10% MOLM (treatment 3) had significantly (P<0.05) highest feed conversion ratio with those of 25% MOLM. The least (best) FCR was recorded for snails fed the control diet (0% MOLM) and those fed 20 and 5% MOLM. For shell length, snails fed 20% MOLM diet had significantly (P<0.05) highest shell length value (1.87cm) compared to other treatments which were statistically of comparable values. Snails fed 20% MOLM diet had significantly (P<0.05) highest shell width followed by snails fed 15% MOLM diet which in turn surpassed (P<0.05) those fed 25% MOLM. The shell width of snails fed 0, 5, and 10% MOLM were least and similar. For daily protein intake, snails on 5% MOLM had significantly (P<0.05) highest daily protein intake (1.65g) followed by those fed 10% MOLM (0.95g) while snails fed 20% MOLM had the least daily protein intake (0.38g). Protein efficiency ratio was highest (P<0.05) in snails fed 20% MOLM (0.32) but least in snails fed 0, 5, 10 and 15% MOLM (0.23, 0.20, 0.19 and 0.24, respectively).

3.3 Cost implications of feeding MOLM to *Archachatina marginata* snails

The cost of total feed intake was highest for snails fed 10% MOLM (₦9.29) followed by those fed 0, 5, 15, and 20% MOLM which were statistically similar (Table 4). The value for snails fed 25% MOLM was least (₦6.10). The cost of daily feed intake followed the same trend as cost of total feed consumed. The feed cost per kg gain was smallest in snails fed 0, 5, 15, 20, and 25% MOLM but highest in snails fed 10% of the test material (₦0.68).

3.4 Carcass yield of *Archachatina marginata* snails fed *Moringa oleifera* leaf meal

Table 5 shows the carcass yield of *Archachatina marginata* fed varying dietary levels of MOLM. Live weight, and weight of edible portion was highest for snails fed 0% MOLM (36.18 and 9.67g, respectively) followed by those of 10, 15 and 20% for LW (34.90, 34.69 and 34.60, respectively) and 5, 10, 15 and 20% MOLM for weight of edible parts (8.20, 8.27, 8.60, and 8.52g, respectively). The least values for these parameters were observed in snails fed 25% MOLM (32.42, and 7.40g, respectively). Weight of viscera was similar in snails fed 0, 5, and 15% MOLM (5.09, 5.40 and 5.19, respectively) and these were the highest values while the least value was found in snails fed 20% MOLM (4.53g) which was comparable to those of 10 and 25% MOLM (4.63 and 4.75g, respectively). Shell weight was highest in snails fed 15 but this was comparable to those of 0 and 10% MOLM (5.16, 4.97, 4.81g, respectively) while the least shell weight was recorded in snails fed 20 and 5% MOLM (4.09 and 4.16g, respectively). The highest dressing percentage was recorded in snails fed 0, 20, 5, and 15% MOLM while the least value belonged to snails fed 25% MOLM (33.29%). Snails fed 15, and 25% MOLM had highest value for relative shell weight (20.74, and 20.26%, respectively) and these were similar to those of 0, 10 and 20% MOLM (19.10, 19.20, and 19.01%, respectively). The smallest value of relative shell weight occurred in snails fed 5% MOLM (17.70%). The highest relative visceral weight was observed in snails fed diets containing 5, 15, and 25% MOLM while the least values were observed in snails fed 10, 20, and 0% MOLM.

4. Discussion

4.1 Proximate composition of *Moringa oleifera* leaf meal

The proximate values (80.5% DM, 32.27% CP, 0.7% EE, 5.7% ash, 7.9% CF and 33.5% NFE) of Moringa *oleifera* leaf meal used in the present study (Table 4) differed from the proximate values (94.6% DM, 28.0% CP, 5.90% EE, 12.2% ash, 7.10% CF and 46.8% NFE) reported by Olugbemi *et al.* (2010). This variation may have resulted from differences in cultivars/varieties, stage of growth and time of harvest, and geographical location (Amaefule and Obioha, 1998; Ani and Okorie, 2006; Yang *et al.* (2006). When compared to other leaf meals that had been used in earlier studies for feeding snails (Okpeze *et al.,* 2007), the *Moringa oleifera* leaf meal used in the present study had higher crude protein content (32.7%) than *Stylosanthese gracilis* leaf (19.97%), lab-lab leaf (18.18%) and *Carica papaya* leaf (22.53%). Ani and Ugwuowo (2011) had shown that feed sources with crude protein content in the range of 22% to 25% were adequate for optimal performance of growing snails.

4.2 Effect of *Moringa oleifera* leaf meal on growth performance of *A. marginata* snails

The significant increases in total weight gain (TWG), ADWG, FBW and PER with increases in level of MOLM from 0 to 20% indicate beneficial effect of MOLM at these levels of inclusion. Beyond 20% inclusion rate, there was significant reduction in growth performance which may be attributed to the highly increased fiber content. High dietary fiber is known to limit the availability of nutrients, especially energy and protein (Maynard and Loosli, 2000). Depressed apparent nutrient digestibility and nutrient retention as a result of high dietary fiber content was reported in broilers (Maynard and Loosli, 2000), in pigs (Ani and Ikeh, 2011) and in rabbits (Jokthan *et al*., 2006). Such depression in apparent nutrient digestibility and retention was attributed to high rate of passage of digester and excessive nutrient excretion in animals fed high fiber diets (Kung and Grueling, 2000;

Macdonald *et al.,* 2002). The role of dietary materials to promote or depress growth performance in snails has been documented (Odo *et al*., 2010). Okpeze *et al.* (2007) also showed that poor forage utilization resulted in depression in growth performance. The significant variation in shell length and width among the treatments may be due to variations in the degree of mineral absorption and utilization by snails in the various treatments. The low mean shell length and shell width observed in treatments 1, 2, 3, 4, and 6 might be due to nutrient (calcium and phosphorus) imbalance as reported earlier by Fumilayo (2008).

4.3 Cost implication of feeding graded levels of MOLM to *Archachatina marginata*

The significant reduction in feed cost with increases in the inclusion levels of MOLM invariably led to the reduction in the production cost which has the potentials to increase the farmers' profit margin and stimulate increased snail production (Ojebiyi *et al*., 2011). The use of non conventional feed materials in the feeding of non ruminant animals has been shown to reduce the cost of production and enhance profit (Anyanwu *et al*., 2003; Ani, 2008b).

4.4 Effect of graded levels of MOLM on c**arcass yield of *A. marginata* snails**

The observed significant reduction in live weight, weight of edible portion and dressing percentage as the level of MOLM in the diets increased beyond 20% followed from the reduced growth performance beyond 20% inclusion rate which was attributed to poor nutrient absorption and utilization on account of the high fiber content of the diets. This result is supported by Macdonald *et al.* (2002) and Jokthan *et al.* (2006).

5. Conclusion

In conclusion, up to 20% MOLM can be included in the diet of growing snails without adverse effect on growth performance and carcass yield of the snails but with reduced cost of production.

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Table 1: Percentage composition of experimental diet

	***Moringa oleifera* leaf meal levels (%)**					
	0	5	10	15	20	25
Ingredients/ Diets	1	2	3	4	5	6
Maize	28.00	27.00	26.00	25.00	24.00	23.00
Wheat offal	19.00	18.00	17.00	16.00	15.00	15.00
Groundnut cake	22.00	20.00	19.00	17.00	16.00	14.00
Soya bean meal	10.00	9.00	8.00	8.00	7.00	6.00
Fish meal	2.00	2.00	2.00	2.00	2.00	2.00
Palm kernel cake	14.00	14.00	13.00	12.00	11.00	10.00
Moringa oleifera leaf meal	0	5	10	15	20	25
Bone meal	1.75	1.75	1.75	1.75	1.75	1.75
Methione	0.25	0.25	0.25	0.25	0.25	0.25
Limestone	2.50	2.50	2.50	2.50	2.50	2.50
Lysine	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100
Calculated composition:						
Crude protein (%)	24.02	23.82	23.90	23.97	24.05	23.84
Crude fibre (%)	4.71	4.84	4.91	4.97	5.04	5.06
Energy(Mcal/kg ME)	2.78	2.83	2.91	2.98	3.05	3.13
Cost of 100kg of feed (₦)	7,465.5	7,090.50	6,743.6	6,506.5	6,159.5	5,802.5
Cost of 1 kg feed (₦)	74.66	70.91	67.44	65.07	61.60	58.03

Table 2: Proximate composition of *Moringa Oleifera* leaf (MOLM) meal and experimental diet

		Moringa oleifera leaf meal (MOLM) levels (%)					
		0	5	10	15	20	25
Components/ Diets	MOLM	1	2	3	4	5	6
Dry matter (%)	80.5	88.3	88.6	88.5	88.6	88.5	88.9
Crude Protein (%)	32.7	24.05	24.05	23.80	23.78	24.06	24.04
Ether extract (%)	0.7	3.55	3.55	3.65	4.0	4.25	4.20
Ash (%)	5.7	8.10	11.15	9.40	11.90	10.70	6.70
Crude fibre (%)	7.9	6.40	8.95	10.05	14.35	15.50	20.75
Nitrogen-free extract (%)	33.5	46.20	40.90	48.90	34.57	33.99	33.21

Table 3: Growth performance of giant African land snails (*Archachatina marginata*) fed varying dietary levels of *Moringa oleifera* leaf meal

	***Moringa oleifera* leaf meal levels (%)**						
	0	5	10	15	20	25	
Parameters/Treatments	1	2	3	4	5	6	SEM
Initial body weight(g)	21.22	20.05	21.20	21.45	20.99	20.93	0.21
Final body weight(g)	36.18[b]	33.54[cd]	34.90[c]	34.69[c]	39.27[a]	32.42[d]	0.54
Av. daily weight gain(g)	0.21[ab]	0.19[b]	0.20[b]	0.19[b]	0.26[a]	0.16[c]	0.01
Ave. daily feed intake (g)	1.41[b]	1.52[b]	1.97[a]	1.61[b]	1.87[a]	1.50[b]	0.07
Total weight gain(g)	14.96[b]	13.49[b]	13.70[b]	13.26[bc]	18.28[a]	11.49[c]	0.75
Feed conversion ratio	6.56[c]	8.00[c]	10.11[a]	8.58[bc]	7.39[c]	9.35[ab]	0.41
Shell length (Cm)	0.43[b]	0.31[b]	0.51[b]	0.23[b]	1.87[a]	0.34[b]	0.15
Shell width(mm)	0.04[d]	0.02[d]	0.06[d]	4.25[b]	5.40[a]	2.43[c]	0.54
Daily protein intake (g)	0.50[c]	1.65[a]	0.95[b]	0.67[bc]	0.38[c]	0.57[bc]	0.13
Protein efficiency ratio	0.23[b]	0.20[b]	0.19[b]	0.24[b]	0.32[a]	0.07[c]	0.03

[a,b,c,d]: Means having different superscripts are significantly (P<0.05) different, SEM=Standard error of mean.

Table 4: Cost implication of feeding graded levels of MOLM to *Archachatina marginata* snails

	Moringa oleifera leaf meal levels (%)						
	0	5	10	15	20	25	
Treatments/Parameters	1	2	3	4	5	6	SEM
Cost of 1kg of feed (₦)	74.66	70.91	67.44	65.07	61.60	58.03	-
Cost of total feed intake (₦)	7.35[b]	7.54[b]	9.29[a]	7.33[b]	6.69[bc]	6.10[c]	0.30
Cost of daily feed intake (₦)	0.11[b]	0.11[b]	0.13[a]	0.11[b]	0.10[c]	0.09[d]	0.004
Feed cost per kg wt gain (₦)	0.49[b]	0.56[b]	0.68[a]	0.56[b]	0.53[b]	0.53[b]	0.03

[a,b,c]: Means having different superscripts are significantly (P<0.05) different, SEM=Standard error of mean

Table 5: Carcass yield of giant African land snails (*Archachatina marginata*) fed varying dietary levels of *Moringa oleifera* leaf meal

	Moringa oleifera leaf meal levels (%)						
	0	5	10	15	20	25	
Treatments/Parameters	1	2	3	4	5	6	SEM
Live weight (g)	36.18[a]	33.54[bc]	34.90[b]	34.69[b]	34.60[b]	32.42[c]	0.54
Weight of Edible portion (g)	9.67[a]	8.20[b]	8.27[b]	8.60[b]	8.52[b]	7.40[c]	0.25
Weight of Visceral (g)	5.09[ab]	5.40[a]	4.63[bc]	5.19[ab]	4.52[c]	4.75[bc]	0.16
Shell weight (g)	4.97[ab]	4.16[c]	4.81[ab]	5.16[a]	4.09[c]	4.51[bc]	0.20
Dressing (%)	37.23[a]	34.88[ab]	32.58[b]	34.71[ab]	36.75[a]	33.29[b]	1.00
Relative Shell weight (%)	19.10[ab]	17.70[b]	19.20[ab]	20.74[a]	19.01[ab]	20.26[a]	0.82
Relative Visceral weight(%)	19.61[b]	22.92[a]	18.47[b]	20.98[ab]	18.54[b]	21.53[ab]	0.74

[a,b,c]: Means having different superscripts are significantly ($P<0.05$) different, SEM=Standard error of mean