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Digestibility and nutrient intake of African Giant Land Snails (*Archachatina marginata*) hatchlings fed municipal organic waste with foliage and grass/legume

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Target Audience: *Farmers, Food vendors, Researchers and Household Consumers.*

Abstract

Snails are important kind of micro livestock in the animal industry with a wide range of economic value and significance, the study determined the digestibility and nutrient intake of African Giant Land Snails (Archachatina marginata) hatchlings fed municipal organic waste, foliage or grass/legume using Completely Randomized Design. The experiment had four (4) treatments with five (5) replicates each, the experimental diets were diet 1 (100% municipal organic waste), diet 2 (100% grasses), diet 3 (75% grasses and 25% legume) and diet 4 (100% foliage). There were 25 hatchlings per replicate. The experiment lasted for 120 days. Snail hatchlings fed experimental diet 4, maintained higher significant (P<0.05) results for diet protein intake, digestible protein for growth, total digestible protein for gain, digestible protein, gross protein value, protein replacement value, and a better protein utilization efficiency. Dietary fibre intake was (P<0.05) higher on diet 3, 2 and 1, lower on diet 4, digestible fibre for growth showed (P<0.05) higher and similar values for diet 4 and 1, lower values for diet 3 and 2, digestible fibre and fibre replacement value decreased (P<0.05) in the order diet, 2, 3, 1 and 4, for efficiency of fibre utilization, diet 2 and 3 showed better fibre utilization efficiency. Dietary fat intake, digestible fat, fat replacement value showed (P<0.05) higher for diet 1, and with a better fat utilization efficiency. Snail's micro-biota had high substrates dependency role on the quality of feed nutrient utilization in a symbiotic mechanism that helped in the breakdown and digestion of feed materials.

Keywords: *Digestibility; Snails; Hatchlings; Municipal Organic Waste*

Description of Problem

Snails have a long-standing importance as a source of human food and products from snail belong to food stuff with high nutritional value (26), containing food energy, high quality proteins, vitamins and minerals. They are eaten by the rich and poor, urban and rural dwellers as well as in all continents of the world. (29) have assessed the nutritive value of snail meat in relation to some popular conventional animal protein sources, and that snails' meat has a protein content of 88.37%, a value which compares favorably with conventional protein sources whose value ranged from 82.42% (pork) to 92.75% (beef). The flesh of land snails contained at least 70% water while its dry mater consisted of a quality protein with high content of lysine, leucine, arginine and tryptophan. In addition to the high levels of protein and iron, snail meat also contains high levels of calcium and phosphorus. It is low in sodium, fat and cholesterol. The non-edible parts, the visceral and the shell, which represent at least 40% of the snail's weight, can be recuperated for feeding monogastric animals.

Snails are herbivores and will accept many types of feeds including plant wastes. In intensive snail rearing, formulated feeds containing all the needed nutrients for optimal growth are used for all year production. (9), in their work to compare the performance of snails fed forage and concentrate, reported that, snails on forage feed had the best feed conversion ratio, indicating that forage was converted into edible snail meat and shell formation than concentrate and therefore concluded that, the performance of snails on forage was the best.

The limitation to the use of forage however is the presence of anti-nutritional substances found in forage. Anti-nutritional factors (ANFs) are substances that when present in animal feed or water they either by themselves or through their metabolic products reduce the availability of one or more nutrients, uptake of nutrients, digestion, absorption and utilization and may produce other adverse effects (1). They reported that, these compounds elicit both toxic and advantageous biological responses. This has given rise to several investigations in recent time, as to their possible physiological implications in various biological systems (14). The experiment evaluated the comparative performance and digestibility of snails (*Archachatina marginata*) fed forages or municipal organic wastes (MOW).

Materials and Methods

Experimental site

The study was carried out at the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria; located on Latitude 05^0 21'N and Longitude 07^0 33'E. It is approximately 122m above sea level with maximum and minimum temperature of 27 - 37^0C and 20 – 26^0C, respectively. The relative humidity ranged from 50 – 90% with an annual rainfall of about 2177mm (19).

Experimental animals and management

Fifty matured snails (*Archachatina marginata*) sourced from a farm at Ikot Ekpene in Akwa Ibom State of Nigeria were used as parent stock in the multiplication of five hundred hatchlings used for this study. The snails were confined in a wooden hutch (1 x 1 x 1) m where they laid a total of 2750eggs. The eggs were incubated in a rectangular plastic bowl (60 x 45 x 45 cm) that was perforated to enhanced drainage. The eggs hatched between 30-32 days and the hatchlings were collected and housed using 20 rectangular plastic bowl (60 x 45 x 45 cm) that were perforated to enhance easy drainage and flow of air, 136 hatchlings were collected from each rectangular plastic bowl. Each plastic bowl was half filled with the prepared media (loamy soil 60%, saw dust 20% and poultry droppings 20%) and it was allowed to ferment for 10 days before use (4), and the hatchlings in the plastic bowl were watered 2 times daily to keep the soil moistened to prevent the snail from aestivating. The plastic bowl was placed on a raised wooden platform and surrounded by a shallow gutter filled with water mixed with used engine oil to prevent predators like ants from having access to the snails as described by (12).

Experimental diets

The treatments consisted of Diet 1 (100% Municipal organic wastes); Diet 2 (100% Grasses (20% Signal grass, 20% Guinea grass, 20% *Eleucine indica*, 20% Elephant grass, 20% Carpet grass); Diet 3 (75% grasses, 15% Signal grass, 15% Guinea grass, 15% Stubborn grass, 15% Elephant grass, 15% Carpet grass and 25% Centro); Diet 4 (100% Miscellaneous plants, 20% Gourd leaves, 20% Pawpaw leaves, 20% Cocoyam leaves, 20% Bush green leaves, 20% Plantain leaves). The different materials added to any one treatment, is due to high level of availability and low cost per kg.

As presented in table 1.

Nutrient values

Data on nutrient values was based on (5), and (4), as shown below.

Diet nutrient intake (g) =

$$\frac{\%\ \text{Nutrient in feed} \times \text{g of feed taken}}{100}$$

Digestible nutrient for growth (g^{d-1}) =

$$\frac{\text{Body nutrient concentration} \times \text{g of gain/day}}{0.45}$$

Digestible nutrient =

$$\frac{\text{Nutrient of feed}}{\text{Av. Biological value of } 0.775}$$

Total digestible nutrient for gain = Gram gain x 1.6

Gross protein value (%) =

$$\frac{\text{Increase gain/g of test protein} \times 100}{\text{Decrease gain/g of control protein}}$$

Nutrient Replacement Value =

$$\frac{B - A}{\text{Nutrient intake}}$$

Where B = Nutrient value under test in g/basal diet

A = Nutrient value for control in g/basal diet

Nutrient Efficiency Ratio =

$$\frac{\text{Gain in weight (g)}}{\text{Nutrient intake (g)}}$$

Five hundred hatchlings were selected and randomly divided into four groups of 125 hatchlings each and were replicated five times with 25 hatchlings per replicates, using Completely Randomized Design. The data collected were subjected to analysis of variance (ANOVA) as described by (25). Means were separated using Duncan Multiple made by (5) and (22) who indicated that feed intake does not depend on the nutrient composition of feed alone, but on other factors such as palatability, texture and taste mechanism.

Digestible protein for growth

Significant differences (P<0.01) existed

New Range Test (DMRT) as described by (27).

Results and Discussion

Protein values of diets fed to snails

The study investigated the comparative performance of snails (*Archachatina marginata*) fed forages or municipal organic wastes (MOW). The results for protein intake, digestible protein for growth, digestible protein, total digestible protein for gain, gross protein value, protein replacement value and protein efficiency value of snails fed the experimental diets are presented in Table 2.

Diet protein intake

Diet nutrient intake showed significant differences (P<0.01) among treatments as in Table 2. The snails on diet 2 had the lowest, followed by those on diets 1 and 3, while the highest nutrient intake was noted in diet 4. The high protein intake could be traced to high protein content of the diet as revealed in this study while the lowest protein intake is as reflected on the low protein content of the diet 2. (5) and (15) reported the importance of high dietary protein intake in livestock, precisely on goats and broiler birds respectively. (5) further showed that, body weight and feed efficiency are improved with high amount of dietary protein intake especially when there is a corresponding increase in energy on the diet. The high protein intake in diet 3 and 4 could also be traced to high feed intake (10). (20) suggested that low protein intake as noted in diet 2 could be traced to poor acceptability and palatability of the diet. This agrees with the observations

among treatments as in Table 2. Snails on diet 4 had the highest digestible protein for growth and the lowest was recorded in diet 2. The high performance observed in diets 4 and 1 was not surprising, since the diets contained the highest quality protein value and this would have met the snails' optimum requirement for growth, and could have utilized the available protein efficiently to enhanced growth performance (11). The lower value as recorded in diet 2 could be attributed to poor passage and utilization of the feed through the alimentary canal. In *Achachatina fulica,* like other gastropods, the food scraped by radula and ingested by the buccal mass is mixed with the secretions of the salivary gland and accumulates in the crop (ingluvius), a distensible muscular compartment. The crop and stomach are filled via two cannaliculi with the juice produced by the digestive glands. The medial part of the gut is surrounded by the digestive gland, which secretes more enzymes into the mid-gut lumen and also absorbs nutrients. The epithelium of the digestive tube is ciliated along almost its entire length, allowing the food to mix with digestive juices and helping to transport the alimentary mass. The gut of the giant African land snails, are efficient enough to act as a fermentation vessel where a number of metabolic reactions are mediated by the host symbionts. This must be due to high crude fibre and lignified materials content of the feed fed to the snails. This is in line with an assertion by (24) who reported that, as the level of crude fibre increased, the amount of crude protein and digestibility of dry matter decreased.

Table 1: Composition of experimental diets fed Giant African Land Snail (*Archachatina marginata*)

	Treatments			
Feed	**1**	**2**	**3**	**4**
Municipal organic waste (MOW)	100.00	_	_	_
Grasses:				
Signal grass (*Brachiaria decumben*)	_	20.00	15.00	_
Guinea grass (*Pannicum maximum*)	_	20.00	15.00	_
Stubborn grass (*Eleucine indica*)	_	20.00	15.00	_
Elephant grass *(Pennisetum purpureum*)	_	20.00	15.00	_
Carpet grass (*Axonopus compresus*)	_	20.00	15.00	_
Legume:				
Centro (*Centrosema pubescence*)	_	_	25.00	_
Foliage:				
Gourd leaf (*Adenoupus breviflorus)*	_	_	_	20.00
Pawpaw leaf (*Carica papaya*)	_	_	_	20.00
Bush green leaf (*Amaranthus spinosus)*	_	_	_	20.00
Plantain leaf (*Musa spp*)	_	_	_	20.00
Cocoyam leaf (*Colocosia esculenta*)	_	_	_	20.00
TOTAL	**100.00**	**100.00**	**100.00**	**100.00**
Calculated chemical composition				
Dry matter (%)	91.88	87.37	84.74	83.08
Crude protein (%)	12.25	8.20	12.47	20.20
Ether extract (%)	17.90	2.50	2.68	4.24
Crude fibre (%)	16.90	33.40	33.00	15.32
Nitrogen free extract (%)	7.80	47.50	43.60	47.80
Ash (%)	9.29	8.40	8.25	12.32
Metabolizable energy (Kcal/gDM)	2473.84	3018.14	3069.47	3052.44
Ca (%)	1.89	0.50	0.63	1.45
P (%)	0.29	0.22	0.24	0.45

Table 2: Protein value of diets fed to snails

	Experimental Diets					
Parameters	**1**	**2**	**3**	**4**	**SEM**	**SIG**
Diet protein intake (g)	0.34^{c}	0.24^{d}	0.38^{b}	0.60^{a}	0.03	**
Digestible protein for growth (g^{d-1})	6.94^{a}	5.21^{b}	5.64^{b}	7.38^{a}	0.27	**
Digestible protein	15.81^{c}	10.58^{d}	16.10^{b}	26.06^{a}	1.29	**
Total digestible protein for gain (g^{d-1})	0.26^{b}	0.19^{d}	0.21^{c}	0.27^{a}	0.0008	**
Gross protein value (%)	100.00^{b}	75.00^{d}	81.25^{c}	106.25^{a}	3.00	**
Protein replacement value	0.00^{c}	-17.16^{d}	0.59^{b}	13.32^{a}	2.49	**
Protein efficiency ratio	0.47^{c}	0.51^{d}	0.34^{b}	0.28^{a}	0.02	**

^{a,b,c,d} means within the same row, with different superscripts were significantly different (p<0.01)** ; (p<0.05)*, SEM = *standard error mean*.

Table 3: Fibre value of diets fed to snails

	Experimental Diets					
Parameters	**1**	**2**	**3**	**4**	**SEM**	**SIG**
Diet fibre intake (g)	0.47^{c}	0.97^{b}	1.02^{a}	0.45^{d}	0.06	**
Digestible fibre for growth (g^{d-1})	0.64^{a}	0.48^{b}	0.52^{b}	0.68^{a}	0.02	**
Digestible fibre	21.81^{c}	43.10^{a}	42.60^{b}	19.80^{d}	2.54	**
Fibre replacement value	0.00^{c}	17.09^{a}	15.84^{b}	-3.48^{d}	2.11	**
Fibre efficiency ratio	0.34^{b}	0.12^{a}	0.13^{a}	0.38^{c}	0.03	**

^{a,b,c,d} means within the same row, with different superscripts were significantly different (p<0.01)**; (p<0.05)*, SEM = *standard error mean*.

Digestible protein

There were significant differences (P<0.01) among treatments in digestible nutrient. Snails on diet 4 was significantly higher than others. It was followed by snails on diets 3 and 1 respectively. The lowest digestible nutrient was noted on diet 2. The poor digestible nutrient observed in diet 2 could be an indication of the presence of antinutritive factors. (23) in a review of local resources as feed-stuff in the tropic reported that, tannins in *Leucaena leucocephala* leaves and stem can reduce the digestibility of protein. The high digestible protein noted in diet 4 could be an indication of the availability of the protein in the diet. This is in line with the observations made by (5), who reported that, as the level of crude fiber in the feed decreased, the crude protein and digestibility of dry matter increases.

Total digestible protein for gain

There were significant differences (P<0.01) among treatments as in Table 2. Total digestible protein for gain in diet 4 was highest, followed by diets 1, 3 and 2, respectively. The highest total digestible protein for gain in diet 4 indicate that, protein was utilized and converted to snail meat (10). It is a reflection of the optimal utilization of nutrient in the diet, while the lowest as observed in diet 2 was an indication that, what was digested was inadequate for the growth of the snail. (21) confirmed that, weight gain of snails is directly proportional to the level of protein.

Gross protein value

Gross nutrient value differed significantly (P<0.01) among treatments as in Table 2.

Snails on diet 4 had the highest, followed by snails on diets 1 and 3, respectively. The least gross nutrient value was recorded in diet 2. This may be due to poor digestibility of the diet because of the high fiber content of the feeds as presented in the formulation (21).

Protein replacement value

Protein replacement value showed significant differences (P<0.01) among treatments as in Table 2. The protein replacement value of snails fed diet 2 had the lowest value, followed by the group on diets 1 and 3. The highest value was recorded by the group on diet 4. The finding is indicated that, the quality of protein is an index of protein replacement value (20) This indicate that, diet 4 with high quality protein had the highest protein replaced gave highest weight gain in terms of performance. While the least value obtained by the group on diet 2 is an indication of lost nutrient. This could be attributed to high level of fiber and insoluble compound in the diet. High dietary fiber is known to limit the availability of nutrient especially protein and carbohydrate (2).

Protein efficiency ratio

As in Table 2, there were significant differences (P<0.01) among treatments in the protein efficiency ratio. The highest protein efficiency ratio (PER) was observed in diet 2 followed by diet 1 and diet 3. The least was observed in snails on diet 4. This was an indication that, snails on diet 4 (0.28) was efficient in converting the protein to flesh than those in other diets (30 and 10). The highest protein efficiency ratio recorded in diet 2 was an indication that the feed was of poor quality (10). Too high nutrient efficiency indicates poor utilization of the diets.

Fibre values of diets fed to snails

The results of fibre intake, digestible fibre for growth, digestible fibre, fibre replacement value and fibre ratio of snails fed experimental diets are presented in Table 3.

Diet fibre intake

There were significant differences (P<0.01) among treatments in fibre intake. The highest fibre intake was observed in diet 3 followed by diets 2 and 1, respectively. The least fibre intake was observed in snails on diet 4. (2) on their work with *Moringa oleifera* leaf meal observed a significant increase in total weight gain with low inclusion rate, and a significant reduction in growth performance beyond 20% inclusion rate, this was attributed to increased fibre content of the diet. High fibre intake noticed in diet 3 is known to limit the availability of nutrients especially energy and protein (18).

Table 4: Fat value of diets fed to snails

	Experimental Diets					
Parameters	1	2	3	4	SEM	Sig
Dietary fat intake (g)	0.49^a	0.07^d	0.08^c	0.12^b	0.04	**
Digestible fat for growth (g^{d-1})	0.86^b	0.65^d	0.70^c	0.92^a	0.03	**
Digestible fat	23.09^a	3.22^d	3.45^c	5.47^b	1.90	**
Fat replacement value	0.00^a	-213.15^d	-184.79^c	-108.84^b	18.93	**
Fat efficiency ratio	0.32^a	1.66^d	1.57^c	1.35^b	0.12	**

^{a,b,c,d} means within the same row, with different superscripts were significantly different (p<0.01)**; (p<0.05)*, SEM = *standard error mean*.

Digestible fibre for growth

Significant differences (P<0.01) existed among treatments as in Table 3. Snails on diet 4 had the highest digestible nutrient for growth and was not statistically (P>0.01) different from snails on diet 1. The lowest was recorded in diet 2 and was statistically (P>0.01) the same with snails on diet 3. The result as recorded in diet 2 was traced to high dietary fibre. Ani and Ike, (2011) reported depressed apparent nutrient digestibility and nutrient retention in pig as a result of high fibre content. This was attributed to high rate of passage of digester and excessive nutrient excretion in animal fed high fibre diets (17). The high values recorded in diet 4 and 1 could be attributed to the fact that, the fibre was degraded for better performance (20).

Digestible fibre

There were significant differences (P<0.01) among treatments in digestible fibre. The highest was observed in diet 2, followed by diets 3 and 1 respectively. The least digestible fibre was recorded in diet 4. The result of high digestible fibre obtained in diets 2 and 3 contradict the report of (21) who reported high digestibility at low fibre rate. The result was similar to the report of (13) who, recorded low digestibility of nutrient as the fibre level of diet increases in rabbit base diet.

Fibre replacement value

Fiber replacement value showed significant differences (P<0.01) among treatments as recorded in Tale 3. The fibre replacement value of snails fed diet 4 was lowest, followed by diets 1 and 3 respectively. The highest fibre replacement value was recorded in diet 2. The least nutrient replacement value recorded in diets 4 and 1was an indication that the snails had low fibre intake.

Fibre efficiency ratio

The fibre efficiency ratio values differed significantly (P<0.01) among treatments. The snails on diet 2 had the lowest fibre efficiency ratio. Those on diet 4 recorded the highest then followed by those on diet 1. The highest fibre efficiency ratio values recorded in diets 4 and 1 were indication that, snails on the diets were not efficient in fibre utilization of the feeds (21). Fibre efficiency ratio was enhanced in diet 2. This agrees with the principle that, the lower the nutrient efficiency ratio the better the feed quality (11).

Fat values of diets fed to snails

The results for fat intake, digestible fat for growth, digestible fat, fat replacement value and fat efficiency ratio of snails fed experimental diets are presented in Table 4.

Dietary fat intake

There were significant differences (P<0.01) among treatments in diet fat intake. The highest was observed in diet 1, followed by diets 4 and 3, respectively, while the least intake was recorded in diet 2. The highest diet fat intake as in diets 1 could be as a result of the high level of ether extract revealed in this work, while the low intake of fat as recorded in diet 2 could be attributed to low feed intake on account of high fibre and poor fat levels of the diet (2).

Digestible fat for growth

There were significant differences (P<0.01) among treatments in digestible fat for growth as shown in Table 4. The highest was observed in diet 4, followed by diets 1 and 3, respectively, while the least was recorded in diet 2. The highest digestible fat for growth recorded in diet 4 was an indication that snail needed and could digest fat for better performance. (28) reported that, snails fed palm fruit *(Elaeis guineensis*) with a high fat content had the highest mean value in term of weight gain, length and circumference than those fed growers' mash and potato leaves (*Ipomea batatas*). The poor digestible fat for growth observed in diet 2 may be attributed to high level of fibre and poor fat in the diet.

Digestible fat

Significant differences (P<0.01) existed among treatments. Snails on diet 1 had the highest digestible fat followed by diets 4 and 3, respectively, while the lowest digestible fat was recorded in diet 2. The highest digestible fat as recorded in diet 1 was an indication that, the snails were able to digest more fat than in other groups; while the lowest recorded in diet 2 could be traced to high fiber and poor fat levels of the diet. (16) reported depressed digestibility on account of high dietary fibre and low fat.

Fat replacement value

Nutrient replacement value showed significances (P<0.01) among treatments. The nutrient replacement values of diets 2, 3 and 4 were on the negative direction, indicating that, snails on the respective treatments needed fat as in diet 1 as noted in this study. Fat is essential for snail husbandry.

Fat efficiency ratio

There were significant differences (P<0.01) among treatments in nutrient efficiency ratio. Snails on diet 1 had the best nutrient efficiency ratio, followed by diets 4 and 3, respectively, while the highest was observed in diet 2. Diet 1 with the best fat efficiency ratio indicate that, snails were efficient in utilizing the fat than others (10), while snails on diet 2 were on the contrary.

Conclusion and Applications

1. The nutrient value in the diets differed significantly among the parameters measured for protein, fibre and fat.
2. Observation revealed that with high quality nutrients (fat and protein) snails can perform optimally, but fibre should be fed at acceptable level for better result.
3. In conclusion, considering the responses made by *Archachatina marginata* on digestibility, and nutrient value. Snail fed diet 4 (foliage) and diet 1 (Municipal Organic Waste) had better result.
4. It is therefore recommended that, foliage and municipal organic wastes should be used in snail rearing, where they are available and affordable, as they are no competition between man and animal. Nevertheless, foliage and municipal organic waste (MOW), favoured the multiplication of bacteria in the snails' gut microflora in a symbiotic substrates level based mechanism that helps in the breakdown of such specific plant materials.
5. Municipal organic solid waste can be used to feed snails without any adverse effect.

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