Culture and nutrient values of *Limicolaria aurora* (Jay, 1989) (Mollusca: Achatinidae) raised in two different substrates

Valores del cultivo y de nutrimentos de *Limicolaria aurora* (Jay, 1989) (Mollusca: Achatinidae) criados en dos diferentes sustratos

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ABSTRACT

One hundred adult garden snails *Limicolaria aurora* (Jay, 1989) of weight ranging from 2.7g-3.8g (mean weight 3.25±0.55g) and height 4.2cm -5.1cm (mean 4.65±0.4cm) were cultured in soil substrate and cellulose substrate in wooden boxes (0.9mx0.6mx0.3m) for 84 days. The results of the experiment showed that cellulose substrate was a better substrate for the culture of garden snails than soil. Higher mean weight gain 2.23g/snail, relative growth rate 68.65%, hatchling production of 30 hatchlings/week; feed conversion ratio 7.75 and final condition factor of 1.91 were recorded from cellulose substrate while the control substrate (soil) had the lower result. Growth and feed utilization were not significantly different ($p>0.05$) in the two substrates with $t=0.5115$; $p=0.3091$ and $t=0.2011$, $p=0.4252$ respectively. A significantly ($p<0.05$) high positive correlation $r=0.9676$ existed between the bi-monthly growth and time in the two substrates. Higher hatching rates of 30 hatchlings/snail were recorded in cellulose substrate while lower hatchling rates of 20 hatchlings/snail were recorded in soil substrate. The hatchling rates were significantly different ($p<0.05$) between the two substrates. Fish meal had the higher crude protein of 71.46% and garden snail meal had 66.76%. There was no significant difference ($p>0.05$) between the crude protein content of fish meal and garden snail meat. Based on the results of this study cellulose substrate could be recommended as a substitute for soil in the culture of garden snail and that garden snail could be a reliable substitute for fishmeal in fish and livestock diets.

Key words: garden snail, cellulose substrate, soil substrate, growth, feed utilization, productivity

RESUMEN

Cien caracoles de jardín adultos de peso entre 2,7 a 3,8 g (promedio 3,25 ± 0,55g) y altura entre 4.2 a 5.1cm (promedio 4,65 ± 0,4cm) se cultivaron en sustrato de suelo y sustrato de celulosa en cajas de madera (0,9 mx0,6mx0,3m) durante 84 días. Los resultados del experimento mostraron que el sustrato de celulosa fue un mejor sustrato para el cultivo de caracol de jardín que el suelo. Mayor ganancia de peso promedio 2,23g/caracol, tasa relativa de crecimiento 68,65%, eficiencia de eclosión 30 eclosiones/semana; tasa de conversión alimenticia 7,75 y factor de condición final 1,91 se registraron en el sustrato de celulosa, mientras que el control tuvo el menor resultado. El crecimiento y la utilización del alimento no fueron significativamente diferentes ($p>0,05$) en los dos sustratos con $t=0,5115$, $p=0,3091$ y $t=0,2011$, $p=0,4252$, respectivamente. Una alta correlación positiva y significativa ($p<0,05$) ($r=0,9676$) se encontró entre el crecimiento bi-mensual y el tiempo en los dos sustratos. La mayor tasa de eclosión de 30 eclosiones/caracol se registró en el sustrato de celulosa mientras que la menor tasa, 20 eclosiones/caracol se registró en el sustrato de suelo. La tasa de eclosión fue significativamente diferente ($p <0,05$) entre los dos sustratos. La harina de pescado tuvo la proteína bruta más alta con 71,46% y la harina de caracol de jardín tuvo 66,76%. No hubo diferencias significativas ($p>0,05$) entre el contenido de proteína cruda de la harina de pescado y la carne de caracol de jardín. Con base en los resultados de este estudio, el sustrato de celulosa pudiera ser recomendado en el cultivo de caracol de jardín

Palabras clave: caracol de jardín, sustrato de celulosa, crecimiento, utilización alimenticia, productividad

INTRODUCTION

Limicolaria, a snail of the Family Achatinidae, originated from Martinique (West Indies) and was introduced to West Africa by some Martinicans who had lived in West Africa (Crowley and Pain, 1970) and has become widely distributed in West African countries most especially Guinea,

Nigeria, Cameroun and Gabon (Egonmwan, 1988 and Ebenso, 2002). *Limicolaria* is adaptable to different habitats. It is mainly found in woods, fields, sand dunes, and gardens. This adaptability does not only increase range of the genera, but it also makes their farming easier and less risky.

Achatiniculture, the act of snail (belonging to the Achatinidae family) farming (Thompson and Cheney, 1996), on a large-scale basis requires a considerable investment in time, equipment, and resources. *Limicolaria aurora* (Jay, 1989*)*, one of the garden snails found in Nigeria and other West Africa countries (Crowley and Pain, 1970) has high reproductive potential and nutritive value, which favorably competes with that of fish meal. Most works on Achatiniculture have limitations on the culture substrate to soil substare or agro-waste (FAO, 1985; Egonmwanm 1990a; Thompson and Cheney, 1996; Labao *et al.*,2000 and Ebenso, 2002), There is dearth of information on the utilization of another culture substrate apart from the conventional soil hence a need for this study so as to access another culture substrate especially from agro-industrial waste and also the garden snail potential as fish meal replacer in aquaculture and animal husbandry.

MATERIALS AND METHODS

Composition and preparation of culture substrates

Two substrates were investigated for their heliciculture efficiency and production capacity for the Garden snail, *L. aurora* culture. The substrates were:

1. Soil Substrate (Control) - Coded Gs1.
2. Cellulose substrate – Coded Gs2.

Gs1- Soil substrate

Loamy soil as collected from a nearby garden within National Institute for Freshwater Fisheries Research Institute (NIFFR), New-Bussa, Nigeria Hatchery Complex using spade and oven dried at 70^0C for 3 hours, after which the chunk was loose. The baked loamy soil was used to fill the culture boxes (0.9m x 0.6m x 0.3m) to two-thirds of their depth and covered with coarse sand. Stones were placed on top of the sand to mimic a natural habitat. 10 adult Earthworms (*H. euryaulos*) were added to each box to aerate the soil and clean up the culture substrate as detailed out by (Thompson and Cheney, 1996). The pH of the soil varied between 5.5 - 6.8 due to where it was collected.

Gs2- Cellulose substrate

The cellulose substrate used was prepared as described for earthworm culture following Sogbesan and Madu (2003) Method. The cellulose substrate contains 30% saw dust, 20% Rice bran, 20% Mushroom (*Termitomyces sp.*), 15% Centro-leaves (*Centrosema sp*) and 15% Poultry droppings which were composited for 4weeks. The pH varied between 5.2 - 6.0. The substrate was used to fill the culture boxes to two-thirds of its depth. Stones were added to mimic a natural environment and 10 adult earthworms were introduced for aeration of the substrate and clean up the culture substrate as detailed out by (Thompson and Cheney, 1996).

Collection of the garden snails

A total of 100 adult garden snails of weight range, 2.7-3.8g (mean 3.25 ± 0.55g) and height (i.e. the distance between the apex and basal margin of the peristome of the snail's shell) range, 4.2 - 5.1cm (mean 4.65 ± 0.4 cm) were collected randomly for 3 days by handpicking from the wild within NIFFR environment between 6.00 a.m. - 7.00 a.m. They were transported in a plastic container from the wild to the experimental laboratory for culture. The snails were then kept in a wooden box (0.9m x 0.6m x 0.3m) and fed on fresh pawpaw, *Carica papaya* leaves for one week before the commencement of the experiment.

Culture boxes

Four wooden boxes of dimension 0.9m x 0.6m x 0.3m were used for this experiment. The boxes were partitioned in a similar way as those used for earthworm culture. Water and feeding troughs were put in each box. The boxes were placed outdoor under a tree and the lid of each box was covered with banana leaves for shade and moisture conservation.

Bedding and stocking

The boxes were filled to two-thirds of their depth with each culture substrate in duplicates. Water was sprinkled on the substrates twice daily to keep them moist. The boxes were stocked with garden snails of known weights and heights at the rate of 20 (twenty) garden snails per box. The experiment lasted for 14 weeks.

Feeding of garden snails

The snails were fed with fresh pawpaw leaves as a major diet supplemented with bone meal at 15% of the body weight once a day (Thompson and Cheney, 1996 and Ebenso, 2002). The quantity fed was adjusted with changes in the weekly weight of the garden snails.

Sampling of garden snail

All garden snails in each box were sampled fortnightly for their weight and height of shell. The dead snails were removed, the number counted and recorded and discarded. To minimize disturbance, eggs were not search for within the culture substrate rather newly hatched baby snails that emerged were counted and recorded.

Harvesting of garden snails

At the end of the experimental period, all the snails were collected by hand- picking, counted and their weights and heights were measured using sensitive weighing balance (Ohaus-LS200 Model) with maximum weight sensitivity of 300g and Vernier caliper respectively.

Proximate analysis of garden snail meat and fish (Clupeid) meal

The garden snail meat and fish meal were analysed for crude protein, crude fibre, crude lipid, ash, Nitrogen free extracts, mineral salts, gross energy, and amino acids according to Association of Analytical Chemist Methods (A.O.A.C. 2000).The minerals in the ash was brought into solution by wet digestion using Conc. HNO_3 (63%), Perchloric acid (60%) and Sulphuric acid (98%) in the ratio of 4:1:1 (Harris, 1974). Potassium and Sodium was determined using flame photometer (Allen, 1974). Phosphorus was determined using spectronic 20E, while Magnesium by Perkin Elmer Atomic Absorption Spectrophotometer Model 2900.

Statistical Analysis

All data collected were subjected to single analysis of variance [ANOVA}. Least Significance differences (LSD) was used to determine the level of significance among treatments. Correlation and regression analysis was carried out to determine the relationship between the treatments and some of the parameters using SPSS 10.0 Windows 2000.

RESULTS

There was a gradual rise in the bi-monthly growth pattern of the garden snail from the two culture media throughout the experimental period (Figure 1.) with garden snails cultured in the cellulose substrate having higher final total shell's height of 6.6cm/ snail then those cultured in the control (soil substrate), by 6.3cm shell height/snail (i.e. soil substrate). However, growth was not significantly different ($p>0.05$) in the two substrates. Higher significantly ($p<0.05$) positive correlation $r=0.9938$ and lower correlation $r=0.9801$ existed between the bi-monthly growth and culture time in the soil and cellulose substrates respectively as shown in Figure 2 and Figure 3.

Garden snails cultured in cellulose substrate recorded the higher mean weight gain of 2.23g/snail/week while the lower mean weight gain of1.23g/snail/week was recorded in soil substrate (Table 1). There was significant difference ($p<0.05$) between the mean weight gain from the two substrates. The higher relative growth rate of 68.86%

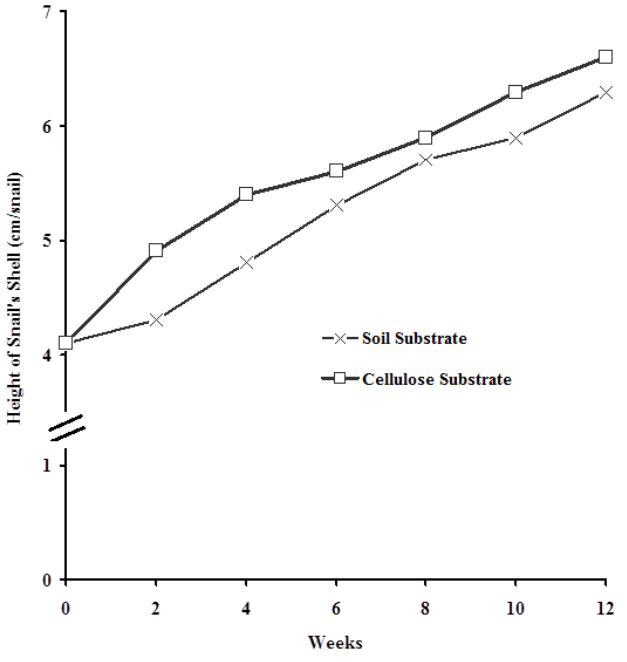

Figure 1. Bi-monthly growth pattern of garden snail *Limicolaria aurora* cultured in different substrates in Nigeria.

was recorded in cellulose substrate while the lower value of 37.85% in soil substrate. The garden snails cultured in soil substrate had lower specific growth rate of 0.17%/day while those cultured in cellulose substrate had higher specific growth rate 0.27%/day. Lower survival rate of 75% was recorded in garden snail cultured in soil substrate while higher survival rate of 90% was recorded from garden snail raised in cellulose substrate. Higher condition factor value of 1.91 was recorded from cellulose substrate while 1.79 was recorded from soil substrate. There was a significant difference ($p<0.05$) between the condition factor derived from the two substrates.

Higher food conversion ratio of 4.34 was recorded in garden snail cultured in soil substrate while lower feed conversion ratio of 3.20 was recorded in cellulose substrate (Table 1). There was

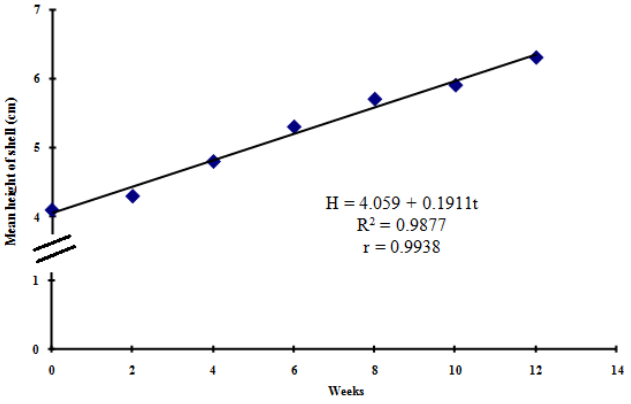

Figure 2. Linear regression of the bimontly growth of garden snail *Limicolaria aurora* cultured in soil substrate in Nigeria.

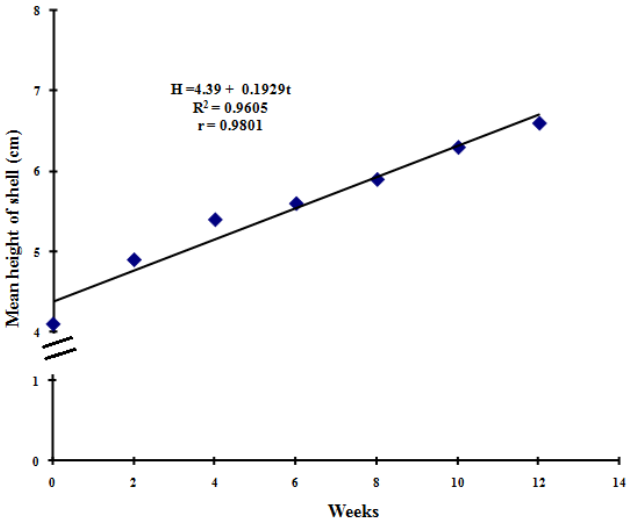

Figure 3. Linear regression of the bimontly growth of garden snail *Limicolaria aurora* cultured in cellulose substrate in Nigeria.

Table 1. Growth performance, productivity indices and feed utilization of garden snail *Limicolaria aurora* using different substrates for 84 days in Nigeria.

Parameters	Soil substrate	Cellulose substrate
Total Initial weight (g)	65.0	65.0
Mean Initial weight (g/snail)	3.25	3.25
Mean Initial height (cm)	4.1	4.1
Total Final weight (g)	67.20 ^{b}	98.64 ^{a}
Mean Final weight (g/snail)	4.48 ^{b}	5.48 ^{a}
Mean final height (cm)	6.3	6.6
Mean weight gain (g/snail)	1.23 ^{b}	2.23 ^{a}
Biomass Production (g/ snail)	0.1 ^{b}	0.19 ^{a}
Relative growth rate (%)	37.85 ^{b}	68.86 ^{a}
Daily growth index (g/day)	0.20 ^{b}	0.34 ^{a}
Specific growth rate (%/day)	0.17 ^{b}	0.27 ^{a}
Production efficiency	4.48 ^{b}	5.48 ^{a}
Hatchling production (no./ week)	20 ^{b}	30 ^{a}
Mean Food Supplied (g/snail)	15.85	17.28
Food Conversion ratio	12.89 ^{b}	7.75 ^{a}
Gross food conversion efficiency (%)	23.04 ^{b}	31.25 ^{a}
Protein efficiency ratio	0.47 ^{b}	0.79 ^{a}
Initial condition factor (k_1)	4.72	4.72
Final condition factor (k_2)	1.79 ^{b}	1.91 ^{a}
Survival rate %	75 ^{b}	90 ^{a}

All values on the same row with the different superscripts are significantly different ($p<0.05$)

significance difference ($p<0.05$) between the means of the food conversion. Higher gross food conversion efficiency of 31.25% was recorded in cellulose substrate while the lower value of 23.04% was recorded in those cultured in soil substrate. Higher protein efficiency rate of 0.79 was recorded in cellulose substrate raised garden snail and lower protein efficiency rate of 0.47 was recorded in those cultures on soil substrate. The means of these values were significantly different ($p<0.05$).

Biomass production value was higher in cellulose substrate with value 0.19g of snail/week and lower in soil substrate (0.10g of snail/week). There was significant difference ($p<0.05$) between the means of the biomass production values. The garden snail cultured in cellulose substrate had the higher production efficiency of 5.48g/snail while lower production efficiency of 4.48g/snail was from soil substrate. There was significant difference ($p<0.05$) between the production efficiency from the two substrates. The hatching production was higher in cellulose substrate with 30 hatchings/week and lower in soil substrate with 20 hatchlings/week.

Table 2 shows the proximate, energy and mineral composition of the garden snail meal and fish meal. Fishmeal had the higher crude protein of 71.64% which is not significantly difference ($p>0.05$) to that of garden snail meat meal, 66.76%.

Table 3. shows the essential amino acids of the garden snail meal and fish meal. Fishmeal had the higher values of amino acids histidine, leucine, lysine and methionine which are significantly different ($p<0.05$) to those of garden snail meat meal. In the other hand, garden snail meat meal had the higher values of amino acids arginine and isoleucine ($p<0.05$) than those of fishmeal.

DISCUSSION

The results from this study show that cellulose substrate had better potential for garden snail culture than the normal and traditionally used soil substrate. In their natural habitat, garden snails prefer high humus, especially humus that contains dead and decayed leaves. In this study, they have demonstrated greater growth in the cellulose substrate, which is richer in organic compounds than the soil substrate since it contains poultry manure. Ademolu *et al*. (2004) reported snails fed poultry manure based-diet to have highest total weight gain, best relative growth rate and highest shell circumference gain. This good performance of poultry

Table 2. Proximate and mineral composition (% dry weight) of garden snail *Limicolaria aurora* meat and fish meal in Nigeria.

Composition	Garden snail meat	Fish meal (Clupeid)
Crude Protein %	66.76 [b]	71.46 [a]
Crude Lipid %	7.85	7.97
Crude fibre %	4.10 [a]	1.18 [b]
Ash %	6.48 [b]	7.33 [a]
Nitrogen free Extract %	5.81 [a]	3.17 [b]
Moisture %	9.00	8.89
Dry matter %	91.00	90.21
Sodium (g/100g)	2.32[a]	0.91[b]
Calcium (g/100g)	1.13[b]	3.53 [a]
Potassium (g/100g)	2.23[a]	0.96[b]
Phosphorus (g/100g)	0.15[b]	2.4[a]
Magnesium (g/100g)	0.28[a]	0.08[b]
Gross Energy kJ/100g	2006.27 [b]	2074.73[a]
Calculated E:P	29.97	29.03
Metabolizable Energy kJ/100g	1504.95	1556.05
Digestible Energy kJ/100g	2.54	3.15

All values on the same row with the different superscripts are significantly difference ($P<0.05$).
E: P – Gross energy: Protein

Table 3. Essential Amino Acids (% dry weight) of garden snail *Limicolaria aurora* meat and fish meal.

Essential Amino Acids	Garden snail meal	Fishmeal (clupeids)
Arginine	11.99±0.11[a]	5.34±0.17[b]
Histidine	1.77±0.12[b]	4.19±0.06[a]
Isoleucine	6.23±0.32[a]	2.62±0.07[b]
Leucine	6.79±0.12[b]	8.31±0.09[a]
Lysine	5.10±0.20[b]	10.96±0.09[a]
Methionine	1.33±0.06[b]	2.26±0.05[a]
Phenylalanine	5.04±0.005	5.52±0.05
Threonine	5.91±0.2	5.28±0.6
Valine	5.90±0.8	5.88±0.05
Total essential amino acids	50.06±2.89	50.36±2.31
Crude Protein %	66.96±3.6	71.64±4.6
Chemical score (%)	95.9±0.52[a]	96.7±0.4[a]
Cs/Ps (%)	68.9±0.50[a]	64.9±0.36[a]
EAA:CP	0.76±0.08[a]	0.72±0.02[a]

Values on the same column with the different superscripts are significantly difference ($p<0.05$). Mean±SE
Keys: Cs:Ps = ratio of the chemical score to crude protein. EAA:CP: ratio of the essential amino acid to crude protein.

manure has been opined by Elbously and Vandan Poel (1994) to the fact that poultry manure contains undigested feed and metabolic excretory products, which may enhance the growth of its consumers. Studies have also shown that poultry manure has a moderate nitrogen content, which could be utilized by animals (Elbously and Vander Poel, 1994), and snails, thus, have the ability to convert animal waste into body protein. The higher weight gain in cellulose substrate could be due to the proper utilization of the poultry dung present in the cellulose substrate.

The fact that weight was gained by the snails from the two substrates was an indication that the feed (pawpaw leaves) fed to them was accepted and utilized for muscle development by the snail. FAO (1985), Amusan and Omidiji (1998) and Labao *et al*. (2000) reported that pawpaw leaves were more preferable by snails than any other vegetables or feeds. Although, the reason for this cannot be ascertained but could not be unlink to the presence of fibre in pawpaw leaves which aids digestion and motility of alimentary canal of the snail.

The better food conversion rate reported in cellulose substrate is in line with the report of Ajayi *et al.* (1987), Marryomez *et al*., (1985) and Egonwam (1988) that garden snail feed well on dead and rotten saw dust and other organic compost. There is possibility of the presence of single cell proteins since the cellulose substrate was a composite and this could also be a reason for better feed conversion rate in snail raised with this substrate. The mean weight gain reported in the two substrates used for this study is similar to the report of Egonmwan (1988), Amusan (1990), Ebenso (2002) and Amusan *et al*. (2002) for garden snails. Better hatchings reported in cellulose substrate than soil substrate is an indication that this substrate has better potential for productivity in snail. The hatching rate reported was higher than that of Egonmwan (1990a and b).

The result from this study also affirmed the possibility of rearing this snail in isolation as a domestic animal which would help in the availability of this animal protein and ensure its survival so as to satisfy the demand for its meat as fish meal replacer; similar observation was reported Ademolu *et al.* (2004) for giant African land snail. The crude protein for garden snail meat meal from this study is higher than crude protein 62% and 60-70% reported by Serra (1998) and Odaibo (1997) respectively for golden snail and African giant snails respectively. The Lipid content presented in this study is lower to 8.3% reported by Serra (1998). The garden snail meat protein was high enough to serve as single animal protein source needed by *H. longifilis* for proper growth and development which is the basic nutrient that cannot be compromised in the choice of ingredients for feed formulation and preparation (Zeitler *et al.*, 1984). Protein has also been the reported as the most costly nutrient in fish diet. The nutrient quality of feed ingredient is one of the major prerequisite apart from availability before such ingredient is recommended for feed production. The crude protein content recorded of each of the non-conventional animals is in line with that of other alternative protein supplements of animal origin fed to fish (Wee, 1988) which indicates that feeding fish with any of these ingredients will not pose the problem of malnutrition on them.

CONCLUSION AND RECOMMENDATION

The utilization of cellulose substrate for the Achatiniculture is environmentally friendly because the cellulose substrate was made of industrial and agro-allied waste which is pollutants. Adopting this method will assist in reducing the problem of disposing the bulk of these wastes. The snails raised could be a better animal protein source to replace the expensive fish meal in raising fish and other domesticated animals meant for man's consumption.

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