



Growth Performance of *Achatina achatina* Fed with Leaf Powder Enriched in Oyster Shell Powder

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10.18805/ajdfr.DRF-419

ABSTRACT

Background: Snail farming is becoming increasingly popular in sub-Saharan Africa. But the real success of snail farming depends on the right feed formulas. With the aim of contributing to the formulation of diets for giant African snails, a study was carried out on the growth performance and meat yield of *Achatina achatina* subjected to different diets based on leaves powder.

Methods: Fifteen batches of 30 two-month-old snails seedlings were fed for 6 months on diets made by enriched the leaves (papaya, taro, moringa and pigeon pea) powder at different rates (0%, 5%, 10%, 15% and 20%) with oyster shell powder. The growth performance and meat yields of these snails were determined and compared with those of a control batch of snails fed fresh papaya, taro, moringa and pigeon pea leaves.

Result: Snails fed with leaf powder enriched with 20% oyster shell showed the greatest gains in weight (97.33 ± 4.2 g) and shell length (3.3 ± 0.8 cm). Although these animals had the highest proportions of shell ($40 \pm 3.2\%$), they provided the greatest quantities of soft tissue (60.3 ± 3.2 g) and edible flesh (33.5 ± 2.9 g). The diet consisting solely of fresh leaves induced the smallest gains in weight (21.6 ± 5.1 g) and shell length (1.08 ± 0.9 cm). Snails fed this diet had the highest percentage of soft tissue ($78.02 \pm 6.53\%$). However, they provided the lowest amounts of soft tissue (19.34 ± 2.8 g) and fresh edible meat (9.66 ± 1.4 g).

Key words: Diet, Formulation, Leaves, Provender, Snail.

INTRODUCTION

Achatines are gastropod molluscs whose flesh is an unsuspected source of highly nutritious protein for human and animal consumption (Otchoumou *et al.*, 2011; Kouadio *et al.*, 2015). The flesh of these molluscs is not only very rich in amino acids, it is also a source of minerals (Ademolu *et al.*, 2004). Apart from their gastronomic qualities, snails are of great importance to humans. The flesh, shell and mucus are used in traditional and modern medicine to treat various ailments (Agbelusi and Ejidike, 1992).

In Africa, despite strong foreign and local demand, there are few commercial snail farms of the kind found in Europe, South-East Asia or the American continents (Cobbinah *et al.*, 2008). Almost all the snails consumed and marketed come from forest collection. The quantity of snails collected in the wild to supply the Abidjan markets was estimated at 1800 tonnes in 2008 (Kouassi *et al.*, 2008). The natural snail stock is therefore increasingly threatened with extinction due to the pressure to collect snails, but also because of deforestation and the abusive use of pesticides (Druart, 2011). Successful snail farming is now seen as the only way to continue satisfying growing consumer demand and to combat the total depletion of natural snail stocks. Feed is one of the most important parts of the livestock production system because it can account for 60-80% of production costs, besides those very elements needed by animal to grow (Fatmawati *et al.*, 2024). Various studies (Koudandé, 2006; Badmos, 2016) have shown that a diet rich in calcium makes a positive contribution to snail growth and reproduction. The majority of concentrated diets offered to breeders include cereal meal, supplemented with mineral and vitamin concentrates,

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How to cite this article: Aman, J.B., Kiendrebeogo, T., Kouato, F., Memel, J.D. and Otchoumou, A. (2025). Growth Performance of *Achatina achatina* Fed with Leaf Powder Enriched in Oyster Shell Powder. Asian Journal of Dairy and Food Research. 44(1): 128-133. doi: 10.18805/ajdfr.DRF-419.

Submitted: 01-07-2024 **Accepted:** 23-10-2024 **Online:** 29-11-2024

which makes it costly to produce the species *Achatina achatina*, which has a relatively long growth cycle. According to Sahib *et al.* (2024), to guarantee the production performance of animals and the profitability of farms, it is advisable to adopt scientific diets. That's why the aim of this study is to determine a diet based on leaf powder capable of ensuring good growth in *Achatina achatina* during breeding.

Experimental site

This study was carried out at the "CHOICE" snail farm in Oussou, a village in Toumodi, a sub-prefecture of the Bélier region. Oussou has transitional vegetation between the

savannah in the north and the forest in the south of Côte d'Ivoire.

MATERIALS AND METHODS

Animals

This study began with *Achatina achatina* snail spat two months old, with an average live weight of 3.17 ± 0.1 g and an average shell length of 1.74 ± 0.05 cm (Fig 1). These snails were selected on the basis of their weight, the condition of their shell edges (unbroken) and their health (Bouyé *et al.*, 2017). These animals were divided into 6 groups and fed various leaf-based diets.

Breeding tanks

The snails were bred in plastic tanks measuring $0.5 \times 0.45 \times 0.25$ m, fitted with covers made from wooden frames and mosquito netting (Fig 2).

Measuring equipment

A JM-1003 electronic balance with a sensitivity of 0.1 g and a capacity of 5 kg (Fig 3) was used to weigh the experimental snails. This scale was also used to weigh the ingredients used in the diets and to weigh the snails' body parts.

A Vernier brand mechanical caliper, with a precision of 0.1 millimeter (Fig 4), was used to measure the length of the snails' shells.

Confection of diets

Taro, moringa, papaya and pigeon pea leaves (Fig 5), which are usually eaten fresh by giant African snails, were harvested on the outskirts of the Nangui Abrogoua University forest and properly washed. The leaves, after being rinsed thoroughly in drinking water, were chopped (Fig 6) before being dried in the shade under air conditioning at 17°C in the Animal Biology and Cytology Laboratory at Nangui ABROGOUA University. After drying

for a week, the mixture of dry leaves was ground in a mortar. Oyster shells (Fig 7) collected from the banks of the "Ebrié" lagoon were dried for 24 h at 250°C in an oven before being ground. Different proportions of the leaf powder and the oyster shell powder were used to make four diets



Fig 1: Spats of *achatina achatina*.

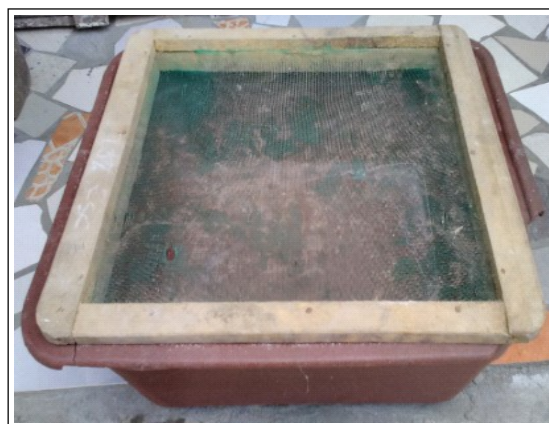


Fig 2: Breeding tank.



Fig 3: Leaves used to make animal feed.

(R_5 , R_{10} , R_{15} and R_{20}). Diet R_5 is therefore made up of 95% leaf powder and 5% oyster shell powder. R_{10} is a diet made up of 90% leaf powder and 10% oyster shell powder. The R_{15} diet is made up of 85% leaf powder and 15% oyster shell powder. The R_{20} diet is made up of 80% leaves and 20% oyster shell. A diet composed exclusively of leaf powder has been developed. A mixture of fresh taro, papaya, moringa and pigeon pea leaves was used as a control diet.

Distribution and breeding of snails

For each diet, 90 snails were selected, divided into three batches. All the snails were placed in the breeding tanks at a single density of 25 snails/m². The choice of this density is based on the fact that several studies (Noumonvi *et al.*, 2012) have shown that snails grow very well at low stocking densities. The snails were fed ad libitum whatever their diet. The food was served every other day after the feed troughs had been properly washed and dried. The first week of the experiments was devoted to preparing the diets and finding the snails. The experiment was conducted for 6 months (1st May to 31st October).

Growth performance

The food was served every other day after the feed troughs had been properly washed and dried. In order to estimate the growth performance of snails according to their diet, they were weighed and measured every fortnight. Before being weighed, the molluscs were freed from the soil, which was sometimes trapped by the pedal sole. These data were used to calculate the average daily gain (ADG) of the snails according to their diet.

$$\text{Average daily gain (ADG)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Rearing period}}$$

Estimating the quantity of edible flesh

The snails intended for human consumption after the experiments were fasted for 24 hours. At the end of the 24 hours, they were marked and weighed individually before being put into net bags in batches of thirty, depending on their diet. The bags containing the snails were placed in damp places to encourage them to sleep. They were then put to sleep and immersed in boiling water for 10 minutes. In this way, they died without feeling any stress beforehand. All the soft tissues of each dead snail were weighed before separating the consumed meat from the viscera, which were in turn weighed. The weights of the various body parts (shell, soft tissues, consumed flesh and viscera) of snails on each diet were determined; which made it possible to calculate their body proportions. Body proportions were calculated using the following formulas:

$$\% \text{ shell} = \frac{\text{Shell weight}}{\text{Snails live weight}} \times 100$$

$$\% \text{ soft tissue} = \frac{\text{Soft tissue weight}}{\text{Snails live weight}} \times 100$$



Fig 4: JM-1003 scale.



Fig 5: Vernier caliper.



Fig 6: Chopped leaves.



Fig 7: Oyster shell.

$$\% \text{ meat consumed} = \frac{\text{Weight of meat consumed}}{\text{Snails live weight}} \times 100$$

$$\% \text{ viscera} = \frac{\text{Weight of viscera}}{\text{Snails live weight}} \times 100$$

Statistical data processing

The variation in the zootechnical performance of snails according to their diet was analysed using STATISTICA 7.1 software. The average weights, average daily gains and average body weights of the snails, determined as a function of diet, were compared using Tukey's HSD test at $P < 0.05$. The mean values for shell length and shell length gain recorded as a function of diet were compared using Tukey's HSD test at $P < 0.05$. The body proportions of snails determined as a function of diet were compared using the non-parametric Chi-square test at $P < 0.05$.

RESULTS AND DISCUSSION

Growth performance

Snail weight growth performance varied according to diet (Table 1). Snails fed a diet of leaf meal supplemented with 20% oyster shell powder (R_{20}) had the highest final average live weight (100.5 ± 3.4 g), with a total weight gain (97.33 g) and a statically better ($p < 0.05$) daily weight gain (0.54 g day⁻¹) than the other snails. The best diet in terms of Snail's shell growth was also the powder of leaves diet supplemented with 20% oyster shell powder, with a gain in total shell length of 3.3 ± 0.8 cm compared with 3 ± 0.7 cm for R_{15} , 2.8 ± 0.9 cm for R_{10} , 2.5 ± 0.6 cm for R_5 and 2.4 ± 0.7 cm for R_0 (Table 2). All these results show that a diet consisting of a mixture of 80% leaf powder and 20% oyster shell powder is an excellent food for *Achatina achatina* in the growth phase. The average daily weight gain value (0.54 ± 0.08 g day⁻¹) recorded with the best diet in this study,

is significantly higher than that (0.45 ± 0.21 g day⁻¹) presented by Bouyé *et al.* (2017) who used a calcium-enriched cereal flour-based concentrate feed. This suggests that a diet of calcium-enriched leaf powder can be a valid substitute for a cereal meal-based feed for growing snails.

Non-calcium-enriched leaf powder induced lower weight (0.12 ± 0.08 g day⁻¹) and shell (0.013 ± 0.002 mm day⁻¹) growths than those (0.014 to 0.018 cm day⁻¹) of snails fed calcium-enriched diets with oyster shell. This could be explained by the fact that, although leaf powder provides the animal with essential elements such as cellulose, phosphorus, proteins and carbohydrates (Kana *et al.*, 2018, Ouoba *et al.*, 2022), it remains insufficient for good snail growth as long as their calcium requirements are not satisfied (Wacker and Baur, 2004, Otchoumou *et al.*, 2005, Kouassi *et al.*, 2007). These results concur with those of Singh *et al.* (2010), who revealed that inadequate feeding is one of the factors that often limit the full utilization of animals' growth potential. According to Wacker and Baur (2004), depletion of body calcium reserves compromises the snail's general metabolic activity. In the wild, the snail, which feeds exclusively on green fodder, makes up its mineral deficiencies, particularly dietary calcium, by drawing on the soil on which it lives (Kouassi *et al.*, 2007, Bouyé *et al.*, 2017). In fact, calcium is the most important factor in the distribution of terrestrial gastropods and there is a strong correlation between population densities, snail abundance and calcium levels in colonised soils (Memel *et al.*, 2011). The results of this study are in agreement with those of Koundandé *et al.* (2006) who showed that feeding *Archachatina* sp snails a mixture of papaya and leucaena leaves supplemented with oyster shell resulted in better weight gain than feeding these animals a leaf-based diet (papaya and leucaena) not supplemented with calcium.

Table 1: Growth performance of *Achatina achatina* as a function of diet.

	R_T (Leaves fresh)	R_0 (Leaf powder)	R_5 (R_0 +5% oyster shell)	R_{10} (R_0 +10% oyster shell)	R_{15} (R_0 +15% oyster shell)	R_{20} (R_0 +20% oyster shell)
Initial weight (g)	$3.19^a \pm 1.3$	$3.18^a \pm 1.2$	$3.17^a \pm 1.1$	$3.19^a \pm 1.4$	$3.16^a \pm 1.2$	$3.17^a \pm 1.3$
final weight (g)	$24.79^c \pm 3.5$	$40.25^a \pm 3.2$	$58.9^d \pm 2.8$	$77.54^c \pm 3.3$	$85.3^b \pm 3.7$	$100.5^a \pm 3.4$
Total weight gain (g)	$21.6^f \pm 5.1$	$37.07^e \pm 4.7$	$55.73^d \pm 3.2$	$74.35^c \pm 4.2$	$82.14^b \pm 3.9$	$97.33^a \pm 4.2$
Average gain of daily weight (g)	$0.12^f \pm 0.08$	$0.21^e \pm 0.08$	$0.31^d \pm 0.07$	$0.41^c \pm 0.09$	$0.46^b \pm 0.07$	$0.54^a \pm 0.08$

NB: Values on the same line indexed by the same letters are not statistically different with Tukey's HSD test at $P < 0.05$.

Table 2: Shell growth performance of snails as a function of their diet.

	R_T	R_0	R_5	R_{10}	R_{15}	R_{20}
ISL (cm)	$1.8^a \pm 0.5$	$1.8^a \pm 0.3$	$1.7^a \pm 0.4$	$1.8^a \pm 0.4$	$1.7^a \pm 0.4$	$1.8^a \pm 0.3$
FSL (cm)	$2.88^d \pm 1.2$	$4.21^c \pm 0.9$	$4.24^c \pm 0.7$	$4.6^b \pm 0.6$	$4.7^b \pm 0.9$	$5.1^a \pm 0.8$
TGSL (cm)	$1.08^e \pm 0.9$	$2.4^d \pm 0.7$	$2.5^d \pm 0.6$	$2.8^c \pm 0.9$	$3^b \pm 0.7$	$3.3^a \pm 0.8$
DGSL (cm/day)	$0.006^e \pm 0.56$	$0.013^b \pm 0.002$	$0.014^b \pm 0.003$	$0.016^{ab} \pm 0.004$	$0.017^a \pm 0.003$	$0.018^a \pm 0.005$

ISL = Initial shell length, FSL = Final shell length, TGSL = Total gain in shell length, DGSL = Average daily gain in shell length.

NB: Values on the same line indexed by the same letters are not statistically different with Tukey's HSD test at $P < 0.05$.

Table 3: Weight (g) and proportions (%) of different snail body parts according to their diet.

	R _T	R ₀	R ₅	R ₁₀	R ₁₅	R ₂₀
Total body weight (g)	24.79 ^f ±3.5	40.25 ^e ±3.2	58.9 ^d ±2.8	77.54 ^c ±3.3	85.3 ^b ±3.7	100.5 ^a ±3.4
Weight of empty shell (g)	5.45 ^f ±1.3	9.26 ^e ±2.2	16.49 ^d ±2.7	26.36 ^c ±1.9	31.56 ^b ±2.1	40.2 ^a ±1.8
% of shell	21.98 ^f ±2.11	23.01 ^e ±3.24	28 ^d ±4.2	34 ^c ±2.3	37 ^b ±4.3	40 ^a ±3.2
Overall weight of soft tissue (g)	19.34 ^f ±2.8	30.99 ^e ±4.5	42.41 ^d ±3.6	51.18 ^c ±4.3	53.74 ^b ±4.1	60.3 ^a ±3.2
% of soft tissue	78.02 ^a ±6.53	76.99 ^a ±7.32	72 ^b ±3.4	66 ^c ±5.4	63 ^d ±4.3	60 ^e ±2.4
Edible flesh weight (g)	9.66 ^f ±1.4	16.02 ^e ±2.7	19.63 ^d ±3.1	25.85 ^c ±2.9	28.43 ^b ±2.8	33.5 ^a ±2.9
% of edible flesh	38.97 ^a ±4.3	39.80 ^a ±4.53	33.33 ^c ±3.4	33.34 ^c ±3.2	33.33 ^c ±4.5	33.33 ^c ±3.23
Weight of viscera (g)	9.68 ^e ±1.2	14.97 ^d ±2.34	22.78 ^c ±3.4	25.33 ^b ±2.97	25.31 ^b ±5.2	26.8 ^a ±4.3
% of viscera	39.05 ^a ±3.6	37.19 ^a ±4.3	38.67 ^a ±2.13	32.66 ^b ±3.25	29.67 ^c ±3.5	26.67 ^d ±3.2

N.B : Body weight values of the same line indexed with the same letters are not statistically different in the TUKEY HSD test at P<0.05. Body percentage values of the same line indexed by the same letters are not statistically different in the Chi-square test.

Fresh meat yield

Table 3 shows the weights and proportions of the various body parts of the snails as a function of their diet. Snails with final average live weights ranging from 24.79±3.5 g to 100.5±3.4 g had soft tissue weights ranging from 19.34±3.6 g to 60.3±3.2 g, corresponding to respective percentages of 78.02±6.53% to 60±2.4% of live weights. Snails from diets R₀ and R_T had the lowest shell proportions (23.01±3.24% for R₀ and 21.98±2.11 for R_T), while those from diet R₂₀ had the highest shell proportions (40±3.2%). The weight of shell and its percentage in relation to the snail's live weight increased as the level of oyster shell in the diet increased. These results are consistent with those of several researchers (Kouassi *et al.*, 2007; Aman *et al.*, 2019; Otchoumou *et al.*, 2005) who have shown that increasing dietary calcium leads to higher shell production in snails, to the detriment of meat production. According to Bonnet *et al.* (1990), the snail uses the calcium in the food and/or substrate to make its shell. The proportion of tissue decreased as the quantity of oyster shell in the feed increased. However, the largest quantities of tissue (60.3±3.32 g), edible flesh (33.5±2.9 g) and viscera (26.8±4.3 g) remained those of snails on the high oyster shell diet (R₂₀). This can be explained by the fact that the value of a low percentage of a high live weight can be higher than that of a high percentage of a low live weight.

CONCLUSION

At the end of this study, it is important to emphasize that the use of a mixture of papaya leaf powder, taro, moringa and pigeon pea enriched with calcium is a highly effective diet for promoting the growth of *Achatina achatina*. On a diet consisting of this leaf powder enriched with 20% oyster shell powder, snails experienced significant weight gain (0.54 g day⁻¹), as well as high production of soft tissue (60.3± 3.2 g), edible flesh (33.5±2.9 g) and shell (40.2±1.8 g). The formulation of snail feed based on leaf powder enables snail farmers to build up forage reserves during the rainy season to avoid food shortages during the dry season.

Authors' contributions

The authors Aman Jean Baptiste and Kiendrébeogo were the initiators of the theme of this study. Data collection, analysis and interpretation of the results were carried out by AMAN Jean Baptiste, KOUATO Fulgence and Memel Jean Didier. The word and drafting of the manuscript were supervised by Otchoumou Atcho.

Conflict of interest

The authors of this article declare that they have no conflict of interest.

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