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Effect of source and amendment rate of rearing substrate on the growth and yield of *Archachatina marginata*

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ABSTRACT:

Several studies have shown that successful breeding of molluscs requires a calcium-rich substrate. Therefore, this study was devoted to the search for a source of calcium and its suitable rate for the amendment of breeding substrates of *Archachatina marginata*. As a result, substrates were made by modifying the soil with either oyster shells or bone powder at different rates (0%, 5%, 10%, 20%, 30% and 40%). On these substrates, spat were raised for 20 months. During breeding, their growth performance was recorded and compared by source and by rate of amendment. At the end of the 20 months, 30 snails on each substrate, saw their soft tissues eradicated from their shells. The different body parts (shell, soft tissues and consumable flesh) of these animals were weighed and then their proportions relative to the live weight were determined and compared. The results showed that increasing the oyster shell substrate amendment rate induced a good growth rate compared to bone powder. As well, the amount of meat produced by snails increased with the oyster shell content of the substrate. The largest amount of meat produced on substrates amended to bone powder (71.12 g) is lower than that recorded (84.13 g) on the substrates with oyster shells added. On the other hand, the increase in the rate of substrate amendment in oyster shells led to a large production of shell at the expense of the flesh. This calcium source, however, is better suited to the amendment of the breeding substrate than the bone powder.

Keywords:

Achatiniculture, Amendment, Limestone.

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INTRODUCTION

The giant African snails are a real source of animal protein and are highly appreciated by many people in West Africa (Stievenart and Hardouin 1990; Zongo, 1990; Kouassi *et al*., 2008). These animals are so prized for the organoleptic quality, nutritional value and flavor of their flesh (Aboua 1990, Hotopp 2002; Otchoumou *et al.,* 2004).

In addition to the high nutritional value of the flesh of these animals, they constitute a privileged biological model (Moquin-tandon, 1851). In addition, shells serve as a source of calcium in the dietary formulation for some livestock (Otchoumou, 2005). These animals occupy habitats that take into account their physiological needs. The choice of these habitats depends among other things on the calcium content of the soil. Moreover, this mineral (calcium) is the most important distribution factor for terrestrial gastropods and there is a strong correlation between sand densities, snail abundance and calcium levels in colonized soils (Johannessen and Solhoy, 2001; Tattersfied *et al*., 2001; Hotopp, 2002).

Given the important role played by the soil minerals in the snail, it appears essential to use in the rearing environment a rich mineral substrate including calcium for the proper growth of snails. Therefore, it is necessary to amend soils to use as a substrate for *Archachatina marginata* farming. However, although there are several available calcium sources that could be used for soil amendment, there is little to be given about the mineral bioavailability including calcium from these different sources. Thus, it is unclear about the rate of amendment is appropriate for the mineral source for good growth and a good meat yield of the snails produced.

For this reason, the main objective of this study is to find calcium sources and the rate of substrate modification suitable for the successful breeding of *Archachatina marginata*.

MATERIALS AND METHODS

Preparation of breeding substrates

The breeding substrates were made by potting soil with either pork bone powder or oyster shell powder. The calcium sources after being collected in the wild were washed well with water and dried in an oven at 70°C for 8 h, before being grinded and sieved (mesh diameters 2 mm). The potting soil used was taken under the forest of Nangui Abrogoua University at a depth of 0 to 10 cm and heated on bio-charcoal for 20 minutes in a large aluminum basin. The heating helps to rid the soil of insect eggs (*Alluaudihella flavicornis* and fungus *Fusarium*) that can tackle snails. This soil was then sieved to get rid of pieces of wood and stones. The soil amendment thus prepared, was added to calcium sources at different rates (5%, 10%, 20%, 30 and 40%) giving a total 10 types of substrates (each of 5 substrates per calcium source). A substrate consisting of 100% potting soil was considered a control substrate. Also, each treatment was replicated three times.

Growth control

Two week old juvenile snails (*Archachatina marginata*) with a mean initial live weight of 1.44±0.2 g and an average shell length of 19.1±1.9 mm (Figure 1) were distributed on the different substrates made at a density of 25 individuals/ m^2 for breeding. These animals were fed *ad libitum* exclusively to the concentrated feed in the flour form. For the control of their growth performance, they were weighed and measured every two weeks. The

Figure 1. *Archachatina marginata* of two weeks old

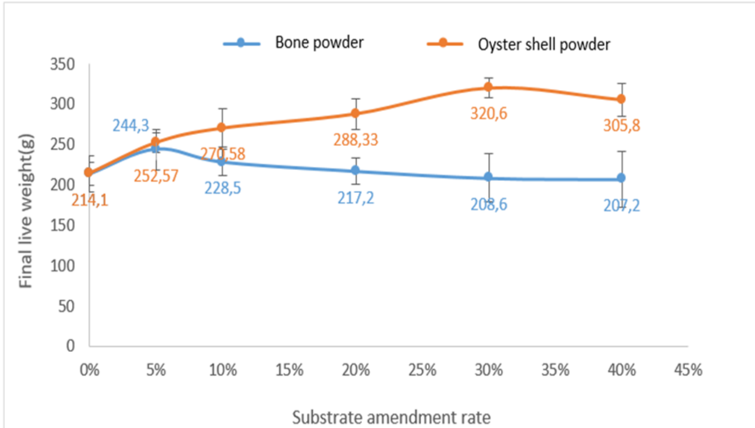

Figure 2. Evolution of the final weight of snails according to source and rate of amendment

choice of two weeks for the measurement and weighing of animals was guided by Kouassi *et al*. (2010). The weighings were carried out using a balance Sartorius brand with a precision 0.01 g. As for the measurements, they were made using a precision 0.1 cm mechanical caliper.

Determination of meat yield

At the end of the 20 months rearing period, thirty snails were taken from each type of substrate and fasted for two days. At the end of the two days of fasting, these snails were marked and weighed before being euthanized by scalding (immersion in boiling water for 15 min). After cooling, the soft tissues were removed from the shells, then the empty shell and soft tissues were drained on wire mesh. A set of organs (foot, head, distal edge of the mantle bearing the last centimeter of the rectum and anus, pneumostome, pallial rim, distal part of the genital tract including the penile sleeve and the anterior digestive tract up to the first half of the crop) corresponding to the portion generally consumed in Côte d'Ivoire, was separated from the rest of the visceral organs (digestive glands, gonads, albumin glands, genital tract, heart and hepatopancreas). For each snail, the weights of all the soft tissues, the flesh

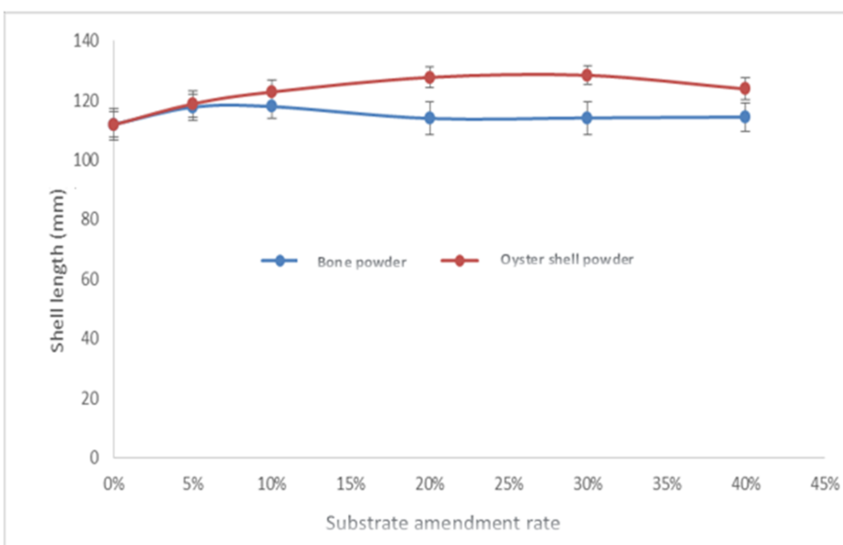

Figure 3. Evolution of the final length of the snails according to the source and the rate of amendment of the substrate

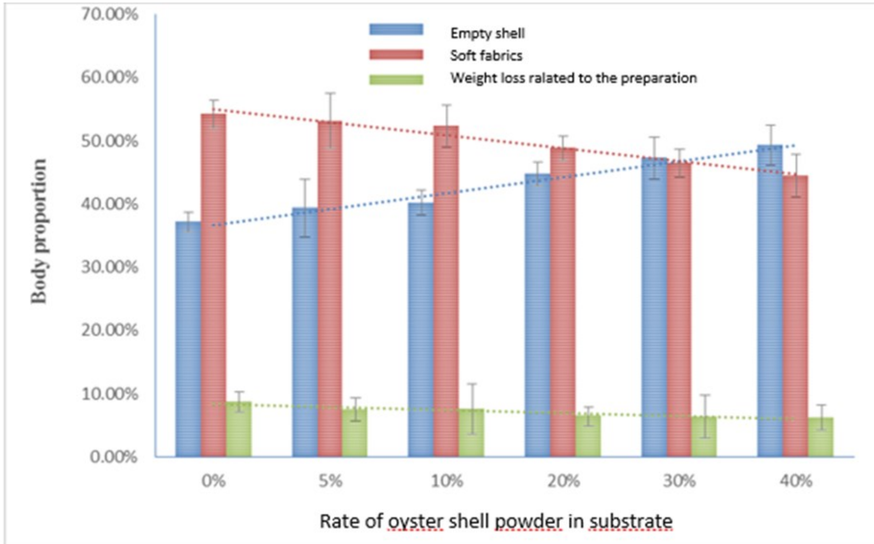

Figure 4. Body proportions of snails according to the rate of amendment of their oyster shell powder substrate

consumed and that of the empty shell, were determined using a Sartorius brand electronic scale to the nearest tenth of a gram. These weighings made it possible to estimate the body proportions (soft tissues, empty shell and flesh consumed) and the meat yield of these animals according to the source and the rate of amendment of their substrate.

Statistical analysis

Mean live weight, mean shell length, and recorded snail meat quantities by source and rate of amendment were compared by ANOVA to the LSD using the software. STATISTICA 7. 1.

RESULTS

Weight and shell growth

The shell and weight characteristics of snails grown on substrates amended to oyster shell powder are summarized in Table 1. The analysis of these results shows that the average weight of snails increases with the powder content of oyster shells of the substrate. So,

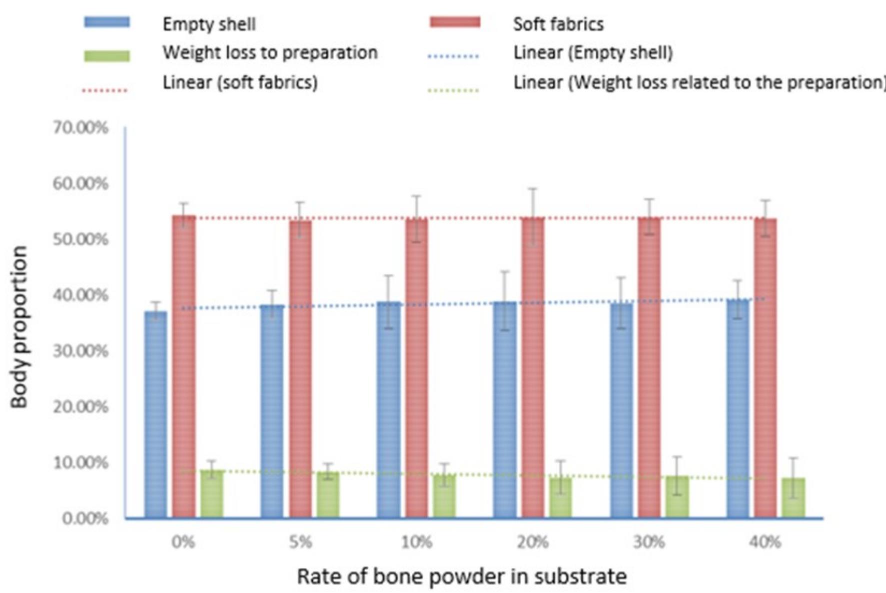

Figure 5. Body proportions of snails according to the rate of amendment of their substrate in bone powder

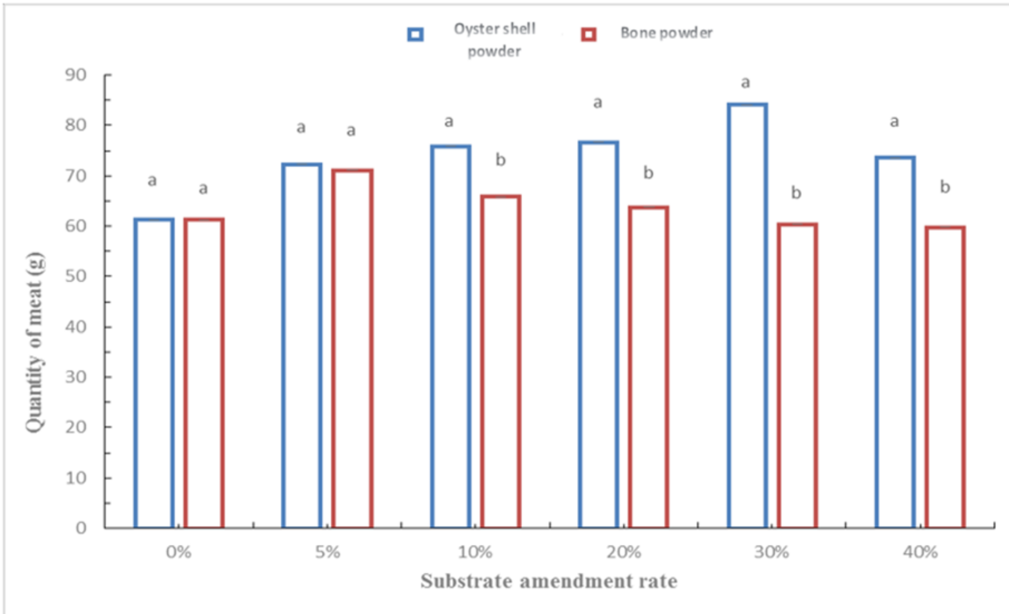

Figure 6. Meat yield of snails according to the source and the rate of substrate amendment

the average weight has gone from 214.1±13.8 g with an average daily gain of 0.38±0.28g/day on the control and at 320.6±29.85 g on the substrate amended to 30%, with an average daily gain of 0.57±0.45g/day, significantly better. Moreover, beyond 30% in the substrate, the oyster shell began to induce a decline in growth, characterized by a low average final weight on the substrate amended to 40%. The snails on the substrate supplemented with 30% of the calcium source (oyster shell), showed the best average shell length with a daily gain of 0.20±0.20mm/day. At the end of the two years of aging, the average weight of snails on different substrates amended to bone powder varied between 207.2±20.25 g and 244.3±12.6 g with average daily gains between 0.367±0.32g/day and 0.433±0.28g/day (Table 2). Substrate amended to 5% showed the best average weight (244.3±12.6g). Beyond this rate (5%), the final average weight of snails on the substrates decreased considerably. Thus, no statistical difference was observed between the weights of the snails produ-

Table 1. Weight and shell characteristics of snails grown on substrates amended to oyster shell powder

S. No	Parameters	Amendment rate of substrate 0%	5%	10%	20%	30%	40%
1	Final live weight (g)	214.1±13.8^{f}	252.57±24.98^{e}	270.58±16.1^{d}	288.33±16.1^{c}	320.6±29.85^{a}	305.8±34.77^{b}
2	Average daily weight gain (g/day)	0.38± 0.28^{b}	0.45±0.34^{ab}	0.48 ±0.36^{ab}	0.51±0.44^{ab}	0.57±0.45^{a}	0.54±0.43^{ab}
3	Initial length (mm)	18.8 ± 1.20^{a}	18.7 ±1.20^{a}	19± 1.2^{a}	18.8± 1.19^{a}	18.8±1.27^{a}	18.7±1.23^{a}
4	Final length (mm)	111.9± 5.4^{d}	118.9± 4.5^{c}	122.9 ±4.1^{b}	127.8± 3.5 ^{a}	128.5±5.5^{a}	123.9±4.7^{b}
5	Daily gain in shell length (mm/day)	0.17 ± 0.14^{a}	0.18 ±0.17^{a}	0.18± 0.16^{a}	0.19±0.18^{a}	0.20±0.20^{a}	0.19±0.15^{a}

The average values of the same indexed line of the same letters are not statistically different from the Fischer LSD test at P>0.05

ced on the control substrate and those raised on the substrates amended to 20%, 30% and 40% of bone powder. Snails on substrates containing 5% and 10% bone powder showed the highest shell lengths with daily gains of 0.18 mm/day.

Figure 2 shows the variation of the average weights recorded at the end of the rearing period, depending on the source (bone dust or powder oyster shell) and the amendment ratio of the substrate. The snails raised on the substrates amended to the oyster shells powder presented at the end of the breeding, average live weights better than those of the animals produced on the substrates amended in powder of bone. Indeed, live weights varied between 252.57 g and 305.8 g on substrates amended in oyster shells against 207.2 and 244.3 g on those supplemented with bone powder. Also, the shell growth of snails as a function of substrate amendment rate remained better with oyster shell powder than with bone meal (Figure 3). Beyond an amendment rate of 5%, the average lengths of shells recorded on substrates with bone powder remained lower than those found on substrates containing oyster shell.

Body proportions

The proportion of shellfish in snails grown on substrates amended to oyster shell powder, increases with the importance of the rate of amendment (Figure 4). Thus, the lowest proportion of shell is obtained on the control substrate (0% calcium source) while the highest is recorded on that containing 40% oyster shell. Contrary to the proportion of shellfish, the proportion of soft tissues decreases with the increase of the calcium source in the breeding substrate.

Thus, the increase in the shell proportion was at the expense of the proportion of tissues with the increase of oyster shell in the substrate so that the percentage of soft tissue that was greater than that of shell for amendment rate from 0% to 20%, became inferior to this one from 30% of calcium source in the substrate. In contrast to oyster shell powder, bone powder had no significant influence on the body proportions of snails (Figure 5). Indeed, the shell proportions as well as the proportions of soft tissues remained equal on all the substrates. With this calcium source, the proportion of soft tissues remained higher than that of shell regardless of the rate of amendment.

Meat yield

The amount of meat produced by snails on oyster shell powder added increased with the rate of amendment (Figure 6). However, beyond 30%, this cal-

Table 2. Weight and shell characteristics of snails grown on substrates amended to bone powder

S. No	Parameters	Amendment rate of substrate					
		0%	5%	10%	20%	30%	40%
1	Final live weight (g)	214.1 ± 22.3^{c}	244.3 ± 12.6^{a}	228.5 ± 24.03^{b}	217.2 ± 19.25^{bc}	208.6 ± 11.73^{c}	207.2 ± 20.25^{c}
2	Average weight gain daily (g/day)	0.38 ± 0.28^{a}	0.433 ± 0.28^{a}	0.405 ± 0.38^{a}	0.385 ± 0.37^{a}	0.369 ± 0.27^{a}	0.367 ± 0.32^{a}
3	Initial length (mm)	18.9 ± 1.0^{a}	18.8 ± 1.2^{a}	18.9 ± 0.9^{a}	19 ± 3.2^{a}	19.1 ± 2.9^{a}	19.3 ± 0.8^{a}
4	Final length (mm)	112 ± 4.2^{c}	117.8 ± 4.4^{a}	118 ± 4.1^{a}	114 ± 3.5^{bc}	114.2 ± 3^{bc}	114.5 ± 3.7^{b}
5	Daily gain in shell (mm/day)	0.17 ± 0.1^{a}	0.18 ± 0.14^{a}	0.18 ± 0.17^{a}	0.17 ± 0.19^{a}	0.17 ± 0.13^{a}	0.17 ± 0.14^{a}

The average values of the same indexed line of the same letters are not statistically different from the Fischer LSD test at P>0.05

cium source has induced a decrease in meat production in these animals. As for the bone powder, it has led to a decrease in production of consumable flesh beyond 5% in the soil. Also, beyond this rate of amendment (5%), the amount of meat of a snail raised on oyster shell amended substrate remained significant that that of a snail raised on substrate amended powdered bone.

DISCUSSION

The rearing substrate is the medium on which the snail lives, grows and reproduces. Its chemical composition has a considerable effect on the biological performance of these animals (Jess, 1989; Stievenart and Hardouin, 1990; Memel *et al*., 2011; Kouassi *et al*., 2008). In fact, they extract nearly 40% of their nutrients in the soil transcutaneously using their sole pedal (Graham, 1978; Jess, 1989).

Our study has shown that increasing the bone meal rate in the rearing substrate is not favorable for good growth in *Archachatina marginata*. This would be related to a low bio-availability of calcium from this calcium source for the snail. The animals on these substrates would therefore have been content with only dietary calcium. This certainly has not been enough to fill the calcium needs of these molluscs. Moreover, according to Wacker and Baur (2004), the depletion of body calcium reserves compromises the general metabolic activity of the snail, which results in a growth disorder in this animal.

The increase in oyster shell powder content of the substrate led to significant growth in snails. This result is explained by the fact that this element is an important source of calcium, which is a mineral that the snail uses to develop its shell, which is essential for its growth (Crowell, 1973; Ireland, 1991). In addition, low growth was observed in animals raised on substrates amended beyond 30% in oyster shell powder. This could be justified by the fact that an excess of calcium intake would lead to an early hardening of the snail shell, which results in a slow growth of shell length in these animals (Otchoumou, 2005). However, according to Stievenard (1996) the weight growth has for corollary shell growth in the snail, hence the low weight found on these substrates.

Snails showed better growth performance on substrates amended to oyster shell powder than on those supplemented with bone powder. This suggests that the snail enhances the oyster shell better than the bone powder. This could be explained by a lower bioavailability of calcium in pig bones than in oyster shells. Indeed, the oyster shell consists of 96% calcium carbonate ($CaCO_3$) and contains the two crystalline forms of calcium carbonate that are also found in the shell of the snail (Stievenard, 1996). Whereas according to Cuif (2008), the calcareous material of animal bones consists mainly of calcium tribasic phosphate (85%), calcium carbonate (9%) and calcium fluoride (4%). Although the increase in the oyster shell powder rate was beneficial for an abundant meat production in *A. marginata*, bone powder (oyster shell powder) did, however, lead to a higher production of meat in larger shell to the detriment of soft tissues. These results corroborate those of Otchoumou *et al*. (2011) who reported that increased dietary calcium results in the increase in the proportion in the snails, *A. ventricosa* and *A. achatina.*

CONCLUSION

The substrate calcium amendment is essential for the proper growth of *Archachatina marginata* snails in the rearing environment. However, an excess of bioavailable calcium intake results in a decrease in meat production in favor of an excessive production of snail shell. The appropriate level of amendment depends on the calcium source used and its bioavailability to calcium. Bone powder is prohibited for the calcium amendment of the substrate for rearing these molluscs. The oyster shell, on the other hand, is well suited for the amendment of the breeding substrate of snails *Archachatina marginata* in fattening and the rate suitable for good growth and abundant production of consumable flesh is at most 30%.

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