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SHORT COMMUNICATION

BODY PROPORTIONS AND CHEMICAL COMPOSITION OF WILD AND REARED EDIBLE SNAILS OF IVORY COAST

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ABSTRACT

The chemical composition and body proportions of *Achatina fulica (Bowdich)*, *Achatina achatina (Linné)* and *Archachatina ventricosa (Gould)* fed a concentrated diet were investigated and compared with wild *A. fulica*, *A. achatina* and *Arch. ventricosa.* Wild and artificially reared snail shell proportion were 42.09 and 46.91%; 47.20 and 52.96%; 48.02 and 51.96% of the whole body, respectively, for *A. fulica*, *A. achatina* and *Arch. ventricosa.* The pedal mass proportion was 41.36 and 36.66%; 27.80 and 26.62% than 36.59 and 32.71%, respectively, for wild and reared *A. fulica*, *A. achatina* and *Arch. ventricosa.* The pedal mass mean energy, dry matter, proteins, lipid and mineral matter content were 53.21cal/100g; 12.86% by weight of deshelled snails; 63.98/DM (% of dry matter); 15.80/DM and 8.96/DM in *A. achatina.* For *A. fulica* pedal mass aver-

- Key words: chemical composition, edible snails, Ivory Coast, pedal mass, visceral mass -

age energy, dry matter, proteins and mineral matter content were 47.82 cal/100 g; 13.63% by weight of deshelled snails; 58.94/DM and 14.92/DM. *Arch. ventricosa* pedal mass mean energy, dry matter, proteins, lipid and mineral matter content were 50.32 cal/100g; 14.19% in weight of deshelled snails; 66.36/DM; 13.43/DM and 10.25/DM. The protein contents differed slightly between artificially reared and wild snails.

INTRODUCTION

The rural populations of under-developed countries and in particular the Ivory Coast suffer from a chronic deficit in animal protein. The Ivory Coast initially imported meat (sheep and oxen) from the Sahelian African countries (Mali, Burkina Faso and Niger), the European Union (sheep, poultry and dairy products) and certain Latin American countries which was a significant expenditure. Therefore, it was necessary to seek new sources of animal protein. Edible terrestrial gastropods occur naturally in the dense forests of sub-Saharan Africa and particularly in the Ivory Coast. These snails belong to the *Achatina* genus, particularly the species *A. achatina* Linné, 1758 and *A. fulica* Bowdich, 1820 and the *Archachatina* genus with the species *Arch. ventricosa* Gould, 1850 and *A. marginata* Swainson, 1821. In the past, snails belonging to the genus *Achatina* were often consumed, while those of the genus *Archachatina* were rarely used as food because of various taboos. Today both juveniles and adults of these genera are consumed (ABOUA and BOKA, 1996). The soft bodies of these snails are rich in amino acids, proteins, minerals and iron and constitute a potentially valuable source of animal protein and iron for rural populations (ABOUA, 1990, ADEYEYE *et al.*, 1996).The snail meat is relished by the forest populations of the Ivory Coast for its taste and especially its aroma. It is consumed in various forms: cooked in sauces, steamed or roasted and served with rice, semolina of cassava, yams and plantain bananas (ABOUA and BOKA, 1996). The visceral mass, which is usually not consumed, could constitute a source of protein and minerals in animal feed. The artificial raising of snails is necessary to make up for seasonal deficits in snail availability and to preserve the species from the pressures that result from the destruction of the forests, the abusive use of pesticides and over-collecting (ZONGO *et al.*, 1990; OTCHOUMOU *et al.*, 1989-1990; 2003a;b; 2004a;b; 2005). However artificially raised snails are not greatly appreciated by consumers compared to wild specimens (KOUASSI *et al.*, 2007).

The aims of the present study were to compare the proportions of some of the body parts (shell, pedal mass and visceral mass) of reared and wild snails and to determine and compare the chemical composition of the meat of reared and wild snails in order to determine if snail culture should be encouraged for human consumption.

MATERIALS AND METHODS

Snail material

One hundred and fifty (50/species) wild snails of the species *A. achatina* (Linné), *A. fulica* (Bowdich) and *Arch. ventricosa* (Gould) were used. The average live weights were 32.05±10.5 g; 32.50±3.44 g and 32.10±9.98 g, respectively, for *A. achatina*, *A. fulica* and *Arch. ventricosa*. They were collected in the forests in the south-west of the Ivory Coast from an area of approximately 3 hectares. For the reared species, 150 snails (50/species) were used. The average live weights were 32.06±7.48 g; 32.61±4.88 g and 32.11±11.58 g, respectively, for *A. achatina*, *A. fulica* and *Arch. ventricosa*. The reared snails were raised at the experimental farm of the University of Abobo-Adjamé. They were fed a concentrated flour diet in accordance with the requirements for the species, as reported by OTCHOUMOU *et al.* (2004a, b) for six months (from June 2006 to December 2007). The formulation of the diet is given in Table 1. The principal characteristics of the diet were checked by chemical analysis (AOAC, 1984) and the results are reported in Table 2.

Sample preparation

Fifty snails were randomly chosen according to species; twenty-five wild snails and twenty-five reared snails. The remainder of the wild snails were released in the forest. They were weighed after a 24-hour fast and sacrificed and the flesh

Table 1 - Meal diet components (g) and characteristics.

Corn	Cotton cattle-cake	Soya grains	Bran soft wheat	Calcium phosphate	Vitamins	Calcium carbonate	Salt	Trace elements	Total
10.00	16.00	16.00	15.00	4.00	0.50	39.20	0.40	0.10	100
Characteristics/DM									
Crude energy	Total Nitrogen	Total calcium	Fat	Starch	Free sugars	crude cellulose	Ash		
2727	17.14	16.01	4.61	12.24	3.04	4.67	43.35		
/DM: Results expressed as % dry matter									

Table 2 - Diet components determined by chemical analysis.

	Components (% of dry matter)					
Sample weight	Dry matter	Proteins	Total Lipids	Calcium	Mineral	Energy (cal/g)
44.66	83.13	18.35	3.34	15.80	45	2.380

was extracted from the shell using a silver fork. The pedal mass (the head and edge of the mantle) was then separated from the visceral mass (digestive glands, gonads, gland of albumin, liver, pancreas, genitals, heart and kidney). The shell, pedal mass and visceral mass were weighed. After drying in an oven at 60°C for 24 h, the snail diet, pedal mass and visceral mass were ground and the chemical composition was determined using 50 g of dry ground snail meat for each sample. The chemical analysis of each sample was repeated three times.

Proximate composition

Dry matter

The diet sample was dried and the loss of mass was determined by weighing. At least 50 g of the sample were mashed without any variation in moisture. A mashed sample (5 g) was then put into a tarred container and heated at 103°C for four h in a drying oven. The mass of dry matter obtained is expressed as a percentage of the sample.

Mineral matter

A 5 g sample was weighed and put in an incineration crucible which was gradually heated until the sample was carbonized. The crucible was then placed in a muffle oven at 550°±5°C until white ash was obtained. The crucible was immediately weighed after cooling. The weight of the residue was calculated by subtracting the tare and is expressed as a percentage of the sample.

Crude proteins

The crude proteins were determined according to the Kjeldahl method. The sample was mineralized by the wet process. The acid solution was alkalized with a solution of sodium hydroxide. The ammonia released was extracted by distillation and collected in a volume of sulphuric acid whose excess was titrated with sodium hydroxide. One mL of sulphuric acid (0.1 N) corresponds to 1.4 mg of nitrogen; the quantity of nitrogen obtained was multiplied by 6.25 and the result are expressed as a percentage of the sample.

Total lipids

The total lipids were determined according to the method of FOLCH *et al.* (1957).

The tissues were homogenized with a 2:1 mixture of chloroform and methanol and the extract was washed by adding pure water (0.2% in volume). The mixture was separated into two phases by centrifuging. The lower phase was the extract of pure total lipids.

Crude energy

The crude energy was determined by the coefficient of ATWATER and ROSA (1899). According to them 1g of carbohydrates and 1 g of protein provides 17 joules and 1 g of lipids 38 joules. One calorie corresponds to 4.18 joules. Crude energy was calculated as follows:

$$CE = \frac{38[\text{Lipids }\%] + 17[\text{Proteins }\%] + 17[\text{Carbohydrates }\%]}{4.18} Cal/100g$$

Starch

The sample was extracted with ethanol (40%). After acidification of the substrate with hydrochloric acid, precipitation and filtration, the optical activity of the solution was measured by polarimetry.

Free sugars

Free sugars were determined by the sulphuric phenol test (DUBOIS *et al.*, 1956).

Crude cellulose

A mixture of 3 g of sample, 2 g of an asbestos, 125 mL of sulphuric acid (1.02N) and 75 mL of distilled water was boiled for 10 min and then filtered. One hundred-twenty mL of potassium hydroxide (0.89N) and 75 mL of distilled water were added to the residue. The solution was filtered after boiling for 10 min on an asbestos. The residue was rinsed with warm water and acetone for drying. The asbestos residue containing cellulose was then placed in a porcelain crucible and dried in an oven at 130°C for 2 h. The mixture was then weighed with the crucible and incinerated at 900°C for 30 min. The crucible and the dry residue were then weighed. The crude cellulose content is expressed as a percentage of the sample.

Statistical analyses

The statistical analyses were carried out with the SAS program (1987). Averages of shell proportions, pedal mass, visceral mass, total mass of flesh proportions, energy, dry matter, proteins, lipids and mineral matter were compared by analysis of variance with ANOVA (5% threshold of confidence). The following model was used:

$Y_{ijk} = \mu + R_I + E_{ijk}$, where Y_{ijk} is the measured variable, μ the general average, R_I the fixed effect of snail origins and E_{ijk} the residual.

RESULTS AND DISCUSSION

Various parts of the body proportions

The results concerning the proportions of the various parts of the body of the three snail species are given in Table 3. The statistical analyses showed that there were no significant differences (P>0.05) between the wild and reared snails with respect to the average proportions of the various parts of the snail body. The consumable pedal mass was equivalent to 33% of the live weight of the three species; the visceral mass of *A. achatina* and *Arch. ventricosa* accounted for 16% of the live weight. The visceral mass of *A. fulica* made up about 20% of its live weight.

Chemical composition

The results of the chemical analysis of some body parts of the three snail species are given in Table 4. Statistical analyses showed that regardless of species, there were no significant differences (P>0.05) between the chemical composition of the wild specimens and those of reared specimens. Regardless of the species and origin, the visceral mass contained more energy, lipids and mineral matter than the pedal mass. The pedal mass was richer in proteins than the visceral mass and reared species had higher protein contents than those of the wild ones.

In Africa and particularly in the Ivory Coast, snails are important for the quantity of meat that they provide and not for their gastronomical finesse (ZONGO *et al.*, 1990). The pedal mass is the part of the body that is consumed (ABOUA and BOKA, 1996). The results of this study should encourage the consumption of reared snail meat and use of the shell and visceral mass. The results indicate that the shell accounts for half of the live snail weight, while the pedal and visceral masses account for 33% and 17% of the body weight, respectively. These results are similar to those of PA-

Table 3 - Body portions are percentage of body weight (%) of edible snails of the Ivory Coast.

	Achatina achatina	
Body weight (g)	Wild	32.05 ± 10.5
	Reared	32.06 ± 7.48
Shell	Wild	42.09[a] ± 4.5
	Reared	46.91[a] ± 14.00
Pedal mass	Wild	41.36[a] ± 6.23
	Reared	36.66[a] ± 7.20
Visceral mass	Wild	16.53[b] ± 2.89
	Reared	16.44[b] ± 7.94
Total flesh mass	Wild	57.91[a] ± 3.6
	Reared	53.09[a] ± 14.00
	Achatina fulica	
Body weight (g)	Wild	32.50 ± 3.44
	Reared	32.61 ± 4.88
Shell	Wild	47.20[a] ± 3.56
	Reared	52.96[a] ± 5.53
Pedal mass	Wild	27.80[b] ± 2.44
	Reared	26.61[b] ± 1.49
Visceral mass	Wild	25.00[b] ± 1.43
	Reared	20.43[b] ± 6.63
Total flesh mass	Wild	52.80[a] ± 7.5
	Reared	47.04[a] ± 5.55
	Archachatina ventricosa	
Body weight (g)	Wild	32.10 ± 9.98
	Reared	32.11 ± 11.58
Shell	Wild	48.02[a] ± 13.99
	Reared	51.95[a] ± 4.47
Pedal mass	Wild	36.59[b] ± 4.3
	Reared	31.71[b] ± 3.64
Visceral mass	Wild	15.37[c] ± 1.2
	Reared	16.34[c] ± 1.82
Total flesh mass	Wild	51.98[a] ± 5.88
	Reared	48.05[a] ± 5.19

NB: Mean values in the same column followed by the same letter have no significant difference (P>0.05).

CHECO *et al.* (1998). GOMOT (1998) studied the proportions of the various parts of the body of Helix snails and reported 10.3 to 11.5% of the live snail weight was constituted by the shell of reared specimens, while the shell constituted 17.5 to 22% of the live weight in the wild individuals. The high proportion of shells of wild specimens of Achatinidae and Helicidae are due to the nature of the soil, the vegetation and the influence of the season. The shell and the visceral mass could be used as a source of calcium and protein in animal feed (RISTIC *et al.*, 2000). ABOUA (1990; 1995) studied the chemical composition of *A. fulica* and showed that the flesh was very rich in protein. The pedal mass had from 53.36 to 74.6 g of protein for the three studied species which was slightly higher than the value (72 g) reported by ABOUA (1990). SALDANHA *et al.* (2001) reported 14.87 g on wet matter. The pedal mass contained more proteins than the visceral mass which was probably due to the components. Pedal mass is primarily made up of contractile proteins (actins and myosin). However, the pedal mass of *Arch. ventricosa*, an object of various taboos, was the richest in proteins compared to the other two species. This explains why it is highly consumed in Benin and Nigeria (EBENSO, 2002). Traces of lipids were found in pedal and visceral masses of *A. fulica* in contrast to what ABOUA (1990) found, 2.10% of the body weight. In the two other species, the lipid contents were low in the pedal mass. This explains why snail meat is recommended for low lipid diets (SALDANHA *et al.*, 2001). The results of this study were slightly higher due to the concentrated diet. In addition the visceral mass was rich in lipids and was more energetic compared to the pedal mass because the lipids are highly energetic. The mineral matter of the pedal and visceral masses exceeded 19.6 g per 100 g of sample regardless of the species. These values were double those obtained by ABOUA (1990) in *A. fulica* and even greater than those of WATT and MERRILL (1975). These results could be explained by the type of diet used to rear the snails. The results of this study have shown that the visceral mass is richer in mineral matter than the pedal mass. It is thought that the mineral content absorbed by the snails is transferred to the internal organs where a storage threshold exists. This threshold differs according to the snail species.

The edible snails of the Ivory Coast are very rich in protein, minerals and energy. For this reason they are gathered by the forest populations of the Ivory Coast. This study has shown that the chemical quality of wild snails differs a little from that of the reared ones. An improvement of the various parameters for raising snails, and particularly diet components could improve the quality of reared snail meat. Thus it is recommended that reared snail meat be consumed in order to preserve wild snail biodiversity and to protect snail consumers from possible intoxication due to frequent use of pesticides and heavy metals.

Table 4 - Chemical composition of the pedal and visceral mass of edible snails of the Ivory Coast

	Pedal mass		Visceral mass	
	Wild snails	Reared snails	Wild snails	Reared snails
Achatina achatina				
Energy (cal/100g)	5135^{ab}±77.78	5027.5^{a}±175.79	5370.5^{ab}±27.58	5614.5^{b}±472.56
Dry matter (%)	10.99^{a}±0.30	13.51^{b}±2.75	11.90^{a}±0.56	14.74^{b}±5.2
Proteins (%DM)	74.6^{b}±0.14	62.6^{ab}±7.61	65.76^{ab}±0.62	53.36^{a}±6.06
Lipids (%DM)	7.17^{a}±0.04	7.54 ^{ab}±0.73	21.04^{ab}±0.66	24.44^{b}±8.02
Mineral matter (%DM)	7.39^{a}±0.13	7.38^{a}±2.25	10.53^{a}±0.25	9.54^{a}±3.01
Achatina fulica				
Energy (cal/100 g)	4958^{a}±172.53	4950^{a}±323	4561.50^{a}±2.12	5002.83^{a}±355.48
Dry matter (%)	12.76^{a}±0.65	14.51^{a}±1.3	13.47^{a}±2.08	14.08^{a}±8.96
Proteins (%DM)	57.18^{a}±0.82	66.22^{a}±10.25	51.67^{a}±1.52	59.56^{a}±10.65
Lipids (%DM)	Traces	Traces	Traces	Traces
Mineral matter (%DM)	10.25^{a}±6.39	10.25^{a}±6.39	19.6^{a}±0.79	13.48^{a}±4.10
Archachatina ventricosa				
Energy (cal/100g)	4777^{a}±80.61	4816.5^{a} ±82.03	5288^{a}±16.97	5267.66^{a}±556.28
Dry matter (%)	15.74^{b}±1.38	14.32^{b}±2.42	11.82^{a}±1.11	16.57^{b}±5.02
Proteins (%DM)	64.36^{a}±1.19	68.37^{a}±5.85	64.39^{a}±0.58	58.24^{a}±12.3
Lipids (%DM)	6.95^{a}±1.39	5.69^{a}±0.61	17.75^{ab}±0.78	21.18^{b}±7.31
Mineral matter (%DM)	8.55^{a}±0.72	10.99^{a}±2.53	10.54^{a}±0.64	11.95^{a}±3.09

NB: Mean values in the same line followed by the same letter are not significantly different ($P>0.05$)
DM: Dry Matter.

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