Evaluation of the Nutritional Potential of Snail (Achatina Spp.) Meat in Rat

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Abstract

The chemical composition of *Achatina achatina* and *Archachatina ventricosa*, nutritional potential of snail *(Achatina achatina)* meat in growing rats was assessed. Five groups of six growing rats were fed for 21 days, with isoprotein diets (10 % protein). The control diet consisting of fish powder is substituted with snail powder levels of 25 %, 50 %, 75 %, and 100 %. The results of the chemical composition of *Achatina achatina* and *Archachatina ventricosa* show that they have a high protein content (68.65%±1.38 and 69.31%±1.82 Dry matter, respectively). Fat levels in *Achatina achatina* and *Archachatina ventricosa* were respectively 8.86±0.12 and 14.68±0.33% dry matter. These snails are rich in all minerals, but most mineral contents of *Achatina achatina* are higher than those of *Archachatina ventricosa*. The growth performance of rats decreased in proportion to the inclusion rates of snail powder in the control diet (25%, 50%, 75%, and 100%). Body weight gain of rats subjected to snail meat (-0.12±0.00 g) is lower than that of rats consuming fish powder (1.81±0.00 g). The optimal rate of recommendable snail powder incorporation is 75%. Over this threshold, animals start to lose weight. Snail meat alone cannot support growth performance in rats.

Keywords: Rat, Snail Meat, Nutritional Values, Chemical Composition

Introduction

Snail meat is very well-known by African people and it's a source of animal protein and income for many households in the African forest area (Brescia, 2002; Kouassi et al, .2008). Snail is appreciated for the flavor and quality of its meat. Its flesh has good nutritional value. Its protein content is over 40% dry matter, with almost all the amino acids that humans need (Otchoumou et al., 2010). This meat is also rich in macro elements. These characteristics make the snail an animal of choice in sub-Saharan Africa (Fagbuaro, 2006). The reality of animal protein needs in West African countries leads them to the development of small snail farms. The following snail family are concerned: Achatina, Burtoa and Limicolaria. The family of the Achatinidae including the species Achatina achatina and Archachatina ventricosa provide high nutrients value and are found from Guinea to Angola (Ekoue and Kuevi-Akue, 2002; Otchoumou et al., 2003). These two species are the subject of a very flourishing trade in Côte d'Ivoire (Kouassi et al., 2008). Considering the rapid population growth and the evolution of eating habits, their consumption has become more important today (N'Da et al., 2004). So therefore these snails provide rural households with a very large portion of the animal protein they need (Atégbo et al., 2000).

Given its importance in human nutrition, the present work is carried out to determine the chemical composition of snail meat, and to evaluate the nutritional potential of snail meat powder in rat.

Materials And Methods

Biological Materials

Dried snail meat powder from *Achatina achatina* and from *Archachatina ventricosa* was used for the determination of chemical composition. The growing rats of average weight of 64.9 g were nourished with *Achatina achatina* meat. The snails used in this work were bought in the market of Abidjan. The snails were washed with clean water before being shelled. Then, they were dried in an oven for 72 hours at 65 °C. The dry sample was ground in a " Moulinex mixer to obtain the dried snail meat powder. The fish powder was produced in the same way, from fresh fish (herring) bought at the fishing market of Abidjan. These powders were used for chemical analyzes and various tests. This protocol is that of Bouafou *et al*. (2011°) with slight modification.

Chemical analysis of snail meat

Fresh snail bought in the market were dried in an oven (MERMERT, Germany) at 50 °C and were reduced to powder with micromill hammer (Culatti, Germany) with a sieve of 10 microns mesh. Moisture, crude proteins, lipids and ash levels were determined according to the methods of AOAC (1975). Moisture content was determined by dehydration of 10 g of a sample of fresh snail in an oven (MERMERT, Germany) at 105 °C until a constant weight. Crude proteins content was determined by Kjeldahl method, using 1 g of a snail powder. But since snail are part of chitin which is not digestible,

digestible proteins (% N× 4.38) were calculated using the adjustment factor 4.38 (Shashireha, 2002). Snail lipids content was determined by extracting 5 g of snail powder in a Soxhlet apparatus for 5 hours, using hexane as extractant. Ash was determined by incineration of 10 g of snail powder in a muffle furnace (MAKER, France), maintained at 550 °C for 6 hours. Content of snail crude fibers was determined by the method of Van Soest (1963). The digestible carbohydrates (DC) and the energy value were on dry matter (DM) basis by calculation (WHO, 1998) as following:

$$\text{DC (\%DM)} = 100 - [\text{proteins (\%DM)} + \text{Lipids (\% DM)} + \text{Fibers (\% DM)} + \text{ash (\% DM)}]$$

$$\text{Energy (kcal/100 g DM)} = 2.44 \times \text{proteins (\% DM)} + 8.37 \times \text{lipids (\% DM)} + 3.57 \times \text{Carbohydrates (\% DM)}$$

Quantification of reducing sugars was performed according to the method of Bernfeld (1995). The total sugar content was determined by the phenol-sulfuric method, as described by Dubois *et al.* (1956). Mineral composition is determined on the basis of ash material, with a scanning electron microscope, coupled with an energy scattering spectrometer (Zeiss supra 40 VP, Germany).

Preparation of diets

For the various tests, the cornstarch (Maizena) used in this experiment was purchased in the market. Five isocaloric (4200kcal / kg dry matter) and isoprotein (10%) diets are prepared with gradual inclusion rates of snail powder versus a control diet containing fish powder as a source of protein (Table I). The preparation of animal feed consists of mixing the different ingredients in the proportions mentioned in the table below. These ingredients are then transferred to a saucepan, and after homogenization in one liter of water. The mixture is cooked over low heat until it sets solid. The food is then placed on a plate and stored in a refrigerator.

Table I: Composition of rat diets

Ingredients	**Ingredients (1 kg of dry food)**				
	100 % F	**25 % S**	**50 % S**	**75 % S**	**100 % S**
Fish(g)	140.26	105.20	70.13	35.07	0
Achatina meat (g)	0	73.52	73.52	110.3	147.06
Corn starch (g)	553.74	557.06	550.56	549.08	547.38
Sugar(g)	250	250	250	250	250
Prémix (g)	1	1	1	1	1
Agar agar (g)	5	5	5	5	5
Sunflower oil (ml)	50	50	50	50	50
Water (ml)	1000	1000	1000	1000	1000
Total energy (kcal /kg)	4246	4246	4246	4246	4246

100% F: control diet based on 100 % fish; 25 % S, 50 % ES 75 % S, 100 % S: different incorporation rates of snail powder in the control diet; protein level in the diets: 10%; amount of energy in all diets: 4200 kcal. Source: Garcin *et al*. (1984)

Animal experimentation

The breeding room had a temperature of 26 ° C, with a humidity between 70% and 80%, 12 hours of daylight and 12 hours of darkness. Five batches of six growing rats were fed with diets. Animal experimentation was carried out according to the method of Garcin *et al.* (1984). The diets are distributed *ad libitum* once a day (between 7 a.m. and 8 a.m.) as a paste. Water is served *ad libitum* in feeding bottles, and renewed daily. During animal testing the rats were housed in individual metabolism cages. The screened bottom of the cages allows the faeces to be retained upstream and the urine to be collected downstream, which is poured into jars through a funnel. These cages are fitted with racks and bottles to feed and water the animals.

Statistical analyses

Comparisons of average nutrient values of chemical composition, growth parameters and serum biochemical parameters were performed using Graphpad prism version 7.0 software. The analysis of variances (ANOVA) followed by the multiple comparison test of Newman-Keuls means were used to classify and compare the means. ($P \leq 0.05$).

Results

Chemical composition

The chemical composition of the snail meat is given in Table II. The results of the analyzes indicate that snail meat is rich in protein. The average protein contents of *Achatina achatina* (68.65 ± 1.38%) and *Archachatina ventricosa* (69.31 ± 1.82%) are same. Likewise, the ash contents of *Achatina achatina* (4.40 ± 0.20%) and *Archachatina ventricosa* (4.21 ± 0.60%) ($P>0.05$). The fibers content of *Achatina achatina* (1.33 ± 0.12%) is lower than that of *Archachatina ventricosa* (2.62 ± 0.42%). The fat content of *Achatina achatina* (8.86 ± 0.12%) is lower than that of *Archachatina ventricosa* (14.68 ± 0.33%). On the contrary, the total carbohydrates and total sugars contents of *Achatina achatina* meat powder are higher than those of *Archachatina ventricosa*. On the other hand, the reducing sugars contents and the energy value of *Achatina achatina* are lower than those of *Archachatina ventricosa* ($P > 0.05$). Overall, values of most parameters of *Achatina achatina* are higher than those of *Archachatina ventricosa.*

Table II: Macronutrient composition of two species of edible snails from Côte d'Ivoire

Parameters	Snail gender		
	Achatina achatina	*Archachatina ventricosa*	**lue**
Humidity (%FM)	81. 43±1.13^{a}	77.72 ±0.41^{a}	0.15
Proteins (%DM)	68.65±1.38^{a}	69.31 ±1.82^{a}	0.24
Fibers (%DM)	1.33 ±0.12^{a}	2.62±0.42^{b}	0.00
Fat (%DM)	8.86 ±0.12^{a}	14.68 ±0.33^{b}	0.03
Total carb. (%DM)	17.33±1.03^{b}	9.17±0.39^{a}	0.00
Ashes (%DM)	4 .40±0.20^{a}	4.21±0.60^{a}	0.28
Sugars (%DM)	0.01±0.00^{a}	0.04±0.00^{b}	<0.00
Total sugars (%DM)	14.25± 0.07^{b}	7.01±0.09^{a}	<0.00
ED (kcal / 100g DM)	303.53±0.00^{a}	324.72±0.00^{b}	<0.00

DE: Digestible energy, FM: fresh matter; DM: Dry matter, Total carb:Total carbohydrates. The analysis of variance followed by the test of Newman-Keuls multiple comparison at 5 % threshold. On the same line, means followed by different letters a, b, *etc*. in super script are different.

Mineral composition of snail meat powder

Achatina achatina and *Archachatina ventricosa* are rich in potassium (value between 484.3 ± 28.9 mg / 100 g DM and 519.9 ± 21.81 mg / 100 g DM) and magnesium (values between 283.4 ± 17.69 mg / 100 g DM and 320.0 ± 15.94 mg / 100 g / 100 MS) As well as copper (3.52 ± 1.73 mg / 100 g DM and 1.98 ± 0, 48 mg / 100 g DM). But the calcium contents (between 1.26 ± 16.99 mg / 100 g DM and 3.66 ± 4.95 mg / 100 g DM) and iron (1.19 ± 0.15 mg / 100g DM and 7.70 ± 0.17 mg / 100 g DM) are relatively low.

Table III: Mineral composition of two species of snails

Minerals (mg/100 g DM)	**Snail genders**		
	Achatina achatina	*Archachatina ventricosa*	P value
Phosphorus	89.03± 0.02^{a}	95.09±0.04^{b}	0.04
Iron	7.70±0.17^{a}	1.19±0.15^{b}	< 0.00
Potassium	519.9±21.81^{a}	484.3±28.9^{b}	< 0.00
Magnesium	283.4±17.69^{a}	320.0±15.94^{b}	0.01
Calcium	1.26±16.99^{a}	3.66±4.95^{b}	0.00
Copper	3.52±1.73^{a}	1.98±0.48^{b}	< 0.00

The analysis of variance followed by the test of Newman-Keuls multiple comparison at 5 % threshold. On the same line, means followed by different letters a, b, *etc*. in super script are different.

Growth characteristics of rats

The results of the growth tests are illustrated in figure1. The incorporation rate of the snail meat powder increases (25%, 50%, 75% and 100%), the growth rate of rats slows down. The growth of rats consuming the snail powder is reduced compared to that of the control rats (fed on fish). Rats on the protein-deprived diet lose weight from start to finish of the experiment. The same tendency is true for the nutritional characteristics of rats subjected to snail powder diets (Table IV). The growth characteristics (Dry matter intake, body weight gain, FCR and PER) of the rats decrease when the rate of substitution of snail powder increases in the control diet (25%, 50%, 75% and 100%). From 75% incorporation rate of snail powder in the control diet (fish), the weight gain, the FCR and PER become negative (75%, 100% and private protein diet).

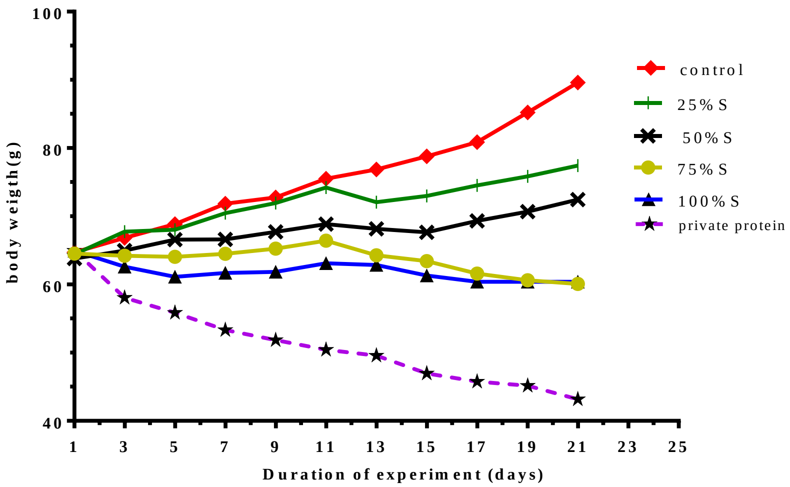

Figure 1: Evolution of the growth of rats subjected to different diets

Table IV: Average value of the growth characteristics of the rats as a function of the rate of incorporation of the snail meat in the control diet

	Diets				
Growth criteria	(100 % F) (n=6)	75 % S (n=6)	50 % S (n=6	75 % S (n=6)	100 % S (n=6)
Initial weight	64.7±4.25 ^{a}	64.4±4.17 ^{a}	63.8±3.97 ^{a}	64.5±3.73^{a}	64.9±3.76 ^{a}
Final weight	89.6±0.28^{d}	77.4±0.00^{c}	72.4±0.03^{b}	62.1±0.00^{a}	62.2±0.04^{a}
Dry matter intake (g/j)	8.02±0.01^{d}	5.34±0.00^{b}	568±0.00^{c}	5.06±0.00^{a}	5.70±0.01^{c}
Protein intake (g/j)	0.80±0,00 ^{d}	0.53±0,00 ^{b}	0.56±0,00^{c}	0.50±0,00^{a}	0.57±0,00 ^{c}
Body weight gain (g/j)	1.81±0.00^{e}	0.62±0.00^{d}	0.41±0.00^{c}	-0.08±0.00^{b}	-0.12±0.00^{a}
FCR	0.22±0,00 ^{e}	0.11±0,00 ^{d}	0.07±0.00^{c}	-0.01±0.00^{b}	-0.02±0.00^{a}
PER	2.25±0.00 ^{e}	1.17±0.00 ^{d}	0.73±0.02^{c}	-0.15±0.02^{b}	-0.22±0.00^{a}

n: number of animals; 100 % F: control diet based on 100 % fish; 25 % S, 50 % S, 75 % S 100 % S: different inclusion rate of achatina powder in the control diet (n): Number of rats per treatment. The analysis of variance followed by the test of Newman-Keuls multiple comparison at 5 % threshold. On the same line, means followed by different letters a, b, c, d, e, etc. in super script are different. FCR: Feed Conversion Ratio, PER: Protein efficiency ratio; F: fish diet; S: snail meat.

Discussion

The results of the nutrient measurements show that the snail powder has important protein content. This value is comparable to that obtained by Otchoumou *et al*. (2010). However, work carried out in Ghana (Engmann *et al.*, 2013) on *Achatina achatina* has reported protein values (82.96 ± 2.12% D.M.) higher than what is found in the present work. The protein content of snails could therefore help to resolve the thorny issue of protein malnutrition. The fat content of *Archachatina ventricosa* snail meat powder is comparable to that of Otchoumou *et al.* (2010) who found 13.43% DM in the same species.

According to Lee *et al*. (1994) and Aboua (1995), the variation in the lipid content of snail meat powder is due to its living environment and its diet. This low fat content of snail meat powder could be useful in dietary supplementation for people who are interested in calorie restriction (Chang, 1996; Fukushima *et al*., 2001; De Román, 2006). This low level of lipids in snail meat is a major asset in the fight against certain diseases such as cardiovascular diseases (Babalola *et al*., 2009). The results obtained in this work corroborate those of carried out by other authors (Offiong *et al*., 2013) who have shown that *Achatina achatina* is rich in minerals such as iron, calcium phosphorus, and magnesium. However, it turns out that *Achatina achatina* and *Archachatina ventricosa* that were used for this work do not contain enough values of calcium and phosphorus. This observation on the content of these minerals could be explained by the stage of evolution and the biotope of these species (Ebenso, 2003).

Snail meat, despite its high protein content, does not give good growth performance in rats. Indeed, the inclusion of snail meat powder in the diet of rats affects their weight growth. From 75 % inclusion, snail meat powder leads to a decrease of growth. This result is shared by Sogbesan *et al*. (2006) and Ahaotu *et al*. (2013) who formulated snail-based diets for African catfish (clarias gariepinus fingerlings) and broiler chicken, respectively, at different inclusion rates. Ahaotou *et al*. (2013) found weight loss in growing and finishing chickens when the diet contained 1.5 % and 2 % of snail meat. As for Sogbesan *et al*., inclusion of 75 % results in poor animal growth. Similarly, the work carried out by Radzki *et al*. (2017) and Bieńko *et al*. (2018), on *wistar* strain rats fed snail meat as the only protein source leads to weight loss, brittleness and low bone density. The negative growth performances are due to the low availability of certain nutrients (Maurice *et al*., 1984). According to Creswell *et al*. (1981), the weight loss in animals subjected to the diet containing snail meat is the result of an unidentified inhibitor, present in snail meat, which is the cause of the poor performance observed. Furthermore, Dreon *et al*. (2014) found that ingestion of snail egg extract by rats results in reduced growth. According to Dreon *et al*. (2014), there are chemical defenses in eggs, notably neurotoxic and anti-nutritive proteins. These proteins induce reversible changes in the intestinal wall that limit the absorption capacity of nutrients. This justifies the decline in animal’s growth.

Conclusion

Snail meat although rich in proteins, however, used as a source of protein, in the diet of rats, it does not give good growth performance from 75 % inclusion rate in fish powder. This implies a lack of certain essential nutrients or an inhibitory factor which would be present in snail meat.

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