International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

http://ijpsat.ijsht-journals.org Vol. 29 No. 2 November 2021, pp.01-11

Morphological Parameters And Assessment Of The Technological, Organoleptic And Nutritional Quality Of Giant African Snails Flesh Meat Harvested In South Benin

Ahmed Adékunlé MAMA ALI[1], Murielle VIGAN[2], Ignace DOTCHE[1], Allogbènou Frimence Sèwanou TOSSOU[3], Pascal Sègbégnon KIKI[1], Guy Apollinaire MENSAH[2], Issaka ABDOU KARIM YOUSSAO[1], Mahamadou DAHOUDA[3].

[1]Laboratory of Animal Biotechnology and Meat Technology, Department of Animal Production and Health, Polytechnic School of Abomey-Calavi, University of Abomey-Calavi, 01 BP 2009 Cotonou, Republic of Benin.

[2]National Institute for Scientific Research, Research Center of Agonkanmey (CRA / NRAB), Abomey-Calavi, Republic of Benin

[3]Faculty of Agronomic Sciences, Department of Animal Production, University of Abomey-Calavi, 01 BP 526, Cotonou, Republic of Benin.

Abstract – The snail meat is very appreciated by the Beninese population, however, its quality is not under control. This study aims to evaluate the morphological characteristics, technological, organoleptic and nutritional quality of snail meat marketed for consumption. For this purpose, 120 giant African snails (*Archachatina marginata*, *Archachatina ventricosa* and *Achatina fulica*) per species were purchased in the markets of Southern Benin and their morphology and the flesh quality were assessed. SAS software was used for statistical analyses. he results that there was a significant difference in the flesh's yield ($p<0.001$) with the highest value obtained for *Archachatina marginata*. *Achatina fulica* and *Archachatina ventricose* had the highest shell proportions ($p <0.01$). Regarding technological quality, a difference ($p <0.001$) in pH values was observed at one hour and 24 hours after slaughter in the flesh. As for the organoleptic quality, the sensory tenderness was better in the flesh of *Achatina fulica.* The flesh of *Archachatina ventricosa* had better juiciness. The flesh of *Achatina fulica* lost more water during cooking than the flesh of other species. The physicochemical and nutritional quality had little variation between species. From these results, we can conclude that, on the one hand, *Archachatina marginata* had a good yield and, on the other hand, the flesh of *Archachatina ventricosa* and *Archachatina marginata* were more tender than that of *Achatina fulica* and also *Archachatina ventricosa* was juicier so the conservation of its flesh would be easy.

Keywords – Archachatina marginata , Archachatina ventricosa, Achatina fulica, Snails, morphology, organoleptic quality, technological quality and nutritional quality, Benin.

I. INTRODUCTION

In West Africa, forest food resources provide rural households with a very large share of animal-based protein. Due to an increasing number of the population, the massive exploitation of forest resources raises questions about the continued availability of wild animals [1]. In Benin, the Giant African snails population are under enormous pressure in their natural environment as a result of the increasingly intensive collection of immature snails. Given the population growth and changes in dietary habits, the consumption of snails continues to increase year after year [1]. To do so, facing the excessive harvests in nature that varies according to natural factors (life cycle of purchasers, habitat and natural events) and socio-economic factors of the actors, an imbalance of the ecosystem is caused [2]. Giant snails are highly prized in the diet of many rural and urban West Africans [3]. Thus, in Nigeria, the consumption of *Archachatina marginata* is more accepted by the population than Achatina Achatina, which is a taboo for some tribes in the south of the country [4]. It is considered to be a form of bush meat or game meat to be consumed occasionally instead of a nutritious meat to be enjoyed daily, much like the meat of other conventional animals [5]. The meat is low in cholesterol and is a source of vital minerals necessary for normal tissue development and maintenance. It is an ideal meat for diabetics and people with vascular diseases such as heart attack, cardiac arrest, high blood pressure and stroke [6]. Snail meat is highly nutritious and has several medicinal values and economic benefits. It provides a necessary supplement for proper human growth. It is highly valued by the local African population who usually consume it cooked or fried or in the form of skewers, sold in restaurants or by street vendors [7].

In Benin, the most consumed African giant snails are *Archachatina ventricosa*, *Archachatina marginata* and *Achatina fulica*. The flesh of the giant African snail is always a delicacy. Apart from the cephalopod, the visceral mass (liver, genital gland, queen and the middle part of the intestine) is also consumed by a part of the population. The flesh is valued because of its ability to considerably reduce the risk of contracting a disease such as the gout is low. This meat is used in animal feed and in pharmacopeia [2].

Given that the consumer subjectively enjoys the snail by its size and with a very primordial acceptability of the quality of its flesh, it is propitious to determine the morphological parameters of the snails ready to be consumed and to evaluate the technological, nutritional and organoleptic characteristics of the flesh of the three species (*Archachatina ventricosa, Archachatina marginata and Achatina fulica*) found at the markets of South Benin.

II. MATERIALS AND METHODS

2.1. Study area

Morphological parameters, slaughter and sensory organoleptic quality were determined at Laboratory of Food Biotechnology and Meat Technology (LBATV) Abomey-Calavi University. The physicochemical and nutritional quality parameters were determined at the National Institute of Agricultural Research of Benin and at the Nutrition and Food Safety Laboratory.

2.2. Sampling

Three species of giant African snails (*Archachatina ventricosa, Archachatina marginata* and *Achatina fulica*) were used for the study. In all, 360 snails (120 snails per species) were purchased from markets in the Atlantic Department of Southern Benin.

2.3. Measurements of morphological parameters

The snails were identified at the shell using a corrector and each snail was attributed a number from 1 to 360. Snails shell length and shell width were taken using an electronic caliper of 1 mm precision. The snail lengths were taken from the top of the shell (apex) to the base of the opening. The shell width was measured at the widest part when the shell is oriented so that the opening facing the observer. It was measured from the side of the shell body to the outermost side of the opening.

2.4. Slaughter

The purchased snails were thoroughly washed using distilled water and stored for ten days to empty their contents to remove any poisonous substance and to refine their taste. The snails were individually weighed using a KERN electronic scale with a capacity of 220 g and the precision of 0.1 mg. After weighing, the animals were batched into basins and kept in a heated water at 60 ° C for fifteen minutes to be slaughtered. Then, the outer shell was removed and the flesh was separated from it and the rest (offals). The cleaning of the flesh was done in a 10% alum solution in order to remove the slime. One Hundred and twenty snail meat were obtained per species after shell removal.

2.5. Yield determination

The average live weight of the animal, the average weight of the raw meat, the shell, the rest (viscera, mucus and blood) were taken for each snail using a KERN electronic scale and the yield of the edible part was calculated using the following formula :

$$\textbf{Yield}=\frac{\text{Snail flesh weight}}{\text{Live weight of the snail}}$$

2.6. Measurements of technological parameters of the flesh of giant African snails

2.6.1. pH measurement

A serie of pH (pH 1 hour (pH_1), 24 hours (pH_24) and 48 hours (pH_48)) after slaughter was taken using a portable HANNA pH meter equipped with a specialized probe. This device was calibrated with two pH meter standards : pH 4.1 and pH 7.1, following a procedure described by the manufacturer (HANNA Instruments R, Italy). The pH was measured on the flesh of each snail. Half of the number of sixty giant African snails per species was used to determine the technological and organoleptic quality while the other half served as material to determine the physicochemical and nutritional parameters.

2.6.2. Colorimetry

The color was determined on the flesh of 120 slaughtered snails per species. After storing the flesh in contact with air inside the refrigerator at + 4 ° C for one and half hour, the color was determined according to the standards of the International Lighting Committee (CIE L*a*b*) after storage of the samples in contact with atmospheric air for 1h 30 mn at 4°C. L* corresponds to the luminosity, a* the red index and b* the yellow index. The saturation or chromaticity (C) and hue (h) were determined respectively according to the formulas $C = (a^{*2} + b^{*2})^{1/2}$ and h = tan-1b*/a*. For each measurement, 5 repetitions were performed on the snail flesh.

2.6.3. Water retention capacity

After color determination, the flesh of one hundred and twenty (120) snails per species were used to determine the water retention capacity. Each flesh was hooked and hung in a plastic bag without touching its bottom. After being stored for 48 hours in the refrigerator (4-5 ° C), the sample was taken out of the bag without touching the bottom that contained the drained water and was weighed after slightly wiping it. In this way, the juice loss, a factor in the juiciness of the meat, was determined. Then, each meat was put in a plastic bag that was tightly sealed to avoid direct contact with water during cooking. Snails cooking was carried out in a water bath at 70 ± 0.5 ° C for 60 minutes. After cooking, each snail was cooled under running water for 45 minutes. Each slice was taken out of the bag and weighed after lightly wiping it. The difference in weight before and after cooking gave the water loss during cooking and was expressed as a percentage. The water-holding capacity was the sum of losses due to flow and cooking.

2.7. Measurements of organoleptic parameters of the giant African snails flesh

The organoleptic parameters evaluated were tenderness, juiciness and flavor. Sixty (60) snails per species were used to assess these parameters. This evaluation was done by a jury of 10 randomly selected people. Each judge assesses the organoleptic quality of the meat and gave a score to each piece during a tasting session. The tasting was done on hot snail cuts. Each judge received six homologous pieces of snail meat on a plate, two by two of each species of snail, and filled out a tasting results form. Ratings ranged from 1 to 5. For tenderness, 1 corresponded to very hard, 2 to hard, 3 to acceptable, 4 to tender and 5 to very tender. As for juiciness, 1 corresponded to very dry, 2 to dry, 3 to acceptable, 4 to soft and 5 to very soft. Finally, the intensity of the flavor was very weak for (1), weak for (2), acceptable (3), strong for (4) and very strong for (5).

2.8. Measurements of the nutritional parameters of the flesh of giant African snails

2.8.1. Dry matter

The determination of the dry matter (DM) was made according to the AOAC standard [8]. The meat was dried to 105 ° C in a ventilated oven for 72 hours until a constant weight was obtained.

2.8.2. Total ash

The samples were weighed and incinerated in a muffle furnace at 550 ° C for 24 hours. They are weighed again after cooling in a desiccator. TCs (total ash) was determined as follows:

Total ash (%) = (Weight of crucible after calcination (g) -Weight of empty crucible (g)) / (Weight of crucible after drying (g) -Weight of empty crucible (g))

The organic matter (OM) content was deduced from the formula:

Organic matter (%) = 100 -Total ash (%)

2.8.3. Mineral salts (Ca, Fe, Mg, N)

The ash obtained was dissolved in 2cc of HCl, 6N which was evaporated on the hot plate at 125 ° C. The more or less viscous residue was dissolved again and collected using 0.1M HNO3 in a 100cc flask. The resulting solution was used to determine metals by atomic absorption spectrometry (AAS). The analyzes were made according to the NF standard in 14082 of June 2003

2.8.4. Proteins.

The total nitrogenous matter (TNM) was determined by the KJELDAHL method according to formula 1. The organic nitrogen of the sample to be analyzed was transformed into mineral nitrogen in the ammoniacal form $(NH4)_2SO_4$- thanks to the oxidizing action of concentrated sulfuric acid (12 ml per sample) in the presence of a Kjeldahl catalyst pellet. Mineralization was carried out using a digester at 420 ° C for three hours. After displacement using sodium hydroxide (strong base added in excess), ammonia was distilled and then titrated in the presence of a colored reagent (boric acid) by acidimetry. Distillation was carried out in the Büchi K 314 distillation unit. The nitrogen content was generated by formula 2.

Formula 1: %TNM=(%P) / (%ADM) ×100

Formula 2: %N (nitrogen)= (0,014×0,1 (V2-V1)) / PE×100

With :

- V2 = volume of HCl from which the indicator turns from green to pink ;
- V1 = volume of HCl used for the blank assay ;
- 0.1 = hydrochloric acid titer ;
- 0.014 = molar weight of nitrogen * 10^{-3}.

TNM : Total nitrogenous matter

ADM : Analytical dry matter

The total protein content was calculated by multiplying the amount of nitrogen by a conversion factor (6.25) or 16% nitrogen in the protein. Finally, the proportion of proteins contained in the Dry Matter (DM) was deduced.

2.8.5. Energy

The assay method was the manipulation of the oxygen bomb 1108. The sample to be assayed was placed in a calorimetric bucket which was previously filled with distilled water (2000 ± 0.5 g) with a temperature of around 1.5 °C. The bucket was then placed in the calorimeter and its clamp was hooked into the holes in the bomb and then was dipped in water. After manipulating the apparatus, the energy was determined as a result of a difference between the energy obtained at the lower temperature and that obtained at the higher temperature. All of these analyses to determine the chemical composition of food ingredients were made on the basis of official [8] approved methods.

2.9. Statistical analysis

The data collected were recorded in a database designed on Excel and analyzed using [9]. The analysis of variance was performed considering the species (*Archachatina marginata, Archachatina ventricosa and Achatina fulica*) as the source of variation and Fisher's exact test clarified the significance of this factor on the variables studied. The means of these parameters were calculated and compared between paired by the t-test.

III. Results

3.1. Morphological parameters of giant African snails

The shell length and width of the three different species are listed in Table 1. The average shell length of snails sold, and ready for consumption did not vary among species. In contrast, the shell width of *Archachatina ventricosa* was greater (p <0.001) than that of *Archachatina marginata* and *Achatina fulica*. Similarly, *Archachatina marginata* had a larger shell width (p <0.001) than that of *Achatina fulica*.

Table 1 : The morphological parameters of the different species studied.

Variables	*A. marginata*		*A. ventricosa*		*A. fulica*		Significance test
	Average	**SD**	**Average**	**SD**	**Average**	**SD**	
Shell length (mm)	98,10	11,28	96,78	5,71	97,11	9,00	NS
Shell width (mm)	54,50 b	5,86	56,12 a	3,76	48,60 c	3,27	***

*** : p<0,001; NS : not significant ; DS : SD : Standard Deviation ; mm : millimeter ; a b c The means on the same line followed by different letters differ significantly at the threshold of %.

3.2. Weight and components characteristics of the giant African snail

The table 2 presented below shows the mean weight of the snail species as well as the means of each component of the snail per species. For snails ready for consumption, a significant difference (p <0.001) was observed in the average weight recorded for all the snail species with *Archachatina marginata* having the highest average weight followed by *Archachatina ventricosa* which in turn had higher average weight than *Achatina fulica*. Undoubtedly, similar results were observed for the values of the flesh and shell weights with *Archachatina marginata* fleshiest and more shelleier than *Archachatina ventricosa* and lastly *Achatina fulica, less fleshy and less shelleier*.. However, for the average weight of the remainder (viscera), it was higher in *Archachatina ventricosa* than in *Archachatina marginata* and lastly *Achatina fulica*. The differences observed are significant at the 1% level. In terms of yield, *Archachatina marginata* had the best while achatina fulica showed the lowest yield.

Table 2 : Average weight of snails and the weight of each snail component by species.

Variables	*A. marginata*		*A. ventricosa*		*A. fulica*		Significance test
	Average	**SD**	**Average**	**SD**	**Average**	**SD**	
Live weight (g)	84,32 a	26,71	78,11 b	14,05	62.16 c	17.51	***
Weight of flesh (g)	17,18 a	5,65	15,20 b	4,51	11,98 c	3,98	***
Shell weight (g)	26,34 a	10,18	18,11 b	5,06	14,33 c	5,65	***
Weight of the rest (g)	40,79 a	14,19	44,80 b	10,49	35,86 c	11,33	***
Yield(%)	20,54 a	3,50	19,45 b	4,45	19,52 b	4,53	*

* : p<0,05 ; *** : p<0,001; SD : Standard Deviation, g : gram, % : percentage ; a b c The means on the same line followed by different letters differ significantly at the threshold of %.

3.3. Technological quality of snail meat according to species

The technological parameters of the different species of African giant snails studied are summarized in Table 3. For the values of hydrogen potentials (pH_1 and pH_24) obtained, *Archachatina marginata* has the highest values followed respectively by *Archachatina ventricosa* and *Achatina fulica* at the threshold of 0.001. The percentage of water loss in *Achatina fulica* was higher than the percentage of water loss of *Archachatina ventricosa* and *Archachatina marginata* at the 0.05 threshold. The species Archachatina ventricosa and Achatina fulica have a better percentage of water loss during cooking than *Archachatina marginata* at the 0.001 threshold. Similarly, *Archachatina ventricosa* had the highest percentage of water holding capacity compared to the percentage of water holding capacity of *Archachatina marginata* and *Achatina fulica*.

Table 3: The average of technological quality parameters according to species.

Variables	*A. marginata*		*A. ventricosa*		*A. fulica*		Significance test
	Average	SD	Average	SD	Average	SD	
pH_1	7.84a	0.39	7.60b	0.50	6.94 c	0.90	***
pH_24	8.43a	0.40	8.35a	0.28	8.11 b	0.66	***
pH_48	8.52 a	0.91	8.42 a	0.24	8.30 a	0.57	NS
Sewer water loss (%)	6.12 b	1.67	4.13 b	5.26	7.19 a	1.31	*
Loss of water during cooking (%)	19.35 b	4.18	28.16 a	4.04	29.56 a	5.39	***
Water retention capacity (%)	4.52 b	4.30	5.75 a	1.37	4.85 b	1.70	*

* : p<0.05 ; *** : p<0.001; NS : not significant (p>0.05) ; SD : Standard Deviation ; % : percentage ; a b c The means on the same line followed by different letters differ significantly at the threshold of %.

3.4. Organoleptic quality of the snail meat

The Table 4 summarizes the average of the organoleptic parameters of the snail meat according to species. There was a significant difference (p<0.05) in the values of the brightness index (L *) with *Archachatina ventricosa* having the highest brightness index value. Similarly, a significance difference (p<0.01) was observed for the red index (a *) of the flesh of *Achatina fulica* and *Archachatina ventricosa* compared to the flesh of *Archachatina marginata*. The yellow index (b *) of the flesh of *Achatina fulica* and *Archachatina ventricosa* was higher than the index (b *) of the flesh of *Archachatina marginata* with the significance of 0.05.

From a sensory point of view, no difference was recorded in the flesh of the three species studied with regard to flavor and acceptability. However, the flesh of *Achatina fulica* had better tenderness than that the flesh of *Archachatina marginata* and *Archachatina ventricosa* with the significance of 0.05. In addition, the flesh of Archachatina ventricosa and Achatina fulica were juicier than the one of *Archachatina marginata* at the threshold of 0.05.

Table 4 : Average of the organoleptic parameters according to species.

Variables	*A. marginata*		*A. ventricosa*		*A. fulica*		Significance test
	Mean	SD	Mean	SD	Mean	SD	
L*	29,50 b	7,73	43,17 a	73,29	33,75 b	6,77	*
a*	2,20 b	1,44	2,87 a	1,67	2,86 a	0,99	**
b*	6,79 b	2,67	9,84 a	2,08	11,56 a	20,87	*
Tenderness	3,30 b	0,67	3,40 b	0,97	4,30 a	0,82	*
Juiciness	2,70 b	0,82	3,50 a	0,53	3,40 ab	1,07	*
Flavor	3,40 a	0,84	3,50 a	0,85	3,10 a	1,10	NS
Acceptability	6,20 a	0,92	7,10 a	1,10	6,00 a	1,25	NS

* : p<0,05; **: p<0,01; NS : not significant (p<0.05); SD : Standard Deviation; a b c The means on the same line followed by different letters differ significantly at the threshold of %.

3.5. Nutritional qualities of giant African snail meat

The average of the physicochemical and nutritional parameters of the three species (*Archachatina marginata*, *Archachatina ventricosa* and *Achatina fulica*) is shown in Table 5. Nine variables were analyzed for the case of this study. However, only the meat composition in calcium showed significant difference (p<0.05) with the meat of *Archachatina marginata* and *Archachatina ventricosa* richer in calcium (p <0.05) than that of *Achatina fulica*. No difference was observed between the other physicochemical parameters of the species studied.

Table 5 : Average parameters of the physicochemical and nutritional composition of the snail by species.

Variables	*A. fulica*		*A. marginata*		*A. ventricosa*		All species		Significance Test
	Average	SD	Average	SD	Average	SD	Average	SD	
Mg (mg/kg)	31,96	11,04	40,84	5,05	41,98	22,02	37,96	14,01	NS
Fe (mg/kg)	83,65	0,55	90,02	52,36	108,24	111,84	93,97	65,56	NS
Ca (mg/kg)	79,05b	29,30	118,84a	20,26	114,12a	73,58	104,04	46,01	*
N (%)	10,26	0,98	10,07	0,25	9,9	2,37	10,08	1,35	NS
Total Ash (%)	7,49	1,03	6,94	0,81	5,71	0,84	6,71	1,13	NS
Dry Matter (%)	32,42	4,02	31,6	1,35	29,09	1,44	31,04	2,77	NS
Humidity (%)	67,58	4,02	68,39	1,35	70,91	1,44	68,96	2,77	NS
Protein (%)	64,11	6,2	62,99	1,57	61,89	14,85	62,99	8,5	4NS
Energy (kcal/kg)	4599,92	241,7	4777,88	8,49	4719	71,92	4699	152,77	NS

* : p<0.05 ; NS : not significant ; SD : Standard Deviation ; % : percentage.

IV. Discussion

4.1. Morphological and weight characteristics

In the giant African snail, the development of the shell rests on a growth organ located in the parietal part of the pallial ridge straddling the labrum. Shell growth is conditioned by the development of soft tissues [10]. In our study, purchases were made according to the size of the snails ready to be consumed by species. Thus, the average shell length recorded in *Archachatina marginata* was 98.10 ± 11.28 mm. These results corroborates those obtained by [11] where snails were reared in a natural environment. On the other hand, Ogbolo *et al.* [12], after evaluating the effect of protein level variation on the zootechnical performance of *Archachatina marginata*, found a longer shell length (118.40 mm) . The average width of the species in this study was 54.50 mm. This was confirmed by [13] after feeding *Archachatina marginata* with several sources of nitrogen. On the other hand, Ogbolo *et al.* [12] evaluated the effect of the variation in protein level on the zootechnical performance of *Archachatina marginata* and found a higher average shell width (78.60 mm). These differences may be due to the diets composed of other raw materials, in addition to Mineral Vitamin Concentrates and fish meal, which are well valued by the snails

Archachatina ventricosa species had an average shell length of 96.78 ± 5.71 mm. This result corroborates the findings of [14] in *Archachatina ventricosa* reared above ground for 48 weeks on rearing substrates. In *Archachatina ventricosa*, the average width obtained for this study was 56.12 mm.

For this study, *Achatina fulica* species have an average shell's length of 97.11 ± 9.00 mm and 48,60 mm of shell's width. This length was higher than that obtained by [15] in *Achatina fulica* (49.4 mm) that fed on the leaves of *Carica papaya*, *Moringa oleifera* and *Talinum triangulare*. In contrary, the shell's width value obtained was less than the one obtained by [16] in *Achatina fulica* which fed on the basis of the vernonia leaves, fluted pumpkins and papaya. The difference in the values of shell's width might be explained by the controlled nutrition provided. As shown by [16], the shell development is better in raised snails than in harvested snails. So, feeding plays a crucial role in shell growth.

As previously stated, Archachatina marginata species were heavier than the other two species. These results are in accordance with those obtained by [3] who found that Archachatina *marginata* had a higher average weight than *Archachatina ventricosa* after six (6) months of rearing. The growth of the giant African snail was related to the species.

4.2. Characteristics of the flesh of the African giant snail

The results of this study showed that *Archachatina marginata* had better yield than *Archachatina ventricosa* and *Achatina fulica*. This result was confirmed by [17] who found that the yield of *Archachatina marginata* was higher than the yield of *Achatina Achatina* and *Achatina fulica*. However, the higher the yield, the lower the percentage of viscera.

4.3. Technological and organoleptic quality

One hour after slaughter, the pH was below 7 in *Achatina fulica*. Compared to the other two species (*Archachatina marginata*, *Archachatina ventricosa*), it was above 7. It is basic after 24 and 48 hours for the three species studied with a highly significant difference ($p < 0.001$) after 24 h for *Archachatina marginata* and *Archachatina ventricosa*. Similar results were obtained by [18] who found that the pH varied according to the percentage of salt in the water used to treat the meat of the giant African snails (*Archachatina marginata*) and the meat preservation. Twenty-four (24h) hours after slaughter, the pH varied between 5.40 and 7.75. This pH was higher for flesh treated with water containing 30% salt. Also, Apata *et al.* [17] found a pH lower than the pH obtained in our study and varying between 6.02 and 6.20 in *Achatina spp*. As for the water retention capacity, it varied from 4.52% to 5.75% with a significant difference ($p < 0.05$) in favor of *Archachatina ventricosa*. These results were much lower than those obtained by [17] after evaluating the physicochemical and organoleptic quality of *Achatina spp* which fed paw-paw leaves and water In regards to the brightness, the red and the yellow index, the results do not corroborate with those obtained by [17] who found that *Achatina fulica* had a better color compared to *Archachatina margianata*. From a sensory point of view, the flesh of *Achatina fulica* (4.30) was more tender ($p < 0.05$) than that of *Archachatina marginata* (3.30) and *Archachatina ventricosa* (3.40). These results were close to those obtained by [19] in *Archachatina marginata* that fed in natural environment. On the other hand, they are unlike those obtained by ([20],[17]) who obtained better sensory tenderness in *Archachatina marginata* despite the fact that the first authors fed with papaya leaves or lettuce or lettuce and cabbage waste and the second bought the snails in the markets. This could be explained by the fact that food has an impact on the sensory tenderness of the snail meat. As for the juiciness, it was better in *Archachatina* *ventricosa* (3.50). These results were contrary to those obtained by [17] in which juiciness was better in *Archachatina marginata*. At the end of our study, we noted acceptability with a score ranging from 6 to 7.20 without any difference between species. On the other hand, [17] found *Achatina fulica* to be more acceptable than *Archachatina marginata* and *Achatina Achatina*.

4.4. Physicochemical and nutritional quality

All species combined, the dry matter (DM) rate was 31.04% against 68.96% for humidity rate (H). These results corroborate those (DM : 20.33% and H : 79.67) obtained by [21] and were contrary to those (DM: 90.6% and H: 9.4%) obtained by [22].Trace elements obtained in the flesh of snails from the dry matter were: magnesium, iron, calcium, nitrogen and total ash. The proportions of magnesium from this study ranging from 31.96 and 41.98 mg / kg% corroborate with the results obtained by [23] who subjected *Archachatina marginata* to several diets containing different sources of protein in the wild. The proportions of total ash obtained were 7.49%, 6.94% and 5.71% respectively in *Achatina fulica*, *Archachatina marginata* and *Archachatina ventricosa*. These results were in agreement with those obtained (8.53%) by [24] and much higher than those obtained (1.14%) by [17]. Iron is the most important trace element in the flesh of giant African snails. This trace element is 83 mg / kg, 90.02 mg / kg and 108.24 mg / kg respectively in *Achatina fulica*, *Archachatina marginata* and *Archachatina ventricosa* without any significant difference. These results are consistent with those obtained by [25] and significantly superior to those obtained by [26]. On the other hand, Akinnusi *et al.* [27] showed that calcium and magnesium are the most found trace elements in *Archachatina marginata* in Nigeria. The snail flesh is low in nitrogen. The nitrogen rate for the three species combined was 10.08 ± 1.35%. However, snails contain 62.99 ± 8.5% protein in dry matter. This is consistent with that obtained by [5] who proved that the meat of the African giant snail (*Archachatina marginata*) contains more protein than the meat of beef, rabbit and chicken in [23]. Also, a study made by [24] proved that not only snails have high protein content but also this protein content obtained is higher than that obtained in fish.

V. Conclusion

This study showed that a snail which has a low visceral weight has better yield. Also, the technological and organoleptic quality of the flesh of giant African snails varies depending on the species. However (i): On the sensory level, the flesh of *Archachatina ventricosa* and *Archachatina marginata* was more tender than that of *Achatina fulica*; (ii): *Archachatina ventricosa* was juicier than the other species; (iii) the three species studied had the same flavor and they were all accepted by consumers. Indeed, the physicochemical composition determined in dry matter consisted of magnesium, iron, nitrogen and total ash without any significant difference in the level of the flesh of the three species studied. But *Achatina fulica* was richer in calcium than the other species studied here. Finally, the protein and energy concentrations were similar among species.

References

[1] Bouye TR, Atchibri LAO-A, Karamoko M, Otchoumou A. Étude de la croissance d'un escargot géant africain comestible: Achatina achatina (Linné, 1758), élevé sur du substrat amendé à la poudre de coquilles d'escargot. J Appl Biosci 2017;109:10630–9.

[2] Sodjinou E, Biaou G, Codjia JC. Caractérisation du marché des escargots géants africains (achatines) dans les départements de l'Atlantique et du littoral au Sud-Bénin. Tropicultura 2002;20:83–8.

[3] Kouassi KD, Karamoko M, Mémel JD. Etude comparative de la croissance des principales espèces d'escargots géants comestibles d'Afrique. Rev CAMES 2010;Serie A 11:80–4.

[4] Uboh FE, Ebong PE, Mbi E. Cultural discrimination in the Consumption of black snail (Archachatina marginata) and white snail (Achatina achatina); any scientific justification? Int Res J Microbiol 2010;1:13–7.

[5] Malik AA, Aremu A, Bayode GB, Ibrahim BA. A nutritional and organoleptic assessment of the meat of the giant African land snail (Archachatina maginata swaison) compared to the meat of other livestock. Livest Res Rural Dev 2011;23:60.

[6] Abere SA, Lameed GA. The medicinal utilization of snails in some selected states in Nigeria. Proceeding the1st Natl. Conf. For. For. Prod. Soc. Akure, Ondo State Niger., 2008, p. 233–7.

[7] Memel JD, Karamoko M, Amani S-CN, Koumé KE, Otchoumou A. Manipulation des escargots dans trois zones de commercialisation d'Abidjan: Conséquences sur leur survie et apport de solutions pour une meilleure conservation. Geo Eco Trop 2017;41:67–76.

[8] AOAC. Official methods of analysis of the Association of Official Analytical Chemists, 15th ed., Association of Official Analytical Chemists, Arlington VA. 1990.

[9] SAS. Base SAS® 9.4 Procedures Guide: Statistical Procedures, Second Edition. 2013.

[10] Stiévenart C. Morphologie coquillière, croissance, reproduction et estivation chez les escargots géants africains: observations au laboratoire sur Archachatina marginata suturalis, Achatina achatina et Achatina fulica. TROPICULTURA 1997;15:217–9.

[11] Kouadio EJP, Konan KH, Brou K, Dabonné S, Dué AE, Kouamé LP. Studies of some parameters of growth and nutritive values of snail Archachatina marginata (Swaison) bred in natural environment. Tropicultura 2015;33:38–45.

[12] Ogbolo E, Toukourou Y, Worogo HSS, Assogba BGC, Traore IA. Effet de la variation du niveau en protéine sur les performances zootechniques de l'escargot Archachatina marginata (Swainson, 1821) et la morphologie des naissains en élevage hors-sol au nord-Bénin. Afrique Sci 2019;15:1–10.

[13] Ademolu KO, Idowu AB, Mafiana CF, Osinowo OA. Performance, proximate and mineral analyses of African giant land snail (Archachatina marginata) fed different nitrogen sources. African J Biotechnol 2004;3:412–7.

[14] Kouassi KD, Otchoumou A, Dosso H. Les escargots comestibles de Côte d'Ivoire: influence de substrats d'élevage sur les paramètres de croissance de Archachatina ventricosa (Gould, 1850) en élevage hors sol. Tropicultura 2007;25:16–20.

[15] Chinedu MT, Joseph OJ, Nwogor UA, Chukwuemeka NM, Nwamaka IK. Preliminary investigation of the influence of housing types on reproductive characteristics of snail (Achatina achatina). Am J Biosci 2013;1:54–8.

[16] Amobi MI, Ezewudo BI, Okpoko VO, Ugokwe CU, Okereke HN. Effects of three leafy vegetables on the growth performance of Giant African Snail Achatina (Lissachatina) fulica. J Agric Rural Dev Trop Subtrop 2019;120:15–20.

[17] Apata ES, Falola AR, Sanwo SK, Adeyemi KO, Okeowo TA. Physicochemical and organoleptic evaluation of African giant land snails (Achatina spp.) meat. Foot 2015;23:32-46a.

[18] Okonkwo TO, Anyaene LU. Meat yield and the effects of curing on the characteristics of snail meat. Agro-Science 2009;8.

[19] Adeola AJ, Adeyemo AI, Ogunjobi JA, Alaye SA, Adelakun KM. Effect of natural and concentrate diets on proximate composition and sensory properties of Giant Land Snail (Archachatina marginata) meat. J Appl Sci Environ Sanit 2010;5:185–9.

[20] Omolara BO, Olaleye AA. Performance, carcass analysis and sensory evaluation of cooked meat of snailets of African giant land snail (Archachatina marginata) fed pawpaw leaves, whole lettuce, lettuce waste and cabbage waste as sole feed ingredient. African J Agric Res 2010;5:2386–91.

[21] Bamidele JA, Ademolu KO, Idowu AB, Aladesida AA, Oladele AO. Biochemical and Nutritional Composition of Giant African Land Snail (Archachatina marginata) from Southwest Nigeria. Pertanika J Trop Agric Sci 2018;41.

[22] Kana JR, Tchakounte FM, Chekam CPM. Effets du régime alimentaire sur la croissance et la valeur nutritive de la viande d'escargots géants africains Archatina marginata. Livest Res Rural Dev 2018;30.

[23] Emelue GU, Dododawa Z. Nutritional composition of african giant land snail (Archachatina marginata) fed on diet from different protein sources. J Agric Ecol Res Int 2017:1–7.

[24] Olorunfemi MF, Olagbaju AR, Umanah JT, Oyelakin MO, Awoite TM, Sanu FT, et al. Quality assessment of processed and packaged garnished Clarias gariepinus and Archachatina marginata(Swainson) Snacks. Int J Adv Agric Rsearch 2014;2:41–7.

[25] Ghosh S, Jung C, Meyer-Rochow VB. Snail farming: an Indian perspective of a potential tool for food security. Ann Aquac Res 2016;3:1–6.

[26] Kehinde AS, Babatunde TO, Kehinde OJ. Effect of Cassava Peel Based Diets on Performance and Meat Quality of Snail (Archachatina marginata Swainson). J Exp Agric Int 2019:1–7.

[27] Akinnusi FAO, Oni OO, Ademolu KO. Mineral composition of giant African land snail's (Archachatina marginata) shells from six south West States, Nigeria. Niger J Anim Sci 2018;20:485–9.