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Performance and flesh quality of giant African snails (*Archachatina marginata)* fed different diets containing fishmeal, vitamin mineral concentrate (VMC) and palm kernel cake

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Abstract

The lack of knowledge on the zootechnical performances and meat technological quality of farm animals is an obstacle to their breeding development. This study aimed at assessing the growing performances and flesh quality of giant African snails (*Archachatina marginata*) fed diets containing fishmeal and Vitamin Mineral Concentrate (VMC). The experiment was carried out at NGO Bouge farm in the south of Benin (Allada). In all, 150 giant African snails were randomly divided into three homogenous groups (group 1, group 2 and group 3) and fed on three concentrated mash diets, containing fishmeal + VMC (diet1); without fishmeal, VMC and palm kernel cake (diet 2) and that of the control group, containing only palm kernel cake (diet 3). Snail's weight, shell length and width were recorded every two weeks. After slaughter, shell, flesh and the rest (offal and viscera) were also weighed and their yields determined. The study revealed that the snail shell length and width were significantly higher for group 1 snails than the over groups at the end of the experiment ($p<0, 05$). No significant difference was observed in the mortality rate between the three groups. The live weight did not vary from one group to another ($p>0, 05$). The flesh yields were higher in group 1 (25.16%) than group 2 (23.71%) and group 3 (23.23%) ($p<0, 05$). The pH values were higher one hour (7, 44) and 24 hours (6, 29) after slaughter. The incorporation of fishmeal and Vitamin Mineral Concentrate in the snails' diet did not induce mortality but on the contrary, allowed normal growth.

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Introduction

The small animals' sector promotion plays an important role in Sub-Saharan countries such as Benin. This sector also contributes to the food and nutritional security of the population. Therefore, in Sub-Saharan Africa, forest food resources provide rural households a very large proportion of animal proteins. The giant African snail flesh is consumed worldwide by humans since prehistoric times and remains meat highly prized by European, American and West African populations (Sika *et al.*, 2015). The snail flesh is an important source of protein and provides a necessary complement to good human growth (Memel *et al.*, 2017). It is an important source of protein, amino acids (lysine, phenylalanine and leucine), energy and minerals (Mensah *et al.*, 2017). Snail flesh in particular that of *Archachatina marginata* species, with a protein content of 33.7% to 43.7%, is one of the most nutritious animal proteins (Kana *et al.*, 2018). That is why several studies have been carried out to improve its production. Thus, Ogbolo *et al.* (2019) showed that the giant African snail (*Archachatina marginata*) is appreciated for its flavor and nutritional quality (richness in essential amino acids). However, the high exploitation of the forest resources by the growing populations raises questions about the continued availability of animal resources such as giant African snails of which picking jeopardizes the species survival and creates an imbalance in nature (Bouye *et al.*, 2017). These last years, drastic deforestation was observed and is becoming a limiting factor to snail picking (Ademolu *et al.*, 2004). Therefore, their presence in the various markets is becoming scarce due to the destruction and the constant aggression of their natural biotope (Kouassi *et al.*, 2010). Because of this long-standing situation, some sub-region countries have promoted the breeding of unconventional species such as grass-cutter and snail (Otchoumou *et al.*, 2005). According to Sodjinou *et al.* (2002), achatina meat is consumed as much as grass-cutter, chicken, sheep or goats, beef and pork in South-Benin. The breeding of giant African snail species was initiated to meet the populations' needs in this consumed and marketed flesh. These snails received a food diet composed exclusively of wild and cultivated plants. But this food diet did not allow their rapid growth (Uboh *et al.*, 2010). It is, therefore, necessary to improve the snails' growth performances in confinement reared conditions and fed on a balanced diet. Improved snails reared can permit the restocking of this seriously endangered species to improve animal protein availability in Benin. Thus, the objective of this study was to evaluate growth performances and flesh technological quality of giant African snails (*Archachatina marginata*) reared in Benin.

Methodology

Study area and experimental design

The growth study was carried out at the NGO Bouge farm in Sékou (Allada, Republic of Benin). Snails were raised under covered pens (surface: 1 m^2 and depth: 0.5 meters). The average monthly temperature and relative humidity in the livestock building (Fig. 1) were respectively 30.01 ± 0.5° C and 66.89 ± 1.4%. The photoperiod was 24 hours of light.

In all, 150 snails five months age fed on banana and papaya leaves were selected from NGO Bouge reproducers. Three groups were fed on different diets and snail weights were not different significantly at the beginning of the experiment. Each group contained 50 snails equally divided into two pens. The snails were raised in pens watered twice daily (morning and evening) to maintain favourable humidity to their survival. The pens were surrounded by a pit containing water to prevent predators (magnetic ants, termites and others) entry. At the experiment beginning, snails were numbered from 1 to 150 using varnish.

Feeding and measurements

Diets' centesimal composition and price per kilogram and their nutritional values are given in Table 1. The feeds were formulated in Excel using a feed formulation program by minimizing prices and adjusting the supply of the required needs for the growing period. The raw materials were weighed and ground together using a mill with a hammer mill, meshes and a mixer allowing elements judicious

mixing. Animals were fed *ad libitum* with mash balanced diets and feed was served once at 6 p.m. every 48 hours. The feeds were mixed proportionally with water and weighed before being served to the snails. The leftovers feed was weighed every 48 hours for feed intake calculation.

Group 3 (control batch) received a control diet usually used on the farm. The group 1 snail was given a diet containing 1% of Vitamin Mineral Concentrate (VMC) and 5% of fishmeal while those of group 2 received a diet without VMC and fish meal.

The shell length and width of each snail were taken using an electronic caliper (1 mm of precision). The snails' length was taken between apex and peristome while the width was taken at the growth line level. The individual weight of growing snails was recorded every two weeks using a Scale balance weighting 220 g.

Slaughtering

After washing with distilled water, snails were slaughtered following different hibernation times (times: 0_hour (T0), 12_hours (T12), 24_hours (T24), 48_hours (T48). Snails and different components such as shells, flesh and rest, were weighed using the same balance Scale balance weighting 220 g. The slaughtering was performed by piercing the shell at the apex level using clean shaft steel and then the shell coat was unstuck. The flesh was removed and separated from the viscera with a knife and was then washed in 1% alum solution to eliminate slime. Shell and flesh were systematically weighed and viscera weight was obtained by subtracting shell and flesh weights from that of the snail. The flesh yield was calculated using the formula:

$$\text{Flesh yield} = \frac{\text{Flesh weight}}{\text{Live weight}} * 100$$

Measurements of quality traits of Archachatina marginata flesh

The pH at 1 hour, 24 hours and 48 hours was taken according to hibernation time (T0, T12, T24, T48) on 140 snail flesh using a calibrated portable pH-meter HANNA brand provides with specialised probe. The Water Holding Capacity (WHC) was determined after storage flesh in the fridge for 48 hours and putting it in a bain-marie at 70 ± 0,5 °C for 60 minutes. The flesh was then chilled under water for 15 minutes. The cooking loss was obtained by the difference between weights before and after cooking. The Water Holding Capacity was the sum of drip losses and cooking losses.

Statistical analysis

The Statistical Analysis System (SAS) 2013 software was used for data analysis. Shell length, shell width, live weight at slaughter, feed intakes, flesh weight, rest weight, pH at 1 hour (pH1), at 24 h (pH24) and 48 h (pH48) after slaughter were first registered. The analysis of variance was performed using the Generalised Linear Models (GLM) procedure and the group was the variation source. The significant difference was determined by the F test. The means were compared by the Student's t-test.

Results

Feed intakes

The daily feed intakes of by snail according to the diet were 1.71 g ± 0.41; 1.58 g ± 0.40 and 1.65 g ± 0.38 respectively for the groups 1, 2 and 3 (Table 2). Values didn't vary significantly by diet (p>0, 05).

Mortality rate

The global mortality rate was 9.33%. The mortality rates were 6% and 10% for snails respectively fed on with or without fishmeal and VMC with no statistically significant difference. Meanwhile, it was 12 % for the control group (Table 3). No significant difference was observed in the mortality rate between the three groups of *Archachatina marginata* each receiving a diet.

Shell length growth

During the fourteen weeks of the trial, the average length varied from 72.33 mm to 80.24 mm for group 1, from 72.85 mm to 76.53 mm for group 2 and from 72.67 mm to 76.68 mm for group 3 (Table 4).

Table 1. Centesimal composition of experimental diets.

Raw materials	Diet 1 (%)	Diet 2 (%)	Diet 3 (%)
Centesimal composition			
Maize bran	28.5	30	-
Wheat bran	24	24	23
Palm kernel meal	-	-	21
Soybean meal	26.5	30	31
Fishmeal	5	-	-
Oyster shell	15	16	25
Vitamin Mineral Concentrate	1	-	-
Total	100	100	100
Price per kilogram (Fcfa)*	210	200	195
Chemical composition			
Metabolizable Energy (kcal/kg)	2276.9	2240	2113.8
Crude protein (%)	20.45	20.34	20.49
P (%)	0.67	0.54	0.57
F (%)	2.58	2.44	3.10
Cal (%)	6.22	6.34	9.67
CF (%)	7.6	8.01	7.90

P: Phosphorus; F: Fat; Cal: Calcium; CF: Crude Fiber

*1 Fcfa = 0, 0018 USD.

The lengths were similar except at the 14th week when it was higher in snails in group 1 than in those of the other groups ($p<0.05$).

Shell width growth

Table 5 presents the average width of the snail shells according to the diet. The average width varied from 38.51 mm to 56.86 mm in group 1, from 38 mm to 55.09 mm in group 2 and from 39.52 mm to 55.26 mm in group 3.

The shell width was higher in snails of group 2 at the trial beginning and in those of group 1 at the 14th week than in snails of the other groups ($p<0.05$).

Table 2. Snail feed intakes (g) and feed prices per group.

Variable	Diets			Significance test
	Group 1	Group 2	Group 3	
Feed intakes (g/d/snail)	1.71± 0.41	1.58±0.40	1.65±0.38	NS
Feed prices (FCFA/kg)	210	200	195	NS

NS: Not significant.

Snail weights

Table 6 presents snails' average weights per group. The average weight was similar in the three groups and varied from 64.30 g to 74.74 g for group 1, from 64.73 g to 73.49 g for group 2 and from 68.02 g to 77.13 g for group 3. Snail weight did not vary from one group to another, however, it tended to be higher for group 3 animals ($p>0, 05$).

Table 3. The mortality rate of *Archachatina marginata*.

Group	Number	Dead	Rate (%)	Significance test
1	50	3	6	
2	50	5	10	NS
3	50	6	12	

NS: Non-significant.

Snail components yield

The weight of the different parts of the snails' body and the flesh yield are presented in Table 7. The shell average weight was 19.78 g; 20.46 g and 23.39 g respectively for groups 1, 2 and 3. Group 3 snail had the highest shell weight ($p<0.01$), but the flesh weight and the rest weight were similar between groups. The flesh yield was 25.16 %; 23.71 % and 23.23 % respectively for diets groups 1, 2 and 3 with a significant difference ($p<0.05$).

Table 4. Snail shell lengths (mm) according to the diet.

Variables	Group 1		Group 2		Group 3		Significance test
	Mean	SD	Mean	SD	Mean	SD	
Wo	72.33a	7.32	72.85a	6.39	72.67a	8.99	NS
W2	73,0a	7.07	73.39a	6.40	73.71a	8.69	NS
W4	75.01a	8.74	73.26a	6.16	73.92a	8.58	NS
W6	75.49a	8.84	73.95a	5.97	74.32a	8.45	NS
W8	76.23a	8.85	74.94a	6.57	74.99a	8.30	NS
W10	76.64a	8.99	74.99a	5.95	75.83a	8.37	NS
W12	77.94a	9.17	75.71a	5.78	75.80a	8.31	NS
W14	80.24 b	9.31	76.53 a	6.28	76.68 a	8.70	*

*Significant at the threshold of 5%; NS: not significant; SD: Standard Deviation; W: week; the means of the same row followed by different letters, differ significantly at the threshold of 5%.

Snail meat technological quality

The pH values obtained at 1, 24 and 48-hour *post-mortem* varied from 6.13 to 7.44 and the water-holding capacity were 7.02; 6.63 and 6.52 respectively for snails of groups 1, 2 and 3 (Table 8). The pH values in group 3 types of meat were higher than those of groups 2 and 3 at 1 hour ($p<0.001$) and at 24 hours ($p<0.05$).

Table 5. Snail shell widths (mm) according to the diet.

Variables	Group 1		Group 2		Group 3		Significance test
	Mean	SD	Mean	Mean	SD	Mean	
Wo	38.51a	3.13	40.11b	2.60	39.52a	3.34	*
W2	39.91	3.60	38	2.30	39.56	7.66	NS
W4	50.94	4.84	49.88	5.13	51.70	5.72	NS
W6	52.34	4.16	52.13	4.22	52.22	5.32	NS
W8	52.77	4.05	52.37	3.43	52.27	4.37	NS
W10	53.48	4.16	52.99	3.72	52.46	4.61	NS
W12	54.77	4.14	55.09	3.64	55.26	4.46	NS
W14	55.86b	4.36	53.57a	3.86	53.20a	5.29	*

*Significant at the threshold of 5%; NS: not significant; SD: Standard Deviation; W: week; the means of the same row followed by different letters, differ significantly at the threshold of 5%.

Relationship between pH and hibernation duration

pH values according to snail hibernation duration (Table 9) varied between 5.93 and 7.44. One hour after slaughter, the highest pH values were recorded in snails of groups 1 and 2 with 12 hours of hibernation and in those of group 3 without hibernation time ($p<0.001$). Meanwhile, the lowest values were recorded in the three groups at 24 and 48 hours of hibernation with similar values. At 24 hours after slaughter, the highest values were recorded in the three groups after 48 hours of hibernation ($p<0.001$).

At 48 hours after slaughter, in group 1, pH of 0 and 12 hours of hibernation were similar and higher than those of the other hibernation times ($p<0.05$).

Table 6. Average weights (g) of snails per diet.

Variables	Group 1		Group 2		Group 3		Significance test
	Mean	SD	Mean	SD	Mean	SD	
WG0	64.30	13.95	64.73	10.46	68.02	18.32	NS
WG1	64.87	14.13	64.45	10.80	67.08	17.65	NS
WG2	68.44	13.60	69.00	12.00	70.30	17.92	NS
WG3	68.42	13.78	67.87	11.50	70.16	17.28	NS
WG4	68.95	13.73	67.59	11.20	68.44	16.76	NS
WG5	71.21	14.35	71.61	11.67	75.68	17.87	NS
WG6	72.52	14.28	71.89	12.17	75.08	17.42	NS
WG7	74.74	14.93	73.49	12.30	77.13	17.84	NS

NS: not significant; SD: Standard Deviation; WG: weight.

Discussion

Effect of diets on the morphological characteristics of snails

Although the Vitamin Mineral Concentrate and the fishmeal contain salt, no significant difference in mortality rates was observed between the giant African snails (*Archachatina marginata*) of the different groups. The results revealed a normal consumption of the feed with fishmeal and VMC. Snails that have eaten fishmeal and vitamin-mineral concentrate are longer. Thus, this feed would have favoured the shell growth. Indeed, Kouadio *et al.* (2015) have studied the growth parameters of *Archachatina marginata* raised on the ground in a natural environment in Côte d'Ivoire for 24 months and fed naturally and they obtained a shell length of 125 mm against initially, 94 mm. Also, other authors have recorded that *Archachatina marginata* snails fed with diets containing different protein levels had varying shell length growth while the initial lengths were not significantly different (Sika *et al.*, 2015). This growth mainly depends on the protein level. It could also depend on other feed components such as calcium and the litter composition (Bouye *et al.* 2017). Anis (2015) also showed that snails have diet preferences that improve their growth and survival.

Table 7. Snail components yield.

Variables	*Group 1*		*Group 2*		*Group 3*		Significance test
	Mean	DS	Mean	DS	Mean	DS	
Flesh (g)	17.80a	4.33	16.33a	3.43	16.96a	4.44	NS
Shell (g)	19.78b	4.92	20.46b	4.23	23.39a	6.59	**
Rest (g)	33.15a	8.89	32.17a	7.38	32.80a	9.35	NS
Flesh yield (%)	25.16a	3.62	23.71b	3.6	23.23b	2.89	*

*Significant at the threshold of 5%; ** significant at the threshold of 1%; SD: Standard Deviation. NS: not significant.

Effect of diets on the growth parameters of snails.

Snail weights didn't vary with fishmeal and Vitamin Mineral Concentrate incorporation in the diet. Snails' weight did not increase with diets. Similar results were recorded by Kouadio *et al.* (2015) in Côte d'Ivoire during a 24 months study on *Archachatina marginanta* snail. By contrast, our results do not confirm those of Sika *et al.* (2014 and 2015) which showed the growth performance improvement in *Achatina fulica* and *Archachatina marginata* snails when the fee protein level was increased.

The feed conversion ratio didn't vary between snails of the three groups. Ogbolo *et al.* (2018) recorded similar results when assessing the impact of crude protein on *Archachatina marginata* growth.

Table 8. pH and Water Holding Capacity in snail flesh according to the diet.

Variables	Group 1		Group 2		Group 3		Significance test
	Mean	SD	Mean	SD	Mean	SD	
pH1	7.21a	0.15	7.17a	0.16	7.44b	0.17	***
pH24	6.13a	0.17	6.13a	0.20	6.29b	0.16	*
pH48	6.16	0.32	6.25	0.28	6.13	0.19	NS
Water Holding Capacity (%)	7.02	1.73	6.63	2.23	6.52	1.99	NS

*Significant at the threshold of 5%; *** significant at the threshold of 1%; NS: not significant; pH1: pH at 1 hour after slaughter; pH24: pH at 24 hours after slaughter; pH48: pH at 48 hours after slaughter; SD: Standard Deviation.

Snail components yield

The results obtained in flesh, shell and rest weights are similar to those obtained by Patami *et al.* (2018) with *Archachatina marginata*. Also, in 2015, Ebunoluwa *et al.* found similar results when studying the physico-chemical and organoleptic quality of giant African snails flesh (*Achatina spp.*).

The flesh yield ($p<0.05$) obtained is 25.16%, 23.71% and 23.23% respectively for groups 1, 2 and 3. Values were better in snails fed with diets containing fishmeal and mineral vitamin concentrate. Okonkwo and Anyaene (2009) obtained similar results in *Archachatina marginata* with flesh yield of 38.4 ± 0.46%, shell yield of 20.9 ± 0.8% and rest (offal and viscera) yield of 40.6 ± 0.78%. On the other hand, in *Achatina fulica*, meat percentage is higher than that of shell and viscera in snails eating feed containing protein at different levels (Sika *et al.*, 2014).

Table 9. pH values according to snails hibernation duration.

Variables		To		T_12		T_24		T_48		Significance test
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Group 1	pH_1	7.21b	0.15	7.40a	0.08	6.55c	0.10	6.51c	0.11	***
	pH_24	6.13c	0.17	6.28b	0.11	6.13c	0.16	6.47a	0.19	***
	pH_48	6.16a	0.32	6.17a	0.14	6.05b	0.17	5.93b	0.19	*
Group 2	pH_1	7.17b	0.16	7.28a	0.13	6.52c	0.05	6.52c	0.08	***
	pH_24	6.14c	0.20	6.23b	0.09	6.20b	0.09	6.51a	0.25	***
	pH_48	6.28	0.28	6.17	0.20	6.17	0.16	6.16	0.30	NS
Group 3	pH_1	7.44a	0.17	7.17b	0.11	6.42c	0.18	6.49c	0.14	***
	pH_24	6.29b	0.16	6.18c	0.07	6.16c	0.14	6.40a	0.12	***
	pH_48	6.16	0.19	6.17	0.10	6.20	0.24	6.12	0.18	NS

*:Significant at the threshold of 5%; ***: significant at the threshold of 1‰; pH: pH at 1 hour, 24 and 48 hours after slaughter; To: slaughter time without hibernation, T_12: slaughter time after 12 hours of hibernation, T_24: slaughter time after 24 hours of hibernation; T_48: slaughter time after 48 hours of hibernation; SD: Standard Deviation.

A study on *Archachatina marginata* production revealed flesh variation according to fishmeal and CMV contents. Thus, the incorporation of fishmeal and CMV in the snails' diet has induced a meat ratio increase. This means that the use of fishmeal and CMV in *Archachatina marginata* diet results in an increase in meat production to the detriment of shell production. These results are not in accordance with those obtained by Aman *et al.* (2011) who observed an increase in shell yield with diet calcium content to the detriment of the pedal and visceral mass for *Achatina Achatina* and *Archachatina ventricosa*.

Fig. 1. Snail pens.

Technological quality of snail flesh

One hour after slaughter, the pH varied from 7.17 to 7.44. It has decreased when hibernation time increases. After 48 hours of hibernation, this pH varied between 6.49 and 6.51. This decrease in pH is observed after 48 hours of hibernation between groups at pH_24 h and pH_48 h with a minimum pH of 5.93 in snails fed a diet containing fishmeal and CMV. This result is similar to that obtained by Ebunolowa *et al.* (2015) when they evaluated the physicochemical quality of the flesh of *Achatina spp* fed on papaya leaves. Our result shows that hibernation duration has an impact on *Archachatina marginata* flesh technological quality because the glycogen reserves were used during hibernation. Thus, snails handled and slaughtered a few minutes later exhaust their glycogenic reserves so that the ultimate pH is not reached after slaughter, making conservation difficult.

Conclusion

This study shows that the giant *Archachatina marginata* snail has the potential to use fishmeal and Vitamin Mineral Concentrate for its growth. The incorporation of fishmeal and Vitamin Mineral Concentrate in the diet did not induce mortality but on the contrary, allowed normal growth. Besides, hibernation duration and diet contents affected snails' flesh technological quality particularly the pH values. The ultimate pH was reached at least 48 hours after slaughter in snail flesh hibernated for 48 hours. It is desirable to extend the time of the experiment to observe the effect of diets on the growth performance of *Archachatina marginata*. Salt is not a cause of non-survival of the giant African snails (*Archachatina marginata*).

References

Ademolu KO, Idowu AB, Mafiana CF, Osinowo OA. 2004. Performance, proximate and mineral analyses of African giant land snail (*Archachatina marginata*) fed different nitrogen sources. African Journal of biotechnology **3,** 412-417.

Anis M. 2015**.** Effect of feed choice on behavior and life history traits of the herbivorous gastropod *Littorina saxatilis*. Master Thesis, University of Québec, Canada, p 12-16.

Bessane-Mbétid E. 2006. Analysis of the Edible Snails Chain in the Equatorial Region of the Central African Republic. Tropicultura **24(2),** 115-119.

Bouye TR, Ocho-Anin AAL, Karamoko M, Otchoumou A. 2017. Étude de la croissance d'un escargot géant africain comestible : *Achatina Achatina* (linne, 1758), élevé sur du substrat amende à la poudre de coquilles d'escargot. Journal of Applied

Biosciences **109,** 10630-10639. https://doi.org/10.4314/jab.v109i1.7

Kana JR, Tchakounte FM, Meffowoet CCP. 2018**.** Effects of the feeding regime on growth performance and nutritive value of giant african snail (Archatina marginata) meat. Livestock Research for Rural Development **30(42),** Retrieved April 2, 2021, from http://www.lrrd.org/lrrd30/3/kana30042.html

Kong AT, Essia U, Ngang DF, Vegah BV. 2017**.** Comparative cost effectiveness of growth and reproductive performance of the *Archatina archatina* fed compounded feed and natural feed materials. Current Journal of Applied Science and Technology **23(3),** 1-8. https://doi.org/10.9734/CJAST/2017/35734

Kouadio EJP, Konan KH, Brou K, Dabonne S, Due AE, Kouame LP. 2015. Studies of some Parameters of Growth and Nutritive Values of Snail *Archachatina marginata* (Swaison) bred in Natural Environment. Tropicultura **33, 1**, 38-45.

Kouassi KD, Karamoko M, Mémel JD. 2010. Comparative study of the growth of the principal edible giant snail species of Africa. Revue CAMES Série A, **11,** 80-84.

Memel JD, Karamoko M, Amani SCN, Kouamé KE, Tchoumou AO. 2017: Manipulation of snails in three marketing zones of Abidjan: consequences on their survival and provision of solutions for better conservation. Geo-eco-trop **41 (1),** 67-76.

Mensah GA, Pomalegni SCB, Ahoyo ANR, Mensah ER, Guedou MSE, Koudande OD. 2013. Gass-cutter breeding: an alternative for food security and wildlife safeguarding in West Africa. Revue Africaine de Santé et de Productions Animales **11,** 113-128.

Ogbolo E, Toukourou Y, Sanni WHS, Assogba BGC, Traore IA. 2019. Effect of variation in protein level on zootechnical performance of the snail Archachatina marginata (Swainson, 1821) and morphology of spat in enclosed breeding in northern Benin. Afrique Science **15(6),** 1-10.

Otchoumou A, Dupont-Nivet M, Dosso H. 2005**.** The edible african snails: effect of diet calcium content on growth performances of *Achatina achatina* (Linné, 1758). Agronomie africaine **17(2),** 81-90.

Sika PNA, Karamoko M, Adou CFD, Otchoumou A, Kouassi KP. 2014. Effect of diet and dietary crude protein content on meat yield of the snail *Achatina fulica* (bowdich, 1720). International Journal of Biological and Chemical Sciences **8(5),** 2296-2305. http://dx.doi.org/10.4314/ijbcs.v8i5.31

Sika PNA, KaramokoM, Adou CFD, Otchoumou A, Kouassi KP. 2015. Effect of dietary protein content on the growth of the land snail *Archachatina marginata* (Swainson, 1821). International Journal of Biological and Chemical Sciences **9(2),** 890-900. http://dx.doi.org/10.4314/ijbcs.v9i2.27

Sodjinou E, Biaou G, Codjia JC. 2002. Characterisation of African Giant Snails Market in Atlantique and Littoral Regions in South-Benin. Tropicultural **20(2),** 83-88.

Uboh FE, Ebong PE, Mbi E. 2010. Cultural discrimination in the consumption of black snail (*Archachatina Marginata*) and white snail (*Achatina Achatina*); any scientific justification? International Research Journal of Microbiology **1(1),** 013-017.