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Effect of replacing wheat bran with dried rumen digesta on the growth performance of Giant African Land Snail (*Archachatina marginata*)

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Abstract The effect of bovine rumen digesta (BRD) was replaced for wheat bran on the growth of Giant African land snail, GALS (*Archachatina marginata*). Results showed that BRD contained 14.89% crude protein, 5.0% crude fiber, 0.5% ether extract, 8.30% ash and 12.50% moisture. The final body weight, body weight gain, and feed conversion ratio of the snails differed ($P < 0.05$) across the treatments. Feed intake and body length measurements were observed to be similar ($P \geq 0.05$) across the treatments. The BWG values were similar for the control (15.30 $\pm$ 1.06 g), T_3 (17.30 $\pm$ 0.57 g) and T_4 (16.87 $\pm$ 0.74 g) groups which were higher than those of T_2 (12.07 $\pm$ 0.62 g). Similarly, FCR values for T_1 (6.10 $\pm$ 0.16), T_3 (6.40 $\pm$ 0.48) and T_4 (5.73 $\pm$ 0.51) were recorded to be similar and were higher than T_2 (8.3 $\pm$ 0.70). From the study, it was concluded that BRD could be fed to snails at the levels of 10-15% and as replacement for wheat bran for a cost effective snail production.

Keywords: *Archachatina marginata*, Diet, Growth performance, Non-conventional, Proximate

Introduction

Animal protein consumption in Nigeria has comparatively remained very low (20% lower than recommended) against the recommendation of the Food and Agriculture Organization (FAO, 2009). Although great efforts have been channeled towards reducing importations and increasing the country's local production of animal protein products, much more is needed to bridge the gap between the demand and supply of animal protein in an increasing populace. Recently, there has been a renewed interest in the farming and commercialization of other non-conventional sources of animal protein such as snails and insects. This serves the benefit of not only providing farmers and

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rural households with alternative sources of income (Etchu *et al.,* 2017) but as well, providing a low cost, high nutritional animal proteins as alternatives for the high priced conventional protein sources as chicken, beef, pork, fish, mutton and chevon (Lawal, 2012).

Snail and snailery are recently gaining popularity in many countries across the globe with a flourishing international trade in Europe and North America (Nyameasem and Borketey-La, 2014). Giant African Land Snails (GALS) are mostly preferred for its larger size at maturity, quality nutritional compositions of proteins, essential amino acids, vitamins and minerals (especially iron); low fat and cholesterol levels; and its therapeutic roles in the management of such ailments as hypertension, conjunctivitis, diabetes, iron-deficiency and anemia (Akinyemi *et al*., 2007). Also, GALS are known to have high adaptability, survivability and with an ability to feed on wide range of cheap items including non-conventional materials as rotten plants and animal matter, leaves, green vegetables, fruits, flowers, cassava peels and other forms of farm and kitchen wastes materials (Akinfala *et al*., 2002). However, GALS are not a viable agricultural product in some regions like south Florida USA due to their potential as an invasive species.

With the numerous benefits and prospect associated with the farming of GALS and other snail species, little attention has been paid to its farming and commercialization especially in the West African regions due to the limited awareness of its nutritional and medicinal potentials (Etchu *et al*., 2017). With the growing interests and involvements in snail production, productivity has been challenged with limited knowledge of feed sources (Okpeze *et al*., 2007), their nutritional compositions and their effect on the growth and reproduction. Because feeding constitute about 50 to 60% of production cost, identifying cheap and quality non-conventional feeding materials that are in less competition with man, will help to reduce the cost of commercial snail production.

Several tons of rumen digesta are wasted in many developing countries' abattoirs and this poses a serious environmental contaminant (Cherdthong and Wanapat, 2013). There is therefore a need to economically maximize the disposal of this slaughter house by-product in an eco-friendly manner. Several attempts at evaluating the nutritional potentials of rumen digesta (alone or combined with blood meal) in livestock production have been made (Odunsi, 2003; Esonu *et al*., 2011).

However, there is limited available information on the growth implications of feeding rumen digesta to snails. This study was therefore designed to determine the effect of dried rumen digesta fed as replacement for wheat bran on the growth performance of Giant African Land Snail (*Archachatina marginata*).

Material and methods

The study was conducted at the Snailery Unit of the Department of Animal Science, University of Nigeria, Nsukka, Nigeria. Nsukka lies within latitude 06 °22′ North and longitude 07 °24′ East. It has an annual rainfall range of 1567.1 mm to 1847 mm. Natural day length is 12 to 13 h, and mean minimum and maximum daily temperatures are 21 ℃ and 30.3 ℃, respectively. Relative humidity ranges from 46.7% to 76.2% (Ugwu *et al.*, 2011). Nsukka belongs to the humid tropical rainforest zone of south-eastern Nigeria.

The rumen digesta/content/fill used for this study was collected from the rumen of cattle (Bunaji breed) immediately after slaughter between 06:00 h to 08:00 h at the abattoir section of Ikpa commodity market, Nsukka, Enugu State. Prior to the slaughter the cattle were fed predominantly with a mixture of roughage and concentrate. The digesta was sun-dried for three days to lower its moisture content to 15%. Afterwards, it was properly shredded and foreign objects removed to enhance milling and mixing with other feed ingredients. It was then milled, bagged and stored in a cool dry place prior to use for feed formulation at different inclusion levels. The digesta was milled through Brabender, Germany hammer mill of 2 mm and 1 mm sieves respectively.

A total of one hundred and twenty GALS' (*A. marginata*) juveniles of similar age and with an average initial body weight of 64.00g (± 0.54) were procured from Songhai farms, Amukpe-Sapele, Delta State, Nigeria and used for the study. After an acclimatization period of two weeks in which the juveniles were fed with palm kernel cake and left-over food, the snails were randomly assigned to four experimental groups (T_1, T_2, T_3, and T_4) in a Completely Randomized Design. The groups were replicated three times with 10 snails per replicate. Each replicate group was kept and reared in wooden cage compartments at the snailery section. The cages stood at a distance of 30 cm off the ground. Snails in treatments 1, 2, 3, and 4 received diets containing 0, 5, 10, and 15 % processed bovine rumen digesta, respectively. The snails were fed the experimental diets for a period of twelve weeks. The soil was thoroughly mixed with water before the snails were introduced into the cages. Regular sprinkling of water on the snails was done using a watering can to keep the interior very moist and cool and to prevent dehydration. Feed and water was provided *ad libitum*. The drinkers and feeders were emptied and washed on daily basis before new feed and water was served. Since snails are primarily nocturnal, the feed was provided between 16:00h to 18:00 h on daily basis. At the end of every two weeks, soil was removed and replaced to prevent any pathogenic manifestation in the pen.

Four experimental feed types were formulated and compounded at the local feed mill in Nsukka to contain 0, 5, 10, and 15 % of processed BRD. The BRD was included as replacement for wheat bran. The percentage compositions of the experimental diets are presented in Table 1. The various feed samples were taken to the Animal Nutrition and Biochemistry laboratory, Department of Animal Science, University of Nigeria, Nsukka, for proximate (chemical) analysis according to Association of Official Analytical Chemists (AOAC, 2005).

Table 1. Percentage compositions of the experimental diets used in the snail feeding trial

Ingredients (%)	**T_1**	**T_2**	**T_3**	**T_4**
	Rumen digesta			
	0 (%)	5 (%)	10 (%)	15 (%)
Maize	52	52	52	52
Soya bean	25	25	25	25
Wheat bran	15	10	5	0
Bovine rumen digesta	0	5	10	15
Fish meal	2	2	2	2
Bone meal	5.75	5.75	5.75	5.75
Vitamin premix*	0.25	0.25	0.25	.25
Chemical Composition				
CP(crude protein)	25.4	23.21	24.96	20.15
CF(crude fibre)	15.8	19.95	19.6	17.3
Fat	0.9	1.3	2.3	0.95
Moisture	9.9	8.6	8.85	9.15
Ash	9.7	9.97	10.85	10.2

*Each 1 kg of vit-premix contains: 10,000 IU vitamin (vit.) A; 2,500 IU vitamin D3; 20 mg vitamin E; 3 mg vitamin K3; 2 mg thiamine; 5 mg riboflavine; 5 mg pyridoxine; 0.015 mg vitamin B12; 40 mg Nicotinicacid; 12 mg Pantothenicacid; 0.75 mg folicacid; 0.05 mg biotine; 100 mg Vitamin C; 70 mg manganese/kg ; 60mg zinc/kg; 60mg iron/kg; 1 mg iodine/kg; 8 mg copper/kg; 0.25 mg selenium/kg; and 0.15 mg cobalt/kg.

Weight (growth response) was determined using digital sensitive weighing balance. The snails were weighed at the onset of the experiment (initial body weight) and subsequently on a weekly basis till the end of the study. Measurements of shell lengths and widths were made using Venier caliper. Other determinations were made as follows: (i) the average body weight gain (g) = Final body weight – Initial body weight; (ii) Daily feed intake = Feed offered (g) − Feed remaining (g) (iii) Total feed intake = daily feed intake (g) × no of days within the period of study; (iv) Feed conversion ratio = Feed intake (g) divided by the weight gain.

Data generated were analyzed using One-way analysis of variance (ANOVA) in IBM SPSS software package (version 21). Significant differences among the treatment means were separated using Duncan's New Multiple Range Test at 0.05% probability level.

Results

The proximate composition of the dried BRD used for the study is presented in Table 2. Results showed that dried BRD contained 14.89 ± 0.71 % crude protein (CP), 5.0 ± 0.12 % crude fibre (CF), 0.5 ± 0.04 % ether extract (EE), 8.30 ± 0.46 % ash, and 12.5 ± 0.87 % moisture content.

Table 2. Mean (± SEM) proximate compositions of bovine rumen digesta (BRD) and wheat bran (WB) used for the study

Parameters	**BRD Compositions (%)**	**WB Composition (%)**
Crude protein	14.89 ± 0.71	12.76±0.54
Crude fibre	5.0 ±0.12	8.34±0.69
Ether extract	0.5 ± 0.04	4.87±0.81
Ash	8.30 ± 0.46	6.83±0.78
Moisture	12.50 ± 0.87	9.82±0.94

The results of the growth performance of Giant African land snails (*A. marginata*) fed varying dietary inclusions of processed rumen digesta as replacements for wheat bran are shown in Table 3. The growth performance indices of final body weight (FBW), body weight gain (BWG), and food conversion ratio (FCR) differed ($P< 0.05$) among the treatment groups. However, the total feed intake, average total feed intake, average daily feed intake, final shell length, shell length gain, final shell width and shell width gain were found to be similar ($P \geq 0.05$) across the groups. Snails in T_3 (10 % BRD) and T_4 (15 % BRD) were observed to be similar ($P \geq 0.05$) FBW values (81.87 and 81.40 g respectively) which were higher ($P < 0.05$) than that of T_2 (5 % BRD) with a FBW of 77.33 g. Snails in the control group had FBW value (79.80 g) which was similar ($P \geq 0.05$) to those of the other groups. Similarly, snails in T_3 and T_4 groups had similar ($P \geq 0.05$) BWG values (17.30 and 16.87 g) which were similar ($P \geq 0.05$) to those of the control (15.30 g) but higher than that of the T_2 group (12.07 g). Snails in T_2 showed the highest FCR value of 8.3 and differed from those of the control, T_3, and T_4 (6.10, 6.40, and 5.73, respectively).

Table 3. Effect of replacing wheat bran with varying levels of dried rumen digesta on the Mean (±SEM) growth performance traits of Giant African Land Snail (*Archachatina marginata*)

Parameters	Control	T_2 (5%)	T_3 (10%)	T_4 (15%)	P-Value
IBW (g)	64.50 ±0.31	65.27 ±0.32	64.57 ±0.44	64.57 ±0.44	0.484^{NS}
FBW (g)	79.80^{ab} ±1.27	77.33^{b} ±0.77	81.87^{a} ±1.00	81.40^{a} ±0.60	0.036*
BWG (g)	15.30^{a} ±1.06	12.07^{b} ±0.62	17.30^{a} ±0.57	16.87^{a} ±0.74	0.005*
TFI (g)	93.03 ±5.29	99.37 ±3.53	111.3 ±10.64	95.97 ±4.79	0.309^{NS}
AvTFI (g)	23.26 ±1.32	24.84 ±0.88	27.76 ±2.66	23.99 ±1.20	0.309^{NS}
AvDFI (g)	0.26 ±0.01	0.28 ±0.01	0.31 ±0.03	0.27 ±0.01	0.309^{NS}
FCR	6.10^{b} ±0.16	8.3^{a} ±0.70	6.40^{b} ±0.48	5.73^{b} ±0.51	0.027*
Initial Length (cm)	6.73 ±0.09	6.87 ±0.03	6.70 ±0.12	6.63 ±0.09	0.344^{NS}
Final Length (cm)	80.23 ±18	80.73 ±0.12	82.50 ±2.60	78.80 ±0.25	0.392^{NS}
Length Gain (cm)	73.50 ±1.10	73.87 ±0.13	75.80 ±2.55	72.17 ±0.18	0.382^{NS}
Initial Width (cm)	3.33 ±0.09	3.33 ±0.33	3.57 ±0.12	3.33 ±0.12	0.301^{NS}
Final Width (cm)	39.33 ±0.49	40.03 ±0.07	42.50 ±2.45	39.63 ±2.21	0.570^{NS}
Width Gain (cm)	36.00 ±0.44	36.70 ±0.64	38.93 ±2.34	36.30 ±2.19	0.604^{NS}
SR (%)	100	100	100	100	

[a,b]: Row means with different superscripts differ significantly ($P< 0.05$); IBW: Initial Body Weight; FBW: Final Body Weight; BWG: Body weight Gain; TFI: Total Feed Intake; AvTFI: Average total feed intake; AvDFI: Average daily feed intake; FCR: Feed conversion ratio; SR: Survival rate.

Discussion

The CP values for rumen digesta reported in this study were lower than those reported by Elfaki and Abdelatti (2015) for cattle (18.53%), camel (17.35%) and sheep (16.93%) but higher than 11.80% reported by Gebrehawariat *et al.* (2016) for bovine rumen digesta. The CP of the digesta from this study compares favourably with those reported by Elfaki and Abdelatti (2015) and Sakaba *et al.* (2017) for goat (14.22%) and Sheep (15.52%), respectively. The disparities in the values obtained for the crude protein contents are attributable to age, season, the diversity and the quality of forage materials consumed by the animals as well as on the nutrient status of the soil on which the fodder plants were grown (Dairo *et al.*, 2005; Agbabiaka *et al.*, 2012). Also, the rumen microbial population and the pre-slaughter feeding regimen and chemical compositions all affect the protein value of the rumen content.

Higher fibre levels of 11.00%, 18.44%, and 22.99% were reported in sheep (Sakaba *et al.*, 2017), goat (Sakaba *et al*., 2018) and cattle (Gebrehawariat *et al.*, 2016), respectively. The percentage ash content of the rumen digesta reported in this study was lower than 14.44%, 21.54% and 48.73%, reported by Sakaba *et al.* (2018), Gebrehawariat *et al.* (2016), and Sakaba *et al.* (2017), respectively. The variations in the ash and fibre levels of the rumen content could be associated with the animals feeding habit, the nature and maturity stage of the forages consumed (Agbabiaka *et al.*, 2012). The fibre levels increases as the forage materials mature.

The moisture levels of the rumen digesta used in this study were higher than 5.51% reported by Sakaba *et al*. (2018) but lower than 14.64% and 17.48% reported by Gebrehawariat *et al*. (2016) and Agbabiaka *et al*. (2012). According to Sakaba *et al*. (2018), the differences in the moisture levels could be attributed to the processing method of the rumen content and this can determine its shelf life. The value for ether extract was lower than the ranges of 1.55-4.23% reported by Elfaki and Abdelatti (2015). Ether extract gives an idea of the total fat content of the rumen digesta. The variations in this index could be attributed to the activities of the rumen microbes and their production of fats. This could also be a function of diet, since the animals were fed predominantly roughage with a mixture of concentrate.

We observed from the results of this study, that dietary inclusions of BRD at 5 % lowered weight gains in snails. However at the levels of 10 and 15 %, the BWG were seen to be comparable to those of the control group. This result shows that BRD can be effectively used to replace wheat bran in the diets of snails at inclusion levels of 10-15%. Contrary results of lowered weight gains were reported by Lawal (2012) in *Achatinaachatina* snails as the dietary levels of decomposed rumen content (DCR) increased from 10% (60.7g) to 15% (41.9g). The results of this study were not consistent with that of Lawal (2012), who reported a decreasing feed consumption rate as the levels of DRC increased in the diet.

Our results showed that inclusion of BRD up to 15% level did not affect feed intake of snails in the various groups. According to Esonu *et al.* (2006), rumen digesta contains an appreciable high amount of fiber especially if the animals were fed predominantly roughage which tends to increase the total fiber level in the diet and resultantly dilute other nutrients. However, the BRD used in this study was seen to contain lower fiber levels (5%) than the values of 11.00%, 18.44%, and 22.99%, reported for rumen content in sheep (Sakaba *et al*., 2017), goat (Sakaba *et al*., 2018) and cattle (Gebrehawariat *et al.*, 2016), respectively in other studies. This was evident in the similar fibre levels observed in the T_1, T_2, T_3, and T_4 diets (15.8%, 19.95%, 19.6% and 17.3%, respectively). This also lends a possible explanation to similar feed intake values reported for the snails in the control (93.03g), T2 (99.37 g), T3 (111.3 g) and T4 (95.97 g) groups. Additionally, rumen digesta is known to contain the end products of microbial metabolic activities such as microbial proteins, vitamins, volatile fatty acids (VFA) and contains no anti-nutritional factors (Esonu *et al.*, 2006; Okpanachi *et al.*, 2010). The improved body weight gains observed at higher inclusion levels of BRD (10 and 15% for T_3 and T_4, respectively) when compared to those of 5% (T_2) shows that more nutrients were made available for utilization and conversion into flesh by the snails. The FCR values obtained in this study although lower than the ranges of 9.40-10.3 reported by Nyameasem and Borketey-La (2014) for *A. achatina* snails fed formulated diets, were comparable to those reported by Odo and Orji (2010) when snails were fed on various forms of leaves. Therefore, lower FCR values indicate greater feed efficiency, so the feed efficiencies on these diets were actually better than that of the Nyameasem and Borketey-La study. Additionally, the survival rates of the snails were also observed to be 100% across the treatment groups.

In conclusion, our findings indicated that replacing wheat bran with dried rumen digesta at the levels of 10% and 15% in the snails' diet was acceptable to the snails and met their growth requirement thereby eliminating the need for costly energy supplements. Thus, rumen digesta, which is a non-competing and non-conventional feedstuff for human beings, was found useful as a possible replacement for energy feed ingredients such as cereals.

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