Asian Journal of Research in Agriculture and Forestry

Volume 9, Issue 3, Page 36-41, 2023; Article no.AJRAF.97972
ISSN: 2581-7418

Effects and Cost-Benefit of Low and High Protein Levels in Snail Diets with Constant Levels of Energy and Calcium

Y. A. Popoola [a*], A. B. Idowu [a], I. A. Omodewu [a], O. T. Ajayi [b], S. R. Ajayi [c] and A. J. Omole [a]

[a] *Institute of Agricultural Research and Training Moor Plantation, Obafemi Awolowo University, Ibadan, Nigeria.*
[b] *Federal College of Animal Health and Production Technology, Ibadan, Nigeria.*
[c] *Federal College of Wildlife Management, New Bussa, Niger State, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRAF/2023/v9i3204

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97972

Original Research Article

Received: 20/02/2023
Accepted: 28/03/2023
Published: 06/05/2023

ABSTRACT

Snails are invertebrates with soft segmented shells. Snail farming is still at the infant stage compared to other farming enterprises because of limited information on the nutrient requirement of the animal. Therefore, a 12-week study was conducted to determine the effect of snails' diets containing low and high Crude protein (CP) levels with constant level of energy and calcium on the growth performance of African giant land snail *Archachatina marginata*. In a completely randomized design, a total of 120 snails of the same weight and breed were randomly allotted to five (5) different dietary treatments: PR1 (20% CP), PR2 (22% CP), PR3 (24% CP), PR4 (26% CP) and

**Corresponding author: E-mail: Popoolayemi75@gmail.com;*

PR5 (28% CP) with constant energy (2.6 Mcal/kg Metabolizable Energy) and calcium level. The snails were placed in 12 experimental compartments each measuring 0.5x 0.5m^2. Results revealed that the body weight gain, feed intake, cost of feed per kg weight gain and dressing percentage yield was significantly ($p < 0.05$) higher at the 28% CP. Furthermore, results showed significant ($P< 0.05$) interactions between protein across the treatments performance indices, shell length, shell width, feed cost per kg weight gain and dressing percentage yield. Feed intake decreased significantly ($p < 0.05$) at 20% CP level while the FCR values decreased ($p < 0.05$) at 28% CP level. Shell length, width and thickness was enhanced ($p < 0.05$) at 20% CP level. Also, the Feed cost per kg weight gain was observed to be significantly ($p < 0.05$) reduced at the 24% CP. The results obtained in the present study showed that the dietary protein of 24% CP, with constant energy of 2.6Mcal/kg ME is optimally suitable for the growth of African giant land snails *Archachatina marginata* at reduced cost.

Keywords: Archachatina marginata; cost-benefit; crude protein; constant levels of energy and calcium.

1. INTRODUCTION

Protein is an essential class of food in human diets. It is necessary for appropriate tissue growth and repair. Protein can be derived from both plant and animal sources. Mostly, plant-based proteins are lacking in certain amino acids which may be linked to anti-nutritional factors. For example, soybean belongs to a lant protein source that contains a trypsin inhibitor but is low in methionine. Animal-derived proteins on the other hand, possess all of the essential amino acids in appreciable quantity.

Snail is a non-conventional livestock always found in cool environment. Snails are common in southern ecological zone of Nigeria. Its meat is highly nutritious, healthy to consume and contains high level of iron and calcium. It is a choice meat for anemic, hypertensive, coronary heart and diabetic patients. Popoola et al. [1] described snails as a major source of essential amino acids such as lysine, leucine, isoleucine, arginine, tryptophan, and phenylalanine. Snail meat provides more lysine and arginine than whole egg. These explains the rising demand for snail meat and, consequently, the increased potential to generate more revenue from snail production. There are several factors affecting snail production; these include slow growth due to feeding, genetic make-up, environment among others. Feed is one of the major factors of production in livestock industry. Feed constitutes about 70% of total cost of production. Unlike other macro livestock, there no standardized snail feed in the market. Formulated feeds that meet snail's specific nutritional requirement can greatly enhance its growth performance [2].

2. METHODOLOGY

This study was carried out at the Snailery Unit of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan. A total of 120 snails of the same weight and breed were randomly allotted to five (5) different diets in a complete randomized designed; PR1 (20% CP), PR2 (22% CP), PR3 (24% CP), PR4 (26% CP) and PR5 (28% CP).

The snails were placed in 12 experimental compartments each measuring 0.5x 0.5m^2. Feed intake and weight gain were measured and recorded on daily and weekly basis using sensitive weighing balance. The leftover feed was subtracted from the feed given to measure feed intake, and the initial weight was subtracted from the end weight to determine weight growth.

Feed intake = Feed Given – Left-over Feed

Weight Gain = Final Weight – Initial Weight

Feed Conversion Ratio = Feed Intake/Weight Gain

A digital vernier caliper was used to measure the length and width of the shells on a weekly basis. The shell thickness was measured using a micrometer screw gauge on a weekly basis. The ratio of Feed intake to weight gain was used to calculate the feed conversion ratio. Costs for feeding and cost per Weight gain were also computed. At the end of the feeding trial, carcass composition was done according to the description of Omole et al.'s [2]. Four (4) snails were randomly selected from each replicate and weighed separately. The shell of each snail was

Table 1. Gross composition of experimental diets

Ingredient (%)	PR_1 (20%)	PR_1 (22%)	PR_2 (24%)	PR_3 (26%)	PR_4 (28%)
Maize	23.75	22.0	20.0	18.0	18.0
Soya bean meal	24.0	24.5	26.0	27.25	28.5
Fish meal (Local)	1.5	2.5	3.0	4.0	4.0
G.N.C	17.0	17.25	19.25	21.0	25.0
Rice-bran	12.0	12.0	11.0	8.0	3.0
Brewer Dry grain	9.0	9.0	8.0	9.0	6.25
Bone meal	**2.5**	**2.5**	**2.5**	**2.5**	**2.5**
Oyster shell	**9.7**	**9.7**	**9.7**	**9.7**	**9.7**
Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.1	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Salt	0.1	0.1	0.1	0.1	0.1
Calculated Composition					
Crude protein (%)	20.22	22.22	24.22	26.22	28.22
Metabolizable energy (kcal/KgME)	2605.2	2605.2	2605.2	2605.2	2605.2

struck with a club to kill it. The viscerals, the foot, and the shell were all dissected and weighed separately. The feeding trial lasted for 12 weeks. The experimental diets and the foot were chemically analyzed (proximate analysis) using the A.O.A.C. [3] method. All data were statistically analyzed using one-way analysis of variance, and the means were separated using the Duncan Multiple Range Test if they differ significantly [4].

3. RESULTS AND DISCUSSION

Table 1 shows the gross composition of diets which comprises different combinations of crude protein (20%, 22%, 24%, 26% and 28%) and constant energy levels of 2.6Mcal/kgME were used. The various combination of protein level and constant energy represented is as shown in Table 1 from treatments 1 to 5. Table 2 reveals the proximate composition of the experimental diets; while the performance of snails fed the experimental diets is shown in Table 3. The total weight gain among the Treatments differ significantly ($P<0.05$) with treatment fed 28% CP recording the highest mean value. The least total weight gain was observed in snails on treatment 20% CP. It was also observed that the increase in protein content across the treatment affect the performance of the snails and body weight gain was significantly enhanced ($P<0.05$) at the highest crude protein levels (28% CP).

According to Table 3, there are significant differences ($p<0.05$) among treatments for average feed intake. Snails on PR5 (28%CP) diet recorded the highest average feed intake which was significantly ($p< 0.05$) different from snails in other treatments. Snails in treatments 20% CP and 22% CP recorded significantly ($p<0.05$) lower mean value for feed intake than those fed 24% CP and 26% CP respectively. Average feed intake as observed was significantly ($p<0.05$) reduced at PR1 and PR2, this aligned with the study of Jackson et al. (1982) which found that higher amounts of dietary protein and energy improved body weight and feed efficiency, indicating the importance of a balanced calorie-protein ratio. Snails are also known to consume high-energy and protein-rich meals for optimal weight gain and production (Hodasi, 1982). The improved performance reported in snails fed the 28% CP diet was not unexpected, as this diet included the highest levels of protein and energy, which would have met the snails' ideal growth requirements. Furthermore, the snails may have used the available protein very efficiently to improve their growth performance. This supported Omole's [5] finding that diets containing 28% CP and 2200Kcal/kgME were best for snail growth. However, the current finding implies that developing snails require more than 20% dietary protein for optimal performance.

The feed conversion ratio (FCR) varied significantly ($P<0.05$) among treatments. The feed conversion ratios (FCR) of the snails on treatments PR3 and PR5 were comparable ($p>0.05$) and significantly (p 0.05) lower and better than their counterparts in the other treatments. The snails in treatment PR1 (20%

CP) recorded the highest feed conversion ratio. Feed conversion ratio was significantly enhanced (p<0.05) at PR4 and PR5. This backed up Elliot's [6] findings that an increase in the diet's protein level relative to its energy value causes an increase in feed consumption, which leads to a more effective utilization of feed as observed across the treatments in this study. There were no significant differences (p>0.05) among treatments in shell length, width and thickness increment as observed in the study, however, they had comparable shell length, width and thickness across the treatments (p>0.05).

Table 4 presents data on snail carcass analysis, which demonstrates that there are significant (P<0.05) differences between treatments in all parameters examined. Snails in PR5 had significantly higher mean live weight, shell weight, foot weight, and visceral weight than snails in the other treatments (P<0.05). Treatment PR1 had the lowest mean live weight, shell weight, foot weight, and offal/live weight. Mean live weight, shell weight, edible weight, and offal/live weight were all comparable (P>0.05) for snails on treatments PR2, PR3, PR4, and PR5. There were also significant (P<0.05) interactions between dietary protein and constant energy levels on snail live body weight, shell weight, foot weight, and offal/live weight. At the 28% CP, the mean live body weight, shell weight, foot weight, and offal/live weight of snails increased considerably (P<0.05). Table 5 shows the cost implications of feeding snails diets with varying protein and constant energy levels. The cost of total feed consumed and feed cost per kg weight growth differed significantly (P<0.05) between treatments. Snails fed diet PR5 had significantly (p<0.05) higher cost of total feed consumed than snails fed other diets. Snails fed diet PR1 had the least cost of total feed consumed, while the highest feed cost per kg weight gain was observed in treatment with PR5. The effects of dietary protein and energy levels on the total cost of feed consumed and feed cost per kg weight gain were also statistically significant (P<0.05). Feed cost per kilogram of weight increase was lower at the PR3 (24%) crude protein level whereas the overall cost of feed consumed was significantly (P<0.05) lower at the 20% CP and 2.6Mcal/kg ME levels [7-15].

Table 2. Determined proximate composition of the experimental diets

Parameters	**PR_1 (20%)**	**PR_2 (22%)**	**PR_3 (24%)**	**PR_4 (26%)**	**PR_5 (28%)**
Dry matter	96.24	93.77	93.78	94.15	93.23
Crude Protein	45.36	23.35	23.45	23.89	24.18
Crude Fibre	3.28	9.35	9.79	10.59	10.75
Ether Extract	5.56	4.28	4.67	4.72	4.88
Ash	7.78	9.68	9.69	9.79	10.12
Nitrogen Free Extract	40.02	53.34	52.40	51.01	50.07

Table 3. Summary of Growth performance of growing snails fed varying levels of Protein in the diets

Parameters (Means)	**PR_1 (20%)**	**PR_2 (22%)**	**PR_3 (24%)**	**PR_4 (26%)**	**PR_5 (28%)**	**±SEM**	***p-value***
Initial weight (g)	126.41	126.47	126.12	126.01	126.11	2.67	NS
Final weight (g)	356.67^b	376.32^b	392.44^a	394.21^a	398.17^a	4.67	0.05
Total weight gain (g)	230.26^d	249.85^c	266.32^b	268.2^{ab}	272.06^a	5.39	0.05
Total feed intake (g)	953.28^c	959.42^c	985.39^b	995.02^a	1006.62^a	9.45	0.05
Feed conversion ratio	4.14^a	3.84^b	3.70^c	3.71^c	3.70^c	0.12	0.05
Shell length increment (mm)	9.88^a	9.89^a	9.89^a	9.91^a	9.91^a	1.03	NS
Shell width increment (mm)	8.35^a	8.35^a	8.38^a	8.39^a	8.39^a	0.78	NS
Shell thickness increment (mm)	0.11^a	0.11^a	0.11^a	0.12^a	0.12^a	0.61	NS
Mortality (Number)	0.00	0.00	0	1	0		NS

Means $^{a, b}$ and ^{c} along rows with different superscript are significantly different from each other (P<0.05)

Table 4. Carcass analysis of growing snails fed varying levels of Protein in the diets

Parameters (Means)	PR_1 (20%)	PR_2 (22%)	PR_3 (24%)	PR_4 (26%)	PR_5 (28%)	±SEM	*p-value*
Live weight (g)	353.14	366.78	392.44	394.21	398.17	43.76	0.05
Shell weight (g)	81.40	85.20	91.59	92.32	93.77	4.13	NS
Offal weight (g)	70.83^c	74.68^b	80.25^b	84.36^a	85.20^a	2.45	0.05
Foot weight (g)	158.91^c	166.70^b	184.37^b	187.41^{ab}	189.58^a	4.86	0.05
Dressing percent (%)	45.01^c	45.45^c	46.28^b	47.54^a	47.61^a	1.13	0.05
Offal/live weight (%)	20.06^a	20.36^a	20.45^a	21.21^a	21.41^a	1.78	NS
Shell/live weight (%)	23.05^a	23.23^a	23.34^a	23.42^a	23.55^a	1.32	NS

Means $^{a, b}$ and ^{c} along rows with different superscript are significantly different from each other (P<0.05)

Table 5. Cost analysis of growing snails fed varying levels of Protein in the diets

Parameters (Means)	PR_1 (20%)	PR_2 (22%)	PR_3 (24%)	PR_4 (26%)	PR_5 (28%)	±SEM	*p-value*
Total weight gain (kg)	0.23	0.25	0.27	0.27	0.27	-	NS
Total feed intake (kg)	0.95	0.96	0.99	1.00	1.01	-	NS
Cost/kg feed (N)	130.12^d	132.23^d	137.17^c	140.4^b	144.89^a	2.02	0.05
Total feed cost (N/kg)	123.62^d	132.23^c	135.80^c	140.4^b	146.34^a	2.12	0.05
Cost/weight gain (N/kg)	537.45^b	528.92^{bc}	502.90^d	520.00^c	541.90^a	5.24	0.05

Means $^{a, b, c}$ and ^{d} along rows with different superscript are significantly different from each other (P<0.05)

4. CONCLUSION

In comparison to other diets, the diet containing 24% CP and 2.6Mcal/kg ME supported higher growth rates, better feed intake, higher feed conversion ratios, and higher foot weight, shell weight, and visceral weight. This suggests that the ideal crude protein and energy requirements for *Archachatina marginata* for normal growth may be 24% CP and 2.6 Mcal/kgME.

Also, the most suitable protein and energy combination for the optimum growth of the African giant land snail (*Archachatina marginata*) is 24% CP and 2.6Mcal/kgME. This is because of the significant effects that dietary protein and energy levels have on growth performance, carcass yield, and feed cost per kg weight gain. Therefore, it is possible to suggest that the diet consisting of 24% CP and 2.6Mcal/kgME is adequate for the African giant land snail (*Archachatina marginata*) to grow to its full potential.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97972