World Journal of Biology Pharmacy and Health Sciences
eISSN: 2582-5542
Cross Ref DOI: 10.30574/wjbphs
Journal homepage: https://wjbphs.com/

(RESEARCH ARTICLE)

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COMPARATIVE EFFECTS OF FRUIT-BASED, LEAF-BASED AND MIXED DIETS ON GROWTH PERFORMANCE AND SURVIVAL OF JUVENILE *ARCHACHATINA MARGINATA* IN SOUTHWESTERN NIGERIA

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World Journal of Biology Pharmacy and Health Sciences, 2026, 28(01), 188–197

Publication history: Received on 12 September 2026; revised on 19 October 2026; accepted on 21 October 2026

Article DOI: https://doi.org/10.30574/wjbphs.2026.28.1.0509

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ABSTRACT

This study compared the effects of fruit-based, leaf-based and mixed diets on the growth performance and survival of juvenile *Archachatina marginata* over a 16-week experimental period. 150 juvenile snails were allocated to three dietary treatments, with 50 snails per treatment. The fruit-based treatment consisted of watermelon and banana, the leaf-based treatment consisted of pawpaw leaf and waterleaf, and the mixed treatment contained all four feed materials in equal proportions. Cumulative weight gain was calculated from baseline to Week 16. At Week 16, mean body weight was 74.05 g in the fruit-based group, 69.05 g in the mixed group and 64.26 g in the leaf-based group. Mean cumulative weight gain was 41.18 ± 7.82 g, 36.18 ± 4.22 g and 31.91 ± 4.73 g for the fruit, mixed and leaf treatments, respectively. Welch's ANOVA showed a significant effect of dietary treatment on weight gain, $F(2, 40.20) = 24.13$, $p < 0.001$. Final survival was 88.0%, 80.0% and 86.0% in the fruit, mixed and leaf treatments, respectively, and did not differ significantly among treatments, $\chi^2(2) = 1.34$, $p = 0.513$. The findings indicate that fruit-based feeding promoted superior juvenile growth over the 16-week period.

Keywords: *Archachatina marginata*; Snail Nutrition; Fruit-Based Diet; Leafy Feed; Mixed Diet; Growth Performance

1 INTRODUCTION

Archachatina marginata, an edible terrestrial gastropod in West Africa, has gained popularity as a low-input animal production species. Its ability to use a wide variety of plant materials makes it appropriate for farming systems in which producers rely on locally available feed resources. Snail farming can also provide households with an extra source of

animal protein and income, especially in areas where conventional livestock production is limited in space and capital (Omoregie *et al.,* 2021; Tchowan *et al.,* 2022).

Although *A. marginata* can grow on a variety of plant materials, its performance varies depending on the feeding conditions. Diet composition, nutritional availability, feed acceptance, and management all have an impact on how fast juvenile snails gain weight. Previous feeding studies have found differences in growth performance across diets comprising various protein sources and plant materials, demonstrating that feed selection is an essential aspect of snail production management (Ogunyemi, 2021; Orsar *et al.,* 2020; Merlin *et al.,* 2018).

The usage of locally available plant resources is appealing due to their convenience and low cost. Leafy materials, particularly pawpaw leaf, are frequently used in snail feeding programs and have been studied as base feed supplies (Omole *et al.,* 2004). However, past research suggests that the performance of leaf-based meals is influenced by diet composition and the inclusion of supplemental nutrient sources (Orsar *et al.,* 2020). Thus, while green foods can promote snail production, they may not always deliver the best growth response when used alone.

A. marginata also relies heavily on fruits for nutrition. Their soft texture, high moisture content, and perceived palatability make them ideal for juvenile feeding. Okafor-Elenwo *et al.* (2021) found that watermelon was one of the most commonly ingested plant materials presented to captive snails in a study of food preferences in *A. marginata*. The authors also saw gradual increases in body weight during the eating session. These findings imply that differences in growth performance may be influenced by feed uptake and the physical properties of plant materials.

Watermelon has also been investigated for its possible physiological effects. Omoregie *et al.* (2021) found that watermelon extract stimulated hunger and had antioxidant properties in *A. marginata.* Although the current study employed fresh watermelon rather than an extract, the previous finding lends credence to investigating watermelon as a component of practical snail feeding systems.

Bananas have also been reported to be an effective fruit feed for African giant land snails. More broadly, investigations comparing locally available diets have revealed that growth responses vary by plant material (Okonta *et al.,* 2023). Raimi & Olomola (2020), for example, discovered variances in the growth performance of *A. marginata* fed various feed materials, whereas Ogunyemi (2021) identified substantial changes in growth linked with dietary protein levels. These results suggest that locally available meals should be evaluated based on biological performance rather than availability alone.

The continuity of feed supply is also essential for juvenile growth. Toukourou *et al*. (2022) observed weight loss during feed restriction in *A. marginata* and discovered that subsequent re-feeding did not entirely compensate for the earlier growth deficit. This shows that disrupting nutrition supply during juvenile growth may have long-term consequences for performance.

Despite the rising volume of research on individual feed materials, direct comparisons of fruit-based, leaf-based, and mixed feeding techniques under the same experimental settings are still rare. Such a comparison is crucial in southwestern Nigeria, where banana, watermelon, pawpaw leaf, and waterleaf are freely available and may be utilised to produce snails with minimum input. There is also a need to analyse growth over a sufficient time period, as short feeding experiments may not completely disclose the persistence of treatment differences.

The current study consequently evaluated fruit-based, leaf-based, and mixed diets in juvenile *A. marginata* over 16 weeks. The study looked at weekly changes in body weight, cumulative weight increase, and differences across nutritional treatments, treatment-specific growth trajectories, responsiveness to a brief feed withdrawal period, and overall survival. The goal was to give practical evidence on the relative effectiveness of locally accessible plant feeding techniques for producing young snails.

2 MATERIALS AND METHODS

2.1 Study area

The experimental set up was carried out in the Zoological Garden of Lagos State University of Education, Oto/Ijanikin, Lagos State, Nigeria. The experimental site was located at approximately 6.5005° N and 3.1093° E. The experimental period covered 16 weeks.

The animals were maintained at the same experimental site throughout the study. Feeding, watering, cleaning, weighing and mortality monitoring were conducted under the same general management conditions for all treatments.

2.2 Experimental animals

A total of 150 juvenile *A. marginata* were used for the experimental study. The animals were obtained from a local snail farm in Lagos State and transported to the experimental site. Apparently healthy individuals were selected for the experiment, while those showing obvious shell damage, deformity or poor response to handling were excluded.

The snail's initial body weight was measured and ranged between 25 and 40 g. The animals were allowed to acclimatize before the experimental feeding programme began.



Figure 1: *Archachatina marginata* fed with Watermelon



Figure 2: *Archachatina marginata* fed with Pawpaw Leaves



Figure 3: *Archachatina marginata* fed with Watermelon and Waterleaf

2.3 Experimental design and dietary treatments

The 150 juvenile snails were assigned to three dietary treatments, with 50 snails per treatment.

The diets were:

- Fruit-based diet: watermelon (*Citrullus lanatus*) and banana (*Musa* spp.).
- Leaf-based diet: pawpaw leaf (*Carica papaya*) and waterleaf (*Talinum triangulare*).
- Mixed diet: pawpaw leaf, waterleaf, watermelon and banana combined in equal proportions.

The selection of these materials was based on their availability and previous evidence of their use as feed resources for *A. marginata* (Okafor-Elenwo *et al.,* 2021; Omoregie *et al.,* 2021; Orsar *et al.,* 2020).

2.4 Feeding management

The feed supplies were collected fresh and cut into appropriate bits before being provided. No commercial concentrates, designed rations, or mineral supplements were included. During feeding periods, fresh feed was provided once a day, and uneaten food was removed during routine cleaning. Water was supplied by spraying the animals and dwelling units to keep them moist.

The experimental feeding program includes a planned one-week feed withdrawal interval. During the withdrawal week, feeding was discontinued, but usual watering and cleaning remained. Feeding resumed, and the animals received their assigned diets until the end of the 16-week observation period.

2.5 Body-weight and survival measurements

Body weight was measured individually at baseline and weekly through Week 16. Weight was recorded in grams.

For each snail with a valid Week 16 measurement, cumulative weight gain was calculated as:

2.5.1 Cumulative weight gain = Week 16 body weight – baseline body weight.

Mortality was monitored throughout the experiment. Dead snails were removed from the housing units and the corresponding identification number and week of death were recorded.

Final survival was calculated as:

Survival (%) = (number surviving at Week 16 / number initially assigned) × 100.

Feed intake, feed conversion ratio, shell length and shell circumference were not recorded and were therefore not included as response variables.

2.6 Statistical analysis

The individual-level Excel dataset was checked and standardized before statistical analysis. Baseline body weight was compared among the three treatments using one-way analysis of variance to assess treatment comparability before the main growth comparison.

Weekly body-weight observations were summarized using treatment means, standard deviations and sample sizes. To account for repeated measurements from the same animals, a longitudinal mixed-effects model was fitted with treatment, time and treatment-by-time interaction as fixed effects and individual snail as a random effect.

Cumulative Week 16 weight gain was compared among dietary treatments. Levene's test was first used to assess homogeneity of variance. Because the assumption of equal variance was violated, Welch's analysis of variance was used as the principal omnibus test. Pairwise Welch comparisons were then conducted and p-values adjusted using the Holm procedure.

Effect size was assessed using eta-squared and omega-squared for the overall treatment effect and Hedges' g for pairwise comparisons.

Final survival was compared among dietary groups using a chi-square test of independence. Statistical significance was set at $p < 0.05$.

Because each treatment was associated with one housing unit, interpretation of treatment effects was made cautiously with respect to independent cage-level replication.

3 RESULTS

3.1 Baseline body weight

The three groups were closely matched in body weight at the beginning of the experiment. Mean baseline weight was 32.56 g in the fruit-based group, 32.40 g in the mixed group and 32.40 g in the leaf-based group.

There was no significant difference among treatments, $F(2,147) = 0.02$, $p = 0.979$. The groups therefore started the experiment with comparable mean body weights.

3.2 Weekly growth over 16 weeks

Mean body weight increased progressively in all three treatments for most of the experimental period. The fruit-based treatment generally recorded the highest mean body weight, followed by the mixed treatment, while the leaf-based treatment remained lowest.

Table 1: Weekly Changes in Mean Body Weight of Juvenile *Archachatina marginata* Fed Fruit-Based, Leaf-Based and Mixed Diets Over 16 Weeks

Week	Fruit-based (g)	Mixed (g)	Leaf-based (g)
Baseline	32.56	32.40	32.40
1	34.86	34.52	33.94
2	38.15	37.91	36.61
3	41.93	41.17	39.84
4	45.47	44.10	41.91
5	49.02	47.10	44.96
6	52.20	50.32	47.42
7	47.20	43.72	43.07
8	48.59	45.72	41.48
9	51.70	48.92	44.61
10	55.00	51.70	47.77

11	58.18	54.58	50.50
12	61.39	57.65	53.07
13	64.61	60.40	55.63
14	67.73	63.20	58.70
15	70.98	66.08	61.37
16	74.05	69.05	64.26

The three groups started at nearly identical weights but progressively separated during the feeding period. By Week 16, the mean body-weight difference between the fruit-based and leaf-based treatments was approximately 9.79 g.

3.3 Effect of feed withdrawal on body weight

A pronounced decline in body weight occurred during the week in which feed was withdrawn.

Table 2: Changes in Mean Body Weight of Juvenile *Archachatina marginata* During the Feed-Withdrawal Period

Treatment	Week 6 (g)	Week 7 (g)	Change (g)
Fruit-based	52.20	47.20	-5.00
Mixed	50.32	43.72	-6.59
Leaf-based	47.42	43.07	-4.36

After feeding resumed, the fruit-based treatment increased from 47.20 to 48.59 g and the mixed treatment increased from 43.72 to 45.72 g. The leaf-based group decreased further to approximately 41.48 g before subsequent growth resumed.

The longer 16-week record showed that the treatment ranking was maintained following the interruption in feeding, with the fruit-based treatment again recording the highest mean body weight.

3.4 Cumulative weight gain at Week 16

The cumulative weight gain differed substantially among treatments.\

Table 3: Cumulative Weight Gain of Juvenile *Archachatina marginata* Fed Different Dietary Treatments at Week 16

Dietary treatment	n	Mean gain (g)	SD	Mean gain per week (g)
Fruit-based	44	41.18	7.82	2.57
Mixed	40	36.18	4.22	2.26
Leaf-based	43	31.91	4.73	1.99

The fruit-based group gained 5.01 g more than the mixed group and 9.27 g more than the leaf-based group. The mixed treatment exceeded the leaf-based treatment by 4.27 g.

3.5 Homogeneity of variance and Welch's ANOVA

Levene's test showed that the variances of cumulative weight gain were significantly different among treatments, $F(2,124) = 10.02$, $p < 0.001$.

Welch's ANOVA was therefore used as the principal test. The result showed a statistically significant effect of dietary treatment:

Welch $F(2, 40.20) = 24.13$, $p < 0.001$.

The overall treatment effect was substantial, with eta-squared of approximately 0.305 and omega-squared of approximately 0.294.

3.6 Pairwise treatment comparisons

Holm-adjusted Welch comparisons showed that each dietary treatment differed significantly from the others.

Table 4: Holm-Adjusted Pairwise Comparisons of Cumulative Weight Gain Among Dietary Treatments

Comparison	Mean difference (g)	Holm-adjusted p-value	Hedges' g
Fruit-based vs mixed	5.01	<0.001	0.78
Fruit-based vs leaf-based	9.27	<0.001	1.42
Mixed vs leaf-based	4.27	<0.001	0.94

The fruit-based versus leaf-based comparison produced the largest standardized effect, indicating a substantial difference in growth performance between the two treatments.

3.7 Growth trajectories

The longitudinal mixed-effects analysis showed a significant treatment-by-time interaction:

$\chi^2(32) = 727.02$, $p < 0.001$.

This demonstrates that body-weight trajectories differed among treatments over the 16-week period. The treatments were closely matched at baseline but separated progressively during the feeding period. The trajectories were temporarily disrupted by feed withdrawal before diverging again after feeding resumed.

3.8 Survival

The 16-week dataset recorded 23 deaths among the 150 experimental snails.

Table 5: Survival and Mortality of Juvenile *Archachatina marginata* Under Different Dietary Treatments Over 16 Weeks

Dietary treatment	Initial n	Survived	Deaths	Survival (%)
Fruit-based	50	44	6	88.0
Mixed	50	40	10	80.0
Leaf-based	50	43	7	86.0
Total	150	127	23	84.7

There was no significant association between dietary treatment and final survival, $\chi^2(2) = 1.34$, $p = 0.513$.

Although the mixed treatment recorded the lowest numerical survival, the observed differences were not statistically significant.

Most deaths occurred during the early weeks of the experiment. The fruit-based group recorded six deaths, with five occurring by Week 3. The mixed group recorded ten deaths, nine of which occurred by Week 4. The leaf-based group recorded seven deaths, with five occurring by Week 3.

4 DISCUSSION

The present study demonstrates that the choice of plant-based diet had a substantial effect on the growth performance of juvenile *A. marginata* over the 16-week experimental period. The fruit-based diet produced the greatest cumulative weight gain, followed by the mixed diet, while the leaf-based diet produced the lowest gain. This finding remained significant after the unequal variance among treatment groups was taken into account using Welch's ANOVA. The result therefore provides strong evidence that the three dietary treatments produced distinct growth responses under the experimental conditions.

The superior growth of the fruit-based treatment is consistent with previous observations that certain fruit materials are readily accepted by *A. marginata*. Okafor-Elenwo *et al*. (2021) found watermelon to be one of the more highly preferred food materials offered to captive *A. marginata*. The present study did not measure feed preference or intake directly, but the higher growth recorded in the fruit treatment is compatible with the possibility that the physical and feeding characteristics of watermelon and banana contributed to greater consumption or nutrient availability.

The role of watermelon in snail feeding has also been examined by Omoregie *et al*. (2021), who reported appetite-stimulating and antioxidant potential of watermelon extract in *A. marginata*. The present experiment involved fresh watermelon rather than an extract, so the antioxidant findings should not be directly attributed to the observed growth response. Nevertheless, the previous study supports the broader relevance of watermelon as a potentially useful component of *A. marginata* diets.

The longer 16-week observation period strengthens the interpretation of the growth result. The treatments started with almost identical mean body weights, but the difference increased progressively during the experiment. By Week 16, the fruit-based group had reached a mean of 74.05 g compared with 69.05 g in the mixed treatment and 64.26 g in the leaf-based treatment. The significant treatment-by-time interaction further shows that diet influenced the trajectory of growth, not merely the final endpoint.

The lower growth recorded in the leaf-based treatment should not be interpreted as evidence that pawpaw leaf and waterleaf are unsuitable feed materials. Leaf-based feeding remains useful because these materials are available locally and can contribute important dietary components. Previous research has shown that pawpaw leaf can support *A. marginata* growth, particularly when additional nutrient sources are included in the ration (Orsar *et al*., 2020). The current findings suggest that the leaf combination used in this experiment was less effective than the fruit combination for achieving rapid juvenile body-weight gain.

This interpretation agrees more broadly with Raimi and Olomola (2020), who reported different growth responses among *A. marginata* fed different plant materials. Ogunyemi (2021) likewise demonstrated that varying plant-derived protein levels influenced growth performance. These studies indicate that the biological value of a feed cannot be judged simply by whether the snail can consume it. Nutrient density, physical form, palatability and dietary balance all need to be considered.

The mixed diet produced an intermediate growth response. This finding has practical significance because many farmers may not always have enough fruits to sustain fruit-only feeding throughout a production cycle. The mixed treatment produced significantly greater weight gain than the leaf-only treatment, suggesting that the inclusion of fruit materials can improve performance relative to leafy feeding alone. However, the mixed diet remained significantly below the fruit-only treatment, so the present results do not support the claim that equal-proportion mixing is the optimum feeding strategy.

An important feature of the study was the response to feed withdrawal. All three treatments lost body weight during the week in which feed was withheld. Such weight loss is biologically reasonable because, in the absence of external nutrient supply, animals must depend on stored reserves to meet maintenance requirements. The present findings are consistent with Toukourou *et al*. (2022), who reported weight loss during feed restriction in *A. marginata* and incomplete compensation following re-feeding.

The present experiment differed from the longer restriction regime reported by Toukourou *et al*. (2022), so the results should not be treated as quantitatively equivalent. Nevertheless, both studies indicate that interruption of feed supply can negatively affect growth. In the present study, feeding resumed after the withdrawal period, but the treatment differences remained evident through Week 16. The fruit-based group regained weight more effectively and retained the highest trajectory after feeding was restored.

The survival results provide a useful contrast to the growth findings. Although final survival was numerically higher in the fruit-based treatment than in the mixed treatment, the differences were not statistically significant. The fruit-based, mixed and leaf-based treatments recorded 88%, 80% and 86% survival, respectively. The absence of a significant treatment effect suggests that the dietary differences that clearly influenced growth were not sufficient to produce a detectable difference in final survival under the experimental conditions.

The concentration of mortality during the early weeks is also noteworthy. A large proportion of the deaths occurred shortly after the animals were introduced to the experimental environment. The animals had been transported from another farm and were exposed to a new housing environment and new dietary conditions. Tchowan *et al*. (2022) emphasized the importance of management, environmental conditions and other production factors in the performance of captive *A. marginata*. It is therefore reasonable to consider environmental adjustment and handling as possible contributors to early mortality, although the present study did not directly measure physiological stress.

The practical implication of the growth findings is important for small-scale snail production. Fruit-based feeding, using locally available resources such as watermelon and banana, produced the highest body-weight gain over 16 weeks. This suggests that fruit materials can be useful components of juvenile snail feeding programmes where they are sufficiently available. However, the results should not be interpreted as a direct economic recommendation because feed costs, feed intake and feed conversion ratio were not measured.

The lack of feed-intake data is particularly important. A treatment can produce greater body-weight gain because animals consume more of the feed, because the feed contains more readily available nutrients, because nutrient utilization is more efficient, or through a combination of these factors. The present study cannot distinguish among these explanations. Additional work involving measured feed intake and proximate analysis would therefore be needed to identify the mechanism underlying the observed treatment effect.

The absence of shell measurements is another limitation. Body weight is an important indicator of growth, but shell length and circumference provide additional information about development in land snails. Future nutritional studies should include these variables so that dietary effects can be assessed across both body mass and shell development (Orsar *et al*., 2020).

The experimental structure should also be considered when interpreting the statistical findings. Although 50 snails were initially allocated to each treatment, each treatment was associated with a single housing unit. Therefore, the individual snails do not provide the same level of independent replication as multiple treatment-specific cages would. The results should consequently be interpreted as evidence of strong treatment-associated growth differences under the conditions of this experiment, while recognizing that cage-level replication would strengthen future inference.

The 16-week dataset nevertheless provides a consistent and biologically meaningful pattern. Fruit-based feeding produced the highest cumulative growth, mixed feeding produced an intermediate response, and leaf-based feeding produced the lowest response. These differences were confirmed using robust statistical procedures and remained evident across the longitudinal record. At the same time, final survival was statistically similar among treatments.

Taken together, the findings support the value of locally available fruit materials in juvenile *A. marginata* production. The results are particularly relevant to southwestern Nigeria, where locally sourced plant materials can potentially be incorporated into low-input production systems. Further experimentation with replicated cages, quantified feed intake, dietary composition, shell growth and economic returns would help establish the most efficient feeding strategy for practical production.

5 CONCLUSION

The 16-week feeding experiment demonstrated that dietary treatment had a significant effect on the growth performance of juvenile *Archachatina marginata*. The fruit-based diet produced the highest cumulative weight gain, followed by the mixed diet, while the leaf-based diet produced the lowest weight gain.

The treatment differences remained statistically significant after the unequal variances among groups were taken into account. All pairwise comparisons were significant, and the longitudinal analysis confirmed that the diets produced different growth trajectories over time.

The one-week feed-withdrawal period resulted in body-weight loss in all treatments. Partial recovery followed re-feeding, but the differences among the dietary groups remained evident during the remainder of the experiment.

In contrast to growth, final survival did not differ significantly among treatments. Survival remained above 80% in all three groups, suggesting that the diets were broadly capable of supporting survival under the management conditions used.

Overall, the findings indicate that fruit-based feeding is a promising strategy for improving juvenile body-weight gain of *A. marginata* in southwestern Nigeria. However, the results should be interpreted within the limitations of the study, particularly the lack of feed-intake and feed-conversion measurements and the limited cage-level replication.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

We appreciate the management, Dean and HOD of Natural Science Education Department, Lagos State University of Education Oto/Ijanikin campus who permitted us to make use of the zoological garden in carrying out the research.

Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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