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GROWTH PERFORMANCE AND LIPID PROFILE OF ARCHACHATINA MARGINATA (GIANT AFRICAN LAND SNAIL) FED VARYING LEVELS OF RIPE EGGPLANT FRUITS BASED DIETS

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ABSTRACT

The performance of African giant land snails (Archachatina marginata) fed ripe eggplant fruits was studied using eighty-four (84) juvenile (four months old) Archachatina marginata for eight (8) weeks. The study evaluated the snails' growth performance and lipid profile (total cholesterol, low-density lipoprotein, high-density lipoprotein and triglycerides). The snails were divided into four treatment groups, with twenty-one (21) snails per group in a completely randomized design (CRD). Treatments 1, 2, 3 and 4 had varying levels of ripe eggplant fruits at 0%, 5%, 10% and 15% inclusion levels respectively. Isocaloric and isonitrogenous feeds and water were provided ad libitum, while other management practices were strictly adhered to. The results showed no significant differences (P>0.05) in growth performance across treatments. The results also revealed that total cholesterol decreased (P<0.05) significantly as the levels of ripe eggplant fruits increased across treatments. There were no significant differences (P>0.05) in low-density lipoprotein and triglycerides, while high-density lipoprotein differed (P<0.05) significantly across treatments. The result also showed a linear increase in high-density lipoprotein ("good" cholesterol) as the levels of ripe eggplant fruits increased across treatments. Therefore, a 15% inclusion level of ripe eggplant fruits in the diet of Archachatina marginata reduces total cholesterol levels and increases high-density lipoprotein without any adverse effect on growth. The study recommends using ripe eggplant fruits to formulate diets for animals with high cholesterol content and high levels of low-density lipoprotein in their meat.

INTRODUCTION

Archachatina marginata, a micro livestock, is part of the African Giant Land Snails (AGLS) group and is equally known as big black snails. Snail farming is an eco-friendly practice that requires minimal skills and investment (Ani et al., 2014). Like other species, the well-being and reproduction of AGLS heavily rely on housing and the quality of their diet. However, human-induced factors such as deforestation are causing a rapid decline in wild snail populations (Raimi & Temitayo, 2020), potentially leading to their extinction if this trend persists (Omolara & Olaleye, 2010).

Babalola (2018) says snail meat is delicious and boasts high nutritional and medicinal value. With a crude protein content of approximately 19%, it competes favourably with other animal protein sources (Nyameasem & Borketey-La, 2014). Additionally, it matches well with essential amino acids found in poultry eggs and flesh and is abundant in potassium, phosphorus, essential amino acids, vitamin C, and B complex (Afolabi, 2013). Medically, its low-fat content makes it suitable for individuals with heart-related conditions, as it is low in cholesterol (Babalola et al., 2015; Das & Ingole, 2023). Furthermore, snail meat is a good source of iron, aiding in reducing anaemia caused by iron deficiency.

Despite the evident advantages of snail products, intensive snail farming remains an overlooked sector in African nations like Nigeria, unlike in countries such as the United States of America and Australia (Miegoue et al., 2019), where snail farming is a thriving industry, offering opportunities to numerous farmers. This neglect of intensified snail production

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in Nigeria may stem from more information, knowledge, and skills needed for domestication and commercial snail farming. Therefore, prioritizing the domestication and commercialization of snails is crucial for preserving snails and their health benefits and ensuring a consistent supply of snail meat throughout the year. Nigerians need to focus on domesticating and commercializing snails to meet the recommended animal protein intake set by the Food and Agriculture Organization (Afolabi, 2013; Jimoh & Akinola, 2020).

Feeding is crucial in all livestock production endeavours, including snail farming. Despite the need for comprehensive information on the quality of Feed for snails in Nigeria (Babalola, 2018), snail farmers persistently strive to provide balanced diets. Snails naturally consume a variety of items present in their environment. Research indicates that snails thrive on single-source forage or concentrate Feed or a combination of forage and formulated diets (Okon et al., 2012). Additionally, some farmers have achieved satisfactory results by feeding snails conventional feeds, primarily plant-based materials like leaves, shoots, and fruits (Felici et al., 2020). In a highly managed snail farm, all snails, regardless of their growth stage, receive both external Feed and a formulated mix containing proteins, carbohydrates, minerals, and vitamins necessary for optimal growth. While Nigerians engaged in commercial snail production primarily rely on formulated commercial feeds, these feeds are often costly. Research has shown that snails thrive on compounded or formulated diets (Nyameasem & Borketey-La, 2014). However, due to the high expense associated with these diets, there is a necessity for further research and exploration of alternative, non-conventional feed ingredients (Jamro et al., 2021; Jabessa et al., 2023; Kebede et al., 2024).

In this context, eggplant fruits and leaves could serve as alternative food sources for snails (Cobbinah et al., 2008), although there needs to be more information regarding the performance of snails fed on them. Eggplants (Solanum melongena) are members of the Solanaceae family and are economically significant vegetables cultivated in various countries (Silva et al., 2020). They are widely distributed across tropical, subtropical, and Mediterranean regions because they prefer long, warm weather conditions for optimal growth (Dias, 2012). Known for their high moisture content and low caloric value (Kandoliya et al., 2015), eggplants are also considered valuable sources of antioxidants and essential phytonutrients. The soluble sugar content ranges from 2.7 to 5.0g per 100g (Ghadsingh & Mandge, 2012). According to Kandoliya et al. (2015), the protein content varies from 0.66% to 1.28% depending on the variety, along with the presence of ascorbic acid, a vital antioxidant, high anthocyanin content, and low glycoalkaloid content. Eggplant fruits are recognized as nutritious, offering various health benefits. Additionally, studies have shown significant decreases in the blood levels of low-density lipoproteins and total cholesterol in human volunteers who consumed eggplant powder (Dias, 2012).

Therefore, this study focuses on checking the growth performance of Archachatina marginata fed varying levels of ripe eggplant fruits in their diets. The experiment also analyses the snail meat to ascertain the lipid profile of the experimental animals when this plant byproduct is included in their diet to limit the waste of eggplant fruits when harvested without a ready market for sale.

The broad objective of this study was to check the growth performance and lipid profile of Archachatina marginata fed varying levels of ripe eggplant fruits in their diet. The specific objectives of the study include:

- To evaluate the growth performance, feed intake, and mortality rate of Archachatina marginata, they were fed varying levels of ripe eggplant fruits in their diets.
- To check the lipid profile of Archachatina marginata meat fed varying levels of ripe eggplant fruits in their diets.

LITERATURE REVIEW

The giant African land snail, known scientifically as Archachatina marginata, is commonly encountered in the West African coast's forests. It is the most sought-after snail species in Nigeria due to its notable size, reaching lengths of up to 20 cm and weighing as much as 500g (Okafor-Elenwo et al., 2021). In contrast to other members of the Archachatina genus, its shell exhibits a less pronounced point. Compared to other varieties, the shell of Archachatina marginata is broader towards the rear. These snails typically display a grey hue, with a head darker than their body. Their thick shells showcase a mottled black, brown, and white pattern. Upon reaching maturity, they measure between 11 to 19 cm in length and weigh 150 to 800 grams. It takes them approximately 18 to 24 months to get full size. Because of its roots in the African rainforest, Archachatina marginata is ideally suited for snail farming in Nigeria. This species flourishes in environments with temperatures ranging from 25 to 30°C and a consistent relative humidity of 75 to 95% throughout the year; otherwise, the snails will enter a state of hibernation or dormancy. During dormancy, a white calcareous layer seals off the snail's shell to prevent water loss from the body.

The structured tasks in raising snails are similar to those in traditional livestock farming, such as poultry, pigs, fish, cattle, and goats. Any distinctions that arise are typically related to specific methods or treatments rather than core principles. Site selection is crucial, with a preference for a location near the farmer's home for the snailery. Suppose proximity to the farmer's residence is not feasible. In that case, the farmer with an established farmland can opt for a site within the farm, reasonably close to the service centre, where existing security measures can easily encompass the snailery (Akintomide, 2004). This helps to deter harmful pests, predators, and potential theft. The chosen site should ideally feature a level surface with fertile, loamy soil. Snails are naturally inclined to roam and often stray beyond boundaries, especially in favourable environments. Small-scale farmers raise snails in various makeshift structures such as pits, plastic containers, earthen pots, enclosures crafted from palm fronds and bamboo, and rectangular enclosures built from cement or clay blocks. Additionally, arrangements like stacks of tyres with covers, hutch boxes, and trench pens are suitable for housing snails. Farmers should initially excavate a layer of loamy soil to a depth of around 12 cm before introducing the snails when using plastic containers or earthen pots. Cane, strips of palm fronds, baskets, and large clay pots can be positioned on a stable or concrete surface and placed in shaded areas. Fill them with loamy soil to a depth of 15 cm. The author also suggests covering these enclosures with framed wire net lids to promote ventilation, prevent snail escape, and deter pests. Additionally, small perforations should be made at the bottom of the cage or basket to facilitate drainage and avoid water logging, as snails do not thrive in overly damp conditions. However, for large-scale or commercial snail farming, factors like wind speed and direction, soil composition, temperature, and humidity should be carefully considered before constructing a standardized snail housing facility, as noted by Akintomide (2004). Various housing options, such as cage pens, sand enclosures, concrete pens, and trench pens, are suitable for snail farming. According to Akintomide (2004), selecting breeding stock should prioritize characteristics like fecundity, hatchability, and growth potential. Utilizing the giant land snails, Achatina achatina, and Archachatina marginata is more cost-effective. These species can be acquired from Research Institutes, other snail farmers or dealers, and local markets. It is advisable to procure fully-grown, sexually mature, and active snails weighing 150-250g, capable of promptly producing eggs after introduction. Akinyemi et al. (2007) emphasize that choosing superior or desired traits in breeding stock ensures economically viable snail production. The African giant land snail is predominantly favoured in snail farming. Typically, snails consume approximately 3-4% of their body weight in Feed daily (Jimoh & Akinola, 2020). Like other animals, the growth of snails varies depending on their diet. AA is a significant and beneficial correlation between the Feed's nutrient content and snail growth. Therefore, it is essential to provide a balanced diet comprising the right proportions of carbohydrates, fats and oils, proteins, minerals (especially Calcium), vitamins, and a sufficient water supply. Newly hatched snails are typically nourished with powdered formulated Feed, soft leaves, ripe fruits, mashed food, or a blend of these options. However, they tend to favour powdered formulated Feed during this delicate stage. Snail diet commonly includes lime supplementation, which is crucial for shell development. Lime is essential before reaching sexual maturity to prime the snails for egg production and shell strengthening. Additionally, it aids in repairing shell damage resulting from accidents or egg-laying activities. A study by Jimoh and Akinola (2020) investigated the reproductive performance of laying snails (Archachatina marginata) when fed a diet comprising roughages and various concentrate mixes. The research highlighted the necessity for further studies into using compounded rations for snails to address the scarcity of fruits, tubers, and leaves during the dry season. The experiment's findings suggested that the concentrate ratio is crucial for achieving optimal reproductive output in snails compared to roughages. Providing adequate Feed, supplemented with vitamins, Calcium, minerals, and water during the dry season, can interrupt the aestivation cycle and increase productivity while reducing drug wastage and inhibiting bacterial growth over time. Omolara and Olaleye (2010) studied the performance, carcass analysis, and sensory evaluation of cooked juvenile African giant snails (snails) fed exclusively on pawpaw leaves, whole lettuce, lettuce waste, and cabbage waste. The findings indicated that snails of Archachatina marginata could effectively utilize lettuce and cabbage waste as sole feed ingredients, thereby enhancing the animal protein supply in Nigeria. Moreover, the various dietary treatments did not significantly affect the sensory evaluation of the snails. In a separate study, Eke et al. (2010) investigated the impact of crude oil fractions on the lipid profile of Achatina achatina. The researchers concluded that crude oil fractions induce alterations in the fatty acid composition of the snails, thereby affecting their nutritional values. Nyameasem and Borketey-La (2014) researched the impact of formulated diets on the growth and reproductive performance of the West African giant snail (Achatina achatina). The study compared the performance of snails-fed traditional snail feeds with those fed compounded diets. Their findings indicated that Achatina achatina readily consumed and responded positively to compounded diets. Snails fed compounded diets exhibited notable improvements in growth and reproduction compared to those fed a diet solely consisting of pawpaw fruits. The broiler starter diet also appeared to promote growth in juvenile and adult snails, while layer mash favoured reproductive performance.

In another study, Ozougwu and Ene (2014) investigated the effects of crude oil fractions on the lipid profile of Achatina achatina. Their findings revealed that an increase in the concentration of crude oil fractions significantly decreased the lipid profile of Achatina achatina. Babalola et al. (2015) conducted a study on the growth performance of growing snails (Archachatina marginata) fed milk leaf (Euphorbia heterophylla) supplemented with Calcium from three different sources (eggshell, oyster shell, and bone meal). The experiment concluded that eggshells are the most effective calcium source for growing snails when fed a basal diet of milk leaf, based on overall performance. Oyster shells can be utilized as an alternative in the absence of eggshells. However, the suitability of bone meal as a calcium source for snail performance is questionable, and milk leaf should only be fed to snails with a calcium supplement. In a separate study, Oketoobo et al. (2021) compared the growth performance of snails fed a formulated diet with three selected edible vegetables. Their findings suggested that snails fed these vegetables and fruits exhibited favourable growth performance comparable to those fed a formulated feed. Consequently, these feeding materials can be conveniently utilized for snail rearing.

Eggplant, also known as aubergine in Europe and brinjal in South Asia, is a popular vegetable crop cultivated in many countries across subtropical, tropical, and Mediterranean regions due to its requirement for a prolonged period of warm weather to yield good harvests. Consequently, it is a staple in numerous tropical and subtropical nations (Feleafel, 2005). Recognized as a dietary vegetable, eggplant is valued for its high moisture content and low caloric value. Dias (2012) concurred, noting that various eggplant varieties exhibit estimated soluble sugar levels ranging from 0.154 to 2.40 µg.mg-1 dry weight. These significant sugar components play crucial roles in human health by providing energy and participating in numerous biochemical reactions unrelated to energy metabolism.

Moreover, these carbohydrates may act as substrates for synthesizing aromatic amino acids and phenolic compounds via the Shikimic acid pathway, potentially enhancing the phenolic and antioxidant capabilities of the same variety. The protein found in eggplant fruits contributes significantly to their nutritional value. This protein content suggests that consuming eggplant can aid in hormone production, regulating various bodily functions such as growth, repair, and tissue maintenance. Protein levels range from 0.66% to 1.28%. Eggplants are an excellent source of dietary fibre, supporting digestion and manganese and contributing to bone health.

Additionally, it provides significant amounts of molybdenum, which aids enzyme function, and potassium, which supports heart health. Eggplant also offers vitamin K and magnesium for bone health, copper, vitamin C, vitamin B6, folate, and niacin for heart health. Research indicates that eggplant can effectively aid in reducing high blood cholesterol levels. Studies conducted by Dias (2012) demonstrated a notable decrease in the blood levels of low-density lipoproteins and total cholesterol in human volunteers who consumed eggplant powder. Eggplant phenolics have been shown to possess inhibitory effects on key enzymes relevant to type 2 diabetes and hypertension. In addition to being rich in vitamins and minerals, eggplant contains essential phytochemicals with antioxidant properties. These phytochemicals include phenolic compounds like caffeine and chlorogenic acid and flavonoids like nasunin. Nasunin, also known as delphinidin-3-(coumaroylrutinoside)-5-glucoside, is the predominant phytochemical in eggplant. However, it is worth noting that toxic or anti-nutritional components have been reported in eggplant forage (Okereke, 2015). These anti-nutritional factors pose a significant challenge in fully realizing the nutritional benefits of eggplant forage. Despite their presence in substantial amounts, these anti-nutritional factors have been found to play significant roles in the nutritional quality of food.

Eke et al. (2010) state that a comprehensive understanding of lipid biochemistry is crucial for comprehending the significance of different unsaturated fatty acids in nutrition and health. Lipids represent a chemically diverse group of biological substances composed of non-polar groups. They are soluble organic compounds that can only be extracted from cells using organic solvents and possess a higher caloric value than carbohydrates. Besides their insulator function, essential fatty acids are vital for maintaining healthy skin. Lecithins, for instance, serve both metabolic and structural roles. Lipid biochemistry knowledge also sheds light on the significance of various unsaturated fatty acids in nutrition and health.

Furthermore, lipids play pivotal roles in human nutrition; fats and oils are many organisms' primary stored energy sources, while phospholipids and sterols are major structural components of biological membranes. Other lipids, although present in smaller quantities, are essential as enzyme co-factors, electron carriers, highly absorbent pigments, hormones, and intracellular messengers. Lipids possess higher caloric values compared to carbohydrates. Fat deposits within the body are insulation and provide protective cushioning for organs. Essential fatty acids play a crucial role in maintaining healthy skin. Lipids are vital dietary components due to their high energy content, fat-soluble vitamins, and essential fatty acids in natural food fats. Fat is an efficient energy source within the body, directly and potentially when stored in adipose tissue. It acts as a thermal insulator and facilitates the rapid transmission of nerve impulses along myelinated nerves, given the high-fat content of nerve tissue. Lipoproteins, combinations of fat and protein, are essential cellular components found in cell membranes and mitochondria within the cytoplasm and serve as vehicles for lipid transport in the bloodstream. Understanding lipid biochemistry is crucial for comprehending biomedical topics such as obesity, atherosclerosis, and the roles of various polyunsaturated fatty acids in nutrition and health. The term "lipid profile" refers to the assessment of various lipid parameters, typically including total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, and triglycerides. Adults without additional risk factors for heart disease should undergo fasting lipid profile testing once every five years. Routine lipid profile testing is not necessary for adolescents and children; however, it is recommended for individuals at heightened risk of developing heart disease later in life. The significance of some components of lipid profile testing is outlined below. Total Cholesterol (TC): Cholesterol, a type of fat, is present in human blood and can be synthesized by the body or obtained from dietary sources, particularly animal products. While cholesterol is essential for cellular health, elevated levels are directly associated with an increased risk of heart and vascular diseases, including coronary artery disease.

High-Density Lipoprotein (HDL): HDL is a lipoprotein composed of fat and protein in the bloodstream. It is often referred to as "good" cholesterol because it aids in removing excess cholesterol from the blood and transporting it to the liver (Das & Ingole, 2023). Higher HDL levels correlate with a reduced risk of heart and vascular diseases. Low-Density Lipoprotein (LDL): LDL, like HDL, is a lipoprotein consisting of both fat and protein in the bloodstream. It is commonly called "bad" cholesterol because it collects cholesterol from the blood and transports it to cells (Das & Ingole, 2023). Elevated levels of LDL are associated with an increased risk of heart and vascular diseases. Triglycerides (TG): Triglycerides are a form of fat present in the bloodstream. The level of this fat in the blood is influenced by dietary factors such as sugar, fat, or alcohol intake. However, it can also be elevated due to factors such as obesity, thyroid or liver disease, and genetic conditions. Elevated triglyceride levels are associated with an increased risk of heart and vascular diseases.

MATERIALS AND METHODS

Study Area

The research occurred at the Snail Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka. Nsukka is situated in the derived Savannah region, with coordinates ranging from latitude 7 to 12.510 North and an altitude of 447m above sea level. The climate in the study area is typically tropical, characterized by relative humidity levels between 65% and 80%. The average daily minimum temperature ranges from 22 to 24.7°C, while the average maximum temperature ranges from 33 to 37°C. Annual rainfall in the region falls between 1680 to 1700mm (Ozor et al., 2015).

Duration of Study: The study will last for eight weeks.

Experimental animals: Eighty-four juvenile *Archachatina marginata* were used for the study and were procured from a snail farm in Ibadan, Oyo state.

Materials Used

Twelve plastic baskets were used. Sandy loam soil, procured from the nearby University farm, was also used. The soil was sterilized and put into different baskets labelled accordingly.

Acclimatization

The snails were consistently fed the control diet for two weeks to establish their condition before being fed the treatment ration. The acclimatized snails were then divided into four treatment groups, each with three replicates and seven snails per treatment.

Procurement and processing of the eggplant fruits

The eggplant fruits were obtained from the Department of Crop Science Farm, University of Nigeria, Nsukka. They were sun-dried, ground, and used for diet formulation.

Table 1. Proximate composition of ripe eggplant fruits

Parameters	Protein (%)	Moisture (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)
	16.068	6.118	1.866	2.847	2.367	70.734
	16.060	6.127	1.871	2.841	2.361	70.740
	16.067	6.124	1.875	2.846	2.365	70.723
Average	16.065	6.123	1.871	2.845	2.364	70.732

Experimental Diets

Four diets were formulated using maize, wheat offal, soya bean meal, palm kernel cake, fish meal, Lysine, methionine, Lime, Bone meal and Ripe eggplant fruits. Hence, the table below shows the combination of ingredients for the different experimental diets used for the experiment.

Table 2. Experimental Diets

INGREDIENTS	T1-Control (0% ripe Eggplant)	T2-Treatment2 (5% ripe Eggplant)	T3-Treatment3 (10% ripe Eggplant)	T4-Treatment4 (15% ripe Eggplant)
Maize	20.734	18.714	16.694	14.677
Wheat offal	20.734	18.714	16.694	14.677
Soya bean meal	17.511	17.175	16.839	16.501
Palm Kernel Cake	30.019	29.443	28.867	28.287
Fish meal	2.502	2.454	2.406	2.357
Lysine	0.250	0.250	0.250	0.250
Methionine	0.250	0.250	0.250	0.250
Lime	4.000	4.000	4.000	4.000
Bone meal	4.000	4.000	4.000	4.000
Eggplant Fruits	0.000	5.000	10.000	15.000
Total	100.000	100.000	100.000	100.000

Table 3. Proximate Composition of Experimental Diets

	T1	T2	T3	T4
Crude Protein	20.000	20.000	20.000	20.000
Moisture content	10.369	9.896	8.593	9.289
Ash	3.000	4.500	3.250	4.000
Fibre	7.348	6.967	6.607	6.263
Nitrogen free extract	59.283	58.637	61.550	60.448
Energy (ME), (kcal/kg)	2.233	2.100	2.033	1.843

Laboratory Analysis

The nutrient composition of the dried, ground eggplant fruits was determined through proximate analysis following the protocols outlined by the Association of Analytical Chemists (AOAC, 2005). Additionally, the lipid profile of the snail meat was assessed using the Enzymatic Endpoint Method developed by Allain et al. (1974). This method significantly advances cholesterol determination, replacing traditional chemical saponification with enzymatic saponification for more accurate results.

Experimental design

For the experiment, 84 juvenile *Archachatina marginata* snails, aged four months with an average body weight of 92.730, were utilized. A Completely Randomized Design consisted of four distinct dietary treatments comprising 21 snails. Each treatment was replicated three times, with seven snails per replicate.

T_0 = Control diet

T_1 =Control diet + 5.0% ripped eggplant fruit

T_2 = Control diet + 10% ripped eggplant fruit

T_3= Control diet + 15% ripped eggplant fruit.

Experimental Model
Below is the model for Completely Randomized Design.
$X_{ij} = U + T_i + E_{ij}$

X_{ij}= measurement taken (This means j observation of the i factor)

U= Population mean

T_i= treatment effect

E_{ij}=residual error.

Statistical Analysis
The collected data underwent analysis of variance (ANOVA) within a completely randomized design (CRD) framework using the Statistical Package for the Social Sciences (SPSS). ANOVA was performed for each parameter, with the different treatments as the factors. Significant differences among means were determined using Duncan's new multiple-range test within the same software package.

Data Collected/Measured
Data were gathered concerning growth parameters, including body weight, shell length, and shell circumference. Additionally, feed intake was recorded, and weight gain and feed conversion ratio were computed. Furthermore, lipid profile analysis was conducted in the laboratory.

Growth Performance/ Feeding
Feed Intake: Feed intake was measured by providing the experimental animals with 10g of Feed daily, which was weighed before being supplied. The remaining Feed was weighed the following day, and feed intake was calculated by determining the difference between the leftover Feed and the quantity initially provided.

Body weight: The snails were weighed daily using a sensitive scale, and the weight gain was calculated by comparing two consecutive weigh-ins.

Shell length and Circumference: Shell length and circumference were measured using Venier callipers and taken daily.

Feed Conversion Ratio: The feed conversion ratio was calculated based on the Feed consumed compared to the weight gain ratio. FCR (Feed consumed: weight gain) = $\frac{Feed\ consumed}{Weight\ gain}$

Lipid profile:

- Triglycerides
- High-Density Lipoprotein
- Low-Density Lipoprotein
- Total Cholesterol

RESULTS

Growth Performance and Feeding
Table 4. Growth Performance and Feeding of *Archachatina marginata* fed varying levels of ripe eggplant fruits in their diets

Parameters	T1 (Control)	T2 (5%)	T3 (10%)	T4 (15%)
ADFI (g)	1.11±0.12	1.08±0.11	1.42±0.34	1.24±0.16
Initial body weight (g)	92.53±3.47	91.81±3.47	93.19±0.88	93.39±1.32
Final body weight (g)	99.58±0.83	97.13±0.64	96.88±0.38	96.88±0.13
Daily weight gain (g)	0.50±0.19	0.38±0.19	0.26±0.09	0.25±0.10
Feed conversion ratio	2.64±0.68	3.94±2.22	6.60±3.53	5.73±1.79
Initial shell length (g)	10.09±0.05	9.56±0.29	9.85±0.19	10.12±0.01
Final shell length (g)	10.30±0.05	9.96±0.09	10.29±0.14	12.81±2.49
DSLG (g)	0.01±0.01	0.03±0.02	0.03±0.00	0.19±0.18
ISC (g)	14.28±0.30	14.45±0.40	14.66±0.13	14.58±0.03
FSC (g)	14.33±0.35	14.91±0.09	14.78±0.13	15.37±0.15
DSCG (g)	0.00±0.00	0.03±0.02	0.01±0.00	0.06±0.01
% Mortality	6.25±6.25	12.5±0.00	18.75±6.25	18.75±6.25

ADFI= Average daily feed intake

DSLG = Daily shell length gain

ISC = Initial shell circumference

FSC = Final shell circumference

SCG = Shell Circumference gain

DSCG = Daily shell circumference gain

The results obtained for the growth performance of juvenile *Archachatina marginata*, fed varying levels of ripe eggplant fruits in their diets, are presented in Table 6. There were no notable differences in the mean daily feed intake among juvenile snails in treatments T1, T2, T3, and T4. However, T3 exhibited the highest consumption with a daily feed intake of 1.42g, while T2 displayed the lowest consumption at 1.08g. Similarly, there were no significant variances in the mean daily weight gain; however, a decreasing trend in weight gain was observed as the level of ripe eggplant fruits added increased. Specifically, T1 demonstrated the highest daily weight gain of 0.50g, while T4 exhibited the lowest daily weight gain at 0.25g.

There was no appreciable difference in the shell gain of snails on the T1, T2, T3, and T4 diets, but the values of the shell length gain ranged between 0.19 and 0.01. The shell length of those on T4 had the highest gain (12.81±2.49), while that of T1 was the least (10.30±0.05).

The shell circumference gain result ranges from 0.06 to 0.00. The increase was insignificant, but T1 had the highest increase.

The analysis of feed conversion ratio did not show a significant difference, but the results ranged from 6.60 to 2.64.

Lipid Profile

Table 5. Lipid Profile of *Archachatina marginata* fed varying levels of ripe eggplant fruits in their diet

Parameters	T1 (Control)	T2 (5%)	T3 (10%)	T4 (15%)
Total Cholesterol	83.00±1.00^{a}	65.00±1.00^{b}	61.50±0.80^{bc}	59.00±1.00^{c}
Low-density Lipoprotein	26.00±8.00	9.00±1.00	1250±1.80	14.00±2.00
High-density Lipoprotein	12.00±2.00^{b}	46.50±4.50^{a}	42.80±0.80^{a}	40.50±1.80^{a}
Triglycerides	101.00±7.00	96.50±2.80	88.00±4.00	84.00±4.00

This means that the rows followed by different letters are significantly different (P≤ 0.05).

Table 5 presents the findings from the lipid profile analysis of *Archachatina marginata*, which were fed varying levels of ripe eggplant fruits in their diets. A notable disparity was observed in total cholesterol levels, with significant variations (P<0.05) noted. Specifically, total cholesterol values were 83.00, 65.00, 61.50, and 59.00 for T1, T2, T3, and T4 respectively. Conversely, there was no significant contrast in Low-density lipoprotein levels, ranging from 26.00 to 9.00, with T1 recording the highest value (26.00) and T2 the lowest (9.00). High-density lipoprotein exhibited a statistically significant difference, while no significant variance was found in Triglyceride levels.

DISCUSSIONS

Growth Performance and Feeding

The results obtained showed that there were no significant differences among treatments (p<0 05). However, looking at the initial and final body weight and weight gain, it was observed that the initial and final body weight showed a slight increase. Also, from the weight gain result obtained, it was observed that T1 (0% ripe eggplant fruits) recorded the highest weight gain. There were also slight increases from the initial to the final shell length and from the initial to the final shell circumference, positively correlated to an increase in body weight. However, these increases in growth parameters were not statistically significant (p>0.05). This finding appears to contradict the results presented by Nyameasem and Borketey-La (2014) and Jimoh and Akinola (2020), who investigated the impact of formulated diets on the growth and reproductive abilities of the West African giant snail (*Achatina achatina*). Their studies compared the performance of snails fed conventional snail feeds with compounded feeds. They concluded that *Achatina achatina* could consume and positively respond to compounded diets. In this study, snails fed compounded diets, including ripped eggplant fruits, exhibited no significant improvements in growth performance. This could result from the ripped eggplant fruits in the formulated diet or poor management practices during the experimental period. Looking at the management practices adopted during this experimental period, the snails were obtained from reputable commercial farms in Oyo state, and the acclimatization period was followed correctly. During this acclimatization period, there was a gradual shift from sole forage diets to compounded diets and feeds were provided daily. However, it is worth noting that these snails were acquired during the dry season when the environmental temperature was exceptionally high. This could have impacted their performance since snails typically thrive in moist environments. As stated by Cobbinah et al. (2008), "Without expensive artificial means of climate control, snail farming is restricted to the humid tropical forest zone which offers a constant temperature, high relative humidity, preferably no dry season, and constant day/night rhythm throughout the year" (Cobbinah et al., 2008). Feeding is another vital management practice that positively or negatively affects any animal production venture. Omolara and Olaleye (2010) reported that conventional snail feeds are mainly of plant origin. In contrast, Nyameasem and Borketey-La's (2014) research stated that they can also perform maximally on formulated diets. Ani et al. (2013) reported that decreasing the crude protein level of snail diets to less than 18% crude protein would significantly reduce their growth performance, while Nyameasem and Borketey-La (2014) concluded that juvenile snails fed broiler starter (19.7% CP) perform best compared to others fed with unripe pawpaw fruits and other forms of formulated diets. Therefore, while formulating the diet for this research, the aim was to formulate the four different diets with 20% CP. Therefore, the differences recorded in weight gain are not a result of differences in the crude protein content of the different diets, although the differences were not statistically significant.

The reason for the non-significant result obtained in the case of this experiment, even though formulated diets were used, could also be due to the inclusion of the ripe eggplant fruits in the diets. This is because the result showed that the higher the ripe eggplant fruits added to the snail diets, the lesser the weight gain, although the differences in the weight were insignificant ($P<0.05$). There is also sparse information in the literature about any compound in ripe eggplant fruits that can adversely affect the growth of snails, but Okereke (2015) reported some toxic factors or anti-nutritional factors present in eggplant forage. These anti-nutritional factors (ANFs) interfere with metabolic processes and the availability of nutrients. Hence, the probability of traces of these anti-nutritional factors in eggplant fruits cannot be ruled out since they have been reported to be present in eggplant forages and other feedstuffs of plant origin.

Also, the proximate analysis of ripe eggplant fruits showed an average protein content of 16.065% crude protein. This crude protein value is less than 18%, and Ani et al. (2013) reported that decreasing the crude protein level to less than 18% crude protein would significantly reduce the growth performance of snails. Hence, using ripe eggplant fruits as the sole diet for snails is only advisable when used with other feed ingredients that are protein sources for diet formulation. Findings from the study conducted by Elizabeth and Zira (2009) revealed that fresh eggplant fruits are nutritionally composed of water (92.5%), protein (1%), fat (0.3%), and carbohydrates (6%). Additionally, they contain varying amounts (between 30 and 50%) of iron (Fe), fibre, potassium (K), manganese (Mn), copper (Cu), and vitamins such as thiamin (vitamin B1), B6, folate, magnesium (Mg), sodium (Na), and niacin.

Consequently, disparities exist in the nutritional makeup between ripe and fresh (unripe) eggplant fruits. Even though there were occasional deaths during the acclimatization period, the percentage mortality when the experimental diets were introduced ranged from 6.25 to 18.75 (T1 to T4, respectively). This showed a direct relationship with increased ripe eggplant fruits added. The higher the ripe eggplant fruits added, the more the mortality. Therefore, the rate of mortality could be traceable to dietary effects. This could also be due to traces of anti-nutritional factors in ripe eggplant fruits since Okereke (2015) reported many of these anti-nutritional factors are present in eggplant forages.

Lipid Profile

The lipid profile analysis revealed that the control group (0% ripe eggplant fruits) exhibited the highest cholesterol level compared to the other treatments. Specifically, there was a gradual reduction in cholesterol levels corresponding to the increase in eggplant fruits used in feed formulation. It is important to highlight that while cholesterol is essential for cellular health, excessive levels are directly associated with the risk of heart and vascular diseases. Excessive cholesterol can lead to coronary artery disease (Das & Ingole, 2023). Therefore, these findings align with Dias (2012), who noted a considerable reduction in total cholesterol and low-density lipoprotein levels in human volunteers consuming eggplant powder. However, while this experiment demonstrated a decrease in low-density lipoprotein, it did not reach statistical significance ($p<0.05$). Low-density lipoprotein, commonly called "bad" cholesterol (Das & Ingole, 2023), transports cholesterol from the blood to the cells. Elevated LDL levels are associated with an increased risk of heart and vascular diseases.

Dias (2012) elaborated on phenolic compounds in eggplants, emphasizing that chlorogenic acid is their primary phenolic compound. Chlorogenic acid is one of the most effective free scavengers in plant tissues. The benefits of chlorogenic acid include anti-mutagenic (anti-cancer), anti-microbial, anti-low-density lipoprotein (bad cholesterol), and antiviral properties. The findings also indicated a noteworthy increase in high-density lipoprotein ($p<0.05$). High-density lipoprotein, often called the "good" cholesterol (Das & Ingole, 2023), is crucial in eliminating excess cholesterol from the bloodstream and transporting it to the liver. Elevated levels of HDL are associated with a reduced risk of heart and vascular diseases. Furthermore, the results demonstrated that incorporating 5% ripe eggplant fruits into the diets of the experimental animals yielded the highest value of high-density lipoprotein. Although there was a decrease in triglyceride levels due to treatment with eggplant fruits, this decrease did not reach statistical significance ($p<0.05$).

CONCLUSIONS

From the result obtained, there was no significant increase in the growth performance of *Archachatina marginata* by adding varying levels of eggplant fruits to their diets. The result also showed a significant reduction in total cholesterol and increased High-density lipoprotein. The study recommends the use of ripe eggplant fruits for the formulation of a diet for animals with high cholesterol content and high levels of low-density lipoprotein in their meat is advisable. Care should be taken to embark only on snail production experiments during the peak of the dry season if there are standard constructions to simulate an artificial damp environment for the snails. Villagers should also be enlightened about commercial snail farming so they do not harvest the snails while searching for wild snails.

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