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Abstract

The present study investigated the potential use of giant African land snail (GALS) in formulating an efficient and low-cost diet for laying Japanese quails. A total of 90 five-week-old female laying Japanese quails were reared under controlled conditions with three treatments and three replications using completely randomized design (CRD). The feed formulation is apportioned to the following diet treatments: T1 - formulated feeds as control, T2 - formulated feeds + 30% GALS, and T3 - formulated feed + 60% GALS. The results of the study revealed that T3 significantly excelled in terms of average total eggs produced (39.70), average egg weight (10.01 g), average feed consumption (1,298.73 g), and average color of the egg yolk (5.02). In addition, T3 proved to be the most effective in terms of feed conversion ratio (32.78 g), cost-return analysis with an ROI of 49.79%, and had the lowest cost of formulated feeds at ₱23.58 per kilogram in comparison with the other treatment. It was concluded that 60% of GALS is the optimum level for best laying performance of Japanese quail. Furthermore, the researchers highly recommended the use of 60% GALS and encourage further studies to explore higher substitution levels for fishmeal.

Keywords: *Achatina fulica, alternative protein source, production performance*

Introduction

The global demand for quail products is steadily increasing, with the Asia-Pacific region experiencing particularly rapid growth due to rising meat consumption (Tyagi et al., 2025). This region also holds the largest revenue share in the quail egg market (Business Research Insight, 2025), with countries such as China, Japan, Thailand, and the Philippines being some of the consumers of quail egg products. The adaptability of quails to diverse climates and their potential for scalable production make them a promising component of the poultry industry. In the Philippines, Philippine Statistics Authority [PSA] (2018) recorded an increase in the quail production of nearly eight-fold from 300,000 birds in 1980 to 2.3 million in 2012, raising its farm scale production fivefold.

Additionally, quail eggs have been an important part of Filipino cuisine since the 17th century, making them one of the country's staple foods and part of its culture. Locally known as "pugo", quail meat and egg are commonly enjoyed as street foods and traditional dishes. Quail eggs are not only delicious, but also highly nutritious. It offers more protein, phosphorus, iron and vitamins A, B1, and B2 than any other poultry. These health benefits make them an excellent option for individuals with diabetes (Amit, 2019). Meanwhile, Tsuji and Javier (2023) showed that rising demand has fueled production, solidifying its place in the Philippine poultry industry. Among these producers, Veneracion (2020) stated that Bulacan was one of the crucial players, hosting numerous farms dedicated to quail egg production.

Despite its growth, quail farming in the Philippines faces challenges, including disease outbreaks, poor brooding and management practices, and difficulty accessing affordable high-quality feeds (Lima et al., 2022). Feeds and protein play a critical role in the laying performance of quails. A well-balanced diet ensures consistent egg production, strong eggshell quality, and overall reproductive health. Studies indicate that protein levels between 18% and 22% can influence egg yield, yolk pigmentation, and even income over feed cost (Cuaresma et al., 2021). Additionally, quails require essential vitamins and minerals such as calcium and phosphorus to maintain optimal laying efficiency (Nakyanzi, 2025). Thus, addressing feed ingredient fluctuations is crucial for maintaining production efficiency.

A viable alternative protein source for poultry is the Giant African Land Snail (GALS), scientifically known as *Achatina fulica*, which is rich in protein and suitable for livestock feed (Diarra, 2015). It was originally introduced to the Philippines by the Japanese during World War II as a food source (Fontanilla et al., 2014), and has since become one of the world’s most invasive species. Ranking second on the *100 of the World's Worst Invasive Alien Species* list, this snail poses a threat to public health, biodiversity, and agriculture (Global Invasive Species Database, 2024). It feeds on more than 500 plant species, including cassava, cocoa, papaya, and peanuts, leading to significant crop losses that affect farmers' livelihoods.

Controlling the spread of this pest is crucial for safeguarding crops and maintaining a stable food supply. Rather than treating it solely as a threat, incorporating GALS into poultry feed presents an opportunity to turn its presence into a productive resource (Ifill, 2016).

Thus, the general objective of the study was to evaluate GALS as a partial substitute for fishmeal in the diet of Japanese quail while also offering farmers a sustainable way to mitigate the damage caused by this invasive species. Specifically, it aimed to formulate a low-cost diet for laying quail; identify which treatment provided the highest total number of produced eggs; determine the characteristics of quail egg in terms of weight and yolk color; identify which treatment achieved the best feed conversion ratio (FCR); and find out which treatment obtained the highest return on investment (ROI).

Materials and Methods

Locale of the Study and Collection of Test Material

The experiment was conducted at the College of Agriculture, Bulacan Agricultural State College, located in Poblacion, San Ildefonso, Bulacan. GALS were collected from their natural habitats within the area of San Miguel and San Ildefonso, Bulacan. As nocturnal species, these snails remain hidden during the day and only become active at night or after rainfall. They thrive in various habitats like forest edges, agricultural lands, wetlands, disturbed areas and even urban environments (Atwood, 2024). Unlike cultivated snails, wild GALS vary in age and size and have a diverse diet, influenced by the local vegetation and organic matter within their surroundings. San Ildefonso and San Miguel, Bulacan feature diverse landscapes, including flat agricultural plains and hilly terrains that support both farming and residential activities (The Bulacan, 2024). This makes the location suitable for a wide range of animal species, including GALS.

Experimental Diet Preparation

The collected snails were initially kept in a container for three days to minimize dirt and mucus buildup. They were then thoroughly washed to remove any remaining debris and secretions. After cleaning, the snails were boiled for 10 minutes, and the meat was separated from the shells. The entrails were carefully removed, and the remaining meat was thinly sliced. To reduce moisture content, the sliced snail meat was sun-dried for one hour, followed by oven-drying at 150°C for eight minutes. The drying process was completed once the meat became crisp and fully dehydrated. The dried meat was then pulverized using a blender and sifted through a fine sieve to ensure uniform particle size. The final product, referred to as pulverized GALS, was stored in airtight plastic containers to maintain its quality and prevent moisture absorption. The replacement of fishmeal with GALS was determined based on the specific percentage allocation for each treatment.

All feed ingredients, presented in Table 1, were procured locally, individually weighed, and proportioned according to the experimental treatments. To ensure even nutrient distribution, molasses and corn were first mixed, followed by the addition of rice bran (D1), fishmeal, copra meal, GALS (for T2 and T3), soybean meal, salt, limestone, mono-dicalcium phosphate, DL-methionine, and lysine. The mixture was processed in batches using a large mixer for 10 minutes, then pelletized using a pelletizing machine. The pellets were allowed to cool to room temperature before being packed into separate sacks according to their designated treatment rations (T1, T2, and T3).

Table 1

Composition of Experimental Ration and Calculated Analysis

Ingredients %	T1 (Control)	T2 (30% GALS)	T3 (60% GALS)
Corn	58.10	55.68	53.39
Fish meal	5.30	3.71	2.12
Copra meal	2.11	2.03	1.96
Molasses	1.00	1.00	0.80
Rice bran D1	4.10	6.10	7.97
SBM, USHP	25.40	26.30	27.30
Limestone	3.24	3.09	2.58
Salt	0.30	0.15	0.20
Mono-dicalcium phosphate	0.25	0.15	0.30
DL-Meth	0.10	0.10	0.10
Lysine	0.10	0.10	0.10
GALS	-	1.59	3.18
Total	**100**	**100**	**100**
Calculated Analysis			
ME (Kcal/kg)	2900	2900	2900
C. Protein (%)	19.96	19.96	19.99
C. Fat (%)	3.62	3.64	3.65
C. Fiber (%)	3.67	3.73	3.79
Ca. (%)	1.87	1.61	1.39

Analysis of the GALS diet supplement

As shown in Table 2, the GALS samples were submitted and tested for proximate analysis at the Precisione International Research and Diagnostic Laboratory, Inc., located along San Jose-Marilao Road, Sta. Rosa 1, Marilao, Bulacan.

Table 2

Proximate Analysis of GALS

Parameter	Test Method	Result
Crude Protein (%)	Dumas	19.82
Crude Fat (%)	Extraction	4.49
Crude Fiber (%)	ANKOM Bag Technique	0.34
Ash (%)	Loss on Ignition	4.05
Moisture (%)	Oven Drying	12.58
Metabolic Energy (cal/g)	Bomb Calorimetry	3,326.28

Experimental Design and Treatments

The study utilized a Completely Randomized Design (CRD) as its research method. This involved three treatments and three replications for each treatment. A total of 90 five-week-old female quails were used as the experimental animals in the study, with each treatment replication consisting of 10 quails.

Nutrient Specification for Japanese Quail

Table 3 presents the nutritional requirements of Japanese quail, which were in accordance with the specifications of the 4th edition of the Philippine Society of Animal Nutritionist (PhilSAN) Feed Reference Standards published in 2010. This entails the specified dietary parameters affecting the growth and utilization of laying quails.

Table 3

Nutrient Recommendation for Japanese Quail

Nutrient	Layer/Breeder
Me: Protein ratio	145
Energy, ME (Kcal/kg)	2900
Crude protein (%)	20.00
Calcium (%)	2.50
Phosphorus (%)	0.35
Salt (NaCl) (%)	0.15
Linoleic acid (%)	1.00
Amino acids	
Lysine (%)	1.00
Methionine (%)	0.45
Met + Cys (%)	0.70
Trytophan (%)	0.19

Source: PhilSAN, 4th Edition. (2010). Feed Reference Standards

Management Practices

Housing

The experimental area was thoroughly cleaned and disinfected a week before the quails arrived. The experiment was conducted in three-layer stacked cages, measuring 55 inches in height, 60 inches in length, and 24 inches in width. Each cage replication measured 12 inches in height, 24 inches in width, and 20 inches in length. Of the total height, 8 inches were designated for the quail cage, while the 4 inches were allocated for collecting manure or droppings. The quail house had floor elevation of 19 inches. The cage was divided into nine units, each stacked layer consisting of three units with 10 quails randomly selected per unit. A sloped floor made of plastic chicken wire was used to help the eggs roll out into the egg catcher located outside each cage. Additionally, lighting and radio were installed to reduce stress, with incandescent bulbs used as the artificial light source.

Feeding Acclimatization

The formulated feed was introduced to the quails on a twice-daily schedule starting at five weeks of age. Feed acclimatization was followed to minimize stress and help the quails adapt to new food sources. The process of acclimatization was as follows:

On the first day, the quails were exclusively fed a commercial diet. On the second and third days, the feed composition was modified to 75% commercial feed and 25% formulated feed. This ratio was adjusted to 50% commercial feed and 50% formulated feed on the fourth and fifth days. By the sixth and seventh days, the diet consisted of 25% commercial feed and 75% formulated feed.

From the eighth day onward, the quails were maintained on the experimental diet for the duration of the study. Feeding was closely monitored to optimize production efficiency and ensure proper intake. The diet was provided ad libitum, with weekly assessments of feed consumption levels.

Provision of Drinking Water

Clean fresh water was kept readily available without restrictions to keep the quail hydrated and prevent diseases that could affect their laying performance and capacity throughout the duration of the study. The waterer was located at the back of the quail cage.

Sanitation Practices

The feeder and waterer were cleaned regularly to prevent bacteria and diseases that could affect the quail. Manure was also removed regularly to eliminate unpleasant odors and maintain a clean environment.

Measurement of Production Performance

Eggs were collected twice daily; once in the morning before feeding the quail, and again in the afternoon after feeding. All collected eggs were recorded accordingly, sorted, and kept in containers labeled according to treatment.

The data gathered were analyzed through the use of ANOVA in CRD. For treatment means to be evaluated and compared, the Least Significant Differences (LSD) test was applied at both 5% and 1% levels of significance.

Total egg produced, egg weight, egg yolk color, feed consumption, FCR, and cost-return analysis were the data collected to measure the laying performance of Japanese quail. For total egg produced, it was computed by adding all the egg produced by the quail on each replication per treatment. Egg weight was measured using a digital weighing scale, while egg yolk color was evaluated through comparison with the DSM yolk color fan.

Feed consumption was determined by subtracting the residual feed from the total quantity provided, and the FCR was calculated by dividing the quails' total feed intake by the total number of eggs produced. For the cost-return analysis, expenses from the start to the end of the study were recorded. Additionally, gross sales, net income, and ROI were determined after the eggs had been sold.

Results and Discussion

Comparative Composition of Formulated Feeds

Table 4 presents the feed laboratory analysis conducted by DA-RF03 San Fernando, Pampanga, which revealed that T3, incorporating 60% GALS, exhibited the highest metabolizable energy at 2,936 kcal/kg, surpassing T1 at 2,849.5 kcal/kg and T2 at 2,830.5 kcal/kg. Furthermore, in terms of crude protein (%) content, T3 achieved the highest value at 19.8±0.1, alongside the most cost-effective feed price of ₱23.58 per kilo. It was followed by T2, which recorded 19.3±0.7 crude protein (%) at ₱24.80 per kilo, while T1 had the lowest crude protein (%) content at 17.7±0.1 with the highest feed cost of ₱26.12 per kilo. All treatments met the nutritional standards recommended for Japanese quails, as outlined in the 4th edition of PHILSAN.

Table 4

Complete Proximate Analysis, Metabolizable Energy Results, and Cost/Kg of Formulated Quail Diets

Parameter	Treatment 1 Control	Treatment 2 30% GALS	Treatment 3 60% GALS
Moisture Content (%)	10.0 ± 0.5	11.4 ± 0.4	10.6± 0.1
Crude Protein (%)	17.7 ± 0.1	19.3 ± 0.7	19.8 ± 0.1
Ash (%)	6.8 ± 0.1	6.4 ± 0.5	5.8 ± 0.4
Crude fat (%)	1.2 ± 0.3	1.8 ± 0.4	3.0 ± 0.4
Crude fiber (%)	3.5 ± 0.8	3.9 ± 0.1	4.0 ± 0.1
ME (kcal/kg)	2,849.5	2,830.5	2,936
Cost/kg (₱)	26.12	24.80	23.58

Mean Feed Consumption

The increased intake in treatments with the inclusion of GALS suggests that quails found it more palatable compared to the control diet as shown in Table 5. The nutritional composition of the feed is essential for the growth, health, and egg production of quails. T3, with 2,936 kcal/kg metabolizable energy and 19.8% crude protein, effectively supported healthy intake. T2 provided adequate protein but lacked sufficient energy, leading to increased consumption without notable productivity gains. T1, deficient in both essential nutrients, resulted in poor appetite and lower feed intake. However, Table 5 was in disagreement with the findings of Diarra et al. (2015), as their study showed no significant difference in the feed intake among the control, 33%, and 100% replacement of fishmeal with snail meal diets, as well as among the control, 67% and 100% replacement diets.

Table 5

Mean Total Feed Consumption (Grams) of Japanese Quails Under Different Treatments

Treatment	Replication			Mean
	I	II	III	
T1 - control	1,130.20	1,021.90	1,076.40	1,076.17c
T2 – 30% GALS	1,192.50	1,173.70	1,140.60	1,168.93b
T3 – 60% GALS	1,304.10	1,312.20	1,279.90	1,298.73a

Note: Means of the same letter are not significantly different.

Mean Feed Conversion Ratio

Japanese quails in T3 had the lowest FCR at 32.78, making it the most efficient in converting feed into egg production. The results in Table 6 showed no significant variations in FCR among the different treatments ($p>0.05$). Feed conversion efficiency is strongly associated with both feed intake and egg production. T3 met quail nutritional needs, promoting better feed intake and higher egg yield, resulting in a lower FCR. In contrast, while T2 provided sufficient protein, its lower metabolizable energy led to higher consumption without improved productivity. T1, lacking both essential nutrients, caused reduced intake, lethargy, and lower egg production. This was further supported by Pradeep (2020), stating that FCR remains a valuable metric for measuring feed efficiency—lower FCR indicates better farm performance, as animals convert feed into output more effectively. Reducing FCR is a key strategy for lowering production costs.

Table 6

Mean Feed Conversion Ratio (Grams) of Japanese Quails Under Different Treatments

Treatment	Replication			Mean
	I	II	III	
T1 - control	36.34	34.76	32.52	34.54
T2 – 30% GALS	37.50	36.45	35.98	36.64
T3 – 60% GALS	33.70	34.08	30.55	32.78

Mean Total Egg Produced

A significant difference was observed among the three treatments ($p<0.01$) in Table 7, with T3 producing notably more eggs than T1 and T2, while T1 and T2 had comparable results. The egg production per treatment was influenced by the type and amount of feed consumed, as proper nutrient balance plays a key role in optimizing laying efficiency. Increased feed intake, combined with essential nutrients, enhances egg production. This aligns with N'gbo et al. (2022), who found that a 50% snail meal replacement for fishmeal contributed to higher daily laying rates compared to treatments without snail meal.

Table 7

Mean Total Egg Production of Japanese Quails Under Different Treatments

Treatment	Replication			Mean
	I	II	III	
T1 - control	31.1	29.4	33.1	31.20b
T2 – 30% GALS	31.8	32.2	31.7	31.90b
T3 – 60% GALS	38.7	38.5	41.9	39.70a

Note: Means of the same letter are not significantly different.

Mean Total Egg Weight

Table 8 indicates that the nutrient composition of feed plays a crucial role in egg weight, particularly the recommended 20% crude protein and 2900 kcal/kg metabolizable energy outlined in the PhilSAN Feed Reference Standards for Japanese quails. A balanced diet with adequate protein and energy supports optimal egg development and quality. Among all treatments, only T3 met these nutritional requirements, ensuring better egg production and quality. Congruent with Akramullah et al. (2023), incorporating snail flour into feed up to 10% significantly influenced quail egg weight compared to treatments without it ($p<0.05$). This effect is attributed to the amino acids in snail flour, which play a vital role in egg formation.

Table 8

Mean Total Egg Weight (Grams) of Japanese Quails Under Different Treatments

Treatment	Replication			Mean
	I	II	III	
T1 - control	9.13	9.06	8.98	9.06b
T2 – 30% GALS	9.25	9.06	9.36	9.22b
T3 – 60% GALS	10.02	10.13	9.89	10.01a

Note: Means of the same letter are not significantly different.

Mean Egg Yolk Color

A significantly higher mean score of 5.02 was obtained by T3 compared to T1 and T2, with no significant difference between T1 and T2 (p>0.05) as shown in Table 9. The study found that all formulated feeds contained low pigment levels, resulting in paler yolks. This is because quail egg yolk coloration is primarily influenced by feed composition and pigment levels, with higher pigment concentrations leading to deeper yolk color. However, yolk color is mainly an aesthetic trait and does not impact the egg's nutritional value. In line with the findings of Akramullah et al. (2023), incorporating snail flour into feed significantly improved yolk coloration (p<0.05). The inclusion of up to 10% snail flour enhanced yolk color compared to feed without it, as higher concentrations increased the yolk color score due to the presence of amino acids essential for egg formation.

Table 9

Mean Egg Yolk Color of Japanese Quails as Affected by Different Treatments

Treatment	Replication			Mean
	I	II	III	
T1 - control	4.89	4.54	4.57	4.64b
T2 – 30% GALS	4.57	4.63	4.81	4.67b
T3 – 60% GALS	4.81	5.19	5.06	5.02a

Note: Means of the same letter are not significantly different.

Cost and Return Analysis

Table 10 presents a comparative financial analysis of Japanese quail under three dietary treatments. The table outlines input costs, egg production, gross sales, and profitability indicators, providing insights into the economic viability of integrating GALS as alternative protein source into the quail diets.

The cost and return analysis revealed that T3 generated the highest egg sales at ₱2,382.00, followed by T2 with ₱1,914.00, and T1 with ₱1,872.00. This was due to T3 producing the greatest number of eggs, reaching ₱1,191.00 in total.

Expenses were also highest in T3 at ₱2,231.08, attributed to increased feed intake with 60% GALS. T2 followed with ₱2,182.14, while T1 had the lowest expenses at ₱2,155.56. In terms of profitability, T3 recorded the highest net income at ₱1,110.92, followed by T2 with ₱691.86, and T1 with ₱676.44. The highest return on investment was seen in T3 at 49.79%, compared to 31.71% in T2 and 31.38% in T1.

All treatments produced enough eggs to reach the break-even point. Among them, T3 was the most cost-efficient and profitable, with the lowest cost per egg of ₱1.87.

The economic viability of alternative protein sources has been widely documented. Diarra (2015) demonstrated that replacing fishmeal with snail meal in broiler diets reduced feed costs without compromising performance. Similarly, non-conventional feed resources (NCFRs), including snail-based meals, have been shown to reduce feed costs by 20–30% in smallholder poultry systems (Mugweru, 2025). These findings align with the present study, where the inclusion of 60% GALS not only enhanced laying performance but also yielded the highest return on investment. However, as noted by Buccaro et al. (2023), the economic feasibility of such alternatives is most favorable in small- to medium-scale operations, where local sourcing and flexible feed formulation are more practical.

Table 10

Cost and Return Analysis of Japanese Quail Fed with GALS

	Treatment 1 Control	Treatment 2 30% GALS	Treatment 3 60% GALS
Sales			
Total Eggs Produced	936	957	1,191
Total Sales Of Eggs (₱ 2/Egg)	₱1,872.00	₱1,914.00	₱2,382.00
Sales Of Japanese Quails	30	30	30
90 Female Quails, ₱ 32 Each	₱960.00	₱960.00	₱960.00
Gross Sales	**₱2,832.00**	**₱2,874.00**	**₱3,342.00**
Expenses/Cost			
Cost Of 5-Weeks Old Quail (₱ 32/Quail) (30 Birds/Treatment)	₱960.00	₱960.00	₱960.00
Commercial Feeds Consumed (Kg)	5	5	5
Cost Per Kilogram	₱43.00	₱43.00	₱43.00
	₱215.00	₱215.00	₱215.00
Formulated Feeds Consumed (Kg)	32.28	35.07	38.96
Cost Per Kilogram/Treatment	₱26.12	₱24.80	₱23.58
	₱843.15	₱869.74	₱918.68
Labor Cost at ₱ 0.065/Head X 60 Days	₱117.00	₱117.00	₱117.00
Housing Depreciation Cost	₱20.41	₱20.41	₱20.41
Total Expenses	**₱2,155.56**	**₱ 2,182.14**	**₱2,231.08**
Net Income	**₱676.44**	**₱ 691.86**	**₱1,110.92**
ROI	**31.38%**	**31.71%**	**49.79%**
Break Even Point	**936**	**957**	**1,191**
Cost Per Unit	**₱2.30**	**₱2.28**	**₱1.87**

Conclusion

Incorporating 60% GALS into the diet of Japanese quails significantly enhanced laying performance, egg weight, yolk color, and feed intake, while also achieving the most favorable FCR and ROI. These findings demonstrate that GALS is a viable and cost-effective alternative to fishmeal, offering both nutritional and economic advantages for small to medium-scale quail producers. Moreover, its use contributes to the ecological management of this invasive species, transforming an agricultural threat into a productive resource.

However, despite these promising outcomes, the use of GALS in animal feed presents certain challenges. Variability in nutrient composition due to differences in age, diet, and habitat of wild-caught snails may affect feed consistency and performance outcomes. Additionally, GALS are known carriers of parasitic organisms, such as *Angiostrongylus cantonensis*, which pose potential health risks to humans and animals if not properly handled or processed. Ensuring strict hygiene protocols and standardized processing methods is therefore essential to mitigate these risks. Furthermore, large-scale harvesting of wild GALS without sustainable management could disrupt local ecosystems. Thus, while GALS show strong potential as a feed ingredient, its integration into livestock diets must be approached with caution, supported by further research and appropriate safety measures.

Recommendations

Based on the findings, incorporating 60% GALS into the diet of Japanese quails is strongly recommended for small- to medium-scale farms, as it not only enhances egg production, egg quality, and feed efficiency but also offers a cost-effective alternative to fishmeal. This approach presents a dual benefit: improving farm profitability while contributing to the ecological management of GALS, an invasive species that threatens agricultural productivity. To build on these results, further research should explore higher inclusion levels of GALS to assess their potential impact on meat production and overall growth performance. Additionally, evaluating the applicability of GALS as a feed ingredient in other livestock and poultry species could broaden its utility across the agricultural sector. Given the potential health risks associated with handling GALS, such as parasitic infections, it is essential that future studies emphasize proper safety protocols and the use of protective equipment to ensure both researcher and animal welfare.

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