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Complementing Plant and Animal Protein Sources for Broiler Production: Effects on Growth, Carcass Traits, and Economics

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Authors' contributions

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

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ABSTRACT

This study investigated the effects of complementing plant-based Sesbania grandiflora meal (SGM) and animal-based fermented golden apple snail extract (FGASE) protein sources on the growth performance, carcass characteristics, meat quality, and economic profitability of broiler chickens. A 2x4 factorial experiment was conducted, with SGM levels (0 and 15g kg^{-1}) and FGASE levels in drinking water (0, 10, 20, and 30 mL L^{-1}). SGM diet increased feed and water intake but did not

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affect final body weight or weight gain. FGASE in water did not influence feed or water intake. The combination of SGM and FGASE improved feed conversion ratio, but higher FGASE levels reduced dressing percentage. Neither SGM nor FGASE significantly impacted most meat cut weights or visceral organ weights, except for a significant interaction on back weight. Economic analysis revealed positive returns on investment for all treatments, with the highest net profit obtained from broilers fed a standard diet supplemented with 10 mL L^{-1} FGASE. The findings suggest the potential for incorporating SGM and FGASE in broiler diets to improve feed efficiency and profitability, though optimal inclusion levels and processing methods require further investigation.

Keywords: Broiler chickens; Sesbania grandiflora meal; fermented golden apple snails; growth performance; complementary effects; economic feasibility.

1. INTRODUCTION

The global poultry industry continuously seeks alternative feed materials to reduce production costs or promote eco-friendly approach. As a consequent, there is increasing interest in exploring the use of non-animal protein sources and animal waste products as substitutes for traditional broiler diets. *Sesbania grandiflora*, a leguminous shrub, has garnered attention as a valuable plant protein source rich in amino acids, vitamins, and bioactive compounds such as saponins and tannins [1-3].

Studies show that adding a concentrate mix and *Sesbania sesban* to sheep diets improves growth performance, feed utilization efficiency and increase dressing percentage but may diminish weight gain and feed efficiency as the proportion increases [4, 5]. These anti-nutritional factors may impede nutrient absorption and potentially hinder rapid growth [6, 7]. Conversely, golden apple snails (*Pomacea canaliculata*), an invasive gastropod species, represent an underutilized animal-based protein source. Fermentation techniques can enhance the nutritional value and digestibility of snail meal by deactivating potential antinutrients like thiaminase [8-10]. Studies have reported improved feed intake, weight gain, and feed conversion ratio in poultry and swine fed diets containing fermented or cooked snail meal [11-14]. However, the presence of antinutritional factors, toxins, and contaminants like heavy metals in raw snail meal can limit its use and necessitate proper processing [15-17, 9].

While previous studies have examined the individual effects of plant-based protein sources like Sesbania and animal-based supplements such as snail meal, the potential for synergistic or complementary effects when combining these resources remains largely unexplored. To the best of our knowledge, this is the first study investigating the complementary use of the plant protein *Sesbania grandiflora meal a*nd the animal protein *fermented golden apple snail* in broiler chicken diets. The impact of this combined supplementation on growth performance, carcass characteristics, meat quality, and economic profitability warrants further investigation to unveil potential novel benefits or interactions. Therefore, this study aimed to evaluate the effects of complementing S*esbania grandiflora* meal and fermented golden apple snail extract on the growth performance, carcass characteristics, meat quality, and economic profitability of broiler chickens. The dietary inclusion of SGM and the supplementation of FGASE in drinking water were assessed through a factorial experimental design. The findings of this research could provide valuable insights into the potential incorporation of these alternative feed resources in broiler production systems, contributing to sustainable and cost-effective poultry farming practices.

2. MATERIALS AND METHODS

2.1 Experimental Design and Treatments

The study employed a 2x4 factorial design within a Complete Randomized Design (CRD), with two factors: the level of *Sesbania grandiflora* meal (SGM) and the levels of fermented golden apple snails extract (FGASE). Each treatment combination was replicated four times, totaling one hundred sixty-day-old broiler chicks. The SGM levels included 100% standard diet and 15g Kg^{-1} SGM in the standard diet while FGASE levels comprised 100% tap water and 10ml L^{-1}, 20ml L^{-1}, and 30ml L^{-1} of FGASE in drinking water. Housing arrangements consisted of cages divided into thirty-two compartments, each with 3x2 sq. ft. floor space per treatment per replication.

2.2 Subject Animal

The subjects of this study were one hundred sixty-day-old broiler chicks procured from a reliable agri-veterinary supplier in the community. Upon arrival, the chicks were acclimatized and housed in two separate compartments with a floor space of 4x5.1 sq. ft. each, allowing for adequate space for growth and movement. The brooding environment was maintained at a temperature range of 30-36 degrees Celsius with continuous lighting provided for the initial 48-72 hours post-placement. Following the brooding period, the chicks initially weighing 270±5 g were transitioned to raised cages equipped with ventilation and provided with rice hull flooring for sanitation.

2.3 Preparation of *Sesbania grandiflora* and Golden Apple Snails

The preparation of *Sesbania grandiflora* meal (SGM) involved the collection of young leaves, washed, air-dried to preserve their nutritional integrity and finely chopped to uniform size to facilitate their incorporation into the standard diet. Care was taken to avoid exposure to direct sunlight during the drying process to prevent the degradation of light-sensitive nutrients. Similarly, the golden apple snails (*Pomacea canaliculata*) was collected along river banks and swamps, and the collected golden apple snails underwent thorough washing, fasted for three days to reduce snail gut content and minimize contaminants, followed by the removal of flesh from the shells. The flesh collected snail flesh were washed in distilled water, drained for 10 minutes in a plastic mesh, then mixed with molasses by a standard 1:1 w/v ratio, and the resulting mixture was thoroughly combined by hand and placed in a plastic container for fermentation. After seven days fermentation, the extract was stirred, squeezed, collected and preserved in plastic jars for subsequent inclusion in the broiler chickens' drinking water use golden apple snail extract (FGASE).

2.4 Application of Experimental Treatments

Broiler chickens were allocated to treatment groups according to a 2x4 factorial design, with variations in SGM diet level and FGASE concentrations in drinking water. Each treatment combination was replicated four times, totaling one hundred sixty day-old broiler chicks. The SGM levels ranged from a 100% standard diet to 15g Kg^{-1} SGM supplementation, while FGASE concentrations varied from 100% tap water to 10ml L^{-1}, 20ml L-1, and 30ml L^{-1} FGASE concentration in drinking water. The experimental diets were prepared, incorporating the 15g SGM per kg of commercial diet and 100% commercial feed/standard diet. Similarly, the fermented golden apple snail extract was added to the drinking water at the predetermined concentrations of 10 ml, 20ml, 30ml FGASE per Liter tap water and a 100% tap water

2.5 Data Gathering

Initial and final weights of the broiler chickens at 7 days and 35 days off-brooding, respectively were recorded to calculate weight gain throughout the study period. All surviving broiler chickens during termination were immediately off-feed for 8 hours prior to slaughtering. Additionally, dressing percentage, cut-up parts weight, and internal organ weight were assessed to determine carcass characteristics. Feed intake, including both feed offered and feed refused, was monitored to evaluate feed utilization. To assess water intake, the volume of water consumed by each treatment group was measured daily. Furthermore, cost and return analysis were conducted to assess the economic feasibility of the experimental treatments.

2.6 Statistical Analysis

A 2x4 factorial design was applied to analyze the effects of *Sesbania grandiflora* meal (SGM) supplementation and fermented golden apple snails extract (FGASE) inclusion on broiler chicken performance. Additionally, post-hoc tests, such as the Tukey's HSD Test, were conducted to identify specific differences between treatment means where applicable.

3. RESULTS AND DISCUSSION

3.1 Feed Intake

The dietary inclusion of *Sesbania grandiflora* meal SGM significantly influenced the feed intake of broiler chickens, as evidenced by a significantly higher mean feed intake compared to those on the standard diet while varying levels of fermented golden apple snails extract (FGASE) in the drinking water did not significantly affect feed intake (Table 1). No significant interaction was observed between SGM in the diet and FGASE in the drinking water on the feed intake of broiler chickens.

Sesbania grandiflora (SGM) stands out as a promising source of protein, fiber, vitamins, and minerals, enriching the nutritional content of broiler diets [18]. Its palatable constituents may elicit an increased appetite, thereby fostering heightened feed consumption [19]. Integration of SGM into the diet holds the potential to enhance nutrient digestibility and utilization, consequently bolstering energy availability while mitigating metabolic inefficiencies [5]. This improved nutrient assimilation could spur broiler chickens' appetite as they strive to meet their metabolic demands. Additionally, SGM supplementation may exert a positive influence on gut health and microbial populations within the digestive tract [4]. Sesbania species, including *Sesbania grandiflora* and *Sesbania sesban*, are renowned for their high crude protein content at 30-33%, which has been linked to enhanced feed intake in animals [18]. These high-quality crude protein sources provide essential amino acids vital for protein synthesis and growth [20]. The consumption of feeds rich in such amino acids is known to stimulate appetite and elevate feed intake. Additionally, the balanced amino acid profiles found in high-quality crude protein sources contribute to improved protein utilization and metabolic efficiency in animals [21].

Interestingly, varying levels of fermented golden apple snails extract (FGASE) in the drinking water did not significantly affect feed intake. This observation aligns with the findings of [9], who reported no significant effect on feed intake when incorporating snail meal into the diets of laying hens. Possibly, the methods of supplementation, likely via FGASE in the drinking water instead of direct incorporation into the feed, likely interfered with any potential impact or palatability stimulation. Additionally, the potential presence of antinutritional substances in the form of the enzyme thiaminase or toxins in the fermented golden apple snails should be assessed, as certain snail species have been reported to accumulate heavy metals or other contaminants from their foraging environments [15, 16, 9, 10] that may affect feed palatability.

3.2 Water Intake

Sesbania grandiflora meal in the diet significantly influenced water intake in broiler chickens, as evidenced by birds fed the SGM supplemented diet exhibiting a significantly higher mean water intake compared to those on the standard diet. However, varying levels of FGASE in drinking water did not significantly affect water intake, and no significant interaction was observed between SGM diet and FGASE drinking water.

Table 1. Effects of dietary SGM and FGASE supplementation on feed intake, water intake, initial weight, final weight, and weight gain in broiler chickens

Levels of supplement		**Feed intake**	**Water intake**	**Initial weight**	**Final weight**	**Weight gain**
Level of SGM	100% Standard diet	2464.65^{a}	5764.00^{a}	379.31^{NS}	1033.82^{NS}	643.18^{NS}
	15g Kg^{-1}	2708.06^{B}	6366.56^{b}	360.76^{NS}	1006.16^{NS}	654.07^{NS}
Levels of FGASE	100% Tap water	2686.82^{NS}	6039.13^{NS}	371.00^{NS}	928.87^{NS}	556.12^{NS}
	10%ml L^{-1}	2596.47^{NS}	6118.63^{NS}	363.50^{NS}	1068.35^{NS}	671.66^{NS}
	20%ml L^{-1}	2491.62^{NS}	6021.00^{NS}	362.95^{NS}	1071.92^{NS}	724.5^{NS}
	300ml L^{-1}	2570.50^{NS}	6082.38^{NS}	382.70^{NS}	1010.82^{NS}	642.22^{NS}
P-Value						
Levels of SGM		0.001*	0.007*	0.299^{NS}	0.705^{NS}	0.893^{NS}
Levels of FGASE		0.184^{NS}	0.986^{NS}	0.841^{NS}	0.476^{NS}	0.523^{NS}
Level of SGM x Levels of FGASE		0.751^{NS}	0.391^{NS}	0.110^{NS}	0.543^{NS}	0.84^{NS}

Column means of different letters $^{a, b}$ is statistically significant at 0.05 levels
**Significant different at 0.05, SGM – Sesbania Grandiflora Meal, FGASE – Fermented Golden Apple Snail Extract, g Kg^{-1} – Grams Per Kilogram, and ml L^{-1} – Milliliter Per Liter*

The investigation into the effects of *Sesbania grandiflora* supplementation on the water consumption of broiler chickens remains unexplored in the literature. It is pertinent to acknowledge that alterations in dietary composition can naturally elicit changes in water intake, a response subject to individual variations. Such supplementation might possess attributes that either stimulate thirst or elevate the body's requirement for hydration. *Sesbania grandiflora*, recognized as a multifaceted medicinal plant, boasts numerous antioxidative and anti-inflammatory properties [22]. These anti-nutrients possibly impede the absorption of essential minerals and vitamins by chickens, compelling augmented water intake as a compensatory mechanism to sustain electrolyte equilibrium and hydration levels. Furthermore, these anti-nutrients may influence feed palatability, potentially inducing astringency, thereby prompting increased water consumption as birds endeavor to alleviate the discomfort arising from such compounds [23]. Additionally, the presence of anti-nutritional factors (ANFs) in animal feed can incite intestinal inflammation, diarrhea, and consequent dehydration, necessitating heightened water absorption and subsequent losses through fecal matter, urine, and dermal vapor [24, 25].

In contrast, the non-significant findings of water intake by FGASE in the drinking water suggest that the inclusion of FGASE as a water supplement, within the tested concentration range, did not significantly influence the water consumption behavior of broiler chickens. It is important to note that the potential presence of antinutritional factors or contaminants in the fermented snail extract could potentially impact water intake or overall hydration status, which warrants further investigation. The lack of significant interaction between SGM in the diet and FGASE in the drinking water on the water intake of broiler chickens indicates that these two supplements were independent and did not influence each other synergistically or antagonistically. It is important to consider the potential presence of antinutritional factors or toxins in both SGM and FGASE, as these compounds could potentially affect water intake, hydration status, or overall health and performance of the birds.

3.3 Final Weight and Weight Gain

The dietary inclusion of SGM and the supplementation of FGASE in the drinking water did not significantly influence the final body weight or weight gain of broiler chickens in this study. Final weights were 1033.82g and 1006.16g for birds fed the standard diet and SGM diet, respectively, with no significant difference between the two groups. Similarly, there was no significant difference in weight gain between the standard diet group (643.18g) and the SGM group ((654.07g). The different levels of FGASE in the drinking water at 10, 20, and 30 mL also did not significantly impact final weight or weight gain compared to the control group receiving tap water (Table 1). No significant interactions were observed between SGM in the diet and FGASE in the drinking water for either final weight or weight gain. These findings suggest that under the experimental conditions employed, the dietary inclusion of SGM and the supplementation of FGASE in the drinking water did not significantly alter the overall growth performance of broiler chickens in terms of final body weight and weight gain.

These findings contradict some previous research that has reported improved growth performance and body weight gain in poultry fed diets containing plant-based protein sources [4, 5] or alternative protein supplements [26, 13, 14]. Several factors may contribute to the lack of significant effects on final weight and weight gain observed in the present study. One potential explanation for the lack of significant effects could be related to the bioavailability and utilization of nutrients from SGM and FGASE by the broiler chickens. SGM supplementation led to increased feed intake [4], suggesting improved palatability or appetite stimulation, but the nutrients provided by SGM might not have been effectively utilized for growth and muscle accretion. Similarly, while FGASE could potentially contribute beneficial compounds, their bioavailability when supplemented through drinking water might have been suboptimal for promoting growth due to the presence of antinutritional factors (ANFs) such as saponins, tannins, and phytates in SGM. These ANFs can interfere with the absorption and utilization of essential nutrients, potentially counteracting the growth-promoting effects of SGM supplementation [6, 7, 27, 28].

Furthermore, the fermentation process employed for FGASE might not have been sufficient to eliminate or deactivate potential anti-nutritional compounds present in the snail meal, thus limiting its growth-enhancing potential. It is also possible that the levels of SGM and FGASE supplementation used in the study were not optimal for eliciting significant improvements in final weight and weight gain. Previous research has suggested varying optimal inclusion levels of Sesbania species and snail meal in animal diets, depending on the species and production stage [18, 26], which may have affected the outcomes of this study. Further research exploring different inclusion levels, processing methods, and potential synergistic effects with other feed additives or supplements might provide additional insights into optimizing the use of SGM and FGASE for enhancing growth performance in broiler chicken

3.4 Feed Conversion Ratio

The feed conversion ratio (FCR) result showed a significant interaction between *Sesbania grandiflora* meal (SGM) and fermented golden apple snail (FGASE) supplementation (Fig 1). In the standard diet group, FCR values ranged from 1.87 to 2.40, with the 20 mL and 30 mL FGASE levels resulting in significantly improved FCR of 1.87 and 1.96, respectively, compared to 2.40 for the control (tap water). In the SGM diet group, FCR varied from 1.67 to 2.08, with the 30 mL FGASE level exhibiting the lowest FCR of 1.67, significantly better than the 2.08 observed for the 20 mL FGASE but comparable to the tap water group. These results demonstrate that SGM supplementation enhanced feed conversion efficiency, and its combination with certain FGASE levels further improved FCR in broiler chickens under the conditions of this study. This finding aligns with previous studies that have reported enhanced FCR in poultry fed diets containing plant-based protein sources or alternative protein supplements [12, 4, 26, 13, 14].

The significant interaction between SGM and FGASE levels on FCR suggests that the combination of these two dietary supplements may have synergistic or complementary effects on feed conversion efficiency. The potential benefits of FGASE on FCR could be attributed to the presence of high-quality protein, essential amino acids, and other nutrients derived from the fermented snail extract [11, 10, 14]. Additionally, the fermentation process may have enhanced the bioavailability and digestibility of these nutrients, contributing to better nutrient utilization and growth efficiency [12, 8, 14]. However, it is important to consider the potential presence of antinutritional factors or contaminants in both SGM and FGASE, as these compounds could potentially interfere with nutrient absorption and utilization, counteracting the observed benefits on FCR [1, 6, 15, 9, 10]. Appropriate processing methods and inclusion levels should be explored to mitigate these potential risks.

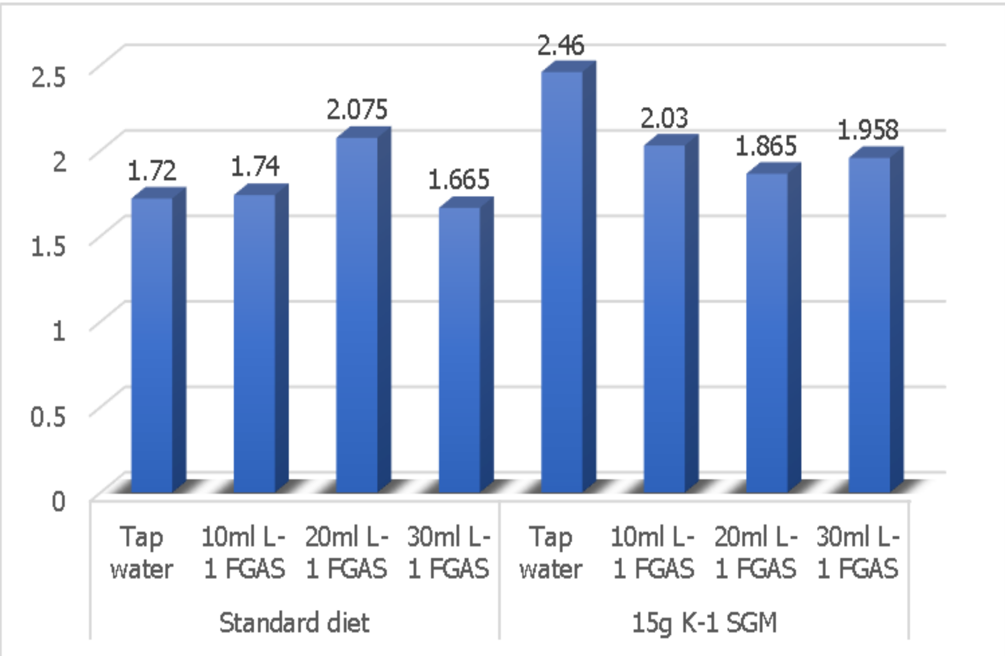

Fig. 1. FCR of broiler chickens fed diets with SGM and supplemented with different levels of FGASE in drinking water

3.5 Dressing Percentage

Table 2 shows dressing percentage of broiler chickens was unaffected by the dietary supplementation of SGM, as demonstrated by [4], who found no significant differences in dressing percentage among sheep fed diets containing varying levels of S. grandiflora. Thus, the inclusion of SGM at the tested level (15g kg^{-1}) did not alter carcass yield or dressing characteristics. Conversely, different levels of FGASE in the drinking water significantly impacted dressing percentage. Birds receiving 30 mL L^{-1} FGASE exhibited lower dressing percentage compared to the control group with 100% tap water. The negative effect of the highest FGASE level on dressing percentage can be attributed to several factors. Firstly, FGASE may contain antinutritional factors or toxins hindering nutrient absorption or metabolic processes [15, 16, 17, 9]. Additionally, FGASE could accumulate contaminants like heavy metals from their environment, impacting bird health and performance [15, 9, 10]. Nutrient imbalances from excessive FGASE inclusion may have further contributed to reduced dressing percentage. Dressing percentage is influenced by various factors including age, breed, nutrition, and individual variations. Alongside potential antinutritional factors, contaminants, or nutrient imbalances, these factors likely contributed to reduced dressing percentage at the highest FGASE inclusion level.

3.6 Quality of Meat Cuts

The dietary inclusion of SGM and varying levels of FGASE in the drinking water did not significantly influence most of the meat cut weights in broiler chickens. For instance, breast weight remained unaffected by either SGM or FGASE levels, with mean values ranging from 222.52 g to 252.70 g across all treatment groups. Similarly, thigh weight showed no significant differences due to SGM supplementation or FGASE levels, and drumstick weights were also comparable among treatments, with no significant effects of SGM or FGASE. Although wings weight tended to be higher in the SGM group (249.82 g) compared to the control (234.06 g), the difference was not statistically significant. However, a significant interaction was observed between SGM and FGASE for back weight, although the main effects were not significant (Fig 2). These findings suggest that under the present experimental conditions, the dietary treatments did not markedly influence the weights of most prime cut-up parts in broiler chickens, except for a potential interaction effect on back weight. The lack of significant effects on most meat cut weights could be attributed to several factors such as balanced nutrient profile, compensatory growth mechanisms, and limited impact on muscle development.

The significant interaction observed for back weight suggests that the combination of SGM and FGASE levels may have influenced the deposition of muscle or fat in the back region. This could be due to potential interactions between the bioactive compounds or nutrient profiles of these two feed resources, which may have modulated metabolic pathways or nutrient partitioning [29, 30]. It is important to consider that the development and quality of meat cuts can be influenced by various factors, including genetics, age, nutrition, environmental conditions, and management practices. While the inclusion of SGM and FGASE did not significantly impact most meat cut weights in this study, further investigations may be warranted to assess potential effects on other aspects of meat quality, such as tenderness, juiciness, color, or sensory attributes.

3.7 Weight of Edible Visceral Organs

The dietary supplementation with SGM and the inclusion of FGASE in the drinking water did not significantly influence the weights of edible visceral organs, namely the liver, gizzard, and heart, in broiler chickens (Table 3). This evidence suggests that the incorporation of these alternative feed resources did not significantly alter the development or physiological functions of these vital organs.

The lack of significant effects on the weights of edible visceral organs could be attributed to several factors. Firstly, despite the inclusion of SGM and FGASE, the overall nutrient composition of the diets may have been adequate to support normal physiological processes and development of these organs [1-3]. Secondly, the levels of SGM and FGASE used in this study may not have contained sufficient concentrations of potential antinutritional factors or contaminants to exert adverse effects on the development or function of the liver, gizzard, and heart [9,15]. Additionally, broiler chickens may have employed compensatory mechanisms to maintain the normal development and function of these vital organs, even in the presence of potential nutrient imbalances or stress factors.

Table 2. Effects of dietary SGM and FGASE supplementation on dressing percentage and weights of breast, thigh, wings, and drumstick in broiler chickens

Levels of supplement		Dressing %	Breast wt. (g G^{-1} LW)	Thigh wt. (g G^{-1} LW)	Wings wt. (g G^{-1} LW)	Drumstick wt. (g G^{-1} LW)
Level of SGM	100% Standard diet	76.16[NS]	236.77[NS]	221.32[NS]	179.95[NS]	113.47[NS]
	15ml L^{-1}	80.95[NS]	233.80[NS]	227.88[NS]	164.80[NS]	105.31[NS]
Levels of FGASE	100% Tap water	86.66[b]	223.67[NS]	219.37[NS]	186.45[NS]	114.27[NS]
	10%ml L^{-1}	80.23[ab]	252.7[NS]	233.45[NS]	173.75[NS]	117.67[NS]
	20%ml L^{-1}	75.14[ab]	242.25[NS]	225.97[NS]	159.09[NS]	100.17[NS]
	300ml L^{-1}	72.19[a]	222.52[NS]	219.62[NS]	170.21[NS]	105.45[NS]
P-Value						
Levels of SGM		0.137[NS]	0.86[NS]	0.67[NS]	0.12[NS]	0.43[NS]
Levels of FGASE		0.017**	0.51[NS]	0.90[NS]	0.26[NS]	0.61[NS]
Level of SGM x Levels of FGASE		0.407[NS]	0.43[NS]	0.26[NS]	0.05[NS]	0.87[NS]

Column means of different letters [a, b] is statistically significant at 0.05 levels

**Significant different at 0.05, [NS] – Not Significant, LW – Liveweight, SGM – Sesbania Grandiflora Meal, FGASE – Fermented Golden Apple Snail Extract, g Kg^{-1} – Grams Per Kilogram, and ml L^{-1} – Milliliter Per Liter*

Table 3. Effects of dietary SGM and FGASE supplementation on weights of liver, heart, and gizzard in broiler chickens

Levels of supplement		Liver wt. (g G^{-1} LW)	Heart wt. (g G^{-1} LW)	Gizzard wt. (g G^{-1} LW)
Level of SGM	100% Standard diet	27.97[NS]	5.52[NS]	19.03[NS]
	15ml L^{-1}	26.84[NS]	5.37[NS]	16.30[NS]
Levels of FGASE	100% Tap water	28.60[NS]	5.22[NS]	13.13[NS]
	10%ml L^{-1}	28.62[NS]	5.88[NS]	15.09[NS]
	20%ml L^{-1}	24.68[NS]	5.59[NS]	15.13[NS]
	300ml L^{-1}	27.73[NS]	5.09[NS]	27.33[NS]
P-Value				
Levels of SGM		0.404[NS]	0.682[NS]	0.674[NS]
Levels of FGASE		0.146[NS]	0.392[NS]	0.399[NS]
Level of SGM x Levels of FGASE		0.251[NS]	0.242[NS]	0.521[NS]

[NS] – Not Significant, LW – Liveweight, SGM – Sesbania Grandiflora Meal, FGASE – Fermented Golden Apple Snail Extract, g Kg^{-1} – Grams Per Kilogram, and ml L^{-1} – Milliliter Per Liter

Table 4. Economic profitability analysis of broiler chicken production using dietary SGM and FGASE supplementation

	Treatment							
	SD+TW	**SD+10ml L^{-1}**	**SD+20ml L^{-1}**	**SD+30ml L^{-1}**	**12g Kg^{-1}+TW**	**12g Kg^{-1}+10ml L^{-1}**	**12g Kg^{-1}+20ml L^{-1}**	**12g Kg^{-1}+30ml L^{-1}**
I. Cash Outflow								
A. Cost of feed Consume	73.64	73.22	67.72	71.31	82.19	77.37	76.79	77.78
B. Transportation	2.90	2.90	2.90	2.90	2.90	2.90	2.90	2.90
C. Cost of Broiler	53.00	53.00	53.00	53.00	53.00	53.00	53.00	53.00
D. Supplementation								
FGASE	0.00	0.00	0.00	0.00	0.00	1.25	1.50	1.75
Molasses	0.00	0.00	0.00	0.00	0.00	1.6	1.85	1.97
SGM	0.00	0.25	0.5	0.75	0.00	0.00	0.00	0.00
E. Vaccine	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
F. Water	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
G. Light	1.60	1.60	1.60	1.60	1.60	1.60	1.60	1.60
H. Rental	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
I. Housing Construction	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25
J. Labor	22.6	22.6	22.6	22.6	22.6	22.6	22.6	22.6
Total Cost of Production	163.79	163.62	158.4	162.2	172.34	168.77	168.44	169.68
II. Total Cash Inflow								
Dressed weight(kg)/broiler	192.23	216.55	165.3	190.6	175.07	200.35	200.61	217.57
Feed sack	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Manure	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Gross Income	195.23	219.55	168.3	193.6	178.07	203.35	203.61	220.57
III. Net Profit	31.44	50.89	9.89	31.38	5.73	34.58	35.17	55.93
IV. Return of Investment	0.19195	0.3418	0.062	0.193	0.0332	0.2049	0.2088	0.2999
ROI%	19.1953	34.183	6.245	19.35	3.3248	20.489	20.88	29.992

SD – Standard Diet, TW – Tap Water, g Kg^{-1} – GRAMS PER KILOGRAM, ml L^{-1} – Milliliter Per Liter

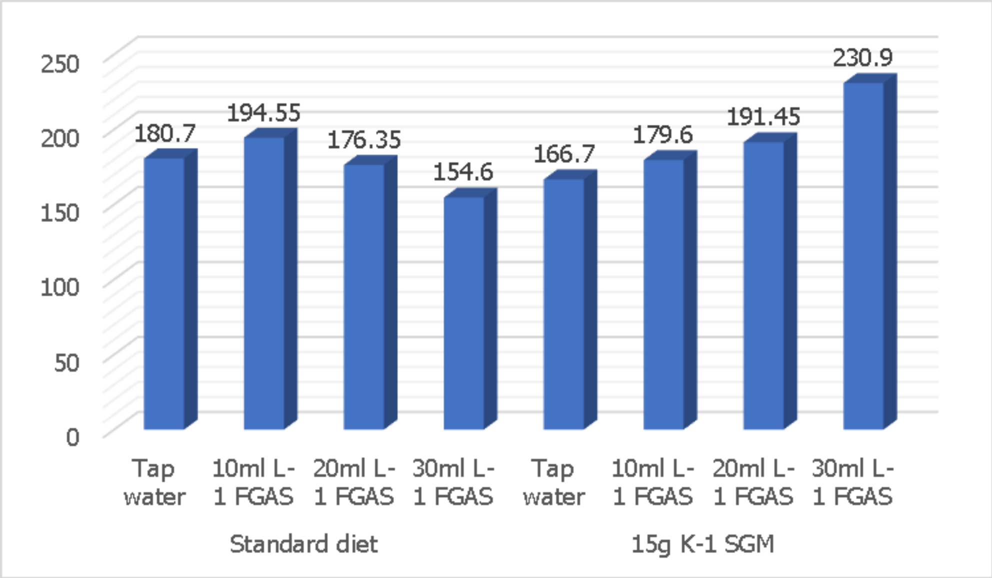

Fig. 2. Back weight of broiler chickens fed diets with SGM and supplemented with different levels of FGASE in drinking water

3.8 Economic Profitability Analysis

The economic analysis conducted in this study revealed that all treatment groups achieved a positive return on investment (ROI), indicating the potential economic viability of incorporating fermented golden apple snail (FGASE) and *Sesbania grandiflora* meal (SGM) into broiler chicken production systems (Table 4). Notably, broilers fed the 100% standard diet (SD) and supplemented with 10 mL/L FGASE in the drinking water obtained the highest net profit and corresponding ROI. Pointedly, the use of locally available and potentially low-cost alternative feed resources, such as FGASE and SGM, can contribute to reducing feed costs, which typically account for a significant portion of the total production expenses in broiler chicken farming [26, 9]. Furthermore, the incorporation of FGASE and SGM not only provides an alternative protein source but also contributes to the sustainable utilization of readily available resources that may otherwise be considered waste or underutilized [13, 31].

4. CONCLUSION

The investigation into complementing plant and animal-based proteins in broiler chicken diets through the dietary *Sesbania grandiflora* (SGM) and water supplementation of fermented golden apple snail (FGASE) has yielded several noteworthy findings. SGM increased feed and water intake, while FGASE inclusion in drinking water showed no significant effects. Neither SGM nor FGASE impacted final body weight and weight gain, but their potential benefits suggest promise for inclusion in broiler diets. The combination of SGM and FGASE improved feed conversion ratio. However, it adversely affected the dressing percentage at higher levels of FGASE inclusion. The study also found that the use of SGM and FGASE had no significant influence on most meat cut weights or weights of edible visceral organs with notable SGM and FGASE interaction on back weight. Finally, it was noted that the highest net profit and corresponding ROI were obtained by broilers fed with the standard diet and supplemented with 10 mL/L FGASE in their drinking water. In conclusion, while the individual effects of SGM and FGASE on various parameters were not uniformly significant, their combined supplementation showed promising results in improving feed conversion ratio without adversely affecting most meat cut weights or visceral organ weights. Nonetheless, ongoing attention to processing and inclusion levels is crucial to maximize the benefits of these feed resources while mitigating potential risks. Moreover, the observation that broilers fed a standard diet supplemented with FGASE achieved the highest net profit underscores the economic viability of incorporating these supplements, highlighting a potential avenue for improving profitability and return on investment in broiler production systems.

ETHICAL APPROVAL

The study was conducted in accordance with ethical guidelines of Animal Welfare Act RA 8485 of the Republic of the Philippines and approved by the institutional animal ethics committee of Surigao del Norte State University, Philippines.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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