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REGULAR ARTICLE

Growth Performance of Chickens (*Gallus gallus domesticus*) Supplemented with Heat-Treated Mungbean (*Vigna radiata* (L.) Wilczek) Sprouts

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Abstract: This study evaluated the chemical composition of mungbean sprouts and the growth performance of broiler chickens supplemented with Heat-Treated Mungbean Sprouts (HTMS). A total of 48 birds were distributed into three treatments using a Randomized Complete Block Design (RCBD). Germination and heat treatment increased crude protein (CP) and neutral detergent fiber (NDF) contents but decreased dry matter, ether extract, and ash after four days. Regarding growth performance, voluntary feed intake (VFI) and average daily gain (ADG) showed no significant differences across treatments, though quadratic tendencies were observed at specific intervals. Notably, significant quadratic effects were found in weight gain (WG) and feed conversion ratio (FCR) by day 56; the control group achieved the most efficient FCR (1.42), which worsened at 5% HTMS (1.68) before improving at 10% HTMS (1.48). Body weight remained consistent across all diets. These results suggest that while HTMS alters the nutritional profile of the feed, high inclusion levels may be necessary to maintain feed efficiency. This research provides a novel baseline for utilizing processed legume sprouts as alternative protein sources in poultry nutrition, offering a sustainable strategy for small-scale farmers to reduce feed costs without compromising bird growth.

Keywords: chicken; growth performance; mungbean sprouts

1. Introduction

Chicken production is a vital component of the Philippine livestock industry, contributing significantly to food security, income generation, and rural livelihoods. According to the Philippine Statistics Authority (PSA), the country's chicken inventory was forecasted at 183.99 million birds in July 2021, reflecting a 1.3 percent decrease from the previous year's total of 186.49 million birds. Despite this decline, native or improved chickens accounted for 45.2 percent of the total broiler and layer population. Among the regions, Western Visayas recorded the highest inventory of native or improved chickens, with 13.16 million birds (PSA, 2021), highlighting the importance of native and heritage-type chickens in regional poultry production systems.

Feed diet supplies the energy and nourishment needed by chickens to live, grow, and reproduce properly (Bell & Weaver, 2002). However, feed cost remains the largest expense in poultry production, accounting for a substantial portion of total operating costs. Mustafa et al. (2017) reported that the nutritional value of feed has a significant impact on poultry production performance, contributing up to 70% of total output in native chickens. Despite this, nutritional optimization of native chicken feed remains underdeveloped due to their lower feed conversion ratio (FCR) compared to commercial broiler chickens. Nevertheless, native chicken feed adaptability allows for various approaches to feeding optimization through the use of alternative feed supplements (Henuk, 2013). To achieve ideal native chicken farming, the use of alternative feeds that are abundant, inexpensive, nutritionally adequate, and non-competitive with human food is critical (Ahmadani, 2015).

Mungbeans (*Vigna radiata* L.) are widely cultivated in the tropical regions of Asia and are commonly consumed as human food. They may also serve as a potential source of essential amino acids and energy in poultry diets, provided that economic feasibility allows. Mungbean sprouts are rich in protein and are good sources of ascorbic acid, thiamin, riboflavin, and niacin (Singh et al., 2013). The nutritional value of sprouted grains improves due to the conversion of complex molecules into simpler and more bioavailable forms, as well as the reduction of anti-nutritional factors (ANFs) during germination (Chavan & Kadam, 1989). Theoretically, germination acts as a natural "pre-digestion" process; it activates endogenous enzymes such as proteases that mobilize stored globulins into free amino acids, which are more readily absorbed in the avian small intestine (Mubarak, 2005). Furthermore, sprouting reduces phytate levels, thereby increasing the bioavailability of essential minerals like phosphorus and calcium for bone development (Chavan & Kadam, 1989). Sprouting enhances not only the quantity but also the quality of protein, accompanied by increased carbohydrate, mineral, and vitamin content. However, sprouting also reduces total starch and dry matter content in grains (Lorenz, 1980) and increases enzyme activity within the plant (Shipard, 2005).

Theoretically, the use of heat-treated mungbean sprouts (HTMS) optimizes nutrition through a two-stage process: biological activation and thermal stabilization. Germination acts as a natural "pre-digestion" phase; it induces the formation of endogenous enzymes that break down complex storage globulins into free amino acids and simpler sugars, which are more readily absorbed in the avian small intestine (Mubarak, 2005; Narale et al., 2024). Furthermore, sprouting significantly reduces phytic acid—a major form of phosphorus storage that binds essential minerals—thereby increasing the bioavailability of calcium and phosphorus required for bone development (Kataria et al., 1989; Mubarak, 2005).

However, raw mungbean sprouts still contain residual heat-labile ANFs, specifically trypsin inhibitors, tannins, and hemagglutinins, which interfere with protein hydrolysis and can lead to reduced feed efficiency and stunted growth in poultry (Kataria et al., 1989; Narale et al., 2024). The application of heat treatment is a critical stabilization step that denatures these residual inhibitors, significantly increasing the biological value and in vitro protein digestibility of the mungbean compared to raw or merely germinated seeds (Kataria et al., 1989). Unlike conventional soybean meal, which requires industrial-scale solvent extraction, HTMS provides a farm-level, low-cost method to produce a high-quality protein supplement that is both sustainable and compatible with the digestive capacity of heritage breeds (Mubarak, 2005).

Despite these potential advantages, there is limited research on the use of mungbean sprouts as a feed supplement for heritage chicken breeds. This lack of information presents a gap in developing cost-effective and nutritionally optimized feeding strategies for non-commercial poultry systems. Given the high cost of conventional poultry feeds and the limited studies on alternative protein supplements for heritage chickens, this study aimed to evaluate the effect of HTMS supplementation on growth performance and production cost in chickens. Specifically, this study aimed to: (1) Determine the chemical composition of heat-treated mungbean sprouts in terms of crude protein (CP), ash, ether extract (EE), gross energy (GE), and neutral detergent fiber (NDF); and (2) Determine the effects of varying levels of heat-treated mungbean sprouts on voluntary feed intake (VFI), average daily gain (ADG), weight gain (WG), body weight (BW), and feed conversion ratio (FCR) of chickens.

Rhode Island Red chickens were used in this study instead of commercial broilers or purely native chickens because they represent a heritage breed with characteristics intermediate between fast-growing commercial broilers and slow-growing native chickens. Rhode Island Reds exhibit moderate growth rates, good adaptability to local environmental conditions, and efficient utilization of alternative feed resources. These traits make them suitable for evaluating the effects of alternative protein supplements such as mungbean sprouts, as their performance is less influenced by highly specialized commercial feed formulations compared to broilers, while still allowing measurable growth and feed efficiency responses. Moreover, the use of Rhode Island Red chickens enhances the applicability of the results to smallholder and semi-intensive poultry production systems commonly practiced in the Philippines.

2. Methodology

2.1 Preparation of Study Area

The experimental area was prepared following the Philippine Agricultural Engineering Standards for poultry housing (PAES 402:2001) to ensure optimum bird welfare and environmental control. Twelve cages were constructed using local materials, including coco lumber and bamboo wood. Each cage measured approximately 0.48 m^2, providing a stocking density of 0.12 m^2 per bird. This floor space allocation follows the minimum requirements for poultry housing in tropical climates to prevent heat stress and overcrowding (PAES, 2001).

To ensure proper waste management and air quality, the floor height was elevated 1.8 meters above the ground to minimize ammonia build-up, while the floor-to-ceiling height was maintained at 2.4 meters to allow for optimum natural ventilation. These elevations are consistent with standard semi-intensive housing designs intended to reduce respiratory pathogens in heritage breeds (BAFS, 2017). Each cage was equipped with a 1-liter round-bubble waterer and a polyvinyl chloride (PVC)-based linear feeder. The feeding space provided was 6–7 cm per bird, meeting the recommended standards for synchronized feeding in growing chickens. Prior to the arrival of the experimental animals, the entire facility, including cages and equipment, underwent thorough cleaning and disinfection to ensure a pathogen-free environment.

2.2 Procurement of Chicks

A reliable supplier provided a total of 48 day-old straight-run Rhode Island Red chicks. Before the experiment, these birds were fully vaccinated against Newcastle Disease. For all experimental birds, a one-week period of adaptation to the new environment was observed, and the recommended management practices were appropriately implemented.

2.3 Preparation of Mungbean Sprouts

To avoid fungal contamination, mungbean seeds were rinsed with water before being steeped in a 0.1 percent hypochlorite solution for 24 hours at room temperature to hasten the metabolic process in pre-germinated seeds (Morgan et al., 1992). In a one-liter bottle of clean water, a 1% hypochlorite solution was mixed. After soaking, the seeds were rinsed two times further to remove any remaining contaminants. Steeped seeds were put uniformly on a sprouting tray and covered with a cloth and plastic mulch to promote optimum seed germination. Using a sprouting tray, 38.1 cm. (length) x 25.4 cm. (width) x 7.62 cm. (depth), prepared grams of soaked seeds were spread uniformly with a thickness of 1-1.5 cm. The sprouting trays were composed of plastic with holes in the bottom to drain excess water, preventing mold growth and seed rotting. During the 4th day of sprouting, the mungbean sprouts were subjected to heat treatment at 60–70 °C for 2 minutes, followed by chopping to reduce particle size (Liener, 1994; Fasina et al., 2004). Heat treatment is commonly applied to sprouted legumes to reduce microbial load, deactivate endogenous enzymes, and minimize the presence of anti-nutritional factors that may interfere with nutrient utilization in poultry. According to Chavan and Kadam (1989), moderate heat application after germination helps stabilize the improved nutritional profile of sprouted grains while preventing further enzymatic degradation of nutrients. After heating, the sprouts were chopped to reduce particle size and improve homogeneity when mixed with the basal diet. Particle size reduction enhances feed intake and nutrient digestibility by increasing surface area for digestive enzyme action and preventing selective feeding behavior in chickens (Amerah et al., 2007).

2.4 Management of Chicks

Day-old chicks were placed in a brooding cage for 28 days (four weeks). To ensure a comfortable environment, papers and rice hull were utilized as litter materials, and incandescent light bulbs were used as a source of heat. The temperature was maintained at 30–33 °C for the first week, then gradually decreased by approximately 2 °C every week as the birds developed their own thermoregulatory capacity, until a temperature of 21 °C was reached or until the birds were fully feathered. Using a 25-watt bulb, a continuous 24-hour lighting program was applied during the brooding stage to ensure adequate feed intake, thermoregulation, and early growth of chicks. Continuous lighting during the brooding period has been shown to stimulate feeding behavior and improve early body weight gain in chickens (Buyse et al., 1996; Olanrewaju et al., 2006). After the brooding stage, the lighting program was adjusted to 23 hours of light and 1 hour of darkness per day until market age. Providing a short dark period allows birds to rest and supports normal physiological rhythms without significantly reducing growth performance (Classen et al., 1991; Schwean-Lardner et al., 2012).

2.5 Experimental Layout

A total of 48 Rhode Island Red chickens were utilized in the study, arranged in a Randomized Complete Block Design (RCBD). To account for variations in growth potential, initial body weight was used as the single blocking factor.

The birds were divided into four blocks based on weight (e.g., Block 1: Heaviest; Block 4: Lightest). Within each block, birds were randomly assigned to the three dietary treatments (Control, 5% HTMS, and 10% HTMS). Each treatment was replicated four times, with each replicate consisting of four birds, ensuring a balanced distribution of initial weights across all experimental groups. The treatments were designated as follows:

Diet A= Commercial feed- free choice
Diet B= Commercial feed + 5% HTMS
Diet C= Commercial feed + 10% HTMS

2.6 Feeding Management of Chicken

Upon arrival of the birds, commercial ration was given ad libitum for a week. In the second week, the experimental birds were gradually introduced to the assigned dietary treatments containing varying levels of heated mungbean sprouts. Fresh and clean drinking water were provided ad libitum. Proper health program and sanitation practices were strictly implemented.

2.7 Chemical Composition Analysis

In determining the nutrient composition of mungbean seed, unheated mungbean and heated mungbean of about 50 g each from roots to tip were taken in sprouted trays, two replicates of each sample were collected and then oven-dried at 105°C, it was ground to pass 1mm mesh screen sieve and analyzed for %DM, %CP, %EE determination using soxhlet extractor, and %Ash using standard AOAC (2006) methods. Moreover, detergent fiber fractions %NDF were analyzed using Van Soest (1991); the gross energy (cal/kg) was analyzed using Bomb Calorimeter, Parr Instrument (IL, USA). These tests were analyzed and done by the author under the supervision of the laboratory technician.

2.8 Data Gathered

The data collection process focused on evaluating the nutritional efficiency and growth trajectory of the chickens over the 70-day experimental period. Growth performance was monitored through bi-weekly assessments of Body Weight (BW), from which Weight Gain (WG) and Average Daily Gain (ADG) were derived to analyze the incremental and daily growth rates of the birds. To determine the nutritional utility of the heat-treated mungbean sprouts, Voluntary Feed Intake (VFI) was meticulously tracked by measuring the daily feed refusal against the total feed offered. These measurements were consolidated bi-weekly to provide a cumulative intake profile. Finally, feed efficiency was quantified using the Feed Conversion Ratio (FCR), which correlated the total biomass produced to the total feed consumed. This comprehensive data set allowed for a precise determination of how varying levels of HTMS affected the metabolic efficiency and commercial viability of the heritage breed under study.

2.9 Statistical Analysis

All data for each variable were analyzed in an analysis of variance (ANOVA) using the Proc Mixed of SAS V.9. Means were tested using Trend analysis, and a significant difference was declared when $P<0.05$ and trend at $0.05<P<0.10$.

3. Results And Discussion

3.1 Chemical Composition

Results of the chemical composition of the mungbean (seeds, unheated sprouts, and heat-treated) are presented in Table 1. It was found that the moisture content of HTMS (67.43%) was higher compared to unheated mungbean sprouts (62.33%). The sprouting process, which normally imbibes water and therefore causes an increase in moisture content. The crude protein content in HTMS was 19.10% higher than that of seeds alone (16.13%) and unheated sprouts (18.99%). This was backed up by Oboh et al. (2000), who showed that heating and sprouting legumes have increased nutrient bioavailability while also improving digestibility and utilization. During sprouting, metabolic enzymes such as proteinases are activated, resulting in the release of some amino acids and peptides, and the synthesis or utilization of these may result in the formation of new proteins. As a result, sprouting legumes and other seeds may improve the nutritional quality of proteins (Gulewicz et al., 2008).

Furthermore, an apparent increase in protein content may be attributed to a loss of DM, particularly carbohydrates, during sprouting (Uppal & Bains, 2012). Higher sprouting temperatures and longer sprouting times would result in more dry weight loss and a higher CP content. Imbibition causes reactivation of protein synthesis, resulting in an increase in protein content in sprouted seeds (Nonogaki et al., 2010). The crude ash content in HTMS is relatively lower (1.69%) than that of unheated mungbean sprouts (2.34%) and mungbean seeds (4.6%).

Table 1. Chemical composition analysis of mungbean (Seeds, UHMS, HTMS) at four days of germination

Analysis	Mungbean Seeds	Unheated Mungbean Sprouts	Heat-treated Mungbean Sprouts
Dry Matter, %	85.28	37.67	32.56
Moisture content, %	14.72	62.33	67.43
Crude Protein, %	16.13	18.99	19.10
Crude Ash, %	4.60	2.34	1.69
Ether Extract, %	1.90	1.16	0.59
NDF, %	20.49	24.00	30.35
Gross Energy, cal/g	3795.50	2749.5	2508.50

These findings contradict the findings of Malama et al. (2020), who discovered that the ash content of unsprouted and sprouted common bean varieties increased significantly after sprouting. In comparison to mungbean seeds and freshly sprouted mungbeans, the crude fat content in HTMS was the lowest. This was due to the fact that during the sprouting and preparation process of HTMS, it first created some catabolic reactions. Also, when HTMS was processed, heating and draining may affect its nutritional content. This was backed up by some authors who suggested that the depletion of the fat reserves that supported the seeds' catabolic processes during sprouting may be the cause of the decrease in fat content (Onimawo & Asugo, 2004).

Moreover, according to Hahm et al. (2009), sesame seeds' lipid content decreased by 44% after 4 days of sprouting. In comparison to unheated mungbean sprouts and seeds, the gross energy in HTMS (cal/g) was the lowest. This occurred because it undergoes a sprouting process that had an adverse effect on the diet's low-fat content. The alterations in carbohydrate content after sprouting by Vidal-Valverde et al. (2002) may be explained by the fact that the carbohydrates were also utilized as a source of energy for embryonic growth. After sprouting, a considerable rise in crude fiber was seen, leading to an increase of 30.35 percent that was higher than that of seeds and UHMS. This finding does not imply that chickens cannot digest HTMS. However, there are some carbohydrates that can be ingested and utilized in the nutrition of the chicken, such as hemicellulose.

3.2 Voluntary Feed Intake

In Table 2, it can be seen that there are no significant differences in the VFI supplemented with varying levels of HTMS. However, there was a quadratic tendency that VFI would decrease at 5% (340.64 grams) but pick up at 10% (359.86 g) level of HTMS at day 56 ($p = 0.0784$). On days 14 to 42, VFI was 150.84 g, 254.88 g, and 325.89 g, respectively. The trend of higher VFI was still obvious at Day 70. It can be noted that the birds have adjusted to the HTMS, especially at 10%, as they grow by age, specifically at Day 56 and Day 70. In the total VFI, the smallest intake was found in Diet C because the birds during the early stages of growth on Day 14 and Day 42 were not consuming much feed.

The shifting of the diet and aging might explain the high VFI at 10% HTMS. Based on the observations, the birds given HTMS became selective to pick and consume sprouts before the commercial ration. This further implies the palatability and acceptability of HTMS among grower chickens. Indeed, the improved nutritional qualities in seeds or grains due to germination, such as the decreased level of anti-nutritional components and fiber content in seeds, have been linked to the increased feed consumption in birds (Singh et al., 2013; Ashom et al., 2016; Maidala et al., 2019).

Table 2. Voluntary Feed Intake(g) of chickens supplemented with different proportions of heat-treated mungbean sprouts

Days	Voluntary feed intake (g)			SEM	Diets	*P value*	
	Diet A	Diet B	Diet C			Linear	Quadratic
Day 14	147.50	150.84	148.93	6.37	0.7897	0.7751	0.5494
Day 28	225.88	254.88	233.04	11.31	0.2363	0.6405	0.1121
Day 42	327.70	325.89	320.63	15.46	0.8791	0.6390	0.8935
Day 56	388.48	340.64	359.86	13.84	0.0784	0.1416	0.0636
Day 70	391.54	388.66	389.29	14.00	0.9884	0.9132	0.9221
Total	1480.39	1461.16	1451.73	42.51	0.8380	0.5754	0.9108

In the case of supplementation of high levels of mungbean sprouts to reduce feed intake, Sharif et al. (2013) hypothesized that bitter taste and unpleasant odor as a result of the sprouting process may reduce the palatability of the sprouted food, thereby reducing chicken feed intake. However, the increased feed intake is not always evident when sprouted grains are fed, as the increased levels of sprouts may also reduce feed consumption and impede the growth performance of chickens (Sharif et al., 2013; Lasisi et al., 2018). It does not, however, conclude that 5% HTMS diets are ineffective; In fact, it had a slight difference in feed intake than 10% HTMS. One factor in considering feed intake is the weight of the birds presented in (Table 4). This was backed up in the study of Morel et al. (2001), which found that variation in feed consumption was primarily explained by variation in live weight. This is in line with the findings of the current study, which showed that feed consumption increased with live weight and/or as the birds matured. The fact that chickens ate the same amount of feed on all treatment diets could be because their taste buds are not fully developed (Nyachoti et al., 1996; Roura et al., 2013). Furthermore, the increase in daily feed consumption was presumably caused by an increase in palatability, as Huang et al. (2014) stated that germinated mungbeans could change their nutrients, with one of the effects being a change in flavor and palatability. This germinated mungbean sprout may also inactivate anti-nutritional factors through the heating process and therefore increase feed intake (Astawan, 2005).

3.3 Average Daily Gain

In terms of average daily gain (ADG), there are also no significant differences across treatments and across different time periods (Table 3). However, there was a tendency for a quadratic effect at Day 28, where supplementing HTMS at 5% (Diet B caused higher ADG (10.86g) and Diet C decreased ADG by 9.52g. However, both Diet B and Diet C with HTMS supplements supplementation had a higher ADG than Diet A (control).

This demonstrates the benefits of supplementing HTMS in terms of ADG. Mungbean is a proteinaceous feed resource and may complement amino acids in other feed ingredients. The improvement in ADG is consistent across the feeding trials.

3.4 Weight Gain

In Table 4, the cumulative weight gain (WG) of the birds with varying levels of HTMS revealed no significant difference across all periods except at Day 56 ($p = 0.0280$). The results at Day 56 showed a quadratic trend ($p = 0.0157$) with 5% HTMS causing a reduction in WG (218.72 g), but with 10%, WG increased to 249.04 grams. It has also been consistently shown that HTMS at 10% had a higher CWG than 5% HTMS and the control.

Table 3. Average Daily Gain(g) of chickens supplemented with different proportions of heat-treated mungbean sprouts

Days	Average Daily Gain (g)			SEM	Diets	*P value*	
	Diet A	Diet B	Diet C			Linear	Quadratic
Day 14	6.13	7.83	7.82	0.568	0.1259	0.0797	0.2620
Day 28	8.37	10.86	9.52	0.596	0.0687	0.2237	0.0395
Day 42	11.16	12.83	11.97	0.702	0.2481	0.3975	0.1503
Day 56	13.24	13.53	13.42	0.814	0.9495	0.8444	0.7999
Day 70	13.98	12.93	14.05	0.802	0.4560	0.9489	0.2293
Total	10.58	11.60	11.35	0.616	0.4863	0.3876	0.4161

The results of this study again affirmed the benefit of supplementing leguminous feed resources in improving the WG of birds. Mungbean has a CP content of 18.99% when heat-treated, which is higher compared to its seed form (16.13%). However, heat treatment will reduce anti-trypsin inhibitors, which can potentially suppress digestibility of protein. Thus, provision of HTMS apparently increases digestibility and absorption of amino acids, which can promote weight gain among birds. This result is backed up by Madzimure et al. (2017) in their study, where they reported higher WG in chickens fed sprouted grains and greater feed intake. Moreover, Singh et al. (2013) reported a similar effect of sprouted mungbean supplements on broilers during 0-35 days, revealing that WG and feed intake were significantly higher.

Table 4. Weight Gain(g) of chickens supplemented with different proportions of heat-treated mungbean Sprouts

Days	Weight Gain (g)			SEM	Diets	*P value*	
	Diet A	Diet B	Diet C			Linear	Quadratic
Day 14	85.85	109.73	99.02	10.71	0.3517	0.4179	0.2348
Day 28	148.62	194.43	167.65	12.61	0.1065	0.3271	0.0571
Day 42	234.18	234.78	235.83	17.48	0.9957	0.9296	0.9891
Day 56	272.83	218.72	249.04	20.49	0.0280	0.1549	0.0157
Day 70	237.28	229.68	231.66	21.11	0.9321	0.7970	0.8002
Total	978.76	987.36	983.19	51.85	0.9922	0.9506	0.9179

3.5 Body Weight

Presented in Table 5 is the body weight (BW) of chickens on a bi-weekly basis supplemented with varying levels of HTMS. Based on the results, there was no significant difference at day 14 ($p = 0.4746$). Control diets had an increase in BW at day 14 ($p = 0.5653$), day 28 ($p = 0.7277$), day 42 ($p = 0.9553$), day 56 ($p = 0.5106$) and day 70 ($p = 0.4837$). The results showed no improvement in BW throughout the period, even if diets were supplemented with high HTMS.

These findings are supported by a similar study of Rama Rao et al. (2018), who found that adding sprouted pulses to a commercial broiler diet had no effect on BW gain at days 21 and 42 ($P > 0.05$). Furthermore, Newman et al. (1985), Scott (2002), and Oduguwa and Farolu (2004) reported that feeding water-treated grains had no effect on chicken BWG. On the other hand, Abbas and Musharaf (2008) investigated the effect of sorghum grain germination duration on broiler bird growth performance.

They found that grains germinated in three days had no effect on broiler bird growth performance, but as days of germination increased, growth depression was observed due to increased tannin content.

Table 5. Body Weight(g) of chickens supplemented with different proportions of heat-treated mungbean sprouts

Days	Body Weight (g)			SEM	Diets	*P value*	
	Diet A	Diet B	Diet C			Linear	Quadratic
Day 14	156.87	155.50	131.07	13.80	0.5653	0.3171	0.5653
Day 28	307.14	328.78	306.53	20.71	0.7277	0.9853	0.4783
Day 42	532.44	522.11	525.32	24.46	0.9553	0.8559	0.8422
Day 52	791.15	712.03	746.35	40.52	0.5106	0.5162	0.3715
Day 70	1050.63	927.21	968.54	60.80	0.4837	0.4405	0.3839

3.6 Feed Conversion Ratio

The feed conversion ratio is the amount of feed required to produce one unit of weight gain; the lower the value, the more efficient it is. Results in Table 6 revealed no significant differences among treatments except on Day 56. On day 56, a significant difference (p=0.05) was noted, and the effect was quadratic (p= 0.0059). The best FCR was from Diet A (1.43), but it decreased with Diet B (1.68), and increased with Diet C (1.48). In other time points, FCR was not significant at Day 14 (p = 0.4331), Day 28 (p = 0.1106), Day 42 (p = 1.0000), Day 70 (p = 0.9167) and overall (p = 0.6853).

Table 6. Feed Conversion Ratio of chickens supplemented with different proportions of heat-treated mungbean sprouts

Days	Feed Conversion Ratio (kg)			SEM	Diets	*P value*	
	Diet A	Diet B	Diet C			Linear	Quadratic
Day 14	1.75	1.38	1.58	0.19	0.4331	0.5398	0.2637
Day 28	1.53	1.33	1.38	0.06	0.1106	0.1158	0.1275
Day 42	1.38	1.38	1.38	0.03	1.0000	1.0000	1.0000
Day 56	1.43	1.68	1.48	0.11	0.0156	0.4533	0.0059
Day 70	1.75	1.75	1.70	0.16	0.9167	0.7285	0.8406
Total	1.57	1.50	1.50	0.06	0.6853	0.4666	0.6694

This was, however, supported by Rama Rao et al. (2018) in terms of FCR in their study of broiler supplemented with different sprouted (black gram, green gram, and wild gram) pulses, wherein broiler supplemented with sprouted pulses had considerably lower FCR than those fed with a control diet at an early stage. However, no equivalent improvement in FE was observed in broilers fed with sprouts at a later age. Though the specific mechanism for increased FE in broilers fed sprouts is unknown, increased fiber and protein digestibility may be responsible for improved feed efficiency in broilers fed with sprouted grains (Chung et al., 1989). Furthermore, the current study discovered that 10% HTMS supplementation resulted in the highest VFI. Thus, a lower FCR on day 56 resulted in a favorable outcome for the diets.

4. Conclusion

Sprouting causes changes in chemical composition, especially in CP and NDF, which increase~~d~~ after germination processes. This will likely improve its bioavailability to the chicken. Moreover, HTMS, particularly at 10% supplementation in the chicken ration, has the potential to increase VFI, FCR, and ADG. Its supplementation in the commercial ration can augment protein requirements among chickens.

While this study established the baseline growth performance for Rhode Island Red chickens, future research should investigate the long-term effects of HTMS on carcass quality and sensory characteristics of the meat. Additionally, further studies are recommended to explore higher inclusion levels (beyond 10%) and to conduct a comprehensive economic analysis to determine the precise cost-benefit ratio for smallholder farmers. Finally, investigating the effect of HTMS on the gut histomorphology and microbial population of the chickens would provide deeper insights into the biological mechanisms behind the observed quadratic trends in feed efficiency.

5. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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