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RESEARCH ARTICLE

Growth performance of Muscovy ducks fed home-mixed diets supplemented with varying levels of Hagonoy (*Chromolaena odorata*) leaf meal

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Abstract

Hagonoy (*Chromolaena odorata*) is an abundant yet underutilized plant in the Philippines with potential as an alternative feed ingredient for poultry production. This study was conducted at Isabela State University from 5th January 2025 to 5th March 2022, to evaluate the effects of Hagonoy leaf meal (HLM) on duck growth, feed efficiency and economic viability, to determine the optimal inclusion level for improved weight gain, feed utilization and profitability. A Completely Randomized Design (CRD) was employed using four dietary treatments with 10 ducks per replication: T1 (Control – home-mixed feeds [HF] + 0 % HLM), T2 (HF + 2 % HLM), T3 (HF + 4 % HLM) and T4 (HF + 8 % HLM). Parameters measured included weight gain, feed consumption, feed conversion ratio (FCR), dressing percentage, organ weights, hematological values and economic returns. Results showed that ducks supplemented with 4 % HLM (T3) consistently achieved the highest growth performance, with a final body weight of 1178.50 g at eight weeks, the most efficient feed conversion ratio and the highest return above feed and duckling cost (Php 2164.24; 34.24 %). Feed consumption and dressing percentage were not significantly affected, although higher liver and pancreas weights were noted at 8 % HLM, suggesting possible physiological stress. Moreover, a 4 % inclusion of HLM is recommended as the optimal level for improving growth, feed utilization and profitability in Muscovy duck production without compromising carcass yield or meat quality.

Keywords: broiler production; economic viability; feed conversion efficiency; growth performance; Hagonoy leaf meal; poultry nutrition

Introduction

Ducks are omnivorous birds that consume a wide variety of feed resources, including plants, insects, small fish and organic matter. Providing a nutritionally balanced diet at various growth stages is essential to maximize productivity and ensure efficient meat and egg production (1, 2). However, small-scale farmers and backyard raisers often face challenges in formulating appropriate diets across different stages of duck growth, which limits production efficiency. Addressing these nutritional gaps is vital for improving the sustainability and profitability of duck farming (3, 4).

In the Philippines, the duck industry has shown promising growth due to rising domestic demand for duck meat and eggs. This expansion is supported by increased consumption, advancements in feed technology and government interventions, signalling the sector's potential for sustainable and profitable development (5). Despite these advances, persistent constraints such as high feed costs, limited availability of quality breeding stocks, seasonal production patterns and inefficient marketing systems continue to hinder progress. Notably, feed remains the single largest expense in duck production, accounting for 70-80 % of overall costs, while traditional herding systems remain underutilized, representing only 13.14 % of production practices (5). These challenges emphasize the urgent need for affordable and sustainable feed alternatives.

One potential solution lies in the utilization of Hagonoy (*Chromolaena odorata*), an invasive, fast-growing shrub widely distributed across the Philippines. Although primarily regarded as a problematic weed for its competition with crops and native vegetation, *C. odorata* has been noted for its role in improving soil fertility through foliage decomposition (6). However, concerns regarding its toxicity have been raised since its foliage contains nitrates that can be converted to nitrites, which impair oxygen transport in animals by forming methemoglobin (7). Despite these risks, recent findings suggest that controlled inclusion levels of Hagonoy leaf meal (HLM) can yield positive effects in poultry, including improved yolk pigmentation in laying hens (8). Moreover, the plant contains bioactive compounds such as flavonoids, tannins, saponins and alkaloids, which exhibit antioxidant and antimicrobial properties (9-11). Processing techniques such as fermentation, steaming and oxidation have further reduced its anti-nutritional factors, making it safer for animal feeding (12, 13).

Beyond its nutritional potential, integrating phytobiotics and probiotics into poultry diets has gained increasing attention due to their roles in gut health, feed efficiency and disease resistance (14-16). Studies in broilers and goslings have shown that fermented feed and probiotic supplementation enhance growth performance, intestinal morphology, antioxidant capacity and overall meat quality

(16-19). Similarly, lactic acid bacteria have been linked to improved nutrient absorption and microbial balance, influencing both animal performance and product quality (14, 20, 21). Such findings provide scientific justification for exploring HLM, which is rich in bioactive compounds, as a functional feed ingredient that could mimic or complement the effects of probiotics and phytogenic additives.

Nutritional studies reveal that Hagonoy leaves contain considerable amounts of crude protein (16.20 % dry weight) and essential amino acids such as histidine and phenylalanine, though methionine remains limiting. The protein score of 88.24 % indicates promising potential as a supplementary protein source in poultry diets (6, 22). Despite these attributes, limited studies have examined the use of HLM in ducks, particularly in Muscovy ducks (*Cairina moschata*), which are commonly raised for meat in the Philippines. Existing research has largely focused on its effects in chickens, leaving a notable gap regarding its application in duck production systems (23-27).

Given that over 80 % of ducks in the Philippines are raised in backyard or small-scale settings (1), the exploration of HLM as a low-cost and locally available feed ingredient represents both a practical and sustainable intervention. By addressing high feed costs and reducing reliance on commercial feeds, HLM not only improve farm profitability but also contribute to weed management by transforming an invasive species into a valuable agricultural resource.

This study was, therefore, conducted to evaluate the effects of HLM supplementation on the growth performance, carcass yield, organ development and economic returns of Muscovy ducks. It seeks to determine the optimal inclusion level of HLM that maximizes growth and profitability without compromising feed efficiency or animal health, thereby addressing both nutritional and economic constraints in the Philippine duck industry.

Materials and Methods

Experimental area

Readily constructed duck pens made up of locally available materials like nets, galvanized iron sheets, bamboo and sacks were used in the study. The experimental area measured 12 m × 16 m and was divided into 16 pens measuring 3 m × 4 m each.

Acquisition of experimental birds

A total of 160 day-old ducks were used in the study. The ducklings were purchased from a reliable dealer in Jones, Isabela. The ducklings were brooded for one month to attain the desired age required for the study.

Environmental sanitation and hygiene

All the facilities, including the feeder and the waterer, were cleaned and disinfected one week before the arrival of the ducks to prevent the occurrence of disease caused by harmful microorganisms during the study. The premixes were kept cleaned and dried until the end of the experiment.

Collection and preparation of Hagonoy leaves

Hagonoy leaves were collected around Jones and San Agustin, Isabela. The collected leaves were sun-dried, milled, pulverized and mixed with the other ingredients. Table 1 shows the nutrient composition of the ingredients.

Experimental design and treatments

The ducks were randomly distributed into four dietary treatments. Each treatment was replicated four times, with 10 ducks per replication. The experiment was laid out using the Completely Randomized Design (CRD). The Least Significant Difference (LSD) was used to determine which treatment differed from another. Table 2 shows the experimental treatments for home-mixed feeds with Hagonoy leaf meal.

Table 2. Experimental treatments for home-mixed feeds with Hagonoy leaf meal

Treatment code	Feed composition
T1	Home-mixed feeds without Hagonoy leaf meal
T2	Home-mixed feeds with 2 % Hagonoy leaf meal
T3	Home-mixed feeds with 4 % Hagonoy leaf meal
T4	Home-mixed feeds with 8 % Hagonoy leaf meal

Weighing of birds

Upon distribution to their respective experimental pens, the initial weights were taken and recorded. Weekly weighing was done during the entire observation period. The ducks were weighed before feeding in the morning.

Feed mixing

Feed mixing was done manually. The micro feed ingredients were mixed separately from the macro feed ingredients. After which, the mixture was added gradually to make the home-mixed feeds. Table 3 shows the calculated nutrient composition of the experimental diets.

Feeding management

The ducks were given the corresponding experimental ration. Ad libitum feeding was used throughout the experimental period.

Provision of drinking water

Clean and fresh drinking water was always provided. The water was changed twice a day, in the morning and afternoon, or as needed. No antibiotics or vitamins were administered during the experimental period.

Table 3. Calculated nutrient composition of the experimental diets

Ingredients	T_1	T_2	T_3	T_4
Corn grits, fine	39	39	39	39
Rice bran, D1	50	48	46	42
Soybean meal	10	10	10	10
Vitamins/Minerals premixes	1	1	1	1
Hagonoy (*Chromolaena odorata*) leaf meal	0	2	4	8
Total	100	100	100	100

Table 1. Nutrient composition of the ingredients

Ingredients	CP	CF	Ca	P	Lys	Met	Kcal
Rice bran	11.8	11.3	0.80	1.70	0.63	0.25	2950.00
Corn grits	8.00	–	0.04	0.39	–	–	2600.00
Soybean meal	44.82	–	0.15	–	–	–	–
Hagonoy leaf meal	16.59	13.19	0.018	0.15	–	–	–

Data gathering and evaluation procedures

The following data were collected and recorded throughout the experimental period for analysis and evaluation of the effects of Hagonoy leaf meal on the performance of Muscovy ducks:

In this study, several performance parameters were collected to evaluate the effects of Hagonoy leaf meal supplementation in Muscovy ducks' diet. The initial body weight of each duck was recorded four hours after arrival and monitored weekly thereafter until the end of the experiment. Feed consumption was recorded weekly by subtracting the weight of leftover feed from the total amount offered to determine the actual feed intake. Growth performance was assessed using the percentage growth rate formula mentioned in the previous study (28),

wherein growth rate (%) was computed as:

$$\text{Growth rate (\%)} = \frac{(W2-W1)}{1/2(W2-W1)} x100 \qquad \text{(Eqn.1)}$$

Where W1: the weight of the ducks at a given period; W2: the current weight of the ducks at a given time.

Gain in weight was calculated by subtracting the initial weight from the final recorded weight. Feed efficiency was assessed using the feed conversion ratio (FCR) and feed conversion efficiency (FCE), as defined in the earlier study (29). FCR was calculated as the ratio of feed consumed to weight gain, while FCE was computed as the weight gain divided by feed consumed, multiplied by 100 to obtain a percentage. The dressing percentage was determined by selecting one representative duck from each replicate. The live weight and dressed weight (with and without giblets) of these samples were recorded and dressing percentage was calculated using the formula:

$$\text{Dressing (\%)} = \frac{(Dressed\ weight)}{(Live\ weight)} x100 \qquad \text{(Eqn.2)}$$

The liver and pancreas weights were also recorded post-slaughter to assess potential signs of toxicity or abnormal organ development resulting from the feed treatment. An economic evaluation was conducted by computing the return above feed and duckling costs (RAFC), which involved subtracting the total cost of feeds and ducklings from the gross market value of each duck at the end of the study. This analysis aimed to determine the financial viability of incorporating Hagonoy leaf meal into duck diets.

Statistical analysis

All gathered data were recorded, tabulated and analyzed using the Analysis of Variance (ANOVA) following the CRD. The Least Significant Difference (LSD) was used to test the significance among the treatment means.

Results

Weekly body weight of Muscovy ducks supplemented with Hagonoy leaf meal

As presented in Table 4, the initial body weights of the Muscovy ducks showed no significant differences across treatments (ns), indicating that the experimental groups started from a relatively uniform baseline. From the first week onwards, significant ($p < 0.05$) to highly significant ($p < 0.01$) differences in weekly body weights were observed among the treatment groups. In the first week, ducks under Treatment 3 (T3), which received 4 % Hagonoy leaf meal (HLM), exhibited the highest body weight (559.25 g), whereas those in Treatment 2 (T2), which received 2 % HLM, showed the lowest (510.75 g), with differences being highly significant ($p < 0.01$). During the second to fourth weeks, T3 consistently maintained significantly higher body weights compared to the other treatments, while T2 continued to yield the lowest values ($p < 0.05$). This trend persisted through the fifth to eighth weeks, with T3 showing a significantly higher final weight (1178.50 g at the eighth week), followed by T4 (1051.00 g), T1 (1021.00 g) and T2 (954.50 g), with differences again being highly significant ($p < 0.01$).

The coefficient of variation (CV %), ranged from 2.72 % to 4.86 %, indicated acceptable variability across data sets. Least Significant Difference (LSD) values revealed that the weight differences among treatment groups became more pronounced over time. The data suggest that the inclusion of 4 % HLM (T3) led to the most favorable growth performance throughout the study, while the lowest performance was consistently observed in T2 (2 % HLM), implying that a 2 % inclusion level may be nutritionally insufficient. By the end of the eighth week, T3 outperformed all other treatments, indicating that 4 % HLM is likely the optimal inclusion rate for enhancing weight gain in Muscovy ducks. Conversely, although T4 (8 % HLM) showed intermediate performance, it was slightly lower than T3, possibly due to the effects of anti-nutritional compounds at higher inclusion levels. These findings underscore the potential of *C. odorata* leaf meal as a cost-effective feed supplement, particularly at moderate inclusion levels, for improving the growth performance of Muscovy ducks.

Feed consumption

The data presented in Table 5 summarize the weekly and cumulative feed consumption of Muscovy ducks fed with varying levels of Hagonoy leaf meal (HLM) as a feed ingredient, with four treatment groups: T1 (0 % HLM), T2 (2 % HLM), T3 (4 % HLM) and T4 (8 % HLM). Across all weeks, feed consumption remained relatively consistent among the treatments, with no noticeable trend indicating a significant increase or decrease in feed intake as the level of HLM inclusion increased. The highest cumulative feed consumption was observed in T3 (4 % HLM) at 49423 g, followed

Table 4. Initial and weekly body weight of Muscovy ducks (g) fed with Hagonoy leaf meal

Treatment	Initial	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
T1 (0 % HLM)	448	552.50^{a}	618.00^{ab}	693.75^{b}	743.00^{b}	801.50^{b}	858.50^{bc}	929.00^{b}	1021.00^{b}
T2 (2 % HLM)	428.5	510.75^{c}	581.50^{c}	657.25^{c}	707.25^{c}	759.00^{c}	813.00^{c}	872.75^{c}	954.50^{c}
T3 (4 % HLM)	449.5	559.25^{a}	638.75^{a}	732.50^{a}	800.75^{a}	875.00^{a}	957.50^{a}	1054.50^{a}	1178.50^{a}
T4 (8 % HLM)	440	534.00^{b}	613.75^{b}	702.75^{b}	756.50^{b}	824.00^{b}	880.25^{b}	953.00^{b}	1051.00^{b}
ANOVA	ns	**	*	*	**	**	**	**	**
CV (%)	2.72	3.11	3.24	3.83	4.02	4.66	4.79	4.86	4.46
LSD (0.05)	-	18.29	21.61	29.08	32.93	41.39	45.81	50.46	51.12

Means with the same letter within a column are not significantly different at $p < 0.05$ using LSD. ns = not significant; * = significant ($p < 0.05$); ** = highly significant ($p < 0.01$).

Table 5. Weekly and cumulative feed consumption of the ducks

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Cumulative
T1 (0 % HLM)	3624.00	3879.00	4663.00	5719.00	6475.00	7369.00	8251.00	9179.00	49159.00
T2 (2 % HLM)	3507.25	3762.25	4546.25	5602.25	6358.25	7252.25	8134.25	9062.25	48225.00
T3 (4 % HLM)	3657.00	3912.00	4696.00	5752.00	6508.00	7402.00	8283.25	9212.00	49423.00
T4 (8 % HLM)	3533.50	3766.00	4572.00	5628.50	6384.50	7278.50	8160.50	9088.50	48435.00
ANOVA	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)	6.14	5.99	4.76	3.88	3.42	3	2.68	2.41	3.61
LSD (0.05)	-	-	-	-	-	-	-	-	-

Means with the same letter within a column are not significantly different at $p < 0.05$ using LSD. ns = not significant.

closely by T1 (0 % HLM) at 49159 g, T4 (8 % HLM) at 48435 g and T2 (2 % HLM) at 48225 g. However, the differences between treatments were negligible.

The analysis of variance (ANOVA) results showed that there were no statistically significant differences ($p > 0.05$) in both weekly and cumulative feed consumption among the treatments, suggesting that varying levels of HLM inclusion did not significantly affect feed intake in Muscovy ducks. The coefficient of variation (CV) values ranged from 2.41 % to 6.14 %, reflecting a relatively low degree of variability in feed consumption across the treatment groups.

These findings suggest that the inclusion of Hagonoy leaf meal at different levels did not negatively affect the palatability or feed intake by the ducks. Since feed consumption remained stable across treatments, further analysis of growth performance and feed efficiency is required to determine whether HLM inclusion offers nutritional or economic benefits.

Percentage rate of growth of the birds

The percentage growth rate of Muscovy ducks fed with different levels of Hagonoy leaf meal (HLM) was analyzed over an eight-week period, as shown in Table 6. The results revealed significant variation in growth rates across treatments, with the highest growth rates consistently observed in T3 (4 % HLM). T3 exhibited the highest growth percentages during the first week (21.76 %), fourth week (8.91 %), fifth week (8.86 %), sixth week (9.01 %), seventh week (9.64 %) and eighth week (11.10 %). On the other hand, T1 (0 % HLM) and T4 (8 % HLM) showed moderate growth rates, while T2 (2 % HLM) had the lowest growth percentages in most weeks. Statistically, significant differences ($p < 0.05$) were observed in the first week, with T3 recording the highest growth rate (21.76 %) and T2 the lowest (17.51 %). From the fourth week onwards, T3 continued to show significantly higher growth rates compared to the other treatments, with the most pronounced differences ($p < 0.01$) occurring in the sixth and seventh weeks. The coefficient of variation (CV) values ranged from 7.62 % to 12.38 %, indicating moderate variability in growth performance across the treatments. Overall, the results suggest that supplementing Muscovy duck diets with 4 % HLM leads to the highest growth rates, particularly in the later weeks, while higher levels of HLM (8 %) did not produce superior growth rates, indicating that excessive HLM may not be beneficial. These findings support the recommendation of 4 % HLM as the optimal inclusion level for maximizing growth performance in Muscovy ducks.

Gain in weight, feed conversion ratio and feed conversion efficiency

Table 7 shows the cumulative gain in weight, feed conversion ratio and feed conversion efficiency of Muscovy ducks. The findings suggest that supplementing Muscovy duck diets with 4 % HLM results in the best performance, as evidenced by the highest weight gain, the lowest FCR and the highest FCE. This indicates that 4 % HLM is the optimal inclusion level for improved growth and feed utilization.

While 8 % HLM (T4) performed better than the control group (T1), its efficiency was still lower than that of T3, suggesting that excessive supplementation may not yield additional benefits. Meanwhile, 2 % HLM (T2) resulted in the lowest performance across all parameters, indicating that this inclusion level may be insufficient for significant improvements. Overall, 4 % HLM supplementation is recommended to maximize growth and feed efficiency in Muscovy ducks.

Average dressing percentage, liver and pancreas weight

Table 8 shows the dressing percentage of Muscovy ducks with and without giblets. The dressing percentage of Muscovy ducks, both with and without giblets, did not exhibit significant differences among the treatments ($p > 0.05$). The dressing percentage with giblets ranged from 80.35 % to 81.79 %, with the highest value recorded in T2 (81.79 %) and the lowest in T4 (80.35 %). Similarly, the dressing percentage without giblets varied from 65.39 % to 66.96 %, where T3 had the highest percentage (66.96 %), while T1 had the lowest (65.39 %). These findings indicate that incorporating varying levels of HLM in the diet did not substantially affect the dressing yield of Muscovy ducks.

Table 6. Percentage growth rate of Muscovy ducks per week

Treatment	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	7th Week	8th Week
T1 – HMF + 0 % HLM	20.86^{ab}	11.37	11.56	6.84^{b}	7.55^{bc}	6.86^{b}	7.87^{bc}	9.45^{b}
T2 – HMF + 2 % HLM	17.51^{c}	12.93	12.18	7.32^{b}	7.03^{c}	6.87^{b}	7.08^{c}	8.98^{b}
T3 – HMF + 4 % HLM	21.76^{a}	13.28	13.69	8.91^{a}	8.86^{a}	9.01^{a}	9.64^{a}	11.10^{a}
T4 – HMF + 8 % HLM	19.30^{bc}	13.9	13.48	7.36^{b}	8.50^{ab}	6.59^{b}	7.95^{b}	9.80^{b}
ANOVA	*	ns	ns	*	*	**	**	*
CV (%)	9.5	10.46	12.38	10.78	10.89	7.62	9.31	9.72
LSD (0.05)	2.05	—	—	0.89	0.95	0.61	0.83	1.04

Means with the same letter are not significantly different at $p < 0.05$. ns = not significant; * = significant; ** = highly significant.

Table 7. Cumulative gain in weight, feed conversion ratio and feed conversion efficiency of Muscovy ducks

Treatment	Cumulative gain in weight (g)	Feed conversion ratio (kg)	Feed conversion efficiency (%)
T1 – HMF + 0 % HLM	573.00^{bc}	8.61^{ab}	11.65^{bc}
T2 – HMF + 2 % HLM	526.00^{c}	9.26^{a}	10.95^{c}
T3 – HMF + 4 % HLM	729.00^{a}	6.78^{c}	14.76^{a}
T4 – HMF + 8 % HLM	611.00^{b}	7.97^{b}	12.62^{b}
ANOVA	**	**	**
CV (%)	7.62	9.19	8.66
LSD(0.05)	50.62	0.82	1.18

Means with the same letter are not significantly different at $p < 0.05$. ** = highly significant.

Table 8. Dressing percentage of Muscovy ducks with and without giblets

Treatment	Dressing percentage (With Giblets)	Dressing percentage (without giblets)
T1 – HMF + 0 % HLM	80.72	65.39
T2 – HMF + 2 % HLM	81.79	66.04
T3 – HMF + 4 % HLM	81.12	66.96
T4 – HMF + 8 % HLM	80.35	65.42
ANOVA	ns	ns
CV (%)	4.93	4.80
LSD (0.05)	2.15	1.85

Means with the same letter are not significantly different at $p < 0.05$. ns = not significant.

Table 9 shows the liver and pancreas weight of Muscovy ducks. In contrast, liver and pancreas weights were significantly influenced by HLM supplementation. Liver weight showed a highly significant difference ($p < 0.01$), with T4 (8 % HLM) recording the highest liver weight (48.50 g), followed by T3 (46.00 g), T1 (41.50 g) and T2 (38.50 g). Similarly, pancreas weight was significantly affected ($p < 0.05$), with T4 (16.00 g) and T3 (15.00 g) displaying significantly higher pancreas weights compared to T1 (13.50 g) and T2 (13.00 g).

The absence of significant differences in dressing percentage suggests that HLM supplementation does not negatively impact carcass yield, implying its potential inclusion in Muscovy duck diets without affecting meat production. However, the observed increase in liver and pancreas weights with higher HLM levels may indicate a physiological response to metabolizing plant compounds present in HLM. The increase in liver weight could be associated with enhanced metabolic activity or detoxification processes, while the pancreas weight changes may reflect alterations in digestive enzyme production. These findings suggest that while moderate HLM supplementation (4 %) optimized feed efficiency and growth performance, higher doses (8 %) may have physiological effects that warrant further investigation to assess potential long-term impacts on duck health.

Table 9. Liver and pancreas weight of Muscovy ducks

Treatment	Liver weight (g)	Pancreas weight (g)
T1 – HMF + 0 % HLM	41.50^{c}	13.50^{b}
T2 – HMF +2 % HLM	38.50^{d}	13.00^{b}
T3 – HMF + 4 % HLM	46.00^{b}	15.00^{a}
T4 – HMF + 8 % HLM	48.50^{a}	16.00^{a}
ANOVA	**	*
CV (%)	5.65	8.75
LSD (0.05)	2.69	1.37

Means with the same letter are not significantly different at $p < 0.05$. ** = highly significant, * = significant.

Return above feed and duckling's cost

Table 10 shows the return above feed and duckling cost. The economic analysis of the different dietary treatments for Muscovy ducks reveals significant variations in profitability based on the inclusion level of HLM. Among the treatments, T3 (HMF + 4 % HLM) yielded the highest net income of Php 2164.24, with a return above feed and duckling cost of 34.24 %, indicating that this inclusion level provided the most cost-effective balance between feed expenses and market returns.

Following T3, T4 (HMF + 8 % HLM) also showed a substantial profit, with a net income of Php 1424.84 and a 23.20 % return above feed and duckling cost. Although slightly lower than T3, this suggests that an 8 % inclusion of HLM remains economically viable, albeit with diminishing returns compared to the 4 % level.

On the other hand, the control group (T1 - HMF + 0 % HLM) had a net income of Php 991.40 and a return above feed and duckling cost of 15.59 %, indicating that traditional feeding methods without HLM supplementation were less profitable. The lowest economic performance was observed in T2 (HMF + 2 % HLM), with a net income of Php 703.52 and an 11.40 % return above feed and duckling cost, suggesting that a 2 % inclusion level may not be sufficient to optimize financial returns.

These findings highlight that moderate supplementation of HLM, particularly at 4 %, provides the highest economic benefit, likely due to enhanced feed conversion efficiency and growth performance. While 8 % HLM inclusion remains profitable, it does not surpass the efficiency of the 4 % level. These results support the use of HLM as a cost-effective feed ingredient, with 4 % being the optimal inclusion level for maximizing profitability in Muscovy duck production.

Table 10. Return above feed and duckling cost

Treatments	Total cost of production (Php)	Total sales (Php)	Net income (Php)	Return above feed and duckling cost (%)
T1 – HMF + 0 % HLM	6359.80	7351.20	991.4	15.59 %
T2 – HMF + 2 % HLM	6168.88	6872.40	703.52	11.40 %
T3 – HMF + 4 % HLM	6320.96	8485.20	2164.24	34.24 %
T4 – HMF + 8 % HLM	6142.36	7567.20	1424.84	23.20 %
ANOVA	ns	ns	*	*
CV (%)	3.15	4.22	8.47	7.96
LSD (0.05)	412.35	635.28	522.14	6.72

Means with the same letter are not significantly different at $p < 0.05$. * = significant, ns = not significant.

Discussion

Weekly body weight of Muscovy ducks supplemented with Hagonoy leaf meal

The absence of significant differences in the initial body weights of Muscovy ducks across treatments indicates that the experimental groups were comparable at the start of the feeding trial, ensuring that subsequent differences in growth performance could be attributed primarily to dietary treatments rather than initial variability. Such uniformity at baseline is essential for evaluating the true effects of dietary supplementation on growth performance in poultry (1, 2).

From the first week onward, significant to highly significant differences in weekly body weights were observed among treatments, suggesting that Hagonoy leaf meal (HLM; *C. odorata*) exerted an early influence on nutrient utilization and growth. Ducks fed 4 % HLM (T3) consistently exhibited superior body weights throughout the experimental period, culminating in the highest final weight at the eighth week. This improvement may be attributed to the favorable nutritional and phytochemical composition of *C. odorata*, which has been reported to contain moderate levels of crude protein, minerals and bioactive compounds that can enhance metabolic efficiency and growth when included at optimal levels (6, 9, 10).

In contrast, the consistently lower body weights observed in T2 (2 % HLM) suggest that this inclusion level may have been insufficient to exert a measurable growth-promoting effect. This finding aligns with poultry nutrition principles emphasizing that suboptimal inclusion rates of unconventional feed ingredients may fail to meet physiological thresholds necessary for performance enhancement (1, 3). Meanwhile, the slightly reduced performance of T4 (8 % HLM) relative to T3 may be explained by the presence of anti-nutritional factors such as tannins, saponins and phenolic compounds, which have been documented in *C. odorata* and may interfere with nutrient digestibility when consumed at higher concentrations (7, 11, 12).

The low coefficient of variation values indicates acceptable experimental precision, while increasing LSD values over time suggest that the cumulative effects of dietary treatments became more pronounced as growth progressed. Overall, the results demonstrate that 4 % HLM optimizes growth performance in Muscovy ducks, confirming the potential of *C. odorata* leaf meal as a cost-effective feed supplement when used at moderate inclusion levels (5, 6).

Feed consumption

The absence of significant differences in weekly and cumulative feed consumption among treatments indicates that HLM inclusion up to 8 % did not adversely affect feed intake or palatability. This finding is consistent with previous reports showing that properly processed plant-based feed ingredients can be incorporated into poultry diets without negatively influencing voluntary feed consumption (3, 8).

The relatively uniform feed intake across treatments suggests that observed differences in body weight gain and growth performance were not driven by increased feed consumption but rather by differences in feed utilization efficiency. This observation supports the hypothesis that HLM at optimal levels may enhance nutrient digestibility or metabolic efficiency rather than simply stimulating appetite (22, 28).

Furthermore, stable feed consumption across treatments implies that the inclusion of HLM did not introduce sensory deterrents such as bitterness or unfavorable texture, which are common concerns with leaf meals (11, 12). From a practical standpoint, this finding is important, as feed ingredients that compromise palatability often limit adoption by poultry producers despite potential nutritional benefits (4).

Percentage rate of growth of the birds

The percentage growth rate data further reinforce the superiority of the 4 % HLM inclusion level. Ducks under T3 consistently exhibited the highest growth rates, particularly during the later stages of the growth period, when nutrient demands are elevated. The significantly higher growth rates observed from the fourth week onward suggest that HLM may exert cumulative physiological benefits, possibly through improved gut function, enzyme activity or microbial balance (16, 19).

The reduced growth performance observed in T4 (8 % HLM) supports earlier findings that excessive inclusion of C. odorata may limit growth due to anti-nutritional effects or increased metabolic costs associated with detoxification processes (7, 11). Similarly, the lower growth rates in T2 (2 % HLM) indicate that minimal inclusion levels may not provide sufficient bioactive or nutritional benefits to enhance growth.

The moderate CV values observed suggest acceptable biological variability and indicate that growth responses were consistently influenced by dietary treatment. These results corroborate the principle that optimal inclusion levels of plant-based supplements can improve growth performance, while excessive or insufficient levels may reduce their effectiveness (22).

Gain in weight, feed conversion ratio and feed conversion efficiency

The superior performance of T3 in terms of cumulative weight gain, lowest feed conversion ratio (FCR) and highest feed conversion efficiency (FCE) confirms that 4 % HLM optimized both growth and feed utilization. Improved FCR indicates more efficient conversion of feed nutrients into body mass, a key determinant of profitability in poultry production (28).

The relatively lower efficiency observed in T4 suggests diminishing returns at higher inclusion levels, likely due to reduced nutrient availability or increased metabolic burdens associated with processing phytochemicals (12). Conversely, the poor performance of T2 highlights that marginal inclusion levels may not justify dietary modification from a performance standpoint.

These findings align with previous studies emphasizing that unconventional feed ingredients must be carefully optimized to balance nutrient supply and metabolic efficiency (22). Overall, 4 % HLM represents the most biologically efficient inclusion level among the treatments evaluated.

Average dressing percentage, liver and pancreas weight

The lack of significant differences in dressing percentage, with or without giblets, indicates that HLM supplementation did not adversely affect carcass yield or meat production. This finding is consistent with reports that moderate dietary modifications often influence growth performance without altering carcass composition (5).

However, the significant increases in liver and pancreas weights with higher HLM inclusion, particularly at 8 %, suggest physiological adaptations to dietary plant compounds. The liver plays a central role in detoxification and metabolism, and increased liver weight may reflect heightened metabolic activity in response to phytochemicals present in *C. odorata* (13). Similarly, increased pancreas weight may indicate enhanced enzyme synthesis to facilitate digestion of fibrous or complex plant components (25).

While these changes did not negatively affect carcass yield, they raise important considerations regarding long-term health and metabolic stress at higher inclusion levels. Thus, while 4 % HLM optimized performance without pronounced organ enlargement, higher levels warrant further investigation to assess potential chronic effects (11).

Return above feed and duckling's cost

The economic analysis clearly demonstrates that 4 % HLM inclusion (T3) yielded the highest net income and return above feed and duckling cost. This superior profitability can be directly linked to enhanced growth performance and improved feed efficiency, which reduced production costs per unit of weight gain (28).

Although 8 % HLM (T4) remained economically viable, its lower return compared to T3 reflects diminishing marginal benefits, likely due to reduced biological efficiency. In contrast, the relatively low profitability of T2 confirms that insufficient supplementation fails to translate biological responses into economic gains.

These findings support the adoption of HLM as a cost-effective feed ingredient in Muscovy duck production systems, particularly at moderate inclusion levels. From both biological and economic perspectives, 4 % HLM represents the optimal inclusion rate for maximizing profitability while maintaining animal performance and health (5).

Conclusion

The study evaluated the effects of varying levels of HLM supplementation in Muscovy duck diets on growth performance, feed efficiency, carcass characteristics and economic returns. Results indicate that incorporating 4 % HLM (T3) in the diet significantly improved cumulative weight gain, feed conversion efficiency and overall profitability. Ducks in this treatment group exhibited the highest net income and return above feed and duckling cost, suggesting that moderate HLM inclusion enhances production efficiency. While an 8 % inclusion level (T4) also yielded favorable economic returns, it did not surpass the efficiency observed at 4 %. The control group (T1) and the 2 % HLM treatment (T2) showed lower economic viability, indicating that minimal or no supplementation may not be beneficial. Based on these findings, it is recommended that poultry producers consider incorporating 4 % HLM in Muscovy duck diets to maximize feed efficiency and profitability. Further research is suggested to explore the long-term effects of HLM inclusion on overall flock health, meat quality and sustainability in commercial duck farming. Cost-benefit analyses in different production settings should be conducted to validate the economic advantages of HLM supplementation across various farming conditions. Studies on the potential of HLM at different growth stages and its interaction with other feed additives could provide more insights into optimizing feeding strategies.

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Authors' contributions

FOL conceptualized the study, designed the experimental methodology, supervised data collection and performed the statistical analysis. He also contributed to the interpretation of results, manuscript writing and final review of the paper. CBSM assisted in the experimental design, conducted data collection and analysis, and contributed to the literature review and discussion. He was also involved in manuscript preparation, editing and finalization for submission.

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During the preparation of this work, the authors used ChatGPT in order to improve language and readability. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

1. Applegate TJ, Angel R. Nutrient requirements of poultry publication: history and need for an update. J Appl Poult Res. 2014;23(3):567–75. https://doi.org/10.3382/japr.2014-00980
2. Dale N. National Research Council nutrient requirements of poultry-ninth revised edition. J Appl Poult Res. 1994;3:101. https://doi.org/10.1093/japr/3.1.101
3. Sonaiya EB, Swan SEJ. Small-scale poultry production: technical guide. Rome: Food and Agriculture Organization; 2004.
4. Rizzo G, Migliore G, Schifani G, Vecchio R. Key factors influencing farmers' adoption of sustainable innovations: a systematic literature review and research agenda. Org Agric. 2023;14(1):57–84. https://doi.org/10.1007/s13165-023-00440-7
5. Lambio AL. The duck industry in the Philippines: challenges and opportunities. Philipp Agric Rev. 2000;82(1):15–28.
6. Apori SO. The role of *Chromolaena odorata* in soil fertility improvement. Agric Sci J. 2000;14(2):102–12.
7. Aro SO, Aluko OB, Akinyemi AA. Toxicity potential of *Chromolaena odorata* in ruminants: a review. Vet Toxicol J. 2009;12(3):67–75.
8. Fasuyi AO, Ojo OB. Effects of *Chromolaena odorata* leaf meal on egg yolk color in laying hens. Poult Sci J. 2005;17(1):89–97.
9. Akinmoladun FO, Akinrinlola BL, Akinwunmi OA. Phytochemical properties and bioactivity of *Chromolaena odorata*. J Plant Res. 2007;21(4):45–56.

10. Odutayo OI, Kolawole AO, Babajide O. Chemical composition and pharmacological properties of *Chromolaena odorata*. Afr J Bot. 2017;12(3):67–79.

11. Onwuka CF. Fermentation as a detoxification method for *Chromolaena odorata*. J Anim Nutr. 2018;29(1):21–37.

12. Ndife MO. Processing methods to reduce anti-nutritional factors in *Chromolaena odorata*. Food Nutr Res. 2016;8(2):34–49.

13. Onwuka GI. Food analysis and instrumentation (theory and practice). 2nd ed. Nigeria: Naphtali Printers; 2018. p. 299–314.

14. DeFilippis F, Pasolli E, Ercolini D. The food-gut axis: lactic acid bacteria and their link to food, the gut microbiome and human health. FEMS Microbiol Rev. 2020;44:454–89. https://doi.org/10.1093/femsre/fuaa015

15. Duangnumsawang Y, Zentek J, Boroojeni FG. Development and functional properties of intestinal mucus layer in poultry. Front Immunol. 2021;12:745849. https://doi.org/10.3389/fimmu.2021.745849

16. Liu Q, Yu Z, Tian F, Zhao J, Zhang H, Zhai Q, et al. Surface components and metabolites of probiotics for regulation of intestinal epithelial barrier. Microb Cell Fact. 2020;19:23. https://doi.org/10.1186/s12934-020-1289-4

17. Fu Z, Ao N, Liang X, Chen J, Wang Y, Wang Q, et al. Effects of fermented feed on growth performance, serum biochemical indexes, antioxidant capacity and intestinal health of lion-head goslings. Front Vet Sci. 2023;10:1284523. https://doi.org/10.3389/fvets.2023.1284523

18. Irawan A, Ratriyanto A, Respati AN, Ningsih N, Fitriastuti R, Suprayogi WPS, et al. Effect of feeding fermented soybean meal on broiler chickens' performance: a meta-analysis. Anim Biosci. 2022;35:1881–91. https://doi.org/10.5713/ab.21.0546

19. Li Z, Li C, Lin F, Yan L, Wu H, Zhou H, et al. Duck compound probiotics fermented diet alters the growth performance by shaping the gut morphology, microbiota and metabolism. Poult Sci. 2024;103:103647. https://doi.org/10.1016/j.psj.2024.103647

20. Heir E, Solberg LE, Jensen MR, Skaret J, Grøvlen MS, Holck AL. Improved microbial and sensory quality of chicken meat by treatment with lactic acid, organic acid salts and modified atmosphere packaging. Int J Food Microbiol. 2022;362:109498. https://doi.org/10.1016/j.ijfoodmicro.2021.109498

21. Johnson A, Miller EA, Weber B, Figueroa CF, Aguayo JM, Johny AK, et al. Evidence of host specificity in *Lactobacillus johnsonii* genomes and its influence on probiotic potential in poultry. Poult Sci. 2023;102:102858. https://doi.org/10.1016/j.psj.2023.102858

22. Ferrer-Lorente R, Fernández-López JA, Alemany M. Estimation of the metabolizable energy equivalence of dietary proteins. Eur J Nutr. 2007;46:1–11. https://doi.org/10.1007/s00394-006-0623-x

23. Eglite S, Ilgaza A, Mancevica L, Zolovs M. The effects of *Lactobacillus farciminis* and *Lactobacillus rhamnosus* on growth, blood biochemical and meat quality indicators of specific pathogen-free broiler chickens. Vet Med Int. 2023;2023:6297068. https://doi.org/10.1155/2023/6297068

24. Grootjans J, Hundscheid IH, Buurman WA. Goblet cell compound exocytosis in the defense against bacterial invasion in the colon exposed to ischemia-reperfusion. Gut Microbes. 2013;4:232–5. https://doi.org/10.4161/gmic.23866

25. Na SW, Guan LL. Understanding the role of rumen epithelial host-microbe interactions in cattle feed efficiency. Anim Nutr. 2022;10:41–53. https://doi.org/10.1016/j.aninu.2022.04.002

26. World Economic Library. National Health and Family Planning Commission; 2015.

27. Li J, Li Z, Shang S, Zhao X, Zhang W, Zhang X, et al. Effect of additives and moisture on the fermentation quality and bacterial community of high moisture ear corn. Front Microbiol. 2023;14:1251946. https://doi.org/10.3389/fmicb.2023.1251946

28. Brody S. Bioenergetics and growth, with special reference to the efficiency complex in domestic animals. New York: Reinhold Publishing Corporation; 1945.

29. Williams KC. A review of feeding practices and nutritional requirements of postlarval groupers. Aquaculture. 2009;292(3-4):141–52. https://doi.org/10.1016/j.aquaculture.2009.04.026

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