American Journal of Agriculture and Forestry
2026, Vol. 14, No. 4, pp. 173–184
https://doi.org/10.11648/j.ajaf.20261404.12

Research Article

Growth Performance, Carcass Characteristics and Economic Viability of Broiler Chickens Fed Partial Levels of Comfrey Leaf Meal (*Symphytum Officinale*)

Atilio Kisanzu[1,*], Claudius Luziga[2], Isack Kerario[1]

[1]Department of Animal and Aquaculture Sciences, Sokoine University of Agriculture, Morogoro, Tanzania
[2]Department of Veterinary Anatomy and Pathology, Sokoine University of Agriculture, Morogoro, Tanzania

Abstract

This study evaluated the effects of partially replacing soybean meal (SBM) with comfrey leaf meal (CLM) on the growth performance, carcass characteristics, and economic viability of broiler chickens. Fresh *Symphytum officinale* leaves were harvested, shade-dried, and milled to produce CLM. Four pelleted experimental diets were formulated to contain 0% (control), 4%, 8%, and 12% CLM inclusion levels. A total of 240 day-old Cobb 500 broiler chicks were brooded for 14 days, after which the birds were randomly assigned to four dietary treatments with three replicates of 20 birds per replicate in a completely randomized design. Growth performance, carcass traits, and economic parameters were evaluated during the growing-finishing phase. Final body weight, average daily gain (ADG), and average daily feed intake (ADFI) were significantly reduced ($P<0.05$) in birds fed 4%, 8%, and 12% CLM compared to the control. Final body weights were 2245.40 g, 2119.06 g, 1833.96 g, and 1485.57 g for 0%, 4%, 8%, and 12% inclusion levels, respectively. Corresponding ADG values were 66.26, 61.30, 51.30, and 38.30 g/bird/day, while ADFI values were 149.86, 148.00, 143.76, and 139.79 g/bird/day, respectively. Feed conversion ratio did not differ between 0% and 4% CLM ($P>0.05$) but was significantly poorer at higher inclusion levels. Slaughter weight differed significantly among treatments ($P<0.05$), whereas dressing percentage and organ weights were not significantly affected ($P>0.05$). Economic analysis indicated that 4% CLM inclusion produced the most favorable cost differential (160.96 TSH/kg gain) and relative cost reduction (5.90%) compared to the control. These findings suggest that partial replacement of SBM with CLM at 4% inclusion level maintains acceptable performance and carcass traits while improving economic efficiency, whereas higher inclusion levels negatively affect broiler performance.

Keywords

Broiler Chickens, Comfrey Leaf Meal, Soybean Meal Replacement, Growth Performance, Carcass Characteristics, Economic Viability

[*]Correspondence: Atilio Kisanzu (akisanzujunior@gmail.com)

Received: 14 June 2026; **Accepted:** 29 June 2026; **Published:** 24 July 2026

1. Introduction

Poultry production is a significant contributor to global food security, providing affordable animal protein with a short production cycle. Global population is projected to exceed 9.2 billion by 2050 [1]. However, Tanzania's population was recorded at 61.741 million in 2022, reflecting a prominent increase in the growth rate from 2.7% in 2012 to 3.2% [2]. Food demand is expected to rise by 35-56% between 2010 and 2050 [3], driven by population growth, urbanisation and rising consumer demand for affordable animal-source protein [4], therefore it is essential for meeting future protein demand. Broiler chickens are short-cycle breeds that produce high-quality protein in a short period, allowing production under diverse agro-ecological conditions [5]. The broiler poultry sector in Tanzania has experienced significant growth over the past two decades [6].

Poultry meat is one of the most nutritious and common animal-origin foods consumed worldwide [7]. Poultry meat consumers perceive chicken meat as heathier food, particularly in comparison to red meat. In addition, there are no ethical restrictions to its consumption as a result chicken meat is a preferred choice for most consumers. Despite this increased demand, the economic sustainability of broiler production in Tanzania remains highly constrained by the numerous challenges, especially the cost of feed, which accounts for 70% of total broiler production cost [8]. Conventional protein sources soybean meal and fish meal, contribute up to 70% of total feed cost, creating a production challenge [9].

Tanzania remains as the main importer of soybeans from Malawi and Zambia to meet the high demand from the growing poultry and livestock feed industry. The dependence on imported protein sources makes poultry production less profitable and often unsustainable for small scale farmer due to limited supply and high price fluctuation of soybean meal [10].

This challenge has triggered more research to be conducted on locally available, non - traditional protein sources as alternative feed sources in the poultry industry. Currently, extensive studies are being undertaken on alternative resources including agro-industrial by-products, animal-derived protein sources, and plant-based ingredients such as leaf meals and legumes [11-13]. In addition, insect species, particularly the Black Soldier Fly, are gaining attention due to their favorable nutrient composition and potential application in broiler nutrition [14]. Varieties of plant leaves and insects were identified as promising alternatives for local use in poultry farming, primarily to reduce the high cost and import dependency of soybean meal. Utilising local plants as protein sources dramatically lowers the cost of feed for smallholder farmers [15]. Among the cultivation of locally produced feed crops is the comfrey *(Symphytum officinale)*. This is a fast growing, drought tolerant perennial herb of the family Boraginaceae that has been cultivated in East Africa since the 1950s, with documented trials in Kenya and Uganda [16].

The plant is characterized by high production per year with minimum input. It is rich in nutrients such as protein content, amino acid profile, minerals and has potential medicinal properties [17, 18]. Studies show that comfrey leaves contain crude protein ranging from 25 to 28.5% in dry matter basis and that its leaves have 2.7% crude fat, 1.08% calcium, 0.69% phosphorus and 6.69% potassium in dry matter basis [18, 19]. The plant is also rich in bioactive compounds such as allantoin, tannins, and phenolics [18]. Comfrey leaves are recently widely used in poultry diets as a non-conventional protein source [18, 20] and other monogastric animals, such as pigs and turkeys [19, 21]. Despite being nutrious comfrey contains pyrrolizidine alkaloids (PA) which are associated with hepatotoxity in mammals, particularly at high and prolonged exposures [22]. The concentration level of PA in comfrey is substantially lower in leaves than in roots [23] and has not been detected in broiler chicken fed 4% inclusion of CLM in liver and breast muscle tissue (below 5 μg/ kg) [18] and that no significant adverse effect has been noted in starter and finisher phases supplemented with the plant leaf extracts [24].

Despite the extensive studies supporting the nutritional and functional potential of comfrey leaves for broiler feeding in other parts of the world, no study has been conducted to evaluate the effect of comfrey plant use as the broiler diet in Tanzania. Therefore, the objective of this study was to to investigate the effect of feeding comfrey leaf meal at inclusion levels of 0, 4, 8, and 12% on growth performance, carcass characteristics and economic viability of growing- finishing broiler chicken raised under a litter system.

2. Materials and Methods

2.1. Study Area

This feeding trial was conducted at the lower farm poultry house of the Department of Animal, Aquaculture and Range Sciences (DAARS), Sokoine University of Agriculture (SUA), Morogoro, Tanzania. University is located at a latitude of 6 052'' S and longitude 37 038 ''59''E. That lies on the slopes of the Uluguru mountains at an altitude of 500-600 meters above the sea level and receives an average rainfall of between 600-1000 mm with an ambient temperature ranges between 180℃ to 300℃ and an annual relative humidity range of 60-80%.

2.2. Sources and Preparation of Comfrey Leaf Meal

Fresh leaves of comfrey were harvested at the blooming stage from an established plantation plot at Morogoro during noon in the month of August, 2025. The leaves were thoroughly washed and air dried under shed at room temperature (26-32℃) for 14 days until they became crispy while still maintaining the green colouration. The leaves were turned carefully and regularly to prevent uneven drying and possible decay. The leaves were then milled using a hammer mill fitted with a 2 mm screen to produce comfrey leaf meal (CLM). A sample of leaf meal was sent to the laboratory at DAARS for proximate analysis according to [25]. CLM was stored in polyethene bags until incorporation into experimental diets.

2.3. Ethical Clearance

The ethical clearance to conduct this experiment referenced REF NO. TLRI/CC.21/109 was provided by the Tanzania Livestock Research Institute (TALIRI), (appendix).

2.4. Experimental Birds, Housing and Management

A total number of 240-day-old chicks of Cobb 500 broiler chicks of mixed sex were obtained from the Irvine commercial hatchery in Dar es Salaam. All chicks were wing-banded, individually weighed, and brooded together in a litter pen for 14 days. During this period, chicks were reared on wood shavings litter (10 cm depth) and fed a common commercial broiler starter diet ad libitum. Temperature was maintained at 32-35 ℃ during the first week and reduced by approximately 3 ℃ per week thereafter. At the end of the brooding phase (day 14), birds were weighed individually and randomly allocated to 12 litter-floor pens (20 birds per pen, 60 birds per treatment across three replicate pens) within the same broiler house. Each pen measured approximately 2.0 m x 2.5 m, providing a stocking density of 4 birds/m^2. Pens were equipped with feeders and drinkers. Birds had ad libitum access to feed and water throughout the trial. Standard vaccination schedules were applied: Newcastle disease vaccine (LaSota strain) on days 7 and 21, and Gumboro disease vaccine on days 14 and 24.

2.5. Experimental Design and Dietary Treatment

At 14-day old, all 240 chicks were weighed and randomly allotted to five dietary treatments using a completely randomized design (CRD), with each treatment replicated three times and each replicate contained 20 chicks. The dietary treatments were: T0 basal diet with 0% CLM (control); T1 basal diet with 4% CLM; T2 basal diet with 8% CLM; T3 basal diet with 12% CLM. The experimental period started from day 15 to 42 (28 days), comprising a growing phase (days 15-28) and a finishing phase (days 29-42).

2.6. Diet Formulation and Composition

Four isoenergetic and isonitrogenous diets in pellet form were formulated to meet the nutritional requirements of broiler chicken at grower and finisher phases as recommended by the National Research Council [26]. The feed ingredients used in formulating the experimental diets, including maize meal, maize bran, soybean meal, sunflower seed cake, blood meal, and fish meal, were purchased from authorised animal feed suppliers in Morogoro Municipality. Representative samples of each ingredient were collected and submitted to the Tanzania Veterinary Laboratory Agency (TVLA), Temeke-Dar es Salaam, for proximate analysis. Chemical analyses were performed using a near-infrared reflectance spectrophotometer (NIRS Systems 5000, Firmware Version 156, USA). Specific calibration for concentrate mixed ration formulations (tmrgpfe.eqa) was applied following the NIRS methodology described by [27, 28]. The analysed feed samples are presented in Table 1. Thereafter, a basal diet (control) was formulated for each phase (grower and finisher) to meet the [26] Minimum requirement for broiler chicken. Three other diets were formulated to contain CLM 4, 8 and 12% levels respectively. All the diets were isocaloric and isonitrogenous (Table 3) grower diet (day 14-28 of life) and finisher diet (day 29 - 42 of life) were formulated in pellet form with 4 mm and 5 mm diameters, respectively, at 0, 4, 8, and 12% inclusion levels partially replacing soya bean meal in the diets. All diets were formulated to meet the recommended dietary energy, crude protein, calcium, available phosphorus and essential amino acid specifications for each production phase. As CLM replaced SBM, maize and other ingredients were adjusted in small proportions to maintain isoenergetic and isonitrogenous status across all four treatments within each phase. Amino acid supplementation (DL-Methionine and L-Lysine HCl) was adjusted accordingly to meet phase-specific methionine and lysine specifications. The ME content of the concentrate diets was analysed using the same NIRS system at the TVLA laboratory.

2.7. Data Collection

2.7.1. Chemical Composition of the Experimental Diets

The ingredients used to formulate the experimental diets were analysed for nutrient composition using the proximate analysis according to [25].

2.7.2. Broiler Performance

Assessment of birds was conducted for each pen at day 14, 21, 28, 35 and 42. The parameters recorded include body weight (BW), feed intake (FI), average daily gain (ADG), average daily feed intake (ADFI) and feed conversion ratio (FCR). Feed intake was recorded daily, and the birds were weighed weekly. Feed intake was determined by weighing the feed offered and the leftover in the next morning; the difference between the two values was the feed consumed. The feed conversion ratio was determined by dividing average daily feed intake by average daily weight gain. The following formula was used.

ADG (g/day) = (Final weight – Initial weight) /Number of

$$\text{daysADG}\left(\frac{\text{g}}{\text{day}}\right) = \text{Finalwt-Initialwt} \quad (1)$$

ADFI (g/day) = (Total feed given – Refusal) /Number of daysADFI $\left(\frac{g}{day}\right) = \frac{\text{Totalfeedgiven-Refusal}}{\text{Numberofdays}}$ (2)

FCR = Feed intake/ Weight gain (3)

2.7.3. Carcass Characteristics

At the end of the experiment, a total of 72 chickens (18 chickens per treatment) were randomly selected. Before slaughter, the chickens were fasted for 12 hours to allow emptying of the gastrointestinal tract. The birds were weighed to obtain the slaughter body weight. After bleeding, the slaughtered chicken were immersed in hot water, defeathered and eviscerated. Weight was taken for carcass and meat cut parts including back, drumstick, thigh, breast, wings, shank, head, neck, gut, proventiculus and gizzard. The dressing percentage (DP) was computed by using the following formula.

DP = (Carcass weight/ Live body weight) × 100% (4)

2.7.4. Economic Viability of Broiler Chicken Feed Varying Levels of CLM

The economic efficiency of feeding broiler chicken diets containing varying inclusion levels of comfrey leaf meal (CLM) was evaluated by calculating the feed cost per kilogram of body weight gain. This was determined by summing the variable costs of all ingredients used to formulate one kilogram of feed for each dietary treatment [29]. To further assess cost-effectiveness, cost differential and relative cost analyses were conducted to evaluate the economic benefits of incorporating CLM at different inclusion levels.

The total feeding cost per bird over the experimental period was calculated by multiplying individual feed intake by the cost per kilogram of the respective diet. Economic feed efficiency was assessed by computing the cost per kilogram of weight gain, obtained by dividing the total feeding cost by the corresponding body weight gain (kg). Economic indicators-cost differential and relative cost benefit were used to compare the CLM-based diets with the control diets T0.

Cost differential was calculated as the difference between the cost per kilogram of weight gain of the control diet and that of the treatment diet Equation (4). Relative cost (%) was determined as the ratio of the cost differential to the cost per kilogram of weight gain of the control diet, multiplied by 100 Equation (5). Relative cost benefit represents the percentage economic gain achieved by feeding CLM at a given inclusion level relative to the control diets T0.

The differential cost was calculated by comparing the cost per kilogram of weight gain for each treatment diet with that of the control diet (T0). This value represents the difference between the control and treatment costs and was computed as:

Differential cost = (Cost/ Kg gain *TO) – (Cost/Kg gain Treatment)* (5)

The relative cost was expressed as the percentage change in cost per kilogram of weight gain in relation to the control diet. It was determined using the following formula:

Relative Cost (%) = Differential cost / (Cost/Kg gain) *TO* (6)

2.8. Data Analysis

For performance data referring to the whole broiler population, a linear model was applied, including dietary group (R language version package stats). Individual data obtained at slaughter were analysed by a linear model considering dietary group in the R language. Differences were considered significant at P< 0.05. The least significant difference (LSD) was used in the comparison of the treatments. The statistical model was as shown in equation (7) bellow:

Yij = μ + αi + εijYij = μ + αi + εij (7)

Where
Yij = The j^{th} observation in response to the treatment
μ = overall population mean
αi = the i^{th} treatment level
εij= the error term/ residual term

3. Results

3.1. Laboratory Analyses of Experimental Raw Materials and Feeds

The proximate composition of comfrey leaf meal (CLM) determined in this study is presented in Table 1. The proximate composition **of** the purchased feed ingredients used in diet formulation maize, maize bran, soybean meal, sunflower seed cake, fish meal, and rice bran was analyzed in accordance with Test Report No. CVL-TR 2025/93374, and the results are presented in Table 2.

Table 1. *Proximate composition analysis of comfrey leaf meal.*

Parameters	Value (%)
Moisture	9.13
Dry matter (DM)	90.87
Crude protein (CP)	20.03
Crude fibre (CF)	13.12
Ether extract (EE)	0.75
Ash	28.85

Table 2. Proximate nutrient composition of major feed ingredients used in experimental diet formulation.

Ingredient	DM (%)	CP (%)	EE (%)	CF (%)	Ash (%)	ME (kcal/kg)
Maize	87.4	8.6	4	3.6	1.5	3231
Soybean meal	92.3	45.5	1.5	6.4	6.5	2443
Fish meal	90.1	57.3	8.5	1	7.3	2820
Sunflower seedcake meal	90	36	2	20	6.8	1980
Maize bran	93.5	8.9	4	9.2	6	1630
Rice bran	88.9	13.5	99.9	7.5	4	3120

DM=Dry Matter; CP=Crude Protein; EE=Ether Extract; CF=Crude Fibre; ME=Metabolisable Energy.

The analyzed parameters for each ingredient included dry matter (DM), crude protein (CP), crude fiber (CF), ether extract (EE), and ash content. Furthermore, the chemical composition of the formulated experimental diets for both the grower and finisher phases was determined, and the results are presented in Table 3.

Table 3. Nutrient composition of experimental diets.

	DM (%)	Crude Protein (%)	Crude Fibre (%)	Crude Fat (%)	Ash (%)	ME Kcal/kgDM
Grower Feed						
T0	87.06	19.85	4.2	4.75	5.56	2971
T1	87.62	19.65	4.58	4.73	6.18	2959
T2	87.78	19.3	4.95	4.65	6.25	2862
T3	87.95	18.9	5.32	4.58	6.32	2862
Finisher Feed						
T0	87.2	19.13	4	5.5	5.8	3008
T1	87.35	18.64	4.35	5.42	5.88	3000
T2	87.5	18.03	4.7	5.35	5.95	3002
T3	87.68	17.86	5.05	5.28	6.02	2960

3.2. Effects of Replacing Soybean Meal with Comfrey Leaf Meal on the Growth Performance of Broiler Chicken

Final body weight, body weight gain, average body weight gain, average daily feed intake, and feed conversion ratio are important for evaluating the growth of an animal. These parameters guide to determine how much weight the birds gained, the utilisation of the feed into body weight gain and total feed consumed. The growth performance results of broiler chickens fed graded inclusion levels (0%, 4%, 8%, and 12%) of comfrey leaf meal (CLM) during the growing-finishing phase are presented in Table 4, which shows the effect of varying dietary levels of CLM on broiler performance. The initial weight showed no significant difference (P>0.05), indicating uniformity among birds at the commencement of the experiment.

The final weight (g/bird), Total weight gain (g/bird) Average daily weight gain (g/bird), and Average daily feed intake (ADFI) were significantly higher (P<0.05) in birds fed the control diet achieving the highest final weight (2245.40+19.32 g), total weight gain (1855.32+18.58 g) and average daily feed intake (149.86+0.00 g). The results revealed that there was a significant difference in feed intake at different inclusion levels of CLM, which was higher in the control and decreased significantly across the treatments. The same trend was observed in ADG T0 (66.26 g/day), followed by T1 (61.30 g/day), T2 (51.30 g/day), and T3 (38.30 g/day). Feed conversion ratio (FCR) was significantly (P < 0.05) decreased as the level of inclusion increased. FCR decreased as follows: CLM 12% > CLM 8%> CLM 4% > control 0% CLM.

Table 4. Results of broiler chickens fed CLM inclusion levels (0%, 4%, 8%, and 12%) during the growing-finishing phase.

Parameter	T0 (0%)	T1 (4%)	T2 (8%)	T3 (12%)	SEM	P-value
Initial Weight (g)	390.08	402.79	397.61	413.06	23.96	0.919
Final Weight (g)	2245.40^{d}	2119.06^{c}	1833.96^{b}	1485.57^{a}	19.32	<0.001
Total Weight Gain (g)	1855.32^{d}	1716.28^{c}	1436^{b}	1072.51^{a}	18.58	<0.001
Average Daily Gain (g/bird/day)	66.26^{d}	61.30^{c}	51.30^{b}	38.30^{a}	0.66	<0.001
Average Daily Feed Intake (g/bird/day)	149.86^{d}	148.68^{c}	143.79^{b}	139.79^{a}	0.00	<0.001
Feed Conversion Ratio (FCR)	2.34^{a}	2.49^{a}	2.89^{b}	3.78^{c}	0.04	<0.001

Notes: T0= negative control diet with 100% soybean meal and 0% comfrey leaf meal (CLM), (*Symphytum officinale*), T1=treatment diet with 4% CLM, T2= treatment diet with 8% CLM, T3= treatment diet with 12% CLM.

3.3. Effects of Replacing Soybean Meal with Comfrey Leaf Meal on Carcass Characteristics and Organ Weights

The effects of inclusion levels (0%, 4%, 8%, and 12%) of comfrey leaf meal (CLM) on carcass characteristics and internal organ weights of broiler chickens during the growing-finishing phase are presented in Table 5. The results indicated that the average slaughter weight of broilers decreased as the inclusion level of CLM increased in the ration. However, no significant difference was recorded up to 4% inclusion level, but it was significantly reduced when CLM was beyond 8%. Birds fed the control diet (T0) and 4% CLM (T4) recorded significantly higher slaughter weights (2385.00 g and 2250.00 g) compared to those fed 8% (1830.33 g) and 12% (1508.00 g), respectively. Average dressed weight or hot carcass weight was comparable up to 4% inclusion level, but decreased significantly (P<0.05) towards 8% and 12%. Additionally, dressing percentage in different treatments was not significantly affected (P> 0.05) by the varying inclusion levels. Average giblet weights were also found to be decreased significantly as the inclusion level of CLM increased in the ration, head weight, drumstick weight, thigh weight, breast weight, wing weight, neck weight and back weight was significantly (P <0.05) reduced with increasing CLM levels, However, thigh, drumstick, neck and wings were significantly higher in control group as compared to the treatment T4% and found to be decreased linearly. Leg weight was not significantly influenced (P>0.05) by dietary treatments. Internal organs, proventriculus, heart, spleen, and liver weights were not significantly (P > 0.05) affected by CLM inclusion. However, gizzard weight increased significantly (P<0.05) with higher inclusion levels, with the highest weight recorded in T12% (26.67 g) compared to T0 (22.33 g).

Table 5. Results of broiler chickens carcass characteristics fed graded inclusion levels (0%, 4%, 8%, and 12%) of comfrey leaf meal (CLM) during the growing-finishing phase.

Parameter	T0 (0%)	T1 (4%)	T2 (8%)	T3 (12%)	SEM	P-value
Slaughter weight (g)	2385.00^{c}	2250.00^{c}	1830.33^{b}	1508.00^{a}	64.51	0.00004***
Hot carcass (g)	1811.00^{b}	1637.33^{b}	1252.33^{a}	992.00^{a}	71.53	0.0002***
Dressing%	75.87^{a}	72.74^{a}	68.59^{a}	65.79^{a}	2.6	0.099ns
Head (g)	51.00^{b}	48.00^{ab}	40.67^{ab}	36.33^{a}	2.58	0.014*
Leg (g)	77.67^{a}	72.00^{a}	72.00^{a}	69.67^{a}	6.94	0.866ns
Drumstick (g)	202.67^{b}	195.00^{b}	172.33^{ab}	139.00^{a}	8.09	0.002**

Parameter	T0 (0%)	T1 (4%)	T2 (8%)	T3 (12%)	SEM	P-value
Thigh (g)	261.33[c]	235.00[bc]	183.67[ab]	150.67[a]	15.45	0.004**
Breast (g)	674.67[b]	606.67[b]	438.67[a]	337.00[a]	32.66	0.0003***
Wing (g)	177.67[c]	160.67[bc]	136.33[ab]	112.67[a]	8.71	0.004**
Back Length (cm)	21.60[b]	21.17[b]	18.90[ab]	17.97[a]	0.7	0.017*
Neck (g)	107.00[b]	95.67[ab]	76.00[ab]	56.00[a]	9.08	0.018*
Back (g)	341.67[c]	305.33[bc]	238.00[ab]	186.33[a]	17.18	0.001***
Proventriculus (g)	10.00[a]	8.33[a]	7.33[a]	7.00[a]	0.85	0.132ns
Gizzard (g)	22.33[a]	23.33[ab]	25.67[bc]	26.67[c]	1.48	0.032*
Heart (g)	12.67[a]	10.67[a]	11.00[a]	8.67[a]	0.91	0.082ns
Spleen (g)	3.67[a]	2.33[a]	2.00[a]	3.00[a]	0.69	0.384ns
Liver (g)	37.67[a]	34.67[a]	39.00[a]	35.00[a]	2.81	0.658ns

Notes: T0= negative control diet with 100% soybean meal and 0% comfrey leaf meal (CLM), *(Symphytum officinale)*, T1=treatment diet with 4% comfrey, T2= treatment diet with 8% comfrey, T3= treatment diet with 12% comfrey.

3.4. Economic Viability of Feeding Broiler Chickens with Different Levels of CLM

The financial evaluation of broiler chickens fed different inclusion levels (0%, 4%, 8%, and 12%) of CLM is presented in Table 6. The cost per kilogram of feed decreased progressively with increasing CLM inclusion, from 1207.00 TSH in T0 to 988.69 TSH in T3. As a result, the total cost of feed intake per bird was highest in T0 (5064.67 TSH) and lowest in T3 (3869.85 TSH). However, when expressed as cost per kilogram of weight gain, T1 (4% CLM) showed a lower value (2568.85 TSH) compared to T0 (2729.81 TSH), indicating better economic efficiency at this inclusion level. Meanwhile, higher inclusion levels increased the cost per kilogram of weight gain to 2871.40 TSH in T2 and 3608.02 TSH in T3. Differential cost per kilogram gain relative to T0 showed a positive economic advantage of 160.96 TSH in T1, whereas T2 and T3 recorded economic losses of -302.55 TSH and -736.62 TSH, respectively. Similarly, the relative cost per kilogram gain compared to T0 was favourable in T1 (5.90%) but declined at higher inclusion levels, with -11.78% in T2 and -25.65% in T3.

Table 6. *Financial analysis of Broiler rearing fed with different levels of CLM Inclusion.*

Parameters	T0	T1	T2	T3
Initial BW (g)	390.08	402.00	397.00	413.00
Final BW (g)	2245.40	2119.06	1833.96	1485.57
weight gain (g)	1855.32	1717.06	1436.96	1072.57
daily weight gain	66.26	61.32	51.32	38.31
Total FI	4196.08	4163.04	4026.12	3914.12
Daily FI	149.86	148.68	143.79	139.79
FCR	2.34	2.49	2.89	3.78
Cost per Kg of feed	1207.00	1059.53	1024.83	988.69
Cost of FI per bird	5064.67	4410.87	4126.09	3869.85
Cost of feed per Kg weight gain (TSH)	2729.81	2568.85	2871.40	3608.02
Differential cost per Kg gain (TSH) of T0		160.96	-302.55	-736.62

Parameters	T0	T1	T2	T3
Relative cost per Kg gain (%) of T0		5.90	-11.78	-25.65

4. Discussion

4.1. Proximate Analysis of CLM

The present study for proximate analysis of CLM showed that the crude protein (20.03% CP) and ash content (28.85% Ash) are greater than the results reported by [24] for crude protein (18.37%) and ash content (6.90%). They also reported higher crude fibre (47.12%) and ether extract (5.25%) than the value recorded in this study. Moreover, the crude protein (18.6%) reported by [23] was lower than the crude protein obtained in the present study. [18] reported higher crude protein (28.5%) than the result recorded in this study. These variations may be related to variations in geographical location as well as variations in the stage of maturity and harvesting time, leaf position on the plant, soil conditions, processing methods, anti- nutritional factors.

The proximate results of CLM in this study are more for the CP (20.03%) when compared to the various leaf meal *pennisetuma purpureum* (18.96%) [30]. However the following leaf meal have higher CP than CLM presented in this study *Acacia angustissima* (23.40%) [31] and *Moringa oleifera* (24.21%), *Telferia occidentalis* (40%) [32]. The common comfrey *(Symphytum officinale)* as compared with other leaf meal by higher content of crude protein, mineral and total soluble sugar, lower content of cell wall fractions which has positive effect on digestibility, relative value and energy concentration [23]. It used as a source of protein in chicken feed according to the proximate analysis.

4.2. Growth Performance

It was observed that inclusion of varying levels of CLM in broiler diets has effects on growth performance, with better performance recorded in control diet which showed highest final weight, total weight gain and average daily gain. The significant decrease in final body weight, total weight gain, and average daily gain (ADG) with increase in CLM levels suggests that higher inclusion rates negatively affected nutrient utilization. This reduction may be associated with the presence of anti-nutritional factors (ANFs), phytochemicals such as tannin and high crude fibre content in CLM. Phytochemicals are known for reducing nutrient digestibility and absorption, thereby impairing growth performance [21]. Phytochemicals can bind to dietary proteins and reduce their availability in the gastrointestinal tract, [33]. Crude fibre can dilute dietary energy and decrease nutrient digestibility in monogastric animals, including broilers [19]. CLM are also known to contain bioactive compounds, including pyrrolizidine alkaloids, which may exert toxic or anti-nutritional effects when consumed at high amount [34]. The combined effects of fibre, tannins, and other phytochemical compounds present in CLM are the reason for the observed reduction in growth performance of the birds. Results obtained in this study are in line with [13] who found optimum growth in broiler chicken fed Gliricidia leaf meal but contradictory to [24] who found increase in body weight gain of broiler chicken with increased comfrey extract supplementation.

The decrease in feed intake at higher inclusion levels of comfrey leaf meal (CLM) in this study may be due to reduced palatability and poor adaptation of broiler to the diet texture and taste. In contrast lower inclusion level were better accepted, resulting in relatively high feed intake. This finding is consistent with [18] who reported that low levels of comfrey were well accepted by broiler. Similarly, [21] observed a decline in feed consumption at higher inclusion level 30% in turkey. Indicating that excessive incorporation of leaf meal may adversely affect palatability.

Absence of flavor additives in the present study may have further reduced diet acceptability. [12] reported that unpalatable feed ingredients can limit feed consumption in chicks. The finding agrees with [13] who reported that inclusion of leaf meal above 5-10% reduces performances. Feed intake values recorded in this study were lower than the 203 g reference value reported for the Cobb 500 strain by [35].

Feed conversion ratio (FCR) is an important index of production efficiency and indicates how effectively feed is converted into body mass [36]. Partial replacement of soybean meal with high levels of CLM was associated with reduced feed utilization compared to the control diet. The present study shows that CLM is a potential alternative feed ingredient; its inclusion above 4% affects growth and feed efficiency in broiler chickens during the growing-finishing phase. This finding aligns with earlier reports indicating excessive inclusion of leaf meals in broiler diets impairs feed efficiency [13, 37-40].

4.3. Carcass Characteristics

The findings of this study showed that the slaughter weight, hot carcass weight, body organ and visceral organ of the experimental birds supplement comfrey leaf meal (CLM) significantly affected but non-significant in dressing percentage, leg, preventiculus and visceral organ (heart, spleen and liver) during the growing-finishing phase. The birds fed control diet and low inclusion level of 4% was non-significant in slaughter weight and hot carcass weight. Birds fed 0%, and 4% CLM, same trend was reported by [18]. Although dressing percentage was not statistically different among treatments, the gradual numerical reduction observed with increasing CLM inclusion suggests that the decrease in live weight proportionally affected carcass output. This indicates that CLM primarily influenced total body growth rather than significantly altering carcass proportion relative to live weight.

The significant reduction in thigh, drumstick, wing, and back weights at higher inclusion levels further confirm that muscle development was compromised. The breast muscle, which is highly responsive to adequate protein and energy supply, showed a notable decline at 8% and 12% CLM inclusion. According to [31] optimal nutrient density and amino acid balance are crucial for maximising muscle deposition in broilers. Any reduction in nutrient availability can therefore limit carcass quality and commercial cut yields.

An increase in gizzard weight was recorded as CLM inclusion increased, while other internal organs, such as the liver, heart, spleen, and proventriculus, were not significantly affected. The enlargement of the gizzard may be explained by the higher fibre content of the diets, which stimulates greater mechanical activity and muscular development of the organ [41]. The lack of significant changes in liver, heart, spleen, and proventriculus weights suggests that CLM inclusion up to 12% did not cause severe adverse effects on major internal organs during the experimental period.

4.4. Economic Viability of Feeding Broiler Chickens with Different Levels of CLM

The findings showed that the cost of feed per kilogram of weight gain was lower in T1 compared with the control diet (T0); however, this cost increased as the level of CLM inclusion increased up to 12% (T3). This increase may be attributed to the feed conversion ratio (FCR) with higher levels of CLM in the diet. Similarly, the differential cost per kilogram of weight gain and the relative cost per kilogram gain compared to the control (specifically, T0) were higher at T1 than at T0, and these costs further increased at inclusion levels of 8% and 12%. These trends are likewise associated with the progressive increase in FCR as dietary CLM levels increased. Higher levels of CLM inclusion in the diet resulted in a significant reduction in broiler growth performance, which consequently lowered the overall economic profitability of the production cycle.

The present results are consistent with the findings of [13] in Nigeria, who evaluated the cost-effectiveness of *Gliricidia sepium* leaf meal (GLM) in broiler diets and reported that the control diet was more expensive than diets containing lower levels of GLM (5%), with a 4.10% reduction in feed cost per kilogram. Furthermore, [42] also corroborated the current findings by demonstrating that feed cost per kilogram decreased with increasing GLM inclusion up to 40%. However, [43] reported contrasting results regarding cost per kilogram of animal produced, noting no significant differences ($p>0.05$) across inclusion levels. From an economic perspective, these findings suggest that CLM can serve as an alternative protein source in poultry diets when used at low inclusion levels.

5. Conclusion and Recommendations

The study results indicated that CLM not affects growth parameters at a lower inclusion level. Moreover, carcass characteristics of dietary treatments with CLM showed marked differences across the treatment. Economic analysis revealed that at 4% CLM inclusion, the most favorable cost benefits were with respect to T0. The study highlights that CLM holds potential as a locally available and sustainable feed resource, whereby its use in broiler diets should be limited to lower inclusion. The study recommends farmers can be encouraged to include CLM up to 4% inclusion level in the diet of the broiler at growing-finishing phase this would offers both growth performances and economic benefits for smallholder poultry farmers in Tanzania. Further studies on other breeds of chickens are recommended.

Abbreviations

ANOVA	Analysis of Variance
CRD	Complete Randomized Design
CLM	Comfrey Leaf Meal
BW	Body Weight
BWG	Body Weight Gain
CF	Crude Fibre
CP	Crude Protein
DM	Drymatter
EE	Ether Extract
FAO	Food and Agriculture Organization
FCR	Feed Conversion Efficiency
FI	Feed Intake
FM	Fish Meal
GLM	General Linear Model
LSD	Least Significant Difference
ME	Metabolizable Energy
MJME	Megajoules of Metabolizable Energy
MJ/Kg DM	Megajoules Per Kilogram of Dry Matter
NBS	National Bureau of Statistics
NDF	Neutral Detergent Fibre
NIRS	Near-infrared Reflectance Spectrophotometer
SBM	Soybean Meal
SUA	Sokoine University of Agriculture
TSH	Tanzanian Shillings
TALIRI	The Tanzania Livestock Research Institute

Acknowledgments

The authors wish to thank the staff of the Poultry farm Unit, Department of Animal Science, aquaculture and Range science, Sokoine University of Agriculture, for their technical assistance during the study. The authors also acknowledge the contributions of farm workers who assisted with day-to-day bird management.

Author Contributions

Atilio Kisanzu: Conceptualization, Data curation, Formal Analysis, Methodology, Validation, Visualization, Writing – original draft

Claudius Luziga: Investigation, Methodology, Supervision, Validation, Visualization, Writing – review & editing

Isack Kerario: Investigation, Methodology, Supervision, Validation, Visualization, Writing – review & editing

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix: Ethical Clearance

UNITED REPUBLIC OF TANZANIA
MINISTRY OF LIVESTOCK AND FISHERIES
TANZANIA LIVESTOCK RESEARCH INSTITUTE (TALIRI)
Director General, Tanzania Livestock Research Institute, Block No. 39,
P. O. Box, 834, Dodoma, Email: dg@taliri.go.tz or hq@taliri.go.tz

REF NO. TLRI/CC.21/109

RESEARCH CLEARANCE CERTIFICATE

1. **This research is hearby presented to**
   ATILIO JEREMIA KISANZU
2. **Title of proposed Research**
   : EFFECTS OF COMFREY LEAF MEAL (Symphytum officinale) ON THE GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, HISTOPATHOLOGY OF THE INTESTINE AND HEMATOLOGICAL INDICES OF GROWING-FINISHING BROILER CHICKENS.
3. **General objective of the Research**
   To determine the optimal inclusion level of comfrey leaf meal that maximises performance and health benefits of broiler chickens during the growing-finishing phase
4. **Study Area**
   1. Morogoro , Morogoro MC
   2. .... , ...
   3. ...., ...
5. **Starting Date** 20th June, 2026
6. **Ending Date** 20th June, 2027

Signature of the Director General: [signature] Date: 20th June, 2026

QR Code Verification

References

[1] Bruinsma, J. (2015). WORLD AGRICULTURE: TOWARDS 2015 / 2030 AN FAO PERSPECTIVE Edited by Jelle Bruinsma.

[2] NBS. (2022). Administrative Units Population Distribution Report Tanzania.

[3] FAO. (2018). The future of food and agriculture - Alternative pathways to 2050. Summary version. Rome. 60 pp.

[4] Ringo, E. J., & Lekule, F. P. (2020). Market trends and consumer behaviors and preferences in the Tanzania poultry subsector. An analytical report with recommendations for the public and private sectors. Embassy of the Kingdom of the Netherlands in Dar es. July.

[5] Leinonen, I. (2019). Environmentally Sustainable Livestock Production. In *Environmentally Sustainable Livestock Production*. https://doi.org/10.3390/books978-3-03897-553-3

[6] Mramba, R. P., & Mwantambo, P. A. (2024). The impact of management practices on the disease and mortality rates of broilers and layers kept by small-scale farmers in Dodoma urban district, Tanzania. *Heliyon*, *10*(8), e29624. https://doi.org/10.1016/j.heliyon.2024.e29624

[7] Petracci, M., Mudalal, S., Soglia, F., & Cavani, C. (2015). Meat quality in fast-growing broiler chickens. *World's Poultry Science Journal*, *71*(2), 363-374. https://doi.org/10.1017/S0043933915000367

[8] Mutayoba et al., 2011. (2011). The structure, marketing and importance of the commercial and village poultry industry: An analysis of the poultry sector in Tanzania. *FAO Animal Production and Health Livestock Country Reviews.*

[9] Hocquette, J. F., Tesseraud, S., & Chilliard, Y. (2007). Responses to nutrients in farm animals: implications for production and quality. *Animal, The International Journal of Animal Biosciences*, *1*(9), 1297-1313. https://doi.org/10.1017/S1751731107000602

[10] FAO. (2024). Soybean value chain: Tanzania. www.fao.org

[11] Tesfaye, E., Animut, G., Urge, M., & Dessie, T. (2013). Moringa olifera Leaf Meal as an Alternative Protein Feed Ingredient in Broiler Ration. 12(5), 289-297.

[12] Onyimonyi, A. E., Olabode, A., Okeke, G. C., State, E., & State, E. (2009). Performance and Economic Characteristics of Broilers Fed Varying Dietary Levels of Neem Leaf Meal (Azadirachta indica). 8(3), 256-259.

[13] Oloruntola, O. D. (2018). Gliricidia Leaf Meal in Broiler Chickens Diet: Effects on Performance, Carcass, and Haemato-biochemical Parameters. 18(3), 1-9. https://doi.org/10.9734/JALSI/2018/43813

[14] de Souza Vilela, J., Andronicos, N. M., Kolakshyapati, M., Hilliar, M., Sibanda, T. Z., Andrew, N. R.,. & Ruhnke, I. (2021). Black soldier fly larvae in broiler diets improve broiler performance and modulate the immune system. *Animal Nutrition*, *7*(3), 695-706.

[15] Nathalie, M. N., Gwladys, N. K., Emile, M., Daloko, D., Lydie, J., Florence, F. A., & Etienne, P. T. (2022). Performance Characteristics and Blood Indices of Broilers Fed Varying Levels of Cassava (Manihot esculenta Crantz) Leaf Meal. 10(4), 94-103. https://doi.org/10.11648/j.avs.20221004.13

[16] Bareeba et al. (1992). ThepotentialofRussiancomfrey (Symphytumofficinale) asananimalfeedstuff inUganda. In: Stares, J. E., Said, A. N., Kategile, J. K. (Eds.), The Complementarity of Feed Resources for Animal Production in Africa. Proceedings of the Joint Resources Networks Workshop Held in Gaborone, Bot.

[17] Hills, L. D. (2011). *Comfrey- Past, Present and Future* (Reprint (ed.)). Faber and Faber.

[18] Oster, M., Reyer, H., Keiler, J., Ball, E., Mulvenna, C., Murání, E., Ponsuksili, S., & Wimmers, K. (2020). Science of the Total Environment Comfrey (Symphytum spp.) as an alternative fi eld crop contributing to closed agricultural cycles in chicken feeding. *Science of the Total Environment*, *742*, 140490. https://doi.org/10.1016/j.scitotenv.2020.140490

[19] Oster, M., Reyer, H., Keiler, J., Ball, E., Mulvenna, C., Ponsuksili, S., & Wimmers, K. (2021). Science of the Total Environment Comfrey (Symphytum spp.) as a feed supplement in pig nutrition contributes to regional resource cycles. *Science of the Total Environment*, *796*, 148988. https://doi.org/10.1016/j.scitotenv.2021.148988

[20] Oliveira, P. R., Santos, F. R., Duarte, E. F., Guimarães, G. S., Mattos, N. S. C., & Minafra, C. S. (2016). Symbiotics and Aloe vera and Symphytum officinale extracts in broiler feed. *Semina: Ciências Agrárias*, *37*(4Supl1), 2677-2690.

[21] Pandey, L. N., Shrestha, R., Shah, M., Baskota, N., & Bhusal, K. (2023). International Journal of Research Publication and Reviews Effects of Comfrey Grass (Symphytum Spp.) Included Diets on the Growth Performance and Carcass Characteristics of Turkey. 4(4), 1442-1447.

[22] Ruzicka, J., Berger-Büter, K., Esslinger, N., & Novak, J. (2021). Assessment of the diversity of comfrey (Symphytum officinale L. and S. ×uplandicum Nyman). *Genetic Resources and Crop Evolution*, *68*(7), 2813-2825. https://doi.org/10.1007/s10722-021-01156-x

[23] Ţiţei, V., Andreoiu, A. C., Coshman, S., Blaj, A. V., Guţu, A., Maruşca, T., & Coşman, V. (2024). Biomass quality of comfrey, Symphytum officinale, and its potential application in the Republic of Moldova. Scientific Papers. Series A. Agronomy, (1), 922-927.

[24] Esiegwu, A. C. and Obih, T. K. (2021). GROWTH PERFORMANCE, HAEMATOLOGICAL AND SERUM BIOCHEMICAL INDICES OF BROILER STARTER CHICKENS OFFERED DIETARY SUPPLEMENT OF COMFREY LEAVES EXTRACT. 19(1), 48-62.

[25] AOAC, Association of Official Analytical Collaboration International. (2019). Official Methods of Analysis. Method 934.01 for Moisture, Method 984.13 (A-D) for Crude Protein, Method 920.39 (A) for Crude Fat, Method 978.10 for Crude Fiber, AOAC Method 942.05 for Ash Content, AOAC Method 982.30 (a, b, c), 2006 for Amino Acid Profiling.

[26] NRC. (1994). Nutrient Requirements of Poultry.

[27] Aufrère, J., Michalet-Doreau, B., & Cartailler, D. (1988). Prediction of nitrogen degradability of feeds in sacco from solubility in a buffer solution and from their enzymic degradation.

[28] Berglund, I., Larsson, K., & Lindberg, J. E. (1990). Estimation of metabolisable energy for ruminants by near infrared reflectance photometry using multivariate methods. *Journal of the Science of Food and Agriculture*, 52(3), 339-349.

[29] Mishra, S., Vartak, V., & Manager, S. P. (2023). Arima Forecasting In Soymeal And Beyond : An Empirical Study Bridging The Path To Millet-Based Forecasting. 3(2), 574-594.

[30] Anyanwu et. (2022). Variation in growth performance characteristics of broiler finisher birds fed three different leaf meals as additive. 24(1), 139-146.

[31] Ncube, S., Halimani, T. E., Chikosi, E. V. I., & Saidi, P. T. (2018). Effect of Acacia angustissima leaf meal on performance, yield of carcass components and meat quality of broilers. 48(2).

[32] Obadire et al. 2019. (2019). Nigerian Journal of Animal Science and Technology. 2(2), 115-125.

[33] Lüscher, A., Mueller-Harvey, I., Soussana, J. F., Rees, R. M., & Peyraud, J. L. (2014). Potential of legume-based grassland-livestock systems in Europe: A review. *Grass and Forage Science*, *69*(2), 206-228. https://doi.org/10.1111/gfs.12124

[34] Geburek, I., Rutz, L., Gao, L., Kupper, J. H., These, A., & Schrenk, D. (2021). Metabolic Pattern of Hepatotoxic Pyrrolizidine Alkaloids in Liver Cells. *Chemical Research in Toxicology*, *34*(4), 1101-1113. https://doi.org/10.1021/acs.chemrestox.0c00507

[35] Cobb-Vantress. (2018). Cobb500 Slow Feather Breeder.

[36] Kudu. (2022). Nutrient Digestibility and Economy of Feed Conversion of. 2195-2199.

[37] Nkukwana, T. T. (2018). Global poultry production : Current impact and future outlook on the South African poultry industry. 48(5).

[38] Morgan, N. K., & Choct, M. (2016). Cassava : Nutrient composition and nutritive value in poultry diets. *Animal Nutrition*, *2*(4), 253-261. https://doi.org/10.1016/j.aninu.2016.08.010

[39] Ubua, J. A., Ozung, P. O., & Inagu, P. G. (2019). Dietary Inclusion of Neem (Azadirachta indica) Leaf Meal Can Influence Growth Performance and Carcass Characteristics of Broiler Chickens. *Asian Journal of Biological Sciences*, *12*(2), 180-186. https://doi.org/10.3923/ajbs.2019.180.186

[40] Adegbenro, M. (2020). Nutritional Significance of Tropical Vegetables in Poultry Feeding: A Review. Turkish Journal of Agriculture - Food Science and Technology, 8(6), 1286-1290. https://doi.org/10.24925/turjaf.v8i6.1286-1290.3298

[41] González et al. (2019). The value of fibre: Engaging the second brain for animal nutrition. *Wageningen Academic Publishers*.

[42] Ayoola, M. A., Balogun, K. B., & Ogunsipe, M. H. (2018). Performance, carcass characteristics and economics of production of broilers fed diets containing Gliricidia sepium leaf meal as replacement for soya bean meal. *Nigerian Journal of Animal Production*, *45*(5), 46-51.

[43] Akorede et al. (2021). Effects of graded levels of Vernonia amygdalina (Bitter) leaf meal based diets on performance of broilers chickens. 23(2), 222-231.

Research Field

Atilio Kisanzu: Animal nutrition and forage, Animal breeding, Animal product and by products, Poultry and hatchery, Pasture establishment and management

Claudius Luziga: Anatomy, Cell biology, Physiology, Biochemistry, Reproduction

Isack Kerario: Animal nutrition, Molecular biology, Tick and tick-borne disease, Population genetic, Animal breeding and genetics