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Effect of Cassava (*Manihot esculenta* Crantz) Leaf Meal as Partial Substitute for Soybean Meal on Growth Performance, Blood Profile and Meat Quality of Broilers

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ABSTRACT

Background: Poultry meat production, particularly broiler chicken, plays a crucial role in meeting the protein demands of Asia's growing population. Cassava, a widely available regional crop, shows promise as an alternative feed ingredient, particularly its nutrient-dense leaves, which provide protein, minerals and vitamins.

Methods: A 35-day feeding trial was conducted to assess the effects of replacing soybean meal with cassava leaf meal (CLM) in broiler diets. Four groups of 100 Arbor Acres broilers (five replicates per group, 20 birds per replicate) were assigned different diets: control (basal diet), T_1 (10% CLM), T_2 (20% CLM) and T_3 (30% CLM). Growth performance, hematobiochemical parameters and meat quality were evaluated.

Result: Broilers fed cassava leaf meal showed significantly (P<0.05) higher body weight than the control, though higher cassava levels led to reductions. Feed intake and FCR varied across weeks, with optimal performance observed at 10-20% inclusion. Mortality rates decreased significantly (P<0.001) in all treatment groups. Biochemical parameters indicated improved protein metabolism, lower cholesterol and enhanced antioxidant activity. Hematological analysis showed increased WBC and neutrophil counts, with reduced lymphocytes. Muscle composition revealed higher metabolizable energy and crude fiber, while meat quality improved with reduced cooking loss and enhanced water-holding capacity.

Key words: Blood profile, Cassava leaf meal, Growth performance, Meat quality.

INTRODUCTION

Bangladesh's poultry sector involves 1 million entrepreneurs and 8 million individuals engaged in commercial poultry farming, produces 1.46 million tons of poultry meat annually and constitutes about 37% of the nation's total consumption of animal protein (UKRI GCRF, 2023). This strategic initiative is expected to enhance the sector's economic sustainability and highlights its potential to contribute more efficiently to Bangladesh's total export revenue (Kamruzzaman *et al.*, 2021). Feed ingredients like maize, soybean and wheat constitute 60-70% of poultry feed and their prices have been rising due to climate change, geopolitical tensions and competition from biofuel industries (Ajide *et al.*, 2023).

Cassava leaf meal (CLM) contains 21.64% crude protein, with amino acid levels superior to maize and soybean and 476-625 mg carotenoids dry matter, which enhance poultry growth and serum biochemistry (Latif and Müller, 2015; Ahmed *et al.*, 2024). However, large-scale commercial adoption remains limited due to concerns over anti-nutritional factors, variability in nutrient composition and processing challenges (Malik *et al.*, 2020). Despite extensive research in parts of Africa and Asia, cassava's potential in Bangladesh's poultry industry remains underexplored. The purpose of this study was to evaluate the effect of dietary cassava leaf meal on growth performance, blood metabolites and meat quality of broiler between the starter and grower stages. Integrating cassava by-products into poultry feed could improve food security, reduce feed costs and mitigate supply chain vulnerabilities, particularly in developing nations.

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MATERIALS AND METHODS

The experiment was conducted during the period from December 2023 to November 2024 at the research cum instructional broiler shed at the Department of Agro Product Processing Technology, Jashore, Bangladesh.

Experimental design, rations, treatments and management of broiler

The open-system chicken house that served as this study shed faced east to west to shield itself from the sun. Broilers were housed on a deep litter floor with *ad libitum* access to feed and water. Standard vaccinations and biosecurity measures were implemented as per Ross Aviagen (2018) guidelines. A feeding trial was conducted using 400 day-old Arbor Acres (AA) broiler chicks (44±2.27g initial weight). Birds were assigned to four treatment groups (Control, T_1, T_2, T_3) with five replications of 20 chicks each. Treatments included a control group and three groups incorporating 10%, 20% and 30% cassava leaf meal as replacements for soybean meal. Diets were formulated per NRC (1994) standards, with starter feed provided for days 1-21 and grower feed for days 22-35. Diet compositions are detailed in Table 1.

Data collection and experimental procedure

Growth performance

Body weight (BW), total feed intake (TFI), feed conversion ratio (FCR), feed efficiency ratio (FER) and mortality rates were monitored weekly. Feed intake was calculated as the difference between feed offered and leftovers. FCR and FER were determined using standard formulas. Mortality was recorded upon occurrence.

Hematological and serum biochemical analysis

Blood samples were collected from wing veins for hematological and serum biochemical evaluations. Hematological analysis followed Ogbuewu and Mbajiorgu (2023); Kurban (2025) and Sagaf *et al.* (2025) while serum analysis employed AGAPPE test kits and standard protocols (Akiba *et al.*, 1982).

Meat quality analysis

Samples of thigh and breast meat were analyzed for moisture, protein, fat and ash content using AOAC, (2003) methods. Drip and cooking losses, pH and antioxidant activities were evaluated using established techniques (Vargas-Ramella *et al.*, 2021; Cheng *et al.*, 2017; Alam *et al.*, 2024). Total phenolics and flavonoids were measured using Folin-Ciocalteu and colorimetric methods, respectively (Hasanuddin *et al.*, 2025).

Statistical analysis

Data normality was confirmed via histogram checks. Results were presented as standard error mean. Statistical significance was analyzed using ANOVA and Tukey's post hoc test in SPSS 22.0. A significance level of $P<0.05$ was used.

RESULTS AND DISCUSSION

Growth performance

The growth performance of broilers fed varying levels of cassava leaf meal (CLM) showed significant ($P<0.001$) differences across treatment groups (Table 2). The final body weight of birds at the 5th week was significantly ($P<0.001$) higher in T_1 and T_2 group compared to the control. Total Feed intake was significantly ($P<0.001$) higher in T_1 treatment, followed by T_2 treatment in week 5, but higher inclusion led to reduced feed intake value. Feed Conversion Ratio improved for 10% CLM, particularly in week 5, while Feed Efficiency Ratio showed better results for T_2 and T_3. Mortality rates significantly ($P<0.001$) decreased in all treatment groups at week 5. CLM inclusion up to 10% enhanced feed intake, growth performance without adverse effects, supporting its viability as a partial feed replacement (Elnour *et al.*, 2020). However, inclusion beyond 10% negatively impacted performance, possibly due to anti-nutritional compounds such as hydrogen cyanide, phenols and protease inhibitors, which may interfere with amino acid availability and feed palatability (Melesse *et al.*, 2018). These results are consistent with earlier findings that recommend CLM inclusion up to 10% for optimal broiler growth and efficiency (Nwoche *et al.*, 2009).

Blood profile

At 35 days, broilers fed cassava leaf meal (CLM) diets showed varied biochemical responses (Table 3). Blood glucose was significantly ($P<0.001$) higher in T_2, likely due to cassava's high carbohydrate content (Hernawan *et al.*, 2012). In contrast, the significantly ($P<0.001$) lower RBS observed in the T_3 group suggests improved glucose regulation, potentially due to the excess inclusion of phytochemicals polyphenols or flavonoids. These components are known to slow glucose absorption, enhance insulin action and support pancreatic function (Soares *et al.*, 2017). Uric acid levels decreased significantly ($P<0.001$) in CLM supplemented birds, possibly due to lower dietary protein and the presence of cyanogenic glycosides affecting nitrogen metabolism (Olanbiwoninu and Odunfa, 2016). T_1 had the highest total protein, consistent with findings that cassava-based diets can maintain protein levels within the normal range (Beski *et al.*, 2015). Cholesterol and triglyceride levels were significantly ($P<0.0001$) lowered in the treatment groups, with the highest reductions observed in those receiving higher levels of cassava, likely due to the fiber in cassava leaves altering lipid absorption (Olugbemi *et al.*, 2010), but the inconsistent trends across groups suggest that other dietary or physiological factors may also be involved. Increased HDL and decreased LDL in T_1 suggest that diets containing cassava lower in saturated fats or energy-dense components, which also contributes to favorable lipid profiles by reducing LDL and promoting HDL synthesis (Eruvbetine *et al.*, 2003; Mujnisa *et al.*, 2025). Liver enzymes (AST, ALT, ALP) were significantly ($P<0.001$)

lower across treatment groups but remained within normal ranges, indicating no liver toxicity (Olanbiwoninu and Odunfa, 2016).

Hematological analysis

At 35 days, broilers fed cassava leaf meal (CLM) showed varied hematological responses (Table 4). Hemoglobin levels was higher in T_2 among the treatment groups but did not surpass the control and while RBC and PCV showed no significant differences, WBC levels increased significantly (P<0.001) in T_1 and T_3, indicating an immune response (Adeyemo and Sani, 2013). MCV and MCH values were significantly (P<0.001) reduced across treatments, with T_3 recording the lowest, possibly due to phytochemicals in CLM interfering with erythrocyte function (Emeji, 2012). Neutrophil counts were significantly (P<0.001) higher, especially in T_2, suggesting active immune modulation, while lymphocyte levels were significantly (P<0.001) reduced across all treatments. Monocytes were elevated in T_2 and eosinophils were highest in T_3 both within normal

Table 1: Ingredients and nutrient compositions of formulating experimental diets (as fresh basis).

Item (%)	Starter (d 1 to 21); Grower (d 22 to 35)							
	Treatments							
	Control		T_1		T_2		T_3	
	Starter	Grower	Starter	Grower	Starter	Grower	Starter	Grower
Corn	57	60	57	60	57	60	57	60
Rice polish	5	4	5	4	5	4	5	4
Choline chloride	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Soybean meal	26	24	23.40	21.60	20.80	19.20	18.20	16.80
Cassava leaf	-	-	2.60	2.40	5.20	4.80	7.80	7.20
Probiozyme[1]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Esel dry[2]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Fishlog	6	6	6	6	6	6	6	6
Turbotox[3]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
$NaHCO_3$	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix[4]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Sqzyme SME[5]	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Soybean oil	2.25	2	2.25	2	2.25	2	2.25	2
Hamecosaldry[6]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Hamecomoltox[7]	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Limestone	1	1	1	1	1	1	1	1
DCP	0.80	1	0.80	1	0.80	1	0.80	1
Coccidiostat	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
DB Vitamin	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Toxol powder	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Total	100	100	100	100	100	100	100	100
Analyzed values								
Crude protein%	21.07	20.36	20.44	19.77	19.81	19.19	19.18	18.61
Crude fat %	3.85	3.80	4.16	4.09	4.47	4.38	3.79	4.67
Crude fibre %	3.46	3.38	3.27	3.21	3.09	3.04	2.91	2.87
Methionine %	0.57	0.61	0.56	0.60	0.56	0.59	0.55	0.59
Lysine %	1.24	1.18	1.21	1.15	1.18	1.13	1.15	1.10
Calculated values								
ME kcal/kg	3038	3039	3047	3048	3057	3056	3067	3065
Digestible protein%	18.12	17.51	17.12	16.59	16.12	16.66	15.12	14.74

[1]Probiotics and Enzyme; [2]Alpha- Tocopherol acetate and Sodium Selenite; [3]Mixture of organic acids and inactivated yeast extract; [4]Vitamins (A, D3, E, K3, thiamine, riboflavin, niacin, B12) and Minerals (manganese sulfate, zinc sulfate, ferrous sulfate, tribasic copper chloride) [5]Multi-enzyme; [6]Organic acids and salt; [7]Toxin binder and mould inhibitor; T_1= 10% of cassava leaf; T_2= 20% of cassava leaf; T_3= 30% of cassava leaf; DCP= Dicalcium phosphate; M= Metabolizable energy.

Table 2: Growth performance of experimental broiler diets on graded levels of cassava leaf meal.

Parameters	Treatments				Sig.	P-value
	Control	T_1	T_2	T_3		
Body weight (g) (n=100)						
Week 1	127.86±1.00^d	147.20±0.731^a	135.28±1.15^b	130.86±0.77^c	***	0.0001
Week 2	401.62±1.46^b	390.28±1.04^c	385.28±0.97^d	410.34±1.54^a	***	0.0001
Week 3	744.96±1.64^d	760.28±1.13^a	754.38±1.76^b	746.00±3.11^c	***	0.0001
Week 4	1184.68±0.47^b	1197.70±0.70^a	1176.52±0.85^c	1171.10±0.65^d	***	0.0001
Week 5	1680.70±0.73^c	1697.14±1.30^a	1688.28±0.64^b	1677.26±0.61^d	***	0.0001
Total Feed intake (g) (n=100)						
Week 1	105.30±0.80^b	117.96±0.50^a	116.80±1.09^a	108.44±1.22^b	***	0.0001
Week 2	465.82±3.06^b	448.02±0.74^c	438.42±3.92^d	472.48±2.12^a	***	0.0001
Week 3	942.34±1.21^d	960.26±1.88^a	944.60±1.31^c	948.30±5.62^b	***	0.00001
Week 4	1612.62±0.39^b	1660.34±1.02^a	1605.72±1.50^c	1585.78±0.54^d	***	0.0001
Week 5	2516.90±1.36^c	2565.64±2.02^a	2524.92±0.57^b	2510.78±0.80^d	***	0.0001
FCR						
Week 1	0.82±0.03^c	0.80±0.07^d	0.86±0.03a	0.83±0.07^b	***	0.001
Week 2	1.16±0.05^a	1.15±0.03^b	1.14±0.06c	1.15±0.04^b	***	0.001
Week 3	1.26±0.08^b	1.26±0.01^b	1.25±0.01c	1.27±0.03^a	***	0.0001
Week 4	1.36±0.03^b	1.38±0.01^a	1.36±0.02b	1.35±0.01^c	***	0.001
Week 5	1.50±0.02^b	1.51±0.03^a	1.49±0.01c	1.50±0.06^b	***	0.0001
FER (%)						
Week 1	121.42±0.37^b	124.78±1.42^a	115.82±0.47^c	120.67±0.88^b	***	0.001
Week 2	86.22±0.49^b	87.11±0.37^a	87.88±0.48^a	86.84±0.31^b	***	0.001
Week 3	79.05±0.08^b	79.17±0.59^b	79.86±0.08^a	78.66±0.17^c	***	0.001
Week 4	73.46±0.16^b	72.13±0.65^c	73.27±0.11^b	73.85±0.06^a	***	0.0001
Week 5	66.77±0.07^a	66.14±0.08^b	66.86±0.02^a	66.80±0.79^a	***	0.001
Mortality (%) (n=100)						
Week 1	0.54±0.02	0.56±0.01	0.54±0.03	0.53±0.04	NS	0.95
Week 2	0.50±0.01^a	0.46±0.04^b	0.37±0.05^c	0.34±0.01^d	***	0.0001
Week 3	0.32±0.02^a	0.29±0.07^b	0.28±0.06^b	0.28±0.04^b	***	0.0001
Week 4	0.26±0.70^a	0.26±0.10^a	0.25±0.01^b	0.24±0.02^b	***	0.001
Week 5	0.24±0.02^a	0.22±0.08^b	0.19±0.06^c	0.16±0.09^d	***	0.0001

^{a,b,c,d} Means with different superscript letters in the same rows are significantly different ; ***significant(P<0.001); **significant(P<0.05); ^{NS}Not significant(P>0.05); FCR= Feed conversion ratio, Total feed intake/Body weight; FER= Feed efficiency ratio, Body weight/Total feed intake*100; g= Gram.

Table 3: Biochemical assay of blood parameters of broiler fed experimental diets cassava leaf meal at 35 days of age (n =10).

Parameters	Treatments				Sig.	P-value
	Control	T_1	T_2	T_3		
RBS mg/dl	163.38±0.10^b	160.74±0.06^c	169.80±0.10^a	157.82±0.06^d	***	0.001
Uric acid mg/dl	4.03±0.01^a	3.91±0.07^b	3.66±0.08^c	3.61±0.06^d	***	0.0001
Total protein g/dl	2.76±0.08^c	3.14±0.08^a	2.85±0.007^b	2.72±0.008^d	***	0.001
BUN mg/dl	6.65±0.02^d	7.26±0.01^c	7.34±0.01^b	8.02±0.01^a	***	0.0001
Cholesterol mg/dl	98.72±0.11^d	115.50±0.12^a	107.68±0.09^c	108.58±0.09^b	***	0.0001
Triglyceride mg/dl	86.60±0.09^c	120.42±0.12^a	82.48±0.13^d	91.18±0.29^b	***	0.0001
HDL mg/dl	40.90±0.08^d	59.14±0.13^a	55.48±0.15^b	44.36±0.15^c	***	0.0001
LDL mg/dl	40.52±0.12^b	32.22±0.09^d	35.42±0.15^c	46.30±0.16^a	***	0.0001
AST U/l	206.24±0.15^a	188.38±0.163^c	170.40±.15^d	192.44±0.13^b	***	0.0001
ALT U/l	14.50±0.17^a	10.52±0.11^c	9.28±0.16^d	13.48±0.13^b	***	0.0001
ALP U/l	8240±0.15^b	7790±0.10^c	8577±0.13^a	6535±0.11^d	***	0.0001

^{a,b,c,d} Means with different superscript letters in the same rows are significantly different ;***significant (P<0.001);**significant (P< 0.05); ^{NS}Not significant (P>0.05); RBS= Random blood sugar; BUN= Blood urea nitrogen; HDL= High-density lipoprotein; LDL= Law-density lipoprotein; AST= Aspartate aminotransferase; ALT= Alanine aminotransferase; ALP= Alkaline phosphatase; mg/dl= Milligrams per deciliter; U/L= Units per liter.

ranges and not indicative of infection (Nowaczewski and Kontecka, 2012). Overall, key parameters such as Hb (9.42-10.32 g/dL), RBC (2.12-2.23 × 10y /mL), PCV (24.72-28.16%), MCV (120.14-130.42 fL) and MCH (42.36-43.96 pg) remained within normal ranges for broilers (Adeyeye *et al.*, 2017), indicating that CLM diets supported normal physiological function.

Proximate composition (Meat)

Proximate analysis of breast and thigh muscles in broilers (Table 5) fed cassava leaf meal (CLM) showed that moisture and crude protein contents remained statistically unchanged across all groups, aligning with normal ranges (Elnour *et al.*, 2020). Crude fiber and Ash content increased significantly (P<0.001) higher in all treatment groups for thigh muscle. Nitrogen-free extract (NFE) was significantly (P<0.001) elevated only in T_1 breast muscle, while thigh muscle NFE remained unaffected. Metabolizable energy (ME) was significantly (P<0.001) higher in all treatments, with T_1 showing the highest values, indicating better energy availability. These findings confirm that all values, including moisture (71.62-74.39%), protein (20.39-22.21%), ether extract (1.42-2.40%) and ash (0.94-1.12%), remained within accepted nutritional ranges (Mohidin *et al.*, 2023), supporting safe inclusion of CLM up to 30% without adverse effects on proximate composition of meat.

Table 4: Hematological parameters of broiler fed experimental diets cassava leaf meal at 35 days of age (n =10).

Parameters	Treatments				Sig.	P-value
	Control	T_1	T_2	T_3		
Hb g/dl	10.72±0.73^{a}	9.66±0.81^{c}	10.32±0.66^{b}	9.42±0.10^{c}	***	0.0001
RBC × 10^{9}/ml	2.36±0.09	2.22±0.09	1.96±0.39	2.23±0.08	NS	0.543
WBC × 10^{6}/ml	19560±50.9^{c}	21260±60.00^{b}	18360±50.99^{d}	25820±73.48^{a}	***	0.0001
PCV %	32.60±0.81	28.16±0.08	24.72±6.05	26.98±0.10	NS	0.350
MCV fL	131.82±0.10^{a}	127.66±0.08^{c}	130.42±0.13^{b}	120.14±0.08^{d}	***	0.0001
MCH pg	46.28±0.22^{a}	43.96±0.08^{b}	43.54±0.13^{b}	42.36±0.13^{c}	***	0.0001
Neutrophil %	20.26±0.21^{d}	28.20±0.15^{b}	30.98±0.09^{a}	25.18±0.13^{c}	***	0.001
Lymphocytes %	76.18±0.17^{a}	70.02±0.09^{c}	66.06±0.11^{d}	71.10±0.08^{b}	***	0.0001
Monocytes %	2.14± 0.14^{a}	1.26±0.16^{b}	2.18±0.09^{a}	1.28±0.15^{b}	***	0.001
Eosinophils %	2.16±0.08^{b}	1.24±0.10^{c}	1.16±0.08^{c}	3.22±0.12^{a}	***	0.0001

^{a,b,c,d} Means with different superscript letters in the same rows are significantly different ;***significant (P<0.001);**significant (P<0.05); ^{NS}-Not significant (P>0.05); Hb= Hemoglobin; g/dl= Grams per deciliter; RBC= Red blood cell; WBC= White blood cell; PCV= Packed cell volume; MCV= Mean corpuscular volume; fL= Femtoliters; MCH= Mean corpuscular hemoglobin; pg= Picograms.

Table 5: Proximate composition of breast and thigh muscles of broiler on graded levels of experimental diets of cassava leaf meal at 35 days of age (n=10).

Meat cuts	Parameters	Treatments				Sig.	P-value
		Control	T_1	T_2	T_3		
Breast muscle	Moisture %	73.23±0.5^{4}	72.12±1.20	72.41±0.46	72.28±0.93	NS	0.715
	CP %	23.17±0.5^{9}	22.21±0.11	21.89±0.60	22.10±1.13	NS	0.746
	EE %	0.80±0.05^{d}	1.42±0.32^{c}	2.03±0.04^{a}	1.50±0.05^{b}	***	0.004
	CF%	0.33±0.06^{d}	0.56±0.13^{c}	0.80±0.40^{b}	1.43±0.06^{a}	***	0.001
	Ash %	1.28±0.03	1.03±0.07	1.05±0.12	1.12±0.04	NS	0.148
	NFE %	0.14±0.05^{c}	2.95±0.12^{a}	0.04±0.05^{d}	0.76±0.05^{b}	***	0.0001
	ME (kcal/kg)	928±0.55^{d}	1035±5.61^{a}	991±0.47^{b}	945±0.42^{c}	***	0.0001
Thigh muscle	Moisture %	75.53±0.56	71.62±1.23	73.35±0.47	74.39±0.96	NS	0.283
	CP %	17.64±0.60	21.55±1.0	20.88±0.60	20.39±1.17	NS	0.290
	EE %	1.12±0.05^{d}	2.40±0.34^{a}	1.76±0.05^{b}	1.43±0.05^{c}	***	0.0001
	CF%	0.33±0.05^{d}	0.60±0.11^{a}	0.46±0.50^{c}	0.55±0.08^{b}	**	0.049
	Ash %	0.43±0.02^{b}	0.94±0.06^{a}	1.01±0.14^{a}	0.96±0.03^{a}	***	0.0001
	NFE %	4.92±0.06	6.25±0.11	3.52±0.005	1.76±0.05	NS	0.383
	ME (kcal/kg)	882±0.57^{d}	1048±5.63^{a}	964±0.45^{b}	909±0.32^{c}	***	0.0001

^{a,b,c,d} Means with different superscript letters in the same rows are significantly different ;***significant (P<0.001); **significant (P<0.05); ^{NS}-Not significant (P>0.05); Kcal/kg = Kilo calorie/kg; CP= Crude protein; EE= Ether extract; CF= Crude fibre; NFE= Nitrogen free extract; ME= Metabolizable energy.

Table 6: Quality attributes of breast and thigh muscles of broiler on graded levels of experimental diets of cassava leaf meal at 35 days of age (n =10).

Meat cuts	Parameters	Treatments				Sig.	P-value
		Control	T_1	T_2	T_3		
Breast muscle	Chemical Analysis						
	DL %	11.62±0.01^a	9.2±0.01^c	9.4±0.05^c	10.61±0.06^b	***	0.0001
	CL %	33.32±1.14^a	26.46±0.43^c	29.55±0.05^b	28.29±0.58^b	***	0.0001
	WHC %	65.87±0.89^d	87.42±0.73^a	67.56±0.58^c	75.38±0.33^b	***	0.0001
	pH	6.51±0.21^c	6.78±0.11^a	6.76±0.04^a	6.68±0.01^b	***	0.004
	Anti-oxidant Analysis						
	DPPH scavenging activity (mg TE/100 g)	44.98±1.73^c	58.62±0.58^a	50.94±1.84^b	51.76±0.60^b	***	0.0001
	TPC (mg GAE/100 g)	31.06±2.17^a	23.13±1.21^d	27.25±0.54^c	29.03±2.46^b	***	0.0001
	TFC (mg QE/100 g)	87.12±1.03^a	88.44±0.54^a	83.64±1.64^b	82.68±1.59^b	***	0.001
	Color Analysis						
	L*	51.92±0.60^c	61.74±1.12^a	58.81±0.55^b	48.24±0.79^d	***	0.0001
	a*	2.95±1.20	2.29±0.74	2.23±0.60	2.07±0.45	NS	0.076
	b*	9.82±1.05	9.33±0.60	8.82±0.45	9.02±1.10	NS	0.514
Thigh muscle	Chemical Analysis						
	DL %	7.68±0.02^a	5.15±0.01^c	5.69±0.06^c	6.53±0.06^b	***	0.0001
	CL %	37.29±1.10^a	27.15±0.55^d	28.49±0.05^c	31.46±0.68^b	***	0.001
	WHC %	68.21±0.79^c	73.86±0.74^a	71.49±0.65^b	73.28±0.44^a	**	0.043
	pH	6.35±0.25	6.41±0.11	6.37±0.04	6.34±0.02	NS	0.093
	Anti-oxidant Analysis						
	DPPH scavenging activity (mg TE/100 g)	55.80±1.63^b	68.38±0.68^a	67.29±1.84^a	56.39±0.60^b	***	0.0001
	TPC (mg GAE/100 g)	118.53±2.14^a	81.82±1.12^b	57.51±0.60^c	39.56±2.25^d	***	0.0001
	TFC (mg QE/100 g)	83.17±1.03^b	86.66±0.64^a	81.69±1.54^c	78.98±1.60^d	***	0.0001
	Color Analysis						
	L*	58.43±0.40^a	58.58±0.65^a	57.44±0.54^b	56.44±1.20^c	NS	0.056
	a*	2.91±1.01^b	3.14±1.02^a	2.94±0.87^b	2.88±0.50^b	***	0.0001
	b*	10.58±1.05^a	5.8±0.607^c	7.13±0.77^b	10.48±0.60^a	***	0.0001

^{a,b,c,d} Means with different superscript letters in the same rows are significantly different;***significant (P <0.001); **significant (P< 0.05); ^{NS}-Not significant (P>0.05);DL = Drip loss; CL = Cooking loss; WHC = Water holding capacity; TPC = Total phenolic content; TFC = Total flavonoid content; mg TE/100 g sample = Milligram of trolox equivalent per 100 g sample; mg GAE/ 100 g sample = Milligram of gallic acid equivalent per 100 g sample; mg QE/ 100 g sample = Milligram of quercetin equivalent per 100 g sample.

Meat quality attributes

Table 6 shows that cassava leaf meal (CLM) positively impacted broiler meat quality. Cooking loss was significantly (P<0.001) reduced in thigh muscle for all treatment groups, particularly in T_1, while drip loss remained unchanged. Water holding capacity (WHC) was significantly (P<0.001) higher in all treatments, except for T_2 in breast muscle. The pH of the breast muscle was significantly lower (P<0.001) in treatment groups, except for T_1 and T_2, which showed no difference. DPPH scavenging activity in breast and thigh and Flavonoid levels in thigh were significantly (P<0.001) higher up to the 20% CLM group and significantly (P<0.001) higher in the 10% CLM group respectively. The phenolic compounds in treatment groups were lower than the control. In terms of color, lightness (L*) was higher in breast muscle up to 20% CLM, while redness (a*) and yellowness (b*) were unchanged in breast muscle but varied in thigh muscle. These findings suggest that CLM supplementation enhances meat quality which supports meat freshness (Akbarian *et al.*, 2015). The increased muscle pH in CLM-fed broilers may be due to the alkaline nature of cassava leaves, helping to neutralize acidic byproducts and prevent protein denaturation (Mohidin *et al.*, 2023). These effects, along with higher DPPH scavenging activity, flavonoid levels and reduced cooking loss, align with previous research showing that CLM enhances meat color stability, antioxidant properties and overall meat quality (Bakare *et al.*, 2021).

CONCLUSION

This study demonstrates the potential of cassava leaf meal (CLM) as a sustainable feed ingredient for broiler. At inclusion levels up to 10%, CLM enhances growth performance and carcass traits, without compromising feed efficiency and health. However, higher levels (20% and above) negatively impact feed intake and feed conversion ratios, likely due to anti-nutritional factors and cyanogens. The observed benefits, including improved blood parameters, antioxidant activity and meat quality, are attributed to CLM's bioactive compounds, vitamins and minerals. Additionally, meat from CLM-fed birds displayed desirable sensory qualities, suggesting consumer acceptance.

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Disclaimers

The authors solely hold responsibility for the views and information in this article, which do not reflect those of their institutions.

Informed consent

This study protocol was reviewed and animal experiments were permitted by the Jashore University of Science and Technology's ethical review committee for animal-based studies approved the research techniques employed in this work (ERC/FBST/JUST/2023-152), Bangladesh.

Conflict of interest

The authors declare that there are no conflicts of interest and confirm that no funding or sponsorship influenced the design of the study.

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