Research Article

Effects of Cassava Leaves Inclusion on Growth Performance, Carcass Traits and Meat Sensory Quality of Goliath Chickens in Benin

Géorcelin Goué Alowanou[1,2*], Habirou Aboudou Kifouly[2], Boris Behingan[3], Jean-David Aboué[1], Challaton Kétomon Pierre[2], Rose-Marie Adékpé[1], Marthe Perpétue Houngue[1], José Philippe Gbetié[1], Gilles-Christ Akakpo[2], John Dossou[2], Sylvie Hounzangbé-Adoté[2]

[1]*Laboratory of Multidisciplinary Research in Technical Education, Higher School of Technical Education, National University of Sciences, Technologies, Engineering and Mathematics, Abomey, Benin;* [2]*Laboratory of Ethnopharmacology and Animal Health, Faculty of Agricultural Sciences, University of Abomey-Calavi, Cotonou, Benin;* [3]*Laboratory of Biomathematics and Forest Estimations, Faculty of Agricultural Sciences, University of Abomey-Calavi, Cotonou, Benin.*

Abstract | Poultry farming is a vital livelihood activity in Benin but remains constrained by high feed costs and reliance on imported ingredients. This study evaluated the effects of including dried cassava leaves in diets of Goliath chickens, a locally adapted breed valued for its large body size and resilience but poorly documented in scientific literature. A total of 240 chicks were randomly assigned to diets containing 0% (F0), 5% (F5), or 10% (F10) cassava leaf meal and reared for 16 weeks. Growth performance, carcass traits, sensory quality, survival, and economic parameters were assessed. Final body weights were significantly ($p < 0.05$) higher in F5 (1,444.7 g) and F10 (1,557.1 g) compared to the control (1,157.8 g). Feed conversion ratio improved ($p < 0.05$), with cumulative values of 4.42 (F5) and 3.94 (F10) versus 4.63 (F0). No mortality was observed in any group, confirming the safety of cassava leaf inclusion. Carcass yields and sensory attributes (flavor, tenderness, juiciness, acceptability) were not negatively affected. Feed cost per kilogram of meat was significantly ($p < 0.001$) lower in cassava-fed groups, especially F10 (620 FCFA) compared to F0 (862 FCFA), while the feed efficiency index was highest ($p < 0.001$) in F10 (2.43). These findings provide the first evidence that cassava leaves can be safely and economically incorporated at 5–10% in Goliath chicken diets. Beyond improving growth and efficiency, cassava leaves reduce feed costs and support the valorization of local feed resources, contributing to food sovereignty and sustainable poultry production in Benin.

Keywords | Goliath chicken, Cassava leaves, Indigenous poultry, Growth performance, Carcass traits, Sensory quality, Feed cost, Benin

Received | August 31, 2025; **Accepted** | October 24, 2025; **Published** | January 06, 2026
***Correspondence** | Géorcelin G. Alowanou, Laboratory of Multidisciplinary Research in Technical Education, Higher School of Technical Education, National University of Sciences, Technologies, Engineering and Mathematics, Abomey, Benin; **Email:** galowanou@gmail.com
Citation | Alowanou GG, Kifouly HA, Behingan B, Aboué J-D, Pierre CK, Adékpé R-M, Houngùè MP, Gbetié JP, Akakpo G-C, Dossou J, Hounzangbé-Adoté S (2026). Effects of cassava leaves inclusion on growth performance, carcass traits and meat sensory quality of goliath chickens in Benin. J. Anim. Health Prod. 14(1): 107-116.
DOI | https://dx.doi.org/10.17582/journal.jahp/2026/14.1.107.116
ISSN (Online) | 2308-2801

INTRODUCTION

Agriculture is a cornerstone of Benin's economy, contributing about 25% of GDP and employing nearly 70% of the labor force (INSAE, 2017). Livestock accounts for around 13% of agricultural GDP and supports rural livelihoods, with poultry farming ranking as the second most important source of household income (Karim, 2015; INSAE, 2017). Poultry production systems range from intensive units in the south to extensive free-range systems in the central and northern regions (FAO, 2008; Ayssiwede *et al*., 2013; Adoligbé *et al*., 2020). Despite this diversity, productivity remains low due to high feed costs, recurrent diseases, limited farmer professionalization, and weak marketing infrastructure (Aguidissou *et al*., 2020; Kulla *et al*., 2021).

Benin's poultry sector also faces strong competition from frozen imports, which undermine local production and increase dependence on external markets. The government has announced a suspension of poultry imports from December 2024 (ACED, 2024), highlighting the urgent need to strengthen local poultry systems through cost-effective feeding strategies.

Indigenous resources such as the "Goliath" chicken also known as the giant bicycle chicken offer unique opportunities. Developed about two decades ago by crossbreeding local and exotic strains, the Goliath chicken is appreciated for its large body size, adaptability, and disease tolerance (Djimènou *et al*., 2022). However, its potential is poorly documented in scientific literature, and high feed costs remain a major constraint.

Cassava (*Manihot esculenta*), widely cultivated in Benin, produces abundant leaves that are rich in protein, minerals, and vitamins. Over the past decade, several studies and systematic reviews have demonstrated that cassava roots, peels, and leaves can partially replace conventional feed ingredients in poultry production, with variable outcomes depending on the inclusion level, processing method, and bird genotype (Bakare *et al*., 2021; Adekeye et al., 2021; Ogbuewu and Mbajiorgu, 2022; Egbune *et al*., 2023; Jumare *et al*., 2024; de Almeida Santos *et al*., 2025). These works confirm the potential of cassava by-products to reduce dependence on maize and soybean meal, while highlighting challenges linked to fiber load and anti-nutritional factors, particularly cyanogenic glycosides. Despite this growing body of evidence, research has largely focused on commercial broilers, guinea fowl, and layers (Dahouda *et al*., 2009a; Kouadio *et al*., 2019; Guembo *et al*., 2021a; Yang *et al*., 2024), with little attention to locally adapted breeds. To our knowledge, no study has evaluated cassava leaves in Goliath chickens a heavy, slow-growing genotype valued in West Africa for its meat quality or integrated growth performance, carcass traits, sensory attributes, and economic parameters within a single trial.

The objective of this study was to evaluate the effects of including 5% and 10% dried cassava leaves in Goliath chicken diets on growth performance, carcass characteristics, sensory quality, mortality, and economic indicators. We hypothesized that cassava leaf inclusion would improve performance and reduce feed cost without compromising carcass yield, meat quality, or survival.

MATERIALS AND METHODS

Study area

The experiment was conducted at the experimental farm of the Faculty of Agricultural Sciences, University of Abomey-Calavi (Benin), located in the municipality of Abomey-Calavi. The region has a subequatorial climate characterized by two dry seasons (August to mid-September and December to March) and two rainy seasons (March to July, and mid-September to early December). The average annual rainfall is approximately 1,200 mm. Mean monthly temperatures range from 27 to 31°C, while relative humidity varies from 65% (January to March, dry season) to 97% (June to July, rainy season).

Cassava leaves collection and preparation

Leaves of the RB 89 509 cassava variety were harvested from farmers in Sékou two weeks before feed preparation. They were collected with petioles, sun-dried for seven days under mild sunlight until brittle but greenish, and stored in clean jute sacks. Sun-drying was applied because it reduces cyanogenic glycosides to safe levels (Wanapat, 2001; Bakare *et al*., 2020). Direct quantification was not performed, which is a limitation of this study. The dried leaves were ground into powder before incorporation into the diets.

Experimental birds and management

A total of 240 one-day-old Goliath chicks were obtained from a commercial hatchery. On arrival, birds were individually weighed and stratified by live body weight to ensure homogeneity across treatments. They were then randomly assigned to three dietary treatments (F0, F5, and F10), with 80 chicks per treatment, further subdivided into four replicates of 20 birds each. The initial average weights were 54 ± 0.5 g for F0, 53 ± 0.7 g for F5, and 54 ± 0.6 g for F10.

All birds were reared under identical housing and management conditions. Brooding was provided with clay pots containing embers during the first week, followed by electric heat lamps during weeks 2–3 to maintain optimal temperature. Feed and water were provided in clean plastic feeders and drinkers, disinfected regularly to minimize contamination.

For the first three days, chicks were given cracked maize to facilitate gut clearance and adaptation. From day 4 onward, they were fed the experimental diets corresponding to their assigned treatment. Feed was offered twice daily (08:00 and 16:00), while clean drinking water was available *ad libitum* throughout the experimental period.

A standard prophylactic program was implemented, which included vaccinations against Newcastle disease, Gumboro disease, and infectious bursal disease, along with routine deworming and strict hygiene practices. Mortality was recorded daily for each replicate and expressed as a percentage of the initial flock size using the following formula:

$$\mathrm{MR}\ (\%) = \frac{\text{Number of dead birds}}{\text{Total number of birds}} \times 100$$

Diet formulation and feeding

Three experimental diets were formulated to be iso-caloric and iso-nitrogenous in accordance with NRC (1994) requirements. Each diet was balanced for metabolizable energy, crude protein, essential amino acids (lysine and methionine), and minerals to ensure nutritional adequacy. Maize and soybean meal were the primary ingredients, while dried cassava leaves were incorporated as the test ingredient. The diets were as follow:

- F0 (control): 0% cassava leaf meal;
- F5: 5% cassava leaf meal ;
- F10: 10% cassava leaf meal.

Cassava leaf powder was homogenously mixed into the basal feed mixture to avoid variability in nutrient distribution. The proximate composition (dry matter, crude protein, crude fiber, ether extract, and ash) was analyzed according to AOAC (1995) procedures to confirm nutrient contents. Nutrient balancing was performed by iterative formulation to match NRC (1994) standards, and calculated values were cross-checked against analyzed results to ensure consistency.

Birds were fed over a 16-week period, subdivided into a starter phase (0–8 weeks) and a grower phase (9–16 weeks). Each treatment was applied to four replicates of 20 birds (80 birds per treatment), with random allocation to pens to ensure initial uniformity across replicates. Daily feed allocations were weighed using a 5-kg electronic scale, and refusals were collected and weighed before each feeding to calculate actual feed intake (FI). Clean drinking water was provided *ad libitum* throughout the experiment. Mortality was recorded daily and expressed as a percentage of initial flock size per replicate; data from pens with mortality were adjusted for feed intake and growth calculations. The feed composition and calculated nutritional values are presented in Table 1.

Growth performance measurements

Live body weights were recorded weekly for each replicate. The following performance indicators, daily feed intake (FI), daily weight gain (DWG), feed conversion ratio (FCR) was calculated using the following formula:

$$\mathrm{FI}\ (\mathrm{g/jr}) = \frac{\text{Distributed feed} - \text{Remaining feed}}{\text{Period given} \times \text{Number of subject}}$$

$$\mathrm{DWG}\ (\mathrm{g/jr}) = \frac{\text{Weight of the current week} - \text{Weight of the previous week}}{\text{Rowth period}}$$

$$\mathrm{FCR} = \frac{\text{Feed intake}}{\text{Weight gained}}$$

Table 1: Composition and calculated nutritional value of experimental diets for Goliath chickens during the starter (0–8 weeks) and grower (9–16 weeks) phases.

	Composition of nutritional value					
Parameters	**Starter (0–8 weeks)**			**Grower (9–16 weeks)**		
	F0	**F5**	**F10**	**F0**	**F5**	**F10**
Dried sweet cassava leaves	0.00	5.00	10.00	0.00	5.00	10.00
Maize	61.80	60.00	56.00	64.80	62.00	58.00
Wheat bran	5.00	5.00	5.00	5.00	5.00	5.00
Soybean meal	26.00	23.00	22.00	21.00	19.00	18.00
Cottonseed meal	4.00	4.00	4.00	5.00	5.00	5.00
Oyster shell	1.80	1.60	1.60	2.00	1.80	1.80
Lysine	0.10	0.10	0.10	0.10	0.10	0.10
Methionine	0.10	0.10	0.10	0.10	0.10	0.10
Dicalcium phosphate	0.70	0.70	0.70	0.70	0.70	0.70
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30
Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20
Calculated nutritional value						
Dry matter (%)	87.10	83.90	80.90	87.00	84.10	81.20
Crude fiber (%)	4.28	4.59	5.00	4.36	4.72	5.13
Metabolizable energy (kcal/kg DM)	2827	2835	2819	2795	2803	2790
Crude protein (%)	18.90	18.70	19.10	17.20	17.00	17.40
Lysine (%)	1.02	0.94	0.90	0.88	0.82	0.78
Methionine (%)	0.41	0.39	0.38	0.38	0.36	0.35
Sulfur amino acids (%)	0.74	0.70	0.67	0.69	0.66	0.63
Calcium (%)	0.93	0.94	1.05	1.00	1.01	1.13
Total phosphorus (%)	0.60	0.66	0.73	0.62	0.67	0.74

[1] Premix composition per kg: Vitamins: A 4,000,000 IU; D_3 800,000 IU; E 2,000 mg; K 800 mg; B_1 600 mg; B_2 2,000 mg; Niacin 3,600 mg; B_6 1,200 mg; B_{12} 4 mg; Choline chloride 80,000 mg. Minerals: Cu 8,000 mg; Mn 64,000 mg; Zn 40,000 mg; Fe 32,000 mg; Se 160 mg.

Economic parameters

Feed cost (FC)

Feed cost was calculated as the product of the feed conversion ratio (FCR) and the unit price of one kilogram of feed (Pf):

$$\mathrm{FC} = \mathrm{FCR} \times \mathrm{Pf}$$

Feed efficiency index (FEI)

The feed efficiency index was calculated as the ratio between the sale price of one kilogram of meat (Pm) and the feed cost (FC):

$$\mathrm{FEI} = \frac{\mathrm{Pm}}{\mathrm{FC}}$$

Carcass evaluation

At 16 weeks, five birds per replicate (20 per treatment) were randomly selected, fasted for 12 h (water available), weighed, and slaughtered by cervical dislocation and bleeding. Carcass characteristics (live weight, plucked weight, eviscerated weight, dressing %, thigh and drumstick, breast, abdominal fat, gizzard, liver, spleen, heart) were recorded. Carcass yield (%) was calculated as:

$$Carcass\ yield\ (\%) = \frac{Carcass\ weight}{Live\ weight\ at\ slaughter} \times 100$$

Sensory evaluation

Meat samples from the leg, wishbone, and thigh were cooked under standardized conditions (boiled in water at 100 °C until an internal temperature of 75 °C was reached) and subjected to sensory analysis. Evaluation was performed by a trained panel of 10 members (5 men and 5 women, aged 22–45), recruited and trained according to ISO 8586:2012 guidelines for sensory panel selection and training (ISO, 2012). Panelists underwent two training sessions to familiarize themselves with poultry meat sensory descriptors and to calibrate their use of the evaluation scale. A 9-point hedonic scale (1 = dislike extremely, 9 = like extremely), widely validated in poultry meat sensory studies (Meilgaard *et al.*, 2007), was used to score appearance, flavor, tenderness, juiciness, and overall acceptability. Each sample was coded with random three-digit numbers and presented in a randomized order to minimize bias. Water and unsalted crackers were provided between samples for palate cleansing.

Statistical analysis

Growth performance data were analyzed using linear mixed-effects models implemented in R (nlme package). Diet was included as a fixed factor, while individual animals were treated as random effects with time (weeks) specified as a repeated measure, to account for the correlation between successive measurements on the same animal. Carcass traits and sensory evaluation scores were analyzed using linear models (agricolae package), with diet as the main fixed factor. Economic parameters were compared using one-way ANOVA. Least-square means were estimated and compared using Tukey's HSD test with adjustment for multiple comparisons (emmeans package).

Model assumptions of normality and homogeneity of variances were assessed by visual inspection of residual plots, Shapiro–Wilk tests for normality, and Levene's tests for homoscedasticity. Where necessary, data were log- or square-foot transformed to better meet model assumptions, and results are reported for the transformed data. Model fit and adequacy were further evaluated by examining AIC values and residual diagnostics.

RESULTS

General observations

No mortality was recorded in any of the treatment groups throughout the 16-week experimental period. The inclusion of cassava leaves (5% and 10%) in the diet did not negatively affect survival.

Feed intake

Feed intake increased progressively with age across all treatments (Figure 1). During the first six weeks, birds fed cassava leaf diets (F5 and F10) consumed significantly less feed (35.4–35.6 g/day) than controls (40.1 g/day; $p < 0.05$). From week 10 onward, feed intake in F5 and F10 exceeded that of F0. By week 16, birds in F5 and F10 consumed 14.5 g/day and 13.4 g/day more, respectively, than the control group.

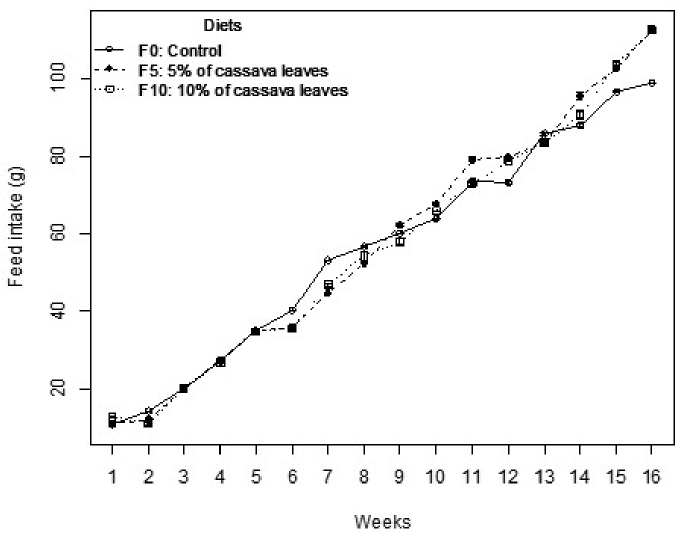

Figure 1: Effect of experimental diets on feed intake.

Live body weight and daily weight gain

Body weight was significantly influenced by dietary treatment (Figure 2). At 16 weeks, birds fed cassava leaves were heavier than controls, reaching 1,444.7 g in F5 and 1,557.1 g in F10 compared with 1,157.8 g in F0 ($p < 0.01$). Average daily gain (ADG) followed the same pattern, with higher values in cassava-fed groups across the rearing period. The greatest improvement occurred during the late growth phase (70–84 days), as shown in Table 2. Over the entire trial, ADG averaged 12.6 g/day in F5 and 13.6 g/day in F10, compared with 10.0 g/day in F0 ($p < 0.05$). These findings indicate that growth performance improved with cassava leaf inclusion, with the 10% level providing the most consistent advantage across both intermediate and final growth stages.

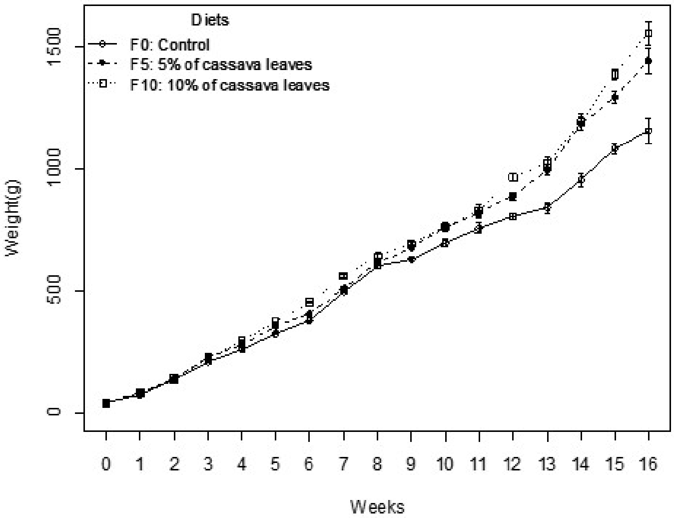

Figure 2: Evolution of live body weight.

Feed conversion ratio

Feed conversion ratio (FCR) varied by treatment and growth stage (Table 3). In the first two weeks, FCR was lower in F5 (1.55) and F10 (1.66) compared with F0 (1.83). During the 70–84-day period, F10 recorded the lowest FCR (3.50), which was significantly lower than both F0 and F5 ($p < 0.05$). Over the entire trial, cumulative FCR values were 4.63 (F0), 4.42 (F5), and 3.94 (F10), indicating that feed efficiency was improved in cassava-fed groups, particularly at the 10% inclusion level.

Table 2: Effect of diet on average daily weight gain (DWG, g/day) of Goliath chickens.

Period	Diets			F	P
	F0	F5	F10		
d1–d14	$6.81^{b}\pm0.01$	$7.46^{a}\pm0.12$	$7.15^{a}\pm0.09$	12.85	0.007
d14–d28	$9.07^{b}\pm0.65$	$9.74^{ab}\pm0.16$	$11.05^{a}\pm0.01$	6.88	0.028
d28–d42	$8.23^{a}\pm0.38$	$9.07^{a}\pm1.48$	$11.40^{a}\pm1.40$	1.88	0.223
d42–d56	$15.91^{a}\pm0.74$	$15.04^{a}\pm0.07$	$13.56^{a}\pm1.33$	1.81	0.240
d56–d70	$7.01^{a}\pm1.71$	$10.46^{a}\pm1.07$	$8.38^{a}\pm0.25$	1.24	0.353
d70–d84	$7.94^{b}\pm0.15$	$9.01^{b}\pm0.28$	$14.73^{a}\pm1.70$	13.05	0.007
d84–d98	$10.52^{a}\pm1.14$	$21.29^{a}\pm1.95$	$16.36^{a}\pm1.95$	3.28	0.109
d98–d112	$14.47^{a}\pm1.35$	$18.14^{a}\pm1.54$	$25.92^{a}\pm1.54$	3.62	0.093
d1–d112	$9.99^{b}\pm0.44$	$12.56^{a}\pm0.64$	$13.57^{a}\pm0.83$	7.86	0.021

Note: Values are means ± SE. Means within a row with different superscripts (^{a}, ^{b}) differ significantly ($p < 0.05$; Tukey's HSD). Means sharing the same superscript are not significantly different. F: Fisher's statistic; p: probability.

Economic parameters

Feed cost per kg of meat

Feed cost per kilogram of meat produced differed significantly ($p < 0.001$) among treatments at all ages (Table 4). The control group (F0) consistently had the highest costs, while F10 recorded the lowest. At the end of the trial, cumulative feed costs were 862.5 FCFA (F0), 689.2 FCFA (F5), and 620.1 FCFA (F10).

Table 3: Effect of diets on feed conversion ratio (FCR) of Goliath chickens.

Period	Diets			F	P
	F0	F5	F10		
d1–d14	$1.83^{a} \pm 0.03$	$1.55^{b} \pm 0.04$	$1.66^{b} \pm 0.04$	14.12	0.006
d14–d28	$2.62^{a} \pm 0.19$	$2.44^{ab}\pm0.05$	$2.10^{b} \pm 0.01$	5.36	0.046
d28–d42	$4.58^{a} \pm 0.23$	$4.10^{a} \pm 0.69$	$3.21^{a} \pm 0.30$	2.32	0.180
d42–d56	$3.46^{a} \pm 0.16$	$3.21^{a} \pm 0.02$	$3.77^{a} \pm 0.27$	2.37	0.178
d56–d70	$4.10^{a} \pm 2.68$	$3.84^{a} \pm 1.35$	$3.38^{a} \pm 0.06$	1.02	0.417
d70–d84	$4.26^{a} \pm 0.19$	$4.12^{a} \pm 0.17$	$3.50^{b} \pm 0.71$	22.15	0.002
d84–d98	$4.44^{a} \pm 0.89$	$4.65^{a} \pm 0.52$	$4.18^{a} \pm 0.89$	4.85	0.056
d98–d112	$4.87^{a} \pm 0.66$	$4.08^{a} \pm 0.62$	$3.75^{a} \pm 0.61$	4.46	0.065
d1–d112	$4.63^{a} \pm 0.24$	$4.42^{a} \pm 0.26$	$3.94^{b} \pm 0.14$	2.63	0.015

Note: Values are means ± SE. Means within a row with different superscripts (^{a}, ^{b}) differ significantly ($p < 0.05$; Tukey's HSD). Means sharing the same superscript are not significantly different. F: Fisher's statistic; p: probability.

Feed efficiency index

Feed efficiency index also varied significantly among treatments ($p < 0.001$; Table 5). The F10 group achieved the highest cumulative index (2.43), compared to 2.26 in F5 and 1.73 in F0. These results confirm that cassava leaves improved both biological efficiency and economic return, with 10% inclusion being most favorable.

Table 4: Feed cost (FCFA) per kg of meat produced in Goliath chickens fed diets with different cassava leaf inclusion levels.

Period	Diets			P-value	Significance
	F0	F5	F10		
d1–d14	503.44^{a}	347.73^{c}	415.16^{b}	0.000202	***
d15–d28	378.16^{a}	283.41^{b}	258.02^{c}	0.00018	***
d29–d42	450.08^{a}	339.69^{b}	310.40^{c}	0.000293	***
d43–d56	821.28^{a}	741.69^{b}	554.84^{c}	0.000969	***
d57–d70	886.24^{a}	659.28^{b}	599.46^{c}	0.000114	***
d71–d84	1185.52^{a}	946.71^{b}	865.24^{c}	0.000150	***
d85–d98	1257.44^{a}	1041.18^{b}	938.96^{c}	0.000144	***
d99–d112	1417.52^{a}	1153.74^{b}	1018.50^{c}	0.000220	***
d1–d112	862.46^{a}	689.18^{b}	620.07^{c}	0.000022	***

Note: Values are means. Means within a row with different superscripts (^{a}, ^{b}, ^{c}) differ significantly ($p < 0.05$; Tukey's HSD). Significance: $^{***}p < 0.001$. FCFA: West African CFA franc. 1 USD is equal to 565 FCFA.

Table 5: Feed efficiency index of Goliath chickens fed diets with different cassava leaf inclusion levels.

Period	Diets			P-value	Significance
	F0	F5	F10		
d1–d14	2.38[c]	3.45[a]	2.89[b]	0.000104	***
d15–d28	3.17[c]	4.23[b]	4.65[a]	0.00018	***
d29–d42	2.67[c]	3.53[b]	3.87[a]	0.000293	***
d43–d56	1.46[c]	1.62[b]	2.16[a]	0.000969	***
d57–d70	1.35[c]	1.82[b]	2.00[a]	0.000114	***
d71–d84	1.01[c]	1.27[b]	1.39[a]	0.000150	***
d85–d98	0.95[c]	1.15[b]	1.28[a]	0.000144	***
d99–d112	0.85[c]	1.04[b]	1.18[a]	0.000220	***
d1–d112	1.73[c]	2.26[b]	2.43[a]	0.000108	***

Note: Values are means. Higher values indicate greater feed efficiency. Means within a row with different superscripts ([a], [b], [c]) differ significantly ($p < 0.05$; Tukey's HSD). Significance levels: ***$p < 0.001$.

Carcass characteristics

Carcass yield and most organ weights were not significantly affected by dietary treatment (Table 6). Live weight, bleeding weight, plucked weight, eviscerated weight, and dressing percentage were comparable across groups ($p > 0.05$). Significant differences were detected for thigh and heart weights. Thigh with bone and boneless thigh were highest in F5 (84.3 g and 69.5 g) and lowest in F10 (73.0 g and 59.2 g; $p < 0.05$). Heart weight was significantly greater in F0 (6.2 g) compared with F10 (5.0 g; $p = 0.038$).

Sensory evaluation

The sensory evaluation of leg meat (Figure 3a) revealed no significant differences among dietary treatments for flavor, appearance, tenderness, juiciness, or overall acceptability ($p > 0.05$). For wishbone meat (Figure 3b), most attributes were comparable across groups, although tenderness was rated significantly lower in birds fed the F5 diet compared with those on F0 and F10 ($p < 0.05$). In thigh meat (Figure 3c), juiciness scores were lowest in the F5 group, whereas no significant differences were observed among treatments for flavor, tenderness, or overall acceptability.

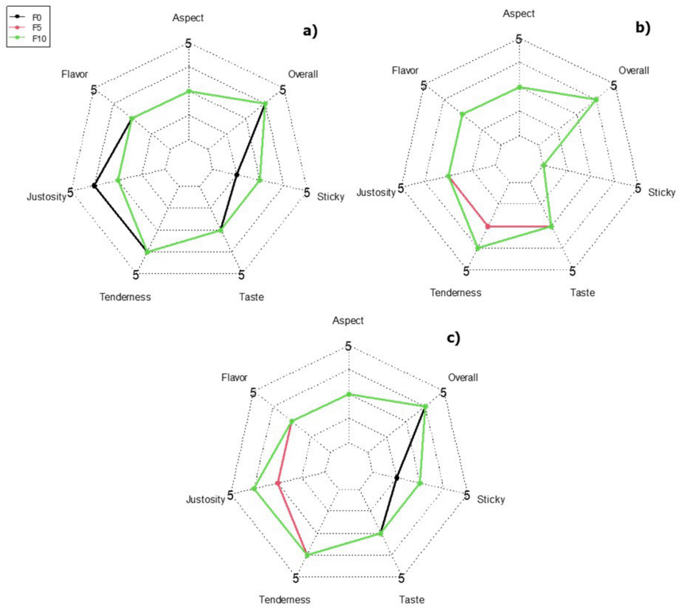

Figure 3: Sensory quality of leg (a), wishbone (b) and thigh (c).

Table 6: Carcass yield and organ weight of Goliath chickens fed diets with different levels of cassava leaf inclusion

Parameters	Diets			F-value	P-value
	F0	F5	F10		
Live weight (g)	1440.20 ± 24.40	1395.70 ± 50.30	1409.00 ± 30.20	0.48	0.631
Bleeding weight (g)	1418.70 ± 25.00	1345.70 ± 48.20	1355.00 ± 29.10	1.55	0.252
Plucked weight (g)	1327.50 ± 20.70	1250.70 ± 44.60	1268.00 ± 41.10	1.89	0.192
Head and leg weight (g)	121.17 ± 9.11	113.33 ± 7.12	114.00 ± 13.50	2.24	0.149
Carcass weight (g)	966.20 ± 19.30	953.20 ± 39.20	953.20 ± 37.20	0.08	0.925
Gutted weight (g)	1090.70 ± 20.80	1067.30 ± 45.60	1068.70 ± 29.90	0.21	0.816
Wishbone weight (g)	63.83 ± 1.62	69.17 ± 3.02	68.00 ± 3.79	1.86	0.198
Thigh with bone (g)	78.50[ab] ± 3.42	84.33[a] ± 3.02	73.00[b] ± 3.79	5.67	0.018
Boneless thigh (g)	64.50[ab] ± 2.55	69.50[a] ± 3.46	59.17[b] ± 4.13	7.43	0.008
Leg with bone (g)	76.17 ± 1.30	74.33 ± 1.36	79.17 ± 2.13	0.81	0.450
Boneless leg (g)	56.83 ± 1.74	54.83 ± 3.93	58.33 ± 2.78	1.07	0.374
Abdominal fat (g)	10.17 ± 3.44	5.00 ± 2.16	8.67 ± 2.20	1.02	0.389
Gizzard weight (g)	55.17 ± 1.80	49.83 ± 2.57	52.17 ± 2.04	0.66	0.534
Heart weight (g)	6.17[a] ± 0.48	5.33[ab] ± 0.21	5.00[b] ± 0.52	4.33	0.038
Liver weight (g)	23.50 ± 1.48	22.17 ± 1.28	20.67 ± 1.01	1.01	0.393
Spleen weight (g)	1.63 ± 0.18	2.15 ± 0.31	1.45 ± 0.13	2.33	0.140

Note: Values within a row bearing different superscript letters (a, b) differ significantly at $p < 0.05$, F = Fisher's statistic, P = probability.

DISCUSSION

This study demonstrates that dried cassava leaves can be safely incorporated into Goliath chicken diets at levels of 5–10%, resulting in improved growth performance, feed efficiency, and reduced production costs without compromising carcass yield or meat quality. These findings add new insights to the growing body of evidence on the use of cassava-derived feed resources in poultry nutrition and represent the first systematic evaluation of cassava leaves in Goliath chickens, a slow-growing indigenous breed of economic and cultural importance in Benin.

The significant improvement in final body weight and ADG, particularly at 10% inclusion, indicates that cassava leaves provide both nutritional and functional benefits to Goliath chickens. The late-phase growth advantage (70–112 days) suggests a physiological adaptation to dietary fiber and secondary compounds, consistent with the hypothesis that poultry can upregulate digestive enzymes or develop microbial consortia capable of fiber degradation (Bakare *et al*., 2021; de Almeida Santos *et al*., 2025). Such adaptive responses are crucial for indigenous breeds with inherently slower growth trajectories compared to commercial broilers.

Recent studies confirm the potential of cassava-based feeds to sustain growth across different poultry genotypes. For example, Yang *et al*. (2024) reported improved nutrient digestibility and slaughter performance in yellow-feathered broilers fed cassava root meal, while Adekeye et al. (2021) demonstrated that high-quality cassava peel (HQCP) diets can maintain growth performance and reduce costs in broilers. Our results align with these observations and extend their relevance to the Goliath chicken, showing that moderate inclusion of cassava leaves (10%) can optimize growth without the penalties often associated with higher inclusion levels (>20%) due to fiber and anti-nutritional loads (Ogbuewu and Mbajiorgu, 2022).

The transient reduction in feed intake followed by recovery mirrors patterns reported in guinea fowl and broilers fed cassava by-products (Dahouda *et al*., 2009b; Chang *et al*., 2020). This likely reflects short-term palatability issues and the presence of residual cyanogenic compounds. However, the observed improvement in cumulative FCR at 10% suggests that once adaptation occurs, cassava leaves enhance nutrient utilization efficiency. Similar improvements in efficiency have been attributed to the protein, mineral, and bioactive compound profile of cassava leaves (Jumare *et al*., 2024; Tadesse, 2024).

Moreover, the positive feed efficiency index in our study resonates with findings by Egbune *et al*. (2023), who showed that fermentation of cassava roots enhances their nutritional profile and reduces anti-nutritional factors, thereby improving feed efficiency. Although our work used sun-dried rather than fermented leaves, both approaches highlight the potential of processing to unlock cassava's nutritional value in poultry diets.

Cassava leaf inclusion did not compromise carcass yield or sensory quality, a crucial finding for consumer acceptance. The increase in thigh mass and slight rise in heart weight may reflect protein-driven muscle development and adaptive cardiovascular changes linked to faster growth, respectively. Since these values remained within normal physiological ranges, cassava leaves can be considered safe for carcass quality traits.

Similar stability in meat quality has been reported in cassava-fed broilers (Yang *et al*., 2024) and guinea fowl (Guembo *et al*., 2021b). Importantly, the absence of negative effects on tenderness, flavor, or juiciness supports the market potential of cassava-fed Goliath chickens, where consumer perception is critical for adoption by smallholders and niche markets.

One of the most significant contributions of this study is the demonstration of clear economic benefits. Feed cost per kilogram of meat was reduced by nearly 30% in the 10% cassava leaf group, and FEI was markedly improved. These findings are particularly relevant in Benin, where feed costs represent more than 60% of poultry production expenses (ACED, 2024). By lowering dependence on maize and soybean, cassava leaves can help stabilize production costs, thereby improving farmer resilience to fluctuating global commodity prices.

This resonates with broader sustainability narratives. Recent reviews emphasize the role of cassava and other alternative feeds in reducing reliance on imported ingredients while enhancing circular economy practices (de Almeida Santos *et al*., 2025; Adli, 2021). Moreover, integrating cassava leaves into poultry diets supports national strategies for food sovereignty by valorizing local resources and mitigating the economic burden of poultry imports (Kulla *et al*., 2021).

While no adverse health effects were observed, the presence of cyanogenic glycosides remains a key concern. Sun-drying reduces but does not eliminate these compounds, and levels may vary by variety, maturity, and processing conditions (Jumare *et al*., 2024). Advanced processing methods such as fermentation (Egbune and Tonukari, 2023) or enzymatic supplementation (Chang *et al*., 2020) could further enhance safety and digestibility, making cassava leaves even more competitive with conventional feed ingredients.

CONCLUSION

This study demonstrates that dried cassava leaves can be safely incorporated at 5–10% in Goliath chicken diets, enhancing growth performance and feed efficiency without compromising carcass yield or meat quality. Beyond zootechnical benefits, cassava leaves represent a practical and low-cost feed alternative that reduces reliance on maize and soybean imports, thereby lowering production costs for smallholder farmers. Their use can improve household incomes, buffer producers against feed price volatility, and contribute to local food security. In the context of Benin's planned poultry import restrictions, integrating cassava leaves into feeding strategies offers a sustainable avenue to reinforce national poultry production and valorize indigenous breeds. Future research should refine processing methods, explore higher inclusion thresholds, and assess long-term impacts to fully harness cassava leaves as a cornerstone of resilient poultry systems in West Africa.

ACKNOWLEDGEMENT

This study could not have been completed without the invaluable support of Mr. Codjo Charles Hounwanou, technician at the Poultry Farm of the Faculty of Agronomic Sciences, University of Abomey-Calavi

NOVELTY STATEMENT

This study provides the first scientific evaluation of dried cassava leaves as a feed ingredient for Goliath chickens, an indigenous slow-growing breed of major economic and cultural importance in Benin. Unlike previous research focused mainly on commercial broilers species, this work demonstrates within a single integrated trial that 5–10% cassava leaf inclusion simultaneously improves growth performance, enhances feed efficiency, reduces production costs, and maintains carcass yield and meat sensory quality in Goliath chickens. The findings generate original evidence supporting the valorisation of locally available cassava leaves as a sustainable, low-cost alternative to maize and soybean meal, thereby contributing to feed autonomy and strengthening national poultry production systems

AUTHOR'S CONTRIBUTION

GGA: conceived the project, designed the study, conducted the experiments, performed data analysis, and drafted the original manuscript. HAK, BB, and JDA: contributed to data collection, laboratory analyses, and statistical processing. CKP, RMA, and MPH: assisted in methodology design, experimental supervision, and critical revision of the manuscript. JPG, GCA, and JD: supported data interpretation, provided technical inputs, and contributed to manuscript editing. SHA: supervised the research, and provided final review and approval of the manuscript. All authors read and approved the final version of the manuscript.

Ethical approval

The experimental protocol was approved by the Ethics Committee for Animal Research of the Agricultural Techniques and Sciences Department at the National University of Sciences, Technologies, Engineering and Mathematics (UNSTIM), under the approval number UNSTIM/ENSET/STA-2024-0105. All procedures involving animals were conducted in strict accordance with relevant national and institutional guidelines and regulations.

Generative AI and AI-assisted technology statement

Generative AI and AI-assisted tools were used solely to improve the grammar, clarity, and spelling of the manuscript. These tools were not used to generate, analyse, or interpret data, nor to produce any part of the scientific content, results, or conclusions. All research design, experimentation, data analysis, and scientific interpretations were performed entirely by the authors. The authors reviewed and validated all AI-assisted editorial suggestions to ensure accuracy and integrity.

Conflict of interest

The authors have declared no conflict of interest.

REFERENCES

ACED (2024). Suspension des importations de volailles au Bénin: Défis et opportunités pour la production locale. ACED Policy Brief, Abomey-Calavi.

Adekeye AB, Amole TA, Oladimeji SO, Raji AA, Odekunle TE, Olasusi O, Bamidele O, Adebayo AA (2021). Growth performance, carcass characteristics and cost benefit of feeding broilers with diets containing high-quality cassava peel (HQCP). Afr. J. Agric. Res. 17(4): 607–614.

Adoligbé CM (2024). Antimicrobial use and resistance in intensive poultry production systems in Benin. One Health Outlook, 6(12): 1–10.

Adoligbé CM, Chrysostome CAA, Koudandé DO, Youssao AKI (2020). Family poultry production systems in Benin: Characterization and importance for rural households. Int. J. Livest. Prod., 11(2): 31–40.

Adli DN (2021). Use of insects in poultry feed as replacement for soybean meal and fish meal in developing countries: A systematic review. Livest. Res. Rural Dev. 33(10).

Aguidissou T, Boko K, Chrysostome CAA (2020). Constraints and opportunities in poultry farming in Benin: A review. Trop. Anim. Health Prod., 52(3): 1231–1240.

AOAC (1995). Official methods of analysis (14th ed.). Association of Official Analytical Chemists, Washington, DC.

Ayssiwede SB, Dieng A, Houinato MR, Chrysostome CAA, Issa Y, Hornick JL, Missohou A (2013). Production systems and constraints of family poultry in sub-Saharan Africa: A review. Livest. Res. Rural Dev., 25(7): Article 116.

Bakare AG, Cawaki P, Ledua I, Kour G, Jimenez V, Sharma A, Tamani E (2020). Acceptability, growth performance and nutritional status of chickens fed cassava leaf meal–based diets. Trop. Anim. Health Prod., 52(5): 2417–2427. https://doi.org/10.1007/s11250-020-02274-x

Bakare AG, Zindove TJ, Iji PA, Chimonyo M (2021). A review of limitations to using cassava meal in poultry diets and the potential role of exogenous microbial enzymes. Trop. Anim. Health Prod., 53: 426. https://doi.org/10.1007/s11250-021-02853-6

Basak B, Pramanik AH, Rahman MS, Tarafdar SU, Roy BC (2002). Azolla (*Azolla pinnata*) as a feed ingredient in broiler ration. Int. J. Poult. Sci., 1(1): 29–34. https://doi.org/10.3923/ijps.2002.29.34

Chang EP, Abdallh ME, Ahiwe EU, Mbaga S, Zhu Z, Fru-Nji F, Omede AA, Iji PA (2020). Replacement value of cassava for maize in broiler chicken diets supplemented with enzymes. Asian-Australas. J. Anim. Sci., 33: 1126–1137. https://doi.org/10.5713/ajas.19.0263

Dahouda M, Toleba SS, Youssao AKI, Hambuckers A, Dangou-Sapoho RK, Hornick JL, Théwis A (2009a). Comparative study on the use of cassava products in guinea fowl and broiler diets: Effects on growth performance and feed cost. Int. J. Poult. Sci., 8(2): 182–189. https://doi.org/10.3923/ijps.2009.882.889

Dahouda M, Toleba SS, Youssao AKI, Kpodekon M, Aboubakar S, Ahounou GS, Senou M, Bouayou J, Hornick JL (2009). Performance of growing local guinea fowl fed diets containing cassava products (*Manihot esculenta* Crantz) as substitute for maize. Int. J. Poult. Sci., 8: 592–597. https://doi.org/10.3923/ijps.2009.882.889

de Almeida Santos AN, Rufino JPF, Beltrão PHSP, Alves ACN, Dias FVN, de Carvalho ML, de Oliveira Souza T, de Lima Silva R, Teixeira de Oliveira A (2025). Potential of alternative feeds in poultry nutrition: A systematic review. World's Poult. Sci. J., 1–28. https://doi.org/10.1080/00439339.2025.2540284

De Mendiburu F (2023). agricolae: Statistical procedures for agricultural research (R package version 1.3-7).

Djimènou D, Edénakpo AK, Adoligbé CM, Eto VL, Osei-Amponsah R, Koudandé DO (2022). Assessment of phenotypic diversity within Goliath chicken populations in Benin. Trop. Anim. Health Prod., 54(359): 1–11. https://doi.org/10.1007/s11250-022-03338-w

Egbune EO, Aganbi E, Anigboro AA, Omoregie ES, Oghenekaro AO, Ayeni EA, Obukohwo OE (2023). Biochemical characterization of solid-state fermented cassava roots (*Manihot esculenta* Crantz) and its application in broiler feed formulation. World J. Microbiol. Biotechnol., 39: 62. https://doi.org/10.1007/s11274-022-03496-x

Egbune EO, Tonukari NJ (2023). Fermented mixture of cassava roots and palm kernel cake can substitute for maize in poultry feed formulation. Afr. J. Biochem. Res., 17: 1–8.

FAO (2008). Poultry sector country review: Benin. Food and Agriculture Organization of the United Nations, Rome.

Guembo HK, Ndomo AF, Noumbissi MG, Teguia A (2021a). Effect of cassava root meal on growth and carcass characteristics of broiler chickens. Tropicultura, 39: A61.

Guembo JR, Adzona PP, Bati JB, Saboukoulou AJ, Ntsoumou VM, Mabanza-Mbanza BB, Pepah PE, Ndingha FA, Hornick JL, Banga-Mboko H (2021b). Effet de l'alimentation séparée à base des feuilles de manioc post-récolte sur les performances des poulets de chair en finition. Int. J. Biol. Chem. Sci., 15(5): 1937–1949. https://doi.org/10.4314/ijbcs.v15i5.20

Houndonougbo MF, Chrysostome CAA, Houndonougbo VP (2012). Performances de ponte et qualité des œufs des poules pondeuses ISA Brown alimentées avec des rations à base de feuilles séchées de manioc (*Manihot esculenta* Crantz). Int. J. Biol. Chem. Sci., 6(5): 1950–1959. https://doi.org/10.4314/ijbcs.v6i5.5

INSAE (2017). Annuaire statistique 2017. Institut National de la Statistique et de l'Analyse Économique (INSAE), Cotonou, Bénin.

ISO (2012). ISO 8586:2012. Sensory analysis General guidelines for the selection, training, and monitoring of selected assessors and expert sensory assessors. International Organization for Standardization, Geneva.

Jumare FI, Salleh MM, Ihsan N, Yusuf AO, Lawal TE, Mohammed A, Usman LA, Kamaruzaman S (2024). Cassava waste as an animal feed treatment: Past and future. Rev. Environ. Sci. Biotechnol., 23: 839–868. https://doi.org/10.1007/s11157-024-09701-7

Karim M (2015). Poultry farming in West Africa: Challenges and opportunities. World's Poult. Sci. J., 71(4): 857–868.

Kouadio JY, Aboh AB, N'Guessan HK, Kouakou B, Kouadio A, Kouadio AM, Kouadio KC (2019). Use of cassava by-products in animal feed in Côte d'Ivoire: Effects on broiler performance. Int. J. Poult. Sci., 18: 47–54.

Kouadio KE, Kouassi NJ, Konan BA, Tetchi FA, Kouadio YJ (2019b). Substitution de la farine de maïs par la farine de pelures de manioc dans l'alimentation des poulets de chair: effets sur la croissance et le coût de production. J. Anim. Vet. Adv., 18(5): 142–149.

Kulla D, Amoussou P, Dognon AY, Gbèdé TR, Glele I, Graser M, Jimmy KP, Karimou S, Kinkpet AT, Klause KA, Castro GM, Marner EM (2021). The impact of chicken imports on the Beninese poultry industry: Analysis of trade issues, consumer preferences and production systems to strengthen the competitiveness of the national sector (1st ed.). Humboldt-Universität zu Berlin, SLE Postgraduate Studies.

Meilgaard M, Civille GV, Carr BT (2007). Sensory evaluation techniques (4th ed.). CRC Press, Boca Raton, FL.

National Research Council (NRC) (1994). Nutrient requirements of poultry (9th rev. ed.). National Academy Press, Washington, DC.

Ogbuewu IP, Mbajiorgu CA (2022). Meta-analysis of substitution value of maize with cassava (*Manihot esculenta* Crantz) on growth performance of broiler chickens. Front. Vet. Sci., 9: 997128. https://doi.org/10.3389/fvets.2022.997128

Pinheiro J, Bates D, DebRoy S, Sarkar D, R Core Team (2021). nlme: Linear and nonlinear mixed effects models (R package version 3.1-152).

R Core Team (2021). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/

Russell LV (2021). emmeans: Estimated marginal means, aka least-squares means (R package version 1.6.1).

Stone H, Sidel JL (2004). Sensory evaluation practices (3rd ed.). Academic Press, San Diego, CA.

Tadesse T (2024). Use of cassava in chicken diet. In: Tonukari NJ (ed.). Cassava – Recent updates on food, feed, and industry. IntechOpen, London. https://doi.org/10.5772/intechopen.110309

Wanapat M (2001). Role of cassava hay as animal feed in the tropics. In: Workshop on the Potential of Cassava as Animal Feed in Asia, Khon Kaen University, Thailand, pp. 13–18. FAO.

Yang Y, Lei F, Zhang Z, Li X, Wang H, Chen L, Huang Q, Xu Z (2024). Effects of cassava root meal on growth performance, apparent nutrient digestibility, organ and intestinal indices, and slaughter performance of yellow-feathered broiler chickens. Trop. Anim. Health Prod., 56: 274. https://doi.org/10.1007/s11250-024-04135-3