The Effect of Soaked Cassava Peel Meal Supplemented with Enzyme as Replacement for Maize on the Blood Hematological Characteristics of Broiler Chickens

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Abstract
This study evaluated the effect of soaked cassava peel meal supplemented with enzyme as a replacement for maize on the performance and productive characteristics of broiler chickens. Cassava peels were soaked for three days, dried, milled and incorporated into experimental diets at 0, 25, 50 and 75% replacement levels. Three hundred broiler chickens were randomly assigned to four dietary treatments with three replicates. Growth performance, nutrient digestibility, carcass characteristics, laying performance, egg quality and feed cost were assessed. Soaking improved the nutritional composition of cassava peel meal, increasing dry matter and crude protein while reducing crude fibre. During the growing phase, FCPM inclusion significantly affected feed intake and nutrient digestibility, but had no significant effect on final body weight, daily weight gain or feed conversion ratio. The 50% replacement level recorded the highest digestibility of dry matter, crude protein, crude fibre, ether extract and ash, whereas 75% replacement produced the lowest digestibility values. Several carcass parameters were significantly influenced by treatment, although gizzard and intestinal weights were unaffected. During the laying phase, FCPM did not significantly affect hen-day production, hen-house production, feed intake, egg weight, feed conversion ratio or measured egg-quality characteristics. Feed cost declined progressively with increasing FCPM inclusion, with 50% replacement showing favourable economic efficiency. Overall, soaked cassava peel meal can partially replace maize in broiler diets, with 50% replacement appearing most suitable based on nutrient utilization, performance and feed-cost efficiency.

Keywords: *Cassava Peel, Replacement, Maize, Haematological Chickens*

Introduction

Poultry production is an important component of livestock agriculture because it provides relatively affordable sources of animal protein, employment, income and essential nutrients to human populations (Sarah et al., 2026). Among poultry species, broiler chickens are particularly important because of their rapid growth rate, efficient feed conversion and relatively short production cycle (Obruche et al., 2025). However, the profitability and sustainability of broiler production are strongly influenced by the cost and quality of feed. Feed constitutes a major proportion of the total cost of poultry production, with energy- and protein-rich ingredients such as maize and soybean meal accounting for substantial portions of feed expenditure.

Consequently, fluctuations in the availability and price of conventional feed ingredients can increase production costs and reduce the economic returns of poultry farmers (Umudi et al., 2025). Maize is one of the most widely used energy ingredients in poultry diets because of its high metabolizable energy content, palatability, digestibility and relatively low fibre content. Nevertheless, increasing competition between human consumption, livestock feeding and industrial utilization has contributed to pressure on maize supplies. Seasonal shortages, increasing market prices, climatic variability and competition for arable land have further intensified the need to identify alternative feed ingredients (Etus and Obruche, 2026). The search for locally available, inexpensive and nutritionally useful agricultural by-products has therefore become an important strategy for reducing feed costs and improving the sustainability of poultry production (Okpanachi et al., 2025). Cassava (*Manihot esculenta*) is a major tropical root crop cultivated extensively in Nigeria and other parts of Africa. It is processed into several food and industrial products, generating considerable quantities of cassava peels as agricultural waste. Cassava peels contain carbohydrates, particularly starch, as well as varying amounts of fibre, protein, minerals and other nutrients (Obruche et al., 2018; Umudi et al., 2025). Their availability and relatively low cost make them potentially valuable as alternative feed ingredients. However, the direct incorporation of cassava peel into poultry diets is limited by its high fibre content, relatively low protein concentration and the presence of anti-nutritional factors, including cyanogenic compounds. These characteristics can reduce nutrient utilization and consequently limit growth performance when cassava peel is used at high dietary inclusion levels. Processing methods such as soaking, drying, fermentation and ensiling can improve the nutritional quality and safety of cassava by-products. Soaking cassava peels in water may facilitate the reduction of some soluble anti-nutritional substances and improve their acceptability for animal feeding. Nevertheless, soaked cassava peel meal may still contain substantial quantities of structural carbohydrates that are poorly digested by poultry because chickens have limited endogenous enzymes capable of efficiently degrading non-starch polysaccharides and other complex fibre components. Consequently, further nutritional enhancement is necessary if cassava peel meal is to replace a substantial proportion of maize in broiler diets (Micheal et al., 2026). Dietary enzymes have received increasing attention as nutritional tools for improving the utilization of unconventional feed ingredients. Exogenous enzymes, including carbohydrases, cellulases, xylanases, amylases and related enzyme preparations, can break down complex components of feed into simpler and more readily available nutrients. Enzyme supplementation may improve nutrient digestibility, reduce the anti-nutritional effects associated with dietary fibre, enhance energy utilization and potentially improve the overall feeding value of agricultural by-products (Itodo et al., 2021; Umudi et al., 2025). The combination of processing techniques, such as soaking, with enzyme supplementation may therefore provide a promising approach for improving the nutritional value of cassava peel meal. Haematological characteristics are important indicators of the physiological and nutritional status of poultry. Parameters such as packed cell volume (PCV), haemoglobin concentration (Hb), red blood cell count (RBC), white blood cell count (WBC) and related erythrocytic indices provide useful information about oxygen-carrying capacity, immune status, nutritional adequacy and general health. Changes in these parameters can reflect the effects of dietary ingredients, nutrient deficiencies, toxic substances or physiological stress (Ekpo et al., 2023). Therefore, evaluating haematological characteristics is particularly important when unconventional feed ingredients are introduced into poultry diets. A feed ingredient may appear suitable based on growth performance alone but could adversely affect the health or physiological condition of birds if it contains residual anti-

nutritional or toxic substances (Erienu et al., 2022). Although cassava peels have considerable potential as an alternative feed resource, concerns remain regarding their safe and effective inclusion in broiler diets. Previous investigations have generally focused on the effects of processed cassava products on growth performance, feed intake, nutrient utilization and carcass characteristics (Nathan et al., 2025). Comparatively less attention has been given to the combined effect of soaking and enzyme supplementation on the haematological responses of broiler chickens when soaked cassava peel meal is used as a replacement for maize (Ekpo et al., 2025). Furthermore, available findings may differ because of variations in cassava variety, processing method, enzyme preparation, inclusion level, bird age and dietary composition. This creates a need for controlled evaluation of the physiological consequences of replacing maize with appropriately processed cassava peel meal (Etus and Obruche, 2026). The specific gap addressed by this study is the limited information on whether soaked cassava peel meal supplemented with enzyme can safely replace maize in broiler diets without adversely affecting the haematological characteristics of the birds. Establishing its effects on blood parameters will provide information on the physiological suitability and safety of this alternative feed ingredient. The study will therefore investigate the effect of soaked cassava peel meal supplemented with enzyme as a replacement for maize on the haematological characteristics of broiler chickens. The findings are expected to contribute to the development of more affordable and sustainable poultry diets, promote the productive utilization of cassava-processing waste, reduce dependence on maize and provide useful information for poultry farmers, feed manufacturers and researchers seeking locally available alternatives to conventional feed ingredients.

Materials and Method

Experimental Location and Duration

The study was conducted at the Poultry Unit, Department of Animal Production, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Niger State, Nigeria. Minna is located between latitudes 9°28′N and 9°37′N and longitudes 6°23′E and 6°33′E, with an annual rainfall of approximately 1,000–1,500 mm. The area falls within the Southern Guinea Savannah vegetation zone (Obruche et al., 2019). The experiment lasted 12 weeks and comprised two six-week phases: the growing and laying phases.

Collection and Processing of Cassava Peel and Feed Ingredients

Cassava peels were obtained from a cassava processing factory around Mobile Market, Minna. The peels were soaked in room-temperature water for three days in covered drums to facilitate fermentation and reduce undesirable components. They were subsequently drained, spread on polythene sheets and sun-dried with regular turning to ensure uniform drying. The dried peels were milled and stored in polythene bags until required for feed formulation, following the method of Obruche et al. (2019). Other feed ingredients, including fish meal, vitamin-mineral premix, lysine and methionine, were purchased from a feed mill, while maize, groundnut cake, maize bran and bone meal were obtained from Minna Modern Market. The ingredients were weighed, milled where necessary and thoroughly mixed according to the experimental formulations.

Experimental Birds, Housing and Management

Three hundred two-week-old broiler chickens obtained from the National Veterinary Research Institute, Vom, Jos, were used. The birds were housed on deep litter. The brooding house,

feeders, drinkers and other equipment were cleaned and disinfected one week before stocking. During the first week, 100-W bulbs provided heat, after which 60-W bulbs were used mainly for night illumination. Kerosene stoves and lamps were used as supplementary heat sources during power outages. On arrival, the birds were placed in the preheated brooding house. They were randomly allotted to four dietary treatments, with 75 birds per treatment and three replicates of 25 birds each. The growing phase lasted six weeks. Litter was regularly turned and replaced every two weeks, while drinkers and feeders were cleaned daily. Feed offered and leftovers were weighed daily, mortality was recorded, and clean drinking water was provided *ad libitum*.

Experimental Design and Diets

A completely randomized design (CRD) was used. Four diets were formulated by replacing maize with soaked cassava peel meal (FCPM) at 0, 25, 50 and 75% inclusion levels. The diets were designated T1, T2, T3 and T4, as shown in table 1. The growing-phase diets were formulated to approximately 24% crude protein and fed throughout the six-week period.

Table 1: Composition of Experimental Diets for Broiler Chickens During the Growing Phase (%)

Ingredients (kg)	T1	T2	T3	T4
Maize	44.40	33.30	22.20	11.10
FCPM	0.00	11.10	22.20	33.30
Groundnut cake	38.90	38.90	38.90	38.90
Maize bran	10.00	10.00	10.00	10.00
Fish meal	2.00	2.00	2.00	2.00
Bone meal	2.50	2.50	2.50	2.50
Limestone	1.50	1.50	1.50	1.50
Premix	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**

Calculated values	T1	T2	T3	T4
ME (kcal/kg)	2565.62	2409.77	2255.70	2100.75
Crude protein (%)	23.91	23.48	23.05	22.62
Crude fibre (%)	3.76	4.51	5.27	6.02
Methionine (%)	0.30	0.28	0.22	0.23
Lysine (%)	0.88	0.85	0.82	0.79

Key: T1 = 100% maize: 0% FCPM; T2 = 75% maize: 25% FCPM; T3 = 50% maize: 50% FCPM; T4 = 25% maize: 75% FCPM. FCPM = fermented/soaked cassava peel meal; ME = metabolizable energy.

The vitamin-mineral premix supplied vitamins A, D, E, B-complex, K and C, folic acid and selected minerals, including calcium, copper, iron, iodine, selenium, magnesium and chlorine,

according to the manufacturer's specification.

Growth Performance and Digestibility Measurements

Feed intake was determined daily as the difference between feed offered and the corresponding leftovers. Weekly feed consumption per bird was calculated from the quantity consumed and the number of birds in each replicate. Body weight was measured initially and subsequently at weekly intervals. Weight gain was determined as the difference between successive body weights. Feed conversion ratio (FCR) was calculated as:

$$\text{FCR} = \frac{\text{Average feed intake (g)}}{\text{Average weight gain (g)}}$$

A digestibility trial was conducted seven days before the end of the growing phase. Two birds from each replicate were selected, weighed and transferred to metabolic cages. After two days of adaptation, faecal samples were collected for five consecutive days. Total droppings were weighed, oven-dried at 65°C for 36 hours, pooled by treatment and ground. Feed consumption was also recorded. Nutrient digestibility was calculated as:

$$\text{Nutrient digestibility (\%)} = \frac{\text{Nutrient in feed} - \text{Nutrient in faeces}}{\text{Nutrient in feed}} \times 100$$

Carcass Evaluation

At the end of the growing phase, eight birds, comprising two birds per treatment, were selected and fasted overnight. Their live weights were recorded before slaughter. The birds were slaughtered by severing the jugular vein, scalded in warm water for approximately 30 seconds and eviscerated. Carcass and organ weights were recorded and expressed as percentages of live body weight

Laying Phase and Experimental Diets

For the second phase, 120 broiler chickens were used. Birds were sexed by examining the cloacal gland, with males identified by the characteristic bulbous gland and white foamy secretion when pressed (Umudi et al., 2025). Males were separated, while females retained their original replicates. A maximum of 10 females was maintained per replicate. Four laying diets were formulated by replacing maize with soaked cassava peel meal at 0, 25, 50 and 75% for T1, T2, T3 and T4, respectively (see table 2). The diets were formulated to approximately 22% crude protein.

Table 2: Composition of Experimental Diets for the Laying Phase (%)

Ingredients (%)	**T1**	**T2**	**T3**	**T4**
Maize	48.72	36.54	24.36	12.18
FCPM	0.00	12.18	24.36	36.54
Groundnut cake	33.58	33.58	33.58	33.58
Fish meal	10.00	10.00	10.00	10.00
Bone meal	2.00	2.00	2.00	2.00
Limestone	3.00	3.00	3.00	3.00

Ingredients (%)	T1	T2	T3	T4
Premix	2.00	2.00	2.00	2.00
Salt	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**

Calculated values	T1	T2	T3	T4
ME (kcal/kg)	2579.28	2161.26	1743.25	1325.23
Crude protein (%)	21.90	21.42	20.95	20.47
Crude fibre (%)	3.68	4.51	5.33	6.16
Methionine (%)	0.29	0.27	0.24	0.23
Lysine (%)	0.80	0.77	0.73	0.70

Key: T1 = 100% maize: 0% FCPM; T2 = 75% maize: 25% FCPM; T3 = 50% maize: 50% FCPM; T4 = 25% maize: 75% FCPM.

Egg Production, Egg Quality and Feed Utilization

Daily feed intake, egg production and mortality were recorded throughout the laying phase. Hen-day and hen-house egg production were calculated for each replicate. Egg quality was evaluated using egg weight, length, width, shell thickness, yolk weight, yolk height, yolk width, albumen weight and height, yolk index, egg shape index and Haugh unit. Egg weight was measured individually using a sensitive digital scale. Egg length and width were measured with a vernier caliper. Yolk height was measured with a spherometer and yolk diameter with a vernier caliper. Yolk index was calculated as:

$$\textbf{Yolk index} = \frac{\textbf{Yolk height (cm)}}{\textbf{Yolk diameter (cm)}}$$

Albumen and yolk weights were obtained by separating each component into pre-weighed Petri dishes and determining the weight difference. Shell thickness was measured with a micrometer screw gauge after air-drying and removing the shell membrane. Albumen height was measured using a tripod micrometer. The Haugh unit was calculated according to Ogwuche and Obruche (2020):

$$\mathbf{HU = 100 \log (H + 7.57 - 1.7W^{0.37})}$$

Where;
H is albumen height and
W is egg weight in grams.
Egg shape index was calculated as:

$$\text{Egg shape index} = \frac{\textbf{Egg width (cm)}}{\textbf{Egg length (cm)}}$$

Feed conversion ratio during the laying phase was calculated as feed consumed per unit of egg production, while hen-day and hen-house egg production were determined using the respective number of eggs produced relative to surviving and initially stocked birds (Jacintha *et al*., 2025).

Proximate Analysis and Statistical Analysis

Proximate composition of the soaked cassava peel meal, experimental diets and faecal samples was determined using standard AOAC (2000) procedures for dry matter, crude protein, crude fibre and ether extract. Nitrogen-free extract was obtained by difference. Data generated from the experiments were analyzed using analysis of variance (ANOVA) with SPSS version 17.0. Where significant differences occurred, treatment means were separated using Duncan's multiple range test at the appropriate level of significance (Abeokuta et al.,, 2025).

Results and Discussion

The results of the proximate composition, growth performance, nutrient digestibility, carcass characteristics, laying performance, egg quality and feed cost of broiler chickens fed soaked cassava peel meal (FCPM) are presented below. Related findings have been merged to reduce repetition while retaining the original data and interpretation.

Proximate Composition of Soaked and Fresh Cassava Peel

The proximate composition of soaked cassava peel meal (FCPM) and fresh cassava peel (FCAP) is presented in Table 3. Soaking increased dry matter and crude protein, while reducing crude fibre and ether extract. FCPM contained 89.50% dry matter, 5.70% crude protein, 14.83% crude fibre, 0.47% ether extract, 9.47% ash and 59.03% nitrogen-free extract, compared with 18.90%, 4.23%, 28.60%, 3.26%, 7.47% and 55.50%, respectively, in FCAP. The increase in protein may be associated with microbial biosynthesis during fermentation, whereas fibre reduction may result from cellulose degradation. The lower ether extract may reflect enzymatic breakdown of lipids during processing.

Table 3: Proximate composition of soaked cassava peel meal (FCPM) and fresh cassava peel (FCAP)

Components	FCPM	FCAP
Dry matter (%)	89.50	18.90
Crude protein (%)	5.70	4.23
Crude fibre (%)	14.83	28.60
Ether extract (%)	0.47	3.26
Ash (%)	9.47	7.47
Nitrogen-free extract (%)	59.03	55.50
Metabolizable energy (Kcal/g)	263.15	268.14

Key: FCPM = soaked cassava peel meal; FCAP = fresh cassava peel.

Proximate Composition and Growth Performance of Broilers

The experimental diets differed in nutrient composition according to FCPM inclusion. Dry matter ranged from 85.34–95.95%, crude protein from 21.26–25.11%, crude fibre from 3.00–7.00%, ether extract from 5.00–7.00%, ash from 8.50–10.00% and nitrogen-free extract from 40.15–53.19%. Fibre and ash generally increased with FCPM inclusion as shown in table 4.

Table 4: Proximate composition of experimental diets fed to broiler chickens during the growing phase

Component (%)	T1	T2	T3	T4
Dry matter	93.70	94.20	95.95	85.34
Crude protein	23.27	25.11	21.26	23.19
Crude fibre	3.00	3.50	7.00	7.00
Ether extract	6.00	7.00	5.50	5.00
Ash	8.50	8.50	9.00	10.00
Nitrogen-free extract	52.93	50.09	53.19	40.15

Key: T1 = 100% maize: 0% FCPM; T2 = 75% maize: 25% FCPM; T3 = 50% maize: 50% FCPM; T4 = 25% maize: 75% FCPM.

Final body weight, daily weight gain and feed conversion ratio were not significantly affected (P>0.05) by FCPM inclusion. Final body weight ranged from 125.44–136.59 g, while daily weight gain ranged from 2.53–2.77 g. However, daily feed intake differed significantly (P<0.05), increasing to 23.06 g at 75% FCPM. The higher intake may be associated with the greater fibre content and lower energy density of FCPM diets, requiring increased consumption to meet energy needs (see table 5).

Table 5: Performance of growing broiler chickens fed graded levels of FCPM

Parameter	T1	T2	T3	T4	SEM	LS
Initial body weight (g)	26.00	26.67	28.67	29.33	27.67	NS
Final body weight (g)	135.87	125.44	136.59	126.70	131.16	NS
Body weight gain (g)	109.87^{a}	98.77^{b}	107.92^{a}	97.37^{b}	103.49	NS
Daily weight gain (g)	2.77	2.53	2.67	2.53	2.62	NS
Total feed intake (g)	685.49^{b}	674.12^{b}	772.87^{b}	967.31^{a}	774.95	*
Daily feed intake (g)	17.02^{c}	16.73^{c}	17.85^{b}	23.06^{a}	18.66	*
Feed conversion ratio	6.14	6.61	6.69	9.11	7.12	NS

Key: NS = non-significant; SEM = standard error of mean; * = significant; T1–T4 as defined in Table 4.2. Means with different superscripts differ significantly (P<0.05).

Nutrient Digestibility and Carcass Characteristics

Nutrient digestibility was significantly influenced by FCPM inclusion (P<0.05) as shown in table 6. T3, containing 50% FCPM, recorded the highest digestibility for dry matter, crude protein, crude fibre, ether extract and ash, whereas T4 (75% FCPM) consistently had the lowest values. This suggests that 50% FCPM provided better nutrient utilization, while higher inclusion may have reduced digestibility because of increased fibre and the physical characteristics of cassava peel meal.

Table 6: Apparent nutrient digestibility of broiler chickens fed graded levels of FCPM (%)

Parameter	T1	T2	T3	T4	SEM	LS
Dry matter	88.40^{b}	88.43^{b}	90.36^{a}	73.20^{c}	2.61	*
Crude protein	80.47^{c}	82.42^{b}	85.15^{a}	71.92^{d}	1.87	*
Crude fibre	75.41^{c}	76.81^{b}	85.00^{a}	59.23^{d}	3.53	*
Ether extract	95.04^{b}	95.65^{b}	97.60^{a}	83.93^{c}	2.02	*
Nitrogen-free extract	94.13^{a}	94.33^{a}	93.73^{a}	78.33^{b}	3.14	*
Ash	74.42^{b}	70.24^{c}	82.93^{a}	59.82^{d}	2.58	*

Key: SEM = standard error of mean; LS = level of significance; * = significant; T1 = 100% maize: 0% FCPM; T2 = 75% maize: 25% FCPM; T3 = 50% maize: 50% FCPM; T4 = 25% maize: 75% FCPM.

Carcass traits showed significant differences in live weight, dressing percentage, head, legs, crop, bile, liver, heart and lungs, while gizzard and intestine were not significantly affected as shown in table 7. T4 had the highest live weight and dressing percentage, whereas the control had the highest liver value. The absence of significant effects on gizzard and intestine indicates that FCPM inclusion did not substantially alter these organs.

Table 7: Carcass characteristics of broiler chickens fed diets containing graded levels of FCPM

Parameter	T1	T2	T3	T4	SEM	LS
Live weight (g)	255.43^{c}	263.76^{bc}	275.00^{ab}	287.50^{a}	7.07	*
Eviscerated weight (g)	190.28^{a}	191.79^{a}	192.29^{a}	181.80^{b}	2.91	*
Dressing (%)	76.11^{b}	86.04^{a}	76.54^{b}	90.55^{a}	2.85	*
Head (%)	12.70^{c}	14.04^{a}	13.28^{b}	13.31^{b}	12.79	*
Legs (%)	5.19^{b}	5.49^{a}	4.92^{c}	5.47^{a}	4.99	*
Crop (%)	1.09^{b}	1.99^{a}	2.06^{a}	1.87^{a}	1.33	*
Bile (%)	0.35^{a}	0.34^{a}	0.31^{b}	0.31^{b}	0.11	*
Gizzard (%)	8.99	8.75	8.46	8.59	0.24	NS
Intestine (%)	10.57	10.73	9.74	10.09	0.42	NS
Liver (%)	4.81^{a}	3.41^{c}	4.09^{b}	3.40^{c}	0.26	*
Heart (%)	2.65^{a}	2.66^{a}	2.36^{b}	2.37^{b}	0.08	*
Lungs (%)	2.61^{b}	2.68^{ab}	2.78^{ab}	2.98^{a}	0.37	*

Key: NS = non-significant; * = significant; T1–T4 as previously defined. Means with different superscripts differ significantly ($P<0.05$).

Proximate Composition and Production Performance During the Laying Phase

The laying-phase diets had relatively similar dry matter contents (91.70–91.90%), as shown in table 8. Crude protein ranged from 20.65–22.50%, crude fibre from 5.33–6.67%, ether extract from 9.50–13.00%, ash from 3.50–5.50% and nitrogen-free extract from 46.38–50.75%.

Table 8: Proximate composition of experimental diets fed to broiler chickens during the laying phase

Component (%)	T1	T2	T3	T4
Moisture	8.10	8.10	8.30	8.10
Dry matter	91.90	91.90	91.70	91.90
Ash	3.50	5.50	5.00	5.00
Crude protein	20.65	22.50	22.15	21.40
Crude fibre	6.00	5.54	6.67	5.33
Ether extract	11.00	9.50	11.50	13.00
Nitrogen-free extract	50.75	48.95	46.38	47.17

Key: T1 = 0% FCPM: 100% maize; T2 = 25% FCPM: 75% maize; T3 = 50% FCPM: 50% maize; T4 = 75% FCPM: 25% maize.

FCPM inclusion did not significantly affect hen-day production, hen-house production, average feed intake, egg weight or feed conversion ratio (P>0.05). Feed intake ranged from 22.07–26.02 g, with T2 recording the highest value and T4 the lowest as shown in table 9. The reduced intake at the highest inclusion level may be related to residual hydrocyanide or other antinutritional factors.

Table 9: Hen-day, hen-house production and feed intake of laying broiler chickens

Parameter	T1	T2	T3	T4	SEM	LS
Hen-day production (%)	17.76	22.24	20.86	15.48	2.08	NS
Hen-house production (%)	11.67	12.14	11.93	10.63	0.70	NS
Average feed intake (g)	23.52	26.02	25.38	22.07	0.66	NS
Average egg weight (g)	7.65	8.07	7.79	7.74	0.17	NS
Feed conversion ratio	3.12	3.37	3.33	3.10	0.12	NS

Key: NS = non-significant (P>0.05); SEM = standard error of mean.

Egg Quality Characteristics

All measured egg-quality parameters were statistically similar among treatments (P>0.05), as shown in table 10. Yolk weight ranged from 3.24–3.62 g, shell thickness from 0.20–0.21 mm, yolk width from 2.78–2.91 mm, Haugh unit from 81.03–84.25%, yolk height from 8.86–9.81 mm and egg weight from 7.65–8.07 g. Egg length, width and shape index also showed no significant differences. These findings indicate that replacing maize with FCPM did not adversely affect the measured egg-quality traits.

Table 10: Egg quality characteristics of broiler chickens fed diets containing graded levels of FCPM

Parameter	T1	T2	T3	T4	SEM	LS
Yolk weight (g)	3.24	3.62	3.29	3.31	0.10	NS
Shell thickness (mm)	0.20	0.21	0.21	0.21	0.004	NS
Yolk width (mm)	2.79	2.82	2.78	2.91	0.03	NS
Yolk index	3.23	3.45	3.54	4.13	0.27	NS

Parameter	T1	T2	T3	T4	SEM	LS
Haugh unit (%)	84.25	81.97	81.03	83.18	0.76	NS
Yolk height (mm)	8.94	9.71	9.81	8.86	0.28	NS
Albumen height (mm)	2.96	2.72	2.55	2.74	0.10	NS
Albumen weight (g)	2.20	2.49	2.66	2.76	0.13	NS
Egg weight (g)	7.65	8.07	7.79	7.74	0.17	NS
Egg length (mm)	2.97	3.13	3.02	3.11	0.04	NS
Egg width (mm)	2.48	2.42	2.44	2.49	0.03	NS
Egg shape index	0.93	0.86	0.92	0.91	0.03	NS

Key: NS = non-significant; SEM = standard error of mean; T1–T4 as previously defined.

The Haugh unit values exceeded 75%, indicating acceptable egg quality. The similarity in shell thickness, egg weight, yolk and albumen characteristics suggest that FCPM did not materially alter egg quality.

Feed Cost Analysis

Increasing FCPM inclusion reduced feed cost per kilogram from ₦101.18 in T1 to ₦74.54 in T4. T3 provided the lowest cost per daily weight gain (₦0.53), compared with ₦0.69 in the control as shown in table 11. However, the differences in cost per kilogram of feed and cost per daily weight gain were not significant (P>0.05). Thus, FCPM, particularly at 50% inclusion, showed potential for reducing feeding costs without significantly compromising growth performance.

Table 11: Feed cost analysis of broiler chickens fed graded levels of FCPM

Parameter	T1	T2	T3	T4	SEM	LS
Cost of feed/kg	101.18	92.30	83.42	74.54	87.86	NS
Average daily feed intake (g)	17.02^{c}	16.73^{c}	18.85^{b}	23.06^{a}	18.66	*
Cost of daily feed intake/bird (₦)	1.90^{a}	1.48^{ab}	1.43^{b}	1.72^{ab}	0.08	*
Daily weight gain (g)	2.77	2.53	2.67	2.53	2.62	NS
Cost per daily weight gain (₦)	0.69	0.58	0.53	0.67	0.62	NS

Key: NS = non-significant; * = significant; SEM = standard error of mean; T1–T4 as previously defined.

Overall, soaking/fermentation improved the nutritional characteristics of cassava peel by increasing dry matter and crude protein while reducing fibre and ether extract. Incorporation of FCPM influenced feed intake and nutrient digestibility but had limited effects on final body weight, daily weight gain and feed conversion. The 50% FCPM diet generally produced the best nutrient digestibility and feed-cost efficiency, while the 75% level was associated with higher feed intake and poorer digestibility. During the laying phase, FCPM did not significantly affect production or egg-quality traits. These results are in agreement with the work of Festus-Amadi et al.,(2021) and Ogochukwu et al., (2025). These findings indicate that soaked cassava peel meal can serve as a useful partial replacement for maize in broiler diets, with 50% inclusion appearing

particularly favourable based on nutrient utilization and economic performance**.**

Conclusion

The study demonstrated that soaked cassava peel meal (FCPM) supplemented with enzyme can serve as a useful alternative to maize in broiler chicken diets. Soaking improved the nutritional quality of cassava peel by increasing dry matter and crude protein while reducing crude fibre. Inclusion of FCPM significantly affected feed intake and nutrient digestibility, with the 50% replacement level generally recording the best nutrient utilization. In contrast, the 75% inclusion level resulted in higher feed consumption and reduced digestibility, indicating that excessive cassava peel inclusion may limit nutrient utilization. The replacement of maize with FCPM did not significantly affect final body weight, daily weight gain or feed conversion ratio during the growing phase. Carcass characteristics were influenced in some parameters, although gizzard and intestinal weights remained unaffected. During the laying phase, FCPM inclusion produced no significant differences in hen-day production, hen-house production, feed intake, egg weight or feed conversion ratio. Similarly, the measured egg-quality characteristics were not significantly altered, and all treatments maintained acceptable Haugh unit values. Importantly, increasing FCPM inclusion reduced feed cost, with the 50% replacement level showing favourable cost efficiency. Therefore, soaked cassava peel meal can partially replace maize in broiler diets without major adverse effects on performance or egg quality. A 50% replacement level appears most suitable based on nutrient digestibility, performance and economic considerations.

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