Journal of Animal Science and Veterinary Medicine
Volume 10(3), pages 226-234, June 2025
Article Number: C68231832
ISSN: 2536-7099
https://doi.org/10.31248/JASVM2025.561
https://integrityresjournals.org/journal/JASVM

Full Length Research

Potential of varying levels of flashed-dried cassava pulp with multi-enzyme supplementation on broiler finishers chickens

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Received 18th April 2025; Accepted 1st June 2025

ABSTRACT: An experiment was carried out to evaluate performance quality, cost implication, haematological indices, serum biochemistry, carcass, internal organ weights and liver histology of broiler finisher chickens fed varying levels of flashed-dried cassava pulp (FDCP) with multi-enzyme supplementation. Ninety-six (96) four-week-old Marshal ® broiler finishers were used for the study. Flashed-dried cassava pulp was substituted at 0, 5, 10 and 15% and supplemented with 50g/100kg multi-enzyme and tagged as T_1, T_2, T_3 and T_4, respectively. T_1 (0% FDCP) served as a control. The birds were randomly assigned to four (4) dietary treatments with four (4) replicates per treatment in a completely randomised design (CRD). The experiment lasted between 5 and 7 weeks. Experimental diets and water were supplied *ad libitum*. Data collected were analysed by using SPSS. Final live weight, cost of feed/kg, cost of the feed intake/weight gain, cost of the feed intake/bird, haemoglobin, white blood cells, platelets, serum biochemistry and liver were significantly (p<0.05) affected. The highest (2272.75 g) significant (p<0.05) final live weight (FLW) and weight gain (WG) weight gain (1111.70%) were obtained from birds on T2 (5% FDCP), while the least (2052.00 g) FLW and WG (879.79%) were obtained from T3 (10% FDCP). Higher (7397.44), significant (p<0.05) cost of feed intake/weight gain was obtained from T3 (10% FDCP), while the least (₦6605.76) was obtained from T4 (15% FDCP). The highest (₦2959.05) significant (p<0.05) feed intake/bird was observed from T1 (0% FDCP), while the least (₦2065.15) was observed from T4 (15% FDCP). Conclusively, this study showed that varied flashed-dried cassava pulp (FDCP) supplemented with multi-enzyme can replace maize in the broiler finisher chickens up to 15% FDCP. Therefore, 5% FDCP with multi-enzyme supplementation is recommended in the broiler finisher chicken diets.

Keywords: Blood, broiler finisher, carcass, cost implication, internal organs weight, multi-enzyme, performance quality.

INTRODUCTION

Although significant progress has been made in global poultry production, it remains essential to continually advance sustainable practices to meet the demands of a rapidly growing global population. The rise in human population and activities has exerted pressure not only on global food resources but also on the environment, particularly in terms of waste generation and management. Consequently, the research for alternative animal feed sources that do not compete with human food, are cost-effective, and promote environmental sustainability in livestock production remains an ongoing endeavour. With Nigeria's recent push for alternative and sustainable fuel sources, it is crucial to proactively explore the potential use of waste products that are emerging from this industry (Oyedele *et al.,* 2021). Therefore, exploring alternative and sustainable poultry feed sources is crucial for enhancing performance, boosting productivity, and improving overall carcass quality. In this context, it is also important to evaluate the impact of unconventional feed ingredients like dried cassava pulp.

Cassava pulp is a moist, solid by-product generated during cassava starch production, accounting for approximately

10 to 15% of the original root weight. The rise in cassava starch production is accompanied by a corresponding increase in the volume of waste by-products generated. Millions of wet tons of cassava pulp are generated annually in Nigeria. Once dried, it is utilised in formulating diets for ruminants and swine. As reported by Adeyeye *et al*. (2024), chemical compositions of cassava pulp revealed 68.25% nitrogen free extract (NFE), 8.00% moisture content, 1.70% ash, 3.25% crude protein (CP), 8.00% crude fiber (CF), and 9.00% extract ether (EE), 1.3 % calcium, and 0.6% phosphorus on a DM basis. In considering the practical use of dried cassava pulp as poultry feed, its fibre content presents a notable concern. Elevated levels of fibre, along with its bulkiness and dustiness, are key factors contributing to reduced growth performance and digestibility in poultry. It has also been reported that poultry fed high-fibre diets exhibit reduced performance and abdominal fat content, along with changes in the length and weight of their digestive organs (Eruvbetine *et al.,* 2003 and Hetland *et al.,* 2003). Therefore, it is imperative to investigate the use of DCP as an energy source for poultry.

The use of enzymes in the poultry industry has attracted considerable attention for its potential to improve the performance and productivity of broiler chickens. Enzymes added to feed have emerged as an advanced strategy to overcome the inherent limitations of the avian digestive system and enhance the utilisation of nutrients in poultry feed (Diarra and Anand, 2020). A key focus of enzyme supplementation is its role in enhancing feed efficiency and promoting growth performance in broiler chickens. It also plays a crucial role in mitigating the negative effects of certain dietary components that can interfere with nutrient availability. For instance, phytate, abundantly found in plant-based feed ingredients, binds essential minerals, rendering them unavailable for absorption (Alshamiri *et al.,* 2021). Therefore, this research investigated performance characteristics, cost implications, haematological, serum biochemistry, carcass quality, internal organs weight, and liver histology of broiler finishers fed varying levels of flashed-dried cassava pulp as a replacement for maize.

MATERIALS AND METHODS

Experimental area

The experiment was carried at the Poultry Unit of the Teaching and Research Farms, Oyo State College of Agriculture and Technology, Igbo-ora, situated in the savannah forest vegetation Zone of Ibarapa Central Local Government, Oyo State, Nigeria.

Sourcing of the flashed-dried cassava pulp (FDCP) and other feed materials

The FDCP (test ingredient) was obtained from Psaltry industry, a starch processing industry along Maya Ado-Awaye Road, Iseyin Local government area, Oyo State, Nigeria, while maize, soybeans, wheat bran, multi-enzyme (Xylanase ≥ 14,300, acid protease ≥ 5,000, neutral protease ≥ 4,000 and amylase ≥ 1,000,000 u/g) etc., were procured at a feed mill in Igbo-Ora Town.

Experimental diets

Four iso-proteinous and iso-caloric diets were formulated, such that FDCP replaced maize at 0, 5, 10 and 15% levels in diets 1, 2, 3, and 4, respectively. The experiment was arranged in a Completely Randomised Design (CRD). Multi-enzyme was used at the rate of 50g/100kg of the feed as recommended by the producer. The gross compositions of the experimental diets are presented in Tables 1 and 2, respectively.

Experimental design and management

A total of ninety-six (96) unsexed four-week-old broiler finishers (Marshal ®) were used for the study. The birds were randomly allotted into 4 treatment groups of 24 birds each in a completely randomised design (CRD). Each group was subdivided into four (4) replicates of six (6) birds each. Prior to the arrival of the birds, the experimental pen was washed clean, disinfected, fumigated, and allowed to rest for 14 days. Tray feeders and fountain drinkers with other brooding equipment were cleaned, disinfected and introduced on a floor pen (1.50 m × 1.50 m) with the use of wood shavings (7 cm) as the bedding materials. On the arrival of the chicks into the pens, the chicks were carefully removed from the boxes and randomly allotted into groups. Water and feed were supplied *ad libitum*. Vaccination and medication were carried out during the study as they came due. The study lasted between 5 and 7 weeks of age.

Data collection

Growth response evaluation

Weekly feed intake and body weight were measured before morning feeding using a sensitive weighing scale. Initial weight, final live weight, weight gain and feed conversion ratio of the birds were calculated. Throughout the course of the experiment, mortality records were maintained.

$$\text{Average weight gain} = \frac{\text{final weight} - \text{initial weight}}{\text{total number of birds}}$$

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed consumed}}{\text{Weight gain}}$$

$$\text{\% Mortality} = \frac{\text{Number of dead birds}}{\text{Number of birds stocked}} \times 100$$

Table1. Gross experimental broiler starter diets (2-4 weeks).

Ingredient (kg)	**T1 (0%)**	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**
Maize	51.00	48.45	45.90	48.35
FDCP	0.00	2.55	5.10	7.65
Soya beans	35.00	35.00	35.00	35.00
Wheat bran	9.95	9.95	9.95	9.95
Lime stone	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30
Premix (B)	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Bone meal	2.00	2.00	2.00	2.00
Enzyme (g)	0.00	50.00	50.00	50.00
Total	100.00	100.00	100.00	100.00
Calculated analysis				
EnergyME (kcal/kg)	2979.30	2933.09	2919.85	2906.60
Crude protein (%)	22.15	21.70	21.37	21.03
Ether extract (%)	3.43	3.23	3.03	2.83
Calcium (%)	1.12	1.12	1.10	1.08

FDCP = Flashed-dried Cassava pulp. *Vitamin/Mineral Premix composition per Kg diet: vit A: 40, 000IU, vit D_3: 4000IU, vit E: 40.0 mg, vit K_3:8mg, vit B_1: 1.0mg,vit B_2: 8mg, vit B_6: 5mg, vit B_{12}: 0.025mg, Niacin: 60mg, Panthothenic acid: 20mg, Folic acid: 2000mg, Biotin: 150mg, Iron: g, Manganese: 64mg, Zinc: 40mg, Copper: 8mg, Cobalt: 80mg, Iodine: 0.15mg, Selenium: 0.2mg, Choline: 300m.* multi-enzyme (Xylanase ≥ 14,300, acid protease ≥ 5,000, neutral protease ≥ 4,000 and amylase ≥ 1,000,000 u/g).

Table 2. Gross experimental broiler finisher diets (5-7 weeks).

Ingredient (kg)	**T1 (0%)**	**T2 (5%)**	**T3 (10%)**	**T4 (15%)**
Maize	67.00	63.65	60.30	56.95
FDCP	0.00	3.35	6.70	10.05
Soya beans	23.00	23.00	23.00	23.00
Wheat bran	4.95	4.95	4.95	4.95
Lime stone	2.00	2.00	2.00	2.00
Lysine	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30
Premix (B)	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Bone meal	2.00	2.00	2.00	2.00
Enzyme (g)	00.00	50.00	50.00	50.00
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Energy ME (kcal/kg)	3046.78	3020.25	3029.38	3032.00
Crude protein (%)	18.00	17.85	17.73	17.65
Ether extract (%)	3.57	3.49	3.42	3.32
Crude fiber (%	1.99	1.75	1.65	1.50
Calcium (%)	3.00	2.93	2.90	2.84

FDCP = Flashed-dried cassava pulp. Premix (B) = Premix Broiler. *Vitamin/Mineral Premix composition per Kg diet: vit A: 40, 000IU, vit D_3: 4000IU, vit E: 40.0 mg, vit K_3:8mg, vit B_1: 1.0mg,vit B_2: 8mg, vit B_6: 5mg, vit B_{12}: 0.025mg, Niacin: 60mg, Panthothenic acid: 20mg, Folic acid: 2000mg, Biotin: 150mg, Iron: g, Manganese: 64mg, Zinc: 40mg, Copper: 8mg, Cobalt: 80mg, Iodine: 0.15mg, Selenium: 0.2mg, Choline: 300m.* multi-enzyme (Xylanase ≥ 14,300, acid protease ≥ 5,000, neutral protease ≥ 4,000 and amylase ≥ 1,000,000 u/g).

Cost implication

The prevailing market prices of the ingredients per kilogram during the period of study were employed in determining the expenditure per kilogram for feed (₦), the cost per kilogram of weight gain (₦), and the overall feed intake cost per bird (₦) throughout the experimental period.

100kg of feed cost in (₦/kg) = Sum of the cost of each ingredient

$$\text{Cost of 1kg in (₦/kg)} = \frac{\text{100kg of feed cost}}{100}$$

Feed cost consumed/weight gain (₦/kg) = FCR X feed cost/kilogram

Feed consumed cost/bird in (₦/kg) = Feed intake in kg X feed cost per kilogram

Haematological parameters

At seven (7) weeks of feeding trials, a sterile needle and syringe were used to draw blood from each of the four (4) broiler chickens in each treatment individually through the jugular vein. A three milliliter (3ml) blood sample was withdrawn from each bird in vials that contain ethylene diamine tetra-acetic acid (EDTA) as an anticoagulant for determination of heamatological parameters (haemoglobin concentration, red blood cell (RBC) count, packed cell volume (PCV), as well as white blood cell (WBC) count were determined as described by (Mitruka and Rawnsely, 1977).

Serum biochemistry

Blood measurements were taken using commercial kits and according to the manufacturer's instructions. Three millilitre (3 ml) blood sample was withdrawn from a bird per replicate into plain bottles without ethylene diamine tetra-acetic acid (EDTA) to measure serum biochemistry (alanine aminotransferase, creatinine, uric acid, albumin, globulin, glucose, cholesterol, and total protein). After allowing the blood samples to clot, they were refrigerated for six hours and then centrifuged for twenty (20) minutes at 900 rpm. The blood sera of each bird were labelled separately and stored in the freezer at 20°C before analysis.

Carcass, internal organ weights and liver histology evaluation

At forty-nine (49th) days of the feeding trial, birds were starved for approximately 12 hours in order to empty their crops. One experimental bird per replicate was randomly selected, slaughtered by cervical dislocation, bled, de-feathered and taken to the laboratory for carcass and internal organ weights and liver histology evaluation, i.e dressed and cut parts weights were measured with a sensitive scale and expressed as the percentage of live weight according to the ‘Modified Kosher’ method as described by Abe *et al* (1996). The liver sample was dehydrated in ascending grades of ethanol, cleared in xylene and inserted in paraffin wax. Haemotoxylin and eosin (H and E) were applied to transverse sections (4-5 micrometres) mounted on glass slides as described by Bancroft and Layton (2013). The slides were studied using a light microscope x 400 magnification. Photomicrographs of the slides were taken using a digital camera, transferred to a computer and appropriately labelled.

Statistical analysis

Data obtained were subjected to one-way analysis of variance by using SPSS (2021). Significance ($p<0.05$) means among the variables were separated by using Duncan’s multiple range test (Duncan, 1955) of the same software package.

RESULTS AND DISCUSSION

Table 3 revealed performance qualities and cost implications of broiler finisher chickens fed graded levels of flashed-dried cassava pulp (FDCP) meal with multi-enzyme supplementation. Initial weight, feed conversion ratio (FCR) and mortality showed no significant ($p>0.05$) effect, while a significant ($p<0.05$) effect was observed on final live weight, weight gain and feed intake. The highest (2272.75 g) final live weight was obtained from T2 (5% FDCP), while the least (2025.00 g) was obtained from T3 (10% FDCP). The highest (1111.70 g) weight gain was observed from T2 (5% FDCP), while the least (879.34 g) was observed from T3 (10% FDCP). Birds on T4 (15% FDCP) consumed the highest (2590.00 g) while birds on T3 (10% FDCP) consumed the least (1985.00g). Cost implication showed significant ($p<0.05$) differences on the cost of feed/kg, cost of feed intake/weight gain and cost of feed intake per bird. Cost of feed/kg significantly ($p<0.05$) ranged from ₦815.18 to ₦1168.03; finisher broilers fed on T4 (15% FDCP) had the lowest value of ₦815.18, while birds on T1 (0% FDCP) had the highest value of ₦1168.03. The cost of feed intake per weight gain recorded a significant ($p<0.05$) effect that ranged from ₦6605.76 to ₦ 7397.44. T4 (15% FDCP) recorded the least value (₦6605.76), T4 was statistically similar ($p>0.05$) with T1 (0% FDCP) and T2 (5% FDCP), while those birds fed on T3 (10% FDCP) recorded the highest (₦7397.44), which was statistically similar ($p>0.05$) with birds on T1 (% FDCP) and T4 (15% FDCP). Feed intake cost/bird showed significant ($p<0.05$) variation from ₦2065.15 to ₦2959.05, birds fed on T4 (15% FDCP) had the least (₦ 2065.15) significant ($p<0.05$) feed intake cost/bird while birds fed on T1 (0% FDCP) had the highest (₦2959.05).

Final live weight and weight gain were fluctuating across dietary treatment groups, but birds fed on T3 (10% FDCP) had the lowest values of 2052.00 and 879.34 g, respectively. Birds fed on 5% FDCP had similar final weight to control (0% FDCP) and higher weight gains, suggesting a better nutrient balance, whereas 10% FDCP

Table 3. Performance quality of broiler finisher chickens fed experimental diets (5-7 weeks).

Parameters	T1(0% FDCP)	T2 (5% FDCP)	T3 (10% FDCP)	T4 (15% FDCP)	SEM	P-value
Initial weight (g)	1288.72	1161.04	1172.66	1182.42	22.77	0.231
Final weight (g)	2212.50^{a}	2272.75^{a}	2052.00^{b}	2182.00^{ab}	30.30	0.037
Weight gain (g)	905.70^{b}	1111.79^{a}	879.34^{b}	990.64^{ab}	36.38	0.041
Feed intake (g)	2535.00^{c}	2569.00^{b}	1985.00^{d}	2590.00^{a}	65.01	0.000
FCR	2.80	2.31	2.92	2.61	0.90	0.060
Mortality (%)	0.00	0.00	1.04	0.00	0.26	0.284
Cost of feed/kg (₦)	1168.03^{a}	827.93^{c}	834.43^{b}	815.18^{d}	38.30	0.000
Cost of feed intake/WG (₦)	7087.11^{ab}	5858.42^{b}	7397.44^{a}	6605.76^{ab}	245.00	0.000
Feed intake cost/bird (₦)	2959.05^{a}	2097.45^{c}	2113.92^{b}	2065.15^{d}	97.03	0.000

^{a,b,c,d} Means within the same row with different superscripts are significantly different (P<0.05). SEM = Standard error of the mean, FCR= Feed conversion ratio.

had lower final weight and weight gains, indicating potential nutrient deficiencies. Also, higher levels of inclusion of FDCP in this study could be less digestible, leading to reduced nutrient absorption and utilisation. Feed conversion ratio was comparable across all dietary groups, suggesting that the birds efficiently utilised feed regardless quantity of FDCP in their diet. This study revealed the efficiency of FDCP in replacing maize in the broiler diets up to 15% FDCP. Broiler finishers fed T3 (10% FDCP) had lower feed intake and weight gain, likely due to the reduced population resulting from mortality. However, the absence of mortality in the 0%, 5% and 15% FDCP groups suggests that the mortality in the 10% FDCP group was not directly related to the dietary FDCP level. This finding is consistent with a report by Poultry International (1994), which noted that factors such as bird age, health, ventilation and season can contribute to flock mortality.

Feed conversion ratio (FCR) is a good indicator of how broilers convert feed intake into weight gain. This was consistent with the findings of Lawan *et al.* (2018), who reported insignificant differences in broiler chickens fed different levels of baobab pulp. The mortality rate between 0.00 to 1.04 (%) obtained for broiler finishers in this finding is lower than values of 6.67-8.89% reported by Inaku *et al.* (2011) from other broiler studies in the tropics. The mortality observed indicates that FDCP from this research contained a cyanide level that is safe for birds, as discovered by Mosobalaje *et al.* (2019).

The feed costs consumed by the broilers during the study period were highest in the control group. During the finishing phase, feed cost/kg and feed intake costs/bird were significantly reduced across dietary treatment groups. This indicates that FDCP reduced feed costs during the finishing phase, thereby maximising profit, showing that the inclusion of FDCP with multi-enzyme supplementation from this study resulted in lowered feed costs per kilogram gained. The drop in the feed intake cost/kg was due to the lower cost of FDCP as an industrial by-product. This was in agreement with the conventional belief that agro-industrial by-products are readily available, cheap and reduce the cost of feeding livestock. This research supports the findings of Alu *et al.* (2012), who found that the cost of producing diet for poultry could be reduced by using agro-industrial by-products. Least cost feed intake per bird observed from varied FDCP showed that FDCP with multi-enzyme supplementation can be used to boost the energy content of broiler finisher diets in order to achieve optimum growth at a reduced cost. This is consistent with the report of Khempaka *et al.* (2014), who stated that dried cassava pulp was relatively cheap compared to maize.

The result of the haematological parameters of broiler finisher chickens fed graded levels of flashed-dried cassava pulp (FDCP) meal with multi-enzyme supplementation is presented in Table 4. There were significant (p<0.05) differences among the haemoglobin, white blood cells (WBC) and platelets, while packed cell volume (PCV) and red blood cell (WBC) showed no significant (p>0.05) differences. Haemoglobin was observed to be 8.33, 9.63, 9.23 and 9.27 g/dl for T_1, T_2, T_3 and T_4, respectively. White blood cells were 20.62 (x $10^6/mm^3$), 14.28 (x $10^6/mm^3$), 14.62 (x$10^6/mm^3$) and 13.67 (x$10^6/mm^3$) for T_1, T_2, T_3 and T_4, respectively while platelets observed were 194.33, 125.00, 145.67 and 135.00 for T1, T_2, T_3 and T_4, respectively. The haemoglobin values obtained in this study ranged from 8.33-9.63g/dL as reported by Nwaoguikpe and Ejele (2010). The highest (9.63g/dl) value obtained in this finding was observed in broilers finisher fed treatment T_2 (5% FDCP) while the least (8.33g/dl) value was from broilers finisher fed on treatment T1 (Control i.e 0%FDCP) which was not significantly (p>0.05) different from broilers finisher fed treatment T_3 (10% FDCP) and T_4 (15% FDCP). The haemoglobin value observed in T_3 (10% FDCP) and T_4 (15% FDCP) compared favourably with the control diet, suggesting that FDCP did not negatively impact the oxygen-carrying capacity of the broilers' blood. The results also suggest that the birds utilised nutrients more efficiently at the 5% FDCP level, leading to improved haemoglobin levels. This was confirmed by the red blood cells (RBC), which were not significantly (p>0.05) different from one another. Red blood cells specialize in the trans-

Table 4. Haematological parameters of broiler finishers fed experimental diet.

Parameters	T1 (0% FDCP)	T2 (5% FDCP)	T3 (10% FDCP)	T4 (15% FDCP)	SEM	p-value
PCV (%)	26.00	29.67	29.00	28.67	0.72	0.313
Haemoglobin(g/dl)	8.33^{b}	9.63^{a}	9.23^{b}	9.27^{b}	0.21	0.166
RBC (x 10^6 mm^3	2.61	2.97	2.84	2.86	0.06	0.190
WBC (x 10^6/ mm^3	20.62^{a}	14.28^{b}	14.62^{b}	13.67^{b}	0.92	0.018
Platelets (µl)	194.33^{a}	125.00^{b}	145.67^{b}	135.00^{b}	11.57	0.186

^{a,b}:Means in the same row with different superscript differed significantly (p<0.05). PCV = Packed Cell Volume, BC = Red blood cells, WBC = White blood cells.

Table 5. Serum biochemistry parameters of broiler finishers fed experimental diets.

Parameters	T1 (0% FDCP)	T2 (5% FDCP)	T3 (10% FDCP)	T4 (15% FDCP)	SEM	P value
TP (g/dl)	2.80^{b}	3.57^{a}	3.47^{a}	3.60^{a}	0.11	0.020
Albumin (g/dl)	0.53^{b}	1.07^{a}	1.00^{a}	1.20^{a}	0.30	0.074
Globulin (g/dl)	2.27^{b}	2.43^{a}	2.46^{a}	2.40^{a}	0.10	0.012
A/G	0.24^{b}	0.47^{a}	0.41^{a}	0.50^{a}	0.12	0.060
Creatinine (g/dl)	0.40^{b}	0.43^{ab}	0.50^{a}	0.47^{ab}	0.05	0.226
Glucose (mg/dl)	206.33^{b}	264.00^{ab}	230.33^{ab}	282.33^{a}	43.40	0.222

^{a,b}:Means in the same row with different superscript differed significantly (p<0.05). SEM = Standard error of mean, TP = Total protein, A/G = Albumin-globulin ratio.

portation of oxygen from the lungs to the body tissue and carbon dioxide from the body tissues to the lungs, as well as the production of haemoglobin. The values of RBC obtained in this finding were within the normal range of 2.0-4 x 10^6 mm^3 for broiler chicken reported by Akinola and Abiola (1999).

White blood cell (WBC) count is one of the important haematology assays in assessing the health status of animals. The range value obtained for WBC ranged from 13.67-20.63 x 10^6 mm$^{3.}$ The significant difference (p<0.05) exists between T_1 (0%FDCP) and others (5, 10 and 15% FDCP). The control (0% FDCP) diet had a higher (20.62 x 10^3/mm^3) value of WBC than diets containing varying levels of FDCP (5, 10 and 15%). There were no significant (p>0.05) differences among T_2, T_3 and $T_{4,}$ but WBC decreased across the group compared with the control diet, which indicates a reduced immune response due to improved health status of the experimental birds. However, the WBC observed from this study were still within the normal range of a healthy chicken of 9-31 x10^3/mm^3 as reported by Mitruka and Rawnskey (1997).

The result of serum biochemistry of broiler chickens fed graded levels of flashed-dried cassava pulp with multi-enzyme supplementation (FDCP+E) is presented in Table 5. There were significant (p<0.05) differences among all the parameters measured, such as total protein, albumin, globulin, albumin-globulin ratio, creatinine and glucose. There were no significant (p > 0.05) differences in the total protein values of birds fed treatments two to four (T_2 to T_4), while the birds fed treatment one (T_1) significantly (p < 0.05) differed from the others. The values obtained ranged from 2.80 to 3.60(g/dL), which were within the range values of normal birds of 3.30 to 5.5 (g/dl) reported by Oguwike *et al.* (2013). Nevertheless, birds fed dietary treatment T1 (0% FDCP) had values below the range. Low total protein level could result in malnutrition, disease conditions causing protein loss, liver failure and renal failure. Albumin values obtained were significantly (p<0.05) different between 0.53 to 1.20 (g/dl), but T_2 to T_4 were not significantly (p>0.05) different. However, the values obtained were within the reference value of normal birds, ranging from 1.3 to 2.8g/dl.

Globulin values obtained in this study ranged from 2.27 to 2.46g/dL. No significant (p>0.05) differences existed among the treatment groups, and values observed were within the range of a healthy bird of 1.5-4.1 g/dl (Osinubi, 2008). Albumin-globulin ratio followed the same pattern as globulin. Treatment two (5% FDCP) and four (15% FDCP) did not show any significant differences (p>0.05) in creatinine level, but significant differences (p<0.05) between treatment one (0 % FDCP) and three (10% FDCP) were observed. Significant (p<0.05) differences were observed between those birds fed on treatment one (0% FDCP) and treatment four (15% FDCP). The glucose level appeared to fluctuate as the level of FDCP increased in the diets. However, the glucose levels in the blood of all the birds fed varying levels of FDCP were higher than the normal range of a healthy bird of 211.33-258.33 mg opined by Ukoha *et al.* (2022). The higher glucose values obtained with 5%, 10% and 15% FDCP inclusion suggest that FDCP contains highly digestible carbohydrate, making it a suitable energy source in broiler diets as a replacement for maize.

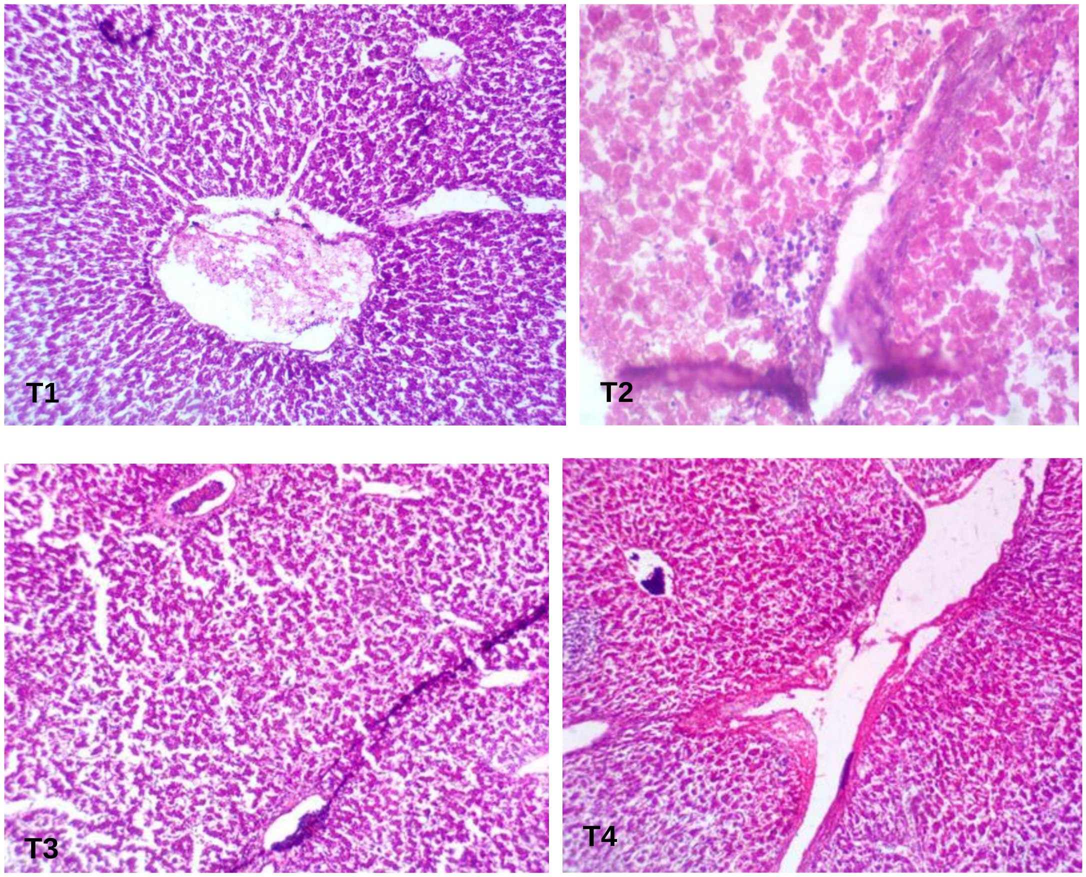
Table 6. Carcass characteristics and internal organ weights of broiler chickens fed experimental diets (0-7 weeks).

Parameters	T1 (0% FDCP)	T2 (5% FDCP)	T3 (10% FDCP)	T4 (15% FDCP)	SEM	p-value
Live weight (g)	2212.50^{a}	2272.75^{a}	2052.00^{b}	2182.00^{ab}	30.30	0.037
Dressed weight (g)	2037.50	2070.25	1899.25	1997.00	26.30	0.092
Dressed weight (%)	92.10	91.14	92.55	91.53	0.42	0.495
Eviscerated weight (g)	1741.25	1763.50	1608.50	1699.50	26.36	0.153
Eviscerated (%)	78.68	77.64	78.34	77.87	0.51	0.816
Head (%)	2.22	2.30	2.12	2.31	0.07	0.608
Neck (%)	5.64	5.76	4.98	4.97	0.15	0.386
Wings (%)	8.32	8.52	8.47	8.31	0.13	0.825
Back (%)	9.35	9.54	10.45	9.26	0.24	0.165
Chest Muscle (%)	25.79	25.12	25.99	26.98	0.53	0.736
Shank (%)	4.66	4.73	4.25	4.19	0.13	0.709
Drumstick (%)	10.99	10.62	10.57	10.57	0.17	0.870
Thigh muscle (%)	11.57	10.90	10.64	11.28	0.20	0.299
Internal organs weight (%)						
Bile	0.15	0.20	0.15	0.12	0.02	0.443
Lungs	0.39	0.43	0.49	0.51	0.03	0.958
Spleen	0.09	0.09	0.12	0.90	0.01	0.383
Liver	2.07	1.84	2.14	1.94	0.05	0.054
Heart	0.66	0.53	0.50	0.48	0.02	0.136
Proventriculous	0.39	0.41	0.46	0.40	0.02	0.591
Whole gizzard	2.93	2.40	3.04	2.88	0.10	0.114
Empty gizzard	2.19	1.91	2.20	2.16	0.07	0.114
Whole intestine	4.56^{b}	5.70^{a}	5.34^{ab}	4.98^{ab}	0.37	0.039

[a,b,:] Means in the same row with different superscript differed significantly (p<0.05), SEM = Standard error of mean.

Results of carcass characteristics and internal organ weights of the experimental broiler finishers chickens fed varied flashed-dried cassava pulp with multi-enzyme supplementation are presented on Table 6. Results revealed non-significant (p>0.05) different on dressed weight, dressed weight percentage, eviscerated weight, eviscerated weight percentage, head, neck, wings, back muscle, chest muscle, shank, drumstick, thigh muscle, bile, lungs, spleen, proventriculous, whole gizzard and empty gizzard except live weight and whole intestine that significantly (p<0.05) affected. Live weight ranged from 2052.00 to 2272.75 g, the highest (2272.75 g) significant (p<0.05) live weight was obtained from broiler chickens fed on 5% FDCP but statistically similar with those fed on 0% and 15% FDCP while the least (2052.00 g) was obtained from birds fed on 10% FDCP and not significantly (p>0.05) different from birds placed on 10% FDCP. Live weight and dressing percentage have been reported to be important indices in broiler operations (Adeyemi *et al.,* 2008). Although the live weight values did not differ significantly with the flashed-dried processing method, there was a significant fluctuation with increasing FDCP diets. This trend is in disagreement with the report of Amos *et al.* (2021), who reported a reduction in the live weight gain when fed differently processed cassava-soya bean blends to broiler chickens. The relative weights of the carcass cuts (dressing percentage, drumstick weight, thigh weight, back weight and breast weight) that were similar in this study indicate that the FDCP diets promoted similar carcass characteristics. This report also is not consistent with Amos *et al. (*2021), who opined that dietary treatment had no impact on carcass characteristics of broilers fed fermented cassava peel meal. Thus, identical carcass characteristics are attainable by feeding varied FDCP with multi-enzyme supplementation. This shows that FDCP with multi-enzyme supplementation improved live weight and compared favourably with the control group. The varied significant (p<0.05) effect between 4.56 and 5.70% was obtained from the whole intestine. FDCP inclusion in the diet increased whole intestine weight compared to the control diet; however, only treatment 2 (5% replacement level) showed a statistically significant difference from the control.

The digestive system of broiler finishers fed with the FDCP from this study compared favourably with the control group, which showed that FDCP with multi-enzymes in this study did not negatively affect the digestive system of broiler finisher chickens. This research is consistent with the report of Khempaka *et al.* (2009), who reported that insoluble fibre modulates gut develop-



Plates 1 to 4. Liver histology of broiler finishers fed varying flashed-dried cassava pulp supplemented with multi-enzymes. **T1 (x 400).** A normal liver architecture with normal-looking hepatocytes arranged in cords; **T2 (x 400).** Mild focal periportal cellular infiltration, suggestive of periportal hepatitis (arrow). Swollen hepatocytes with loss of nuclei, indicating degeneration progressing to necrosis; **T3 (x 400)** Mild liver periportal cellular infiltration and thickening; and **T4 (x 400)** Marked widespread periportal thickening and inflammation. Presence of mild areas of coagulative necrosis (arrow).

ment, digestive function, and digestive system activity.

Plates 1 to 4 show liver histology of broiler finishers fed varying flashed-dried cassava pulp supplemented with multi-enzymes. The treatment groups showed liver damage, characterised by hepatic architecture and cellular composition, most notably in Groups T3 and T4, with evidence of fibrosis, cellular infiltration, necrosis, and sinusoidal changes. The control group (T1) maintained normal liver architecture with minimal infiltration. This research suggests the presence of anti-nutritional factors like cyanide in FDCP that caused the observed liver changes in broiler finishers in this study. The observed liver alteration in this study is consistent with the report of Zaefarian *et al.* (2019), who reported liver changes (necrosis, hepatosis, etc).

Conclusion

Varied levels of flashed-dried cassava pulp (FDCP) improved performance characteristics of broiler finisher chickens and maximised profits. The haematological and serum biochemistry parameters from this finding indicated a non-adverse effect of the flashed-dried cassava pulp up to a 15% inclusion level. The FDCP diets provided nutritional benefits, improving the health status of the broiler finisher chickens. Also, FDCP with multi-enzyme supplementation had a positive effect on the carcass and internal organ weights of broiler finishers.

Recommendation

Based on the outcome of this study, 5% FDCP with multi-enzyme supplementation is recommended in broiler chicken nutrition. Further research should investigate the effects of higher inclusion levels of high-quality flashed-dried cassava pulp, focusing on monitoring cyanide levels through laboratory analysis and ensuring feed balance, particularly protein and amino acid levels.

CONFLICT OF INTEREST

No conflict of interest before, during and after the study of the experiment.

ACKNOWLEDGEMENTS

This research was financially supported by the Tertiary Education Trust Fund (TETFUND). Authors also appreciate the Management of Oyo State College of Agriculture and Technology for the provision of the enabling environment for the conduct of the research.

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