EFFECT OF MULTI-ENZYME SUPPLEMENTED *CASSOYA*-BASED DIETS ON PERFORMANCE, GUT MORPHOLOGY AND ECONOMY OF PRODUCTION OF FINISHING BROILER CHICKENS

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Abstract: This study assessed the effect of multi-enzyme supplemented *cassoya*-based (40:60 mixture of cassava root meal and full-fat soybeans) diets on growth performance morphometric analysis and economy of production of broiler chickens. Three hundred day-old *ROSS 308* broiler chickens were studied for 6 weeks; using 6 dietary treatments with 5 replicates of 10 birds each. *Cassoya* inclusion levels of 0, 50 and 100 % were used in the first to third treatments without enzyme while the fourth to sixth had 10 g/ton multi-enzyme supplementation. Data collected were subjected to Analysis of Variance in a Completely Randomized Design. *Cassoya* inclusion significantly influenced ($p<0.05$) the final weight, daily weight gain, feed intake, feed conversion ratio, feed cost per kg weight gain. Birds fed 0% and 50% cassoya with enzyme inclusion showed higher ($p<0.05$) values 2040.00g and 1918.00g respectively for final weight. Improved values of 1.82 and 257.72 naira/kg gain were recorded respectively for feed conversion ratio and feed cost per kg in birds fed 50% cassoya with enzyme supplementation. Villus height and crepth depth in duodenum and jejunum were significantly influenced by dietary treatments. In conclusion, cassoya diet at 50 % inclusion level with enzyme supplementation improves growth performance and gut health in broiler finisher chickens.

Key words: Growth performance, gut morphology, cassoya, multi enzyme, cost-benefit

Introduction

Poultry meat consumption helps to meet shortfalls in essential nutrients and contributes to the overall quality of the diet in specific ages and conditions (prior to conception, during pregnancy up to the end of breastfeeding, during growth, and in the geriatric age) and is suitable for general population (Mottet and Tempio, 2017). However, in Nigeria, production of poultry meat has been difficult due to high cost of feed impregnated by scarcity due to weather challenges and competition with human beings (Iji *et al*., 2011). Meanwhile, it can be concluded that the major causes of high cost of feed are climate change issues which have posed serious threat to maize availability; maize being the major energy source in poultry feed (Chang'a *et al*., 2020). There is the scarcity and near absence of maize in the Nigerian markets. The factors responsible for this being the scarcity and high cost of this crop, climate change, increased competition between humans and animals for the feed ingredients; especially maize, and activities of traders buying and hoarding the grains (Iji *et al*., 2011; Chang'a *et al*., 2020; Godde *et al*., 2021; Cheng *et al*., 2022). However, with increasing demand for livestock products as a result of rapid growth in the world economies, future hopes of feeding the animals and safeguarding their food security will depend on the better utilization of unconventional feed resources and improved supplementation of cassava (Bhuiyan *et al*., 2012; Beriso, 2022).

Cassava is available throughout the year in Nigeria (Chang'a *et al*., 2020) and its capability to replace maize, regarding its energy and nutrient content among other factors, has been studied, favourably considered and suggested (Morgan and Choct, 2016; Broch *et al*., 2017; Pradyawong *et al*., 2018). Different parts of cassava can be used as animal feed; the leaves and the tubers (FAOSTAT, 2017). Thus, cassava can fill the gap in the feed supply, decrease competition for food between humans and animals, reduce feed cost and contribute to self-sufficiency in nutrients from locally available feed sources (Mnisi *et al*., 2023). Fortification of cassava with full fat soya bean could improve the protein value and reduces dustiness. Enzyme supplementation aids unlocking the nutrient and improve gut health. This study determined the performance characteristics, guts-morphology and economy of broiler chickens production fed *cassoya* diets with multi-enzyme supplementation.

Materials and Methods

Experimental Site

The studies were carried out at the Poultry Unit of the Directorate of University Farms (DUFARMS), College of Animal Science and Livestock Production, Federal University of Agriculture, Abeokuta, Ogun-State, Nigeria. The farm is located on latitude 7° 13' 35.48"N and Longitude 3° 26' 12.38"E with an elevation of 415 feet and eye altitude of 700 feet. This area lies in the rainforest vegetation zone which has humid climatic condition with an average rainfall of 1,037 mm, a mean ambient temperature of about 34.7 ºC and yearly average relative humidity of 83 % (Oni *et al*., 2017).

Experimental Materials

Cassava tubers were procured from a private farm in Odeda Local Government, Ogun State while the full-fat soybean grains were acquired commercially and other feed ingredients were obtained from a reputable feed mill in Abeokuta. Cassava tubers were washed in clean water, grated, screwpressed and dried with solar drier. Cassava and full-fat soya were mixed manually in ratio 40:60 respectively. Nutrivitas limited supplied multi-enzyme Ronoxyme(R) multigrains, which contains endo 1,4 – beta – xylanase (EC 3.2.1.8), glucanase (EC 3.2.1.6) and endo 1,4, beta glucanase EC 3.2.1.4).

Experimental Birds and Management
Three hundred day-old *ROSS 308* broiler chickens purchased from AGRITED Nigeria limited were reared on battery cage system from day old to the finisher phase (4 – 6 weeks). Routine management and medication (drug and vaccines) programmes were observed. The birds were given feed and water *ad libitum.*

Experimental Design
The three hundred day–old broiler chicks were randomly allotted to six dietary treatments with each treatment group being further divided into five replicate groups of ten birds each in a 3x2 factorial arrangement. Complete Randomized Design was used.

Experimental Diets
The experimental diets (Tables 1) consisted of six dietary *cassoya* inclusion levels replacing 0 %, 50 %, and 100 % maize with full-fat soya; with and without multi-enzyme supplementation at 10 g/ton.

Table 1: Percentage composition of experimental diets during the starter phase (0 - 3weeks)

	-Enzyme			**+Enzyme**		
	0%	**50%**	**100%**	**0%**	**50%**	**100%**
Ingredients	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
Maize	41.2	20.6	-	41.2	20.6	-
FFSB	49.0	24.5	-	49.0	24.5	-
Cassoya	-	45.1	90.2	-	45.1	90.2
W/offal	5.8	5.8	5.8	5.8	5.8	5.8
Bone meal	1.0	1.0	1.0	1.0	1.0	1.0
Oyster shell	2.0	2.0	2.0	2.0	2.0	2.0
Lysine	0.1	0.1	0.1	0.1	0.1	0.1
Methionine	0.3	0.3	0.3	0.3	0.3	0.3
Premix	0.3	0.3	0.3	0.3	0.3	0.3
Salt	0.3	0.3	0.3	0.3	0.3	0.3
Total	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis						
Crude protein (%)	23.26	22.66	21.23	23.26	22.66	21.23
Fat (%)	8.50	8.42	7.90	8.50	8.42	7.90
Fibre (%)	6.50	6.71	7.54	6.50	6.71	7.54
Ash (%)	8.60	8.42	8.36	8.60	8.42	8.36
NFE (%)	50.74	51.35	52.98	50.74	51.35	52.98

FFSB – full-fat soya bean. Premix composition per 2.5kg feed the following; Vitamin A (I.U.) 12,000,000, Vit. D_3 (I.U.) 2,500,000, Vit. E (mg) 40,000, Vit. K (mg) 2,000, Vit. B_1 (mg) 3,000, Vit. B_2 (mg) 4,000, Biotin (mg) 75, Folic Acid (mg) 1,000, Niacin (mg) 50,000, Co.(mg) 300, Cu (mg) 8,000, I (mg) 1,500 Se (mg) 120, Zn (mg) 60,000, Fe (mg) 40, 000, Mn (mg) 100,000, Cl (mg) 300,000. NFE - Nitrogen free extract.

Table 2: Percentage composition of experimental diets during the finisher phase (4 – 6 weeks)

	-Enzyme			**+Enzyme**		
	0%	**50%**	**100%**	**0%**	**50%**	**100%**
Ingredients	**D1**	**D2**	**D3**	**D4**	**D5**	**D6**
Maize	48.0	25.96	-	48.0	25.96	-
FFSB	36	18	-	36	18	-
Cassoya	-	42.9	85.8	-	42.9	85.8
W/offal	12	12	11	12	12	11
Bone meal	0.7	0.7	0.7	0.7	1.0	0.7
Oyster shell	2.0	2.0	2.0	2.0	2.0	2.0
Lysine	0.5	0.1	0.5	0.5	0.1	0.5
Methionine	0.2	0.3	0.2	0.2	0.3	0.2
Premix	0.3	0.3	0.3	0.3	0.3	0.3
Salt	0.3	0.3	0.3	0.3	0.3	0.3
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis						
Crude protein (%)	20.34	20.01	19.57	20.34	20.01	19.57
Fat (%)	9.00	8.51	8.50	9.00	8.51	8.50
Fibre (%)	6.50	6.71	7.54	6.50	6.71	7.54
Ash (%)	8.60	8.60	10.00	8.60	8.60	10.00
NFE (%)	56.83	55.08	53.62	56.83	55.08	53.62

FFSB - full-fat soya bean. Premix composition per 2.5kg feed the following; Vitamin A (I.U.) 12,000,000, Vit. D_3 (I.U.) 2,500,000, Vit. E (mg) 40,000, Vit. K (mg) 2,000, Vit. B_1 (mg) 3,000, Vit. B_2 (mg) 4,000, Biotin (mg) 75, Folic Acid (mg) 1,000, Niacin (mg) 50,000, D Caal. Pn (mp) 11,000, Co. (mg) 300, Cu (mg) 8,000, I (mg) 1,500 Se (mg) 120, Zn (mg) 60,000, Fe (mg) 40, 000, Mn (mg) 100,000, Cl (mg) 300,000. NFE - Nitrogen free extract.

Data collection

Performance characteristics

The initial weights of the birds were taken. The live weights of the birds as well as the feed consumption of each replicate were measured weekly. Feed conversion ratio for each replicate was calculated by dividing the feed intake by the weight gain.

$$Feed\ intake/bird\ (g) = \frac{Quantity\ of\ feed\ fed - Quntity\ of\ feed\ left\ over}{Number\ of\ birds\ \times 28\ days}$$

$$Daily\ weight\ gain\ (g) = \frac{Final\ live\ weight - Initial\ weight}{Number\ of\ birds\ \times 28\ days}$$

$$Feed\ conversion\ ratio = \frac{Quantity\ of\ feed\ consumed}{Weight\ gain}$$

Gut morphometry

About 0.5 cm portion was taken at the medium part of each of the three intestinal segments (duodenum, jejunum and ileum) and used for histological measurements. The samples were opened longitudinally, rinsed with cold saline and fixed in a buffered formalin solution. Histological analysis was done according to the procedures of Goodlad *et al*. (1991). The preparations were mounted between slide and strip. Intestinal villi with their crypts were, individually, separated under a dissecting microscope while the length and width of the villi were measured according to the procedures described by Hampson (1986).

Experimental model

$Y_{ijkl} = \mu + S_i + P_j + (SP)_{ij} + \sum_{ijk}$

Where

Y_{ijk} = Trait of interest

μ = Population mean

S_i = Fixed effect due to i^{th} cassoya level

P_j = Fixed effect due to $_j{}^{th}$ enzyme supplementation

$(SP)_{ij}$ = Interaction effect of i^{th} cassoya level and $_j{}^{th}$ enzyme supplementation

$\sum_{ijk}$ = Random residual error

Results

Proximate Analysis of Cassava and Full-fat Soya

The proximate analysis of cassava and full-fat soya used in *cassoya* diet formulation (Table 3) revealed 94.0 % and 84.50 % dry matter, 1.75 % and 34.74 % crude protein, 5.0 % and 16.5 % ether extract, 13 % and 8 % crude fibre and 1.5 % and 6.5 % ash respectively. Neutral detergent fibre, Acid detergent fibre and Acid detergent lignin for cassava were 26 %, 7 % and 0.59 % while they were 44 %, 29 % and 3.0 % respectively for full-fat soya.

Table 3: Proximate composition of cassava root and full-fat soybeans

Parameter	Cassava	Full-fat soybeans
Moisture (%)	6.00	15.50
Ash (%)	1.50	6.50
Ether Extract (%)	5.00	16.50
Crude fibre (%)	13.00	8.00
Dry matter (%)	94.00	84.50
NFE (%)	78.75	34.26
Crude protein (%)	1.75	34.74
ADL (%)	0.50	3.00
NDF (%)	26.00	44.00
ADF (%)	7.00	29.00
Calculated		
Metabolisable energy (kcal/kg)	3265.88	3839.76

NFE: Nitrogen free extract, ME: metabolisable energy, NDF: neutral detergent fibre, ADF: acid detergent fibre, ADL: acid detergent lignin.

Effects of cassoya inclusion and enzyme supplementation on performance characteristics and cost benefit analysis of finishing broiler chickens (4-6 weeks)

The effects of *cassoya* inclusion and enzyme supplementation on performance characteristics and cost benefit analysis of finishing broiler chickens as shown in Table 4 revealed that final live weight, daily weight gain, feed intake, feed conversion ratio, feed cost per kg weight gain, feed cost per kg were significantly influenced ($p<0.05$). Final live weight (1890.00 g and 1719.00 g), total weight gain (1181 g and 1088.70 g), and daily weight gain (56.20 g and 51.80 g) were significantly similar and higher ($p<0.05$) for birds fed 0 % and 50 % *cassoya* while the least values of 1220 g, 621.10 g, 29.62 g were recorded for birds fed 100 % *cassoya* respectively. Improved value of 2.10 was recorded for feed conversion ratio in birds fed 50 % cassoya. Enzyme supplementation also showed lower value of 2.10 for FCR at comparative level. Feed intake and feed cost per kg decreased with increased inclusion level of *cassoya* and values ranged from 74.67 g to 122.20 g and ₦ 117.90 to ₦149.70 g respectively. The mean value of cost per kg weight gain of birds fed 50 % *cassoya* (₦277.92) was the least while that of 0 % cassoya recorded the highest value (₦332.72). Protein efficiency ratio was not significantly influenced ($p>0.05$) by *cassoya* inclusion. Enzyme supplementation showed significant effect ($p<0.05$) on initial weight, finial live weight, total weight gain, protein efficiency ratio and feed cost per kg. Feed conversion ratio and feed cost per kg weight gain were better in birds fed enzyme supplemented diets (2.10 and ₦291.48) compared to (2.57 and ₦ 319.83) obtained in birds fed diets without enzyme supplementation. Daily weight gain and feed intake were not significantly ($p>0.05$) affected by enzyme supplementation.

Interaction effect of cassoya inclusion and multi-enzyme supplementation on performance characteristics and cost benefit analysis of finishing broiler chickens (4-6 weeks)

Table 5 shows the interaction effect of *cassoya* inclusion and multi-enzyme supplementation on performance characteristics and cost benefit analysis of finishing broiler chickens. *Cassoya* inclusion and enzyme supplementation significantly ($p<0.05$) affected the initial weights of the birds with values that ranged from 540.40 g to 803.80 g. Birds on 0 % and 50 % *cassoya* with enzyme had similar values of 803.80 g and 752.00 g, those offered 0 % and 50 % *cassoya* without enzyme and 100 % *cassoya* with enzyme also had similar values ($p<0.05$) of 614.00 g, 625.80 g and 655.40 g respectively. The final live weight of birds ranged from 1090 g to 2040 g, higher values 2040 g and 1918 g were obtained in birds fed 0 % and 50 % *cassoya* with enzyme, followed by 1740.00 g recorded for birds on 0 % *cassoya* without enzyme, while the least value was obtained in 100 % *cassoya* without enzyme. Similar trend was observed for total weight gain of birds fed 50 % and 100 % *cassoya*. Daily weight gain values ranged from 26.17 g to 61.10 g, higher numerical values of 58.88 g and 61.10 g were obtained in 0 % and 50 % *cassoya* respectively while the least was obtained in birds fed 100 % *cassoya* without enzyme supplementation. Higher feed intake value of 125.04 g was recorded for birds on 0 % *cassoya* without enzyme, followed by 119.50 g and 110.19 g recorded for birds on 0 % and 50 % *cassoya* with enzyme supplementation. Lowest similar values 72.28 g and 77.00 g were obtained in birds offered 100 % *cassoya* with and without enzyme supplementation respectively. Feed conversion ratio value of 1.82 was recorded in birds fed 50 % *cassoya* with enzyme and highest value of 3.01 was obtained in birds fed 100 % *cassoya* without enzyme. Protein efficiency ratio values ranged from 1.74 to 2.94, highest value was obtained in those on 50 % *cassoya* with enzyme while least was recorded for those on 100 % *cassoya* without enzyme. Feed cost per kg varied significantly (p<0.05) among the dietary treatments, the values ranged from ₦109.70 to ₦157.90; highest value was recorded for birds on 0 % *cassoya* with enzyme and least in 100 % *cassoya* without enzyme. Feed cost per kg weight gain ranged from ₦257.62 to ₦334.10. Birds fed 0 % *cassoya* with enzyme had the highest value of ₦334.10, similar to those obtained in 0 % and 100 % *cassoya* without enzyme. Lowest value of ₦257.62 per kg weight gain was obtained in birds on 50 % *cassoya* with enzyme supplementation.

Table 4: **Main effects of *cassoya* inclusion and multi-enzyme supplementation on performance characteristics and cost benefit analysis of finishing broiler chickens (4-6) week**

	Cassoya inclusion				Enzyme supplementation		
Parameters	0%	50%	100%	SEM	-Enzyme	+ Enzyme	SEM
Initial weight (g/bird)	709.00[a]	688.90[a]	597.90[b]	12.69	593.53[b]	737.07[a]	10.3
Final weight (g/bird)	1890.00[a]	1719.00[a]	1220.00[b]	47.89	1450.00[b]	1769.30[a]	39.10
Total weight gain (g/bird)	1181.00[a]	1088.70[a]	621.10[b]	51.69	856.50[b]	1071.40[a]	42.21
Daily weight gain (g/bird)	56.20[a]	51.80[a]	29.62[b]	2.46	40.78[b]	51.02[a]	2.01
Daily feed intake (g/bird)	122.20[a]	106.04[b]	74.67[c]	2.71	100.66	101.33	2.22
Feed conversion ratio	2.20[ab]	2.10[b]	2.63[a]	0.09	2.57[a]	2.10[b]	0.10
Protein efficiency ratio	2.35	2.47	2.03	0.12	1.95[b]	2.62[a]	0.33
Feed cost per kg (₦)	149.70[a]	133.40[b]	117.90[c]	0.00	125.54[b]	131.60[a]	0.00
Feed cost per kg gain (₦)	332.72[a]	277.92[b]	306.27[ab]	15.74	319.80 [a]	291.48 [b]	12.85

[abc]Means on the same row having different superscript are significantly (P<0.05) different

Table 5: Interaction effect of *cassoya* inclusion and multi-enzyme supplementation on performance characteristics and cost benefit analysis of finishing broiler chickens (4-6) week

	-Enzyme			+Enzyme			
Parameter	0%	50%	100%	0%	50%	100%	SEM
Initial weight gain (g/bird)	614.00[b]	625.80[b]	540.40[c]	803.80[a]	752.0[a]	655.40[b]	17.95
Final weight (g/bird)	1740.00 [b]	1520.00[c]	1090.00[e]	2040.00[a]	1918.00[a]	1350.00[d]	67.73
Total weight gain (g/bird)	1125.60[b]	894.20[c]	549.60[e]	1236.40[a]	1283.20[a]	694.6[d]	73.11
Daily weight gain (g/bird)	53.60[a]	42.58[b]	26.17[d]	58.88[a]	61.10[a]	33.08[c]	3.48
Daily feed intake (g/bird)	125.04[a]	101.90[c]	77.06[d]	119.50[ab]	110.19[bc]	72.28[d]	3.85
Feed conversion ratio	2.34[bc]	2.33[b]	3.01[a]	2.12[bc]	1.82[c]	2.24[bc]	1.65
Protein efficiency ratio	2.09[bc]	2.01[c]	1.74[c]	2.60[ab]	2.94[a]	2.32[bc]	0.28
Feed cost per kg (₦)	141.62[b]	125.30[e]	109.70[f]	157.90[a]	141.60[c]	125.30[e]	0.00
Feed cost per kg gain (₦)	331.39[a]	298.21[ab]	329.90[a]	334.10[a]	257.62[b]	282.72[ab]	22.25

[abcdef] Means on the same row having different superscript are significantly different (P<0.05)

Main effects of *cassoya* inclusion level and multi-enzyme supplementation on morphology indices of finishing broiler chickens (4-6 weeks)

The main effects of *cassoya* inclusion and enzyme supplementation on morphology indices of finishing broiler chickens (Table 6) showed significant differences (p< 0.05) in values obtained in duodenum villus height, ileum villus height, and ileum villus height to crepth ratio. Higher significant similar (p<0.05) values of 1136.70 µm and 1150.00 µm, 736 µm and 738 µm and 2.89 µm and 3.15 µm were obtained in birds fed 0 % and 50 % *cassoya* respectively, and least values were obtained in birds fed 100 % *cassoya* inclusion. No significant value (p> 0.05) was obtained for other parameters measured. Enzyme supplementation has significant (p<0.05) differences in all the parameter measured, with the exception of ileum crepth depth. Birds fed enzyme supplemented diets had the highest values while those on diet without enzyme recorded the least values.

Interaction effect of *cassoya* inclusion level and multi-enzyme supplementation on morphology indices of finishing broiler chickens (4-6 weeks)

Table 7 shows the interaction effect of *cassoya* inclusion and multi-enzyme supplementation on the morphology indices of finishing broiler chickens. There were significant differences ($p<0.05$) in duodenum villus height, duodenum crepth depth, jejunum villus height, jejunum crepth depth, jejunum villus height to crepth ratio, and ileum villus height. Other parameters were not affected ($p<0.05$) by the interaction of *cassoya* and enzyme supplementation. Duodenum villus height values ranged from 873.80 µm to 1365 µm, with the birds on 0 % and 50 % *cassoya* with enzyme having the highest values of 1365 µm and 1300 µm. Duodenum villus height to crepth depth ratio and jejunum villus height ranged from 3.65 to 5.81 µm, and 758 µm to 986 µm respectively, with the highest similar values in birds fed 0 % and 50 % *cassoya* with enzyme while the least was recorded for birds fed 100 % *cassoya* without enzyme. For jejunum villus height to crepth depth ratio, birds fed *cassoya* diets supplemented with enzyme had higher values of 4.41, 4.34 and 4.03 µm compared to 2.59, 3.43, and 3.26 µm recorded for those on diets without enzyme. Highest jejunum crepth depth was obtained in birds fed 50 % *cassoya* with enzyme. Ileum villus height had higher similar values 924 µm and 818 µm in birds fed 0 % and 50 % *cassoya* with enzyme while the least values were recorded in other dietary treatment.

Table 6: Main effects of *cassoya* inclusion level and multi-enzyme supplementation on morphology indices of finishing broiler chickens

		Cassoya inclusion				Enzyme supplementation		
	Parameters(µm)	0%	50%	100%	SEM	-Enzyme	+Enzyme	SEM
Duodenum	Villus height	1136.70[a]	115.00[a]	887.40[b]	40.10	904.07[b]	1188.67[a]	40.60
	Crepth depth	244.00	225.00	246.0	8.50	233.33[b]	243.33[a]	9.00
	Villus height/ crepth depth	4.82	4.98	3.75	0.20	3.98[b]	5.05[a]	0.70
Jejunum	Villus height	873.00	883	809.9	21.30	771.33[b]	939.27[a]	21.8
	Crepth depth	261.50	241.00	231	9.10	264.67[a]	225.67[b]	9.60
	Villus height/ crepth depth	3.88	3.88	3.31	0.18	3.09[b]	4.26[a]	0.68
Ileum	Villus height	736.00[a]	737.00[a]	564.00[b]	29.40	597.00[b]	772.0[a]	29.90
	Crepth depth	265.00	241.00	268.00	8.70	261.33	254.67	9.20
	Villus height/ crepth depth	2.89[a]	3.15[a]	2.17[b]	0.14	2.36[b]	3.12[a]	0.64

[abc] Means on the same row having different superscript are significantly ($P<0.05$) different

Table 7: Interaction effect of *cassoya* inclusion level and multi-enzyme supplementation on morphology indices of finishing broiler chickens

		-Enzyme			+Enzyme			
	Parameter (µm)	0%	50%	100%	0%	50%	100%	SEM
Duodenum	Villus height	908.40[b]	930.00[b]	873.80[b]	1365[a]	1300[a]	901[b]	40.80
	Crepth depth	248	210	242	240	240	250	9.20
	Villus height/ crepth depth	3.83[b]	4.46[b]	3.65[b]	5.81[a]	5.50[a]	3.85[b]	0.90
Jejunum	Villus height	776.0[b]	780.00[b]	758[b]	970.00[a]	986.00[a]	861.80[b]	22.00
	Crepth depth	238[a]	248[b]	308[a]	224[b]	238[b]	215[b]	9.80
	Villus height/ crepth depth	2.59[b]	3.43[b]	3.26[b]	4.41[a]	4.34[a]	4.03[a]	0.88
Ileum	Villus height	583[b]	654[b]	554[b]	924[a]	818[a]	574.0[b]	30.10
	Crepth depth	250	262	272	280	220	264	9.40
	Villus height/ crepth depth	2.39	2.50	2.18	3.40	3.79	2.16	0.84

[abcdef] Means on the same row having different superscript are significantly ($P<0.05$) different

Discussion

Improved final live weight and daily weight gain observed with inclusion levels of 0 % and 50 % *cassoya* with enzyme supplementation could be attributed to better feed intake and better nutrient utilization. It also implies that more energy must have been made available and utilized by the birds for improved weight gain. This improvement on 0 % and 50 % *cassoya* could be linked to favourable nutrients composition and improved feed utilization (Bhuiyan and Iji, 2015; Chang'a *et al*., 2020). This is supported by the report of Bedford *et al*. (1998). Generally, *cassava* is low in crude protein and more fibrous but with the formulation of *cassoya* that is mixture of cassava and full-fat soya, the oil improved the palatability. The use of carbohydrase enzyme in the present study supported increase in total weight gain, final live weight, and daily weight gain (Wickramasuriya *et al*., 2021). This corroborated the previous findings of Agbede *et al.* (2002) that synthetic enzymes complement the digestive enzymes of poultry to enhance the digestibility. Generally, *cassoya* diets either supplemented or not supply energy similar to that of maize for growth. The joint effect of maize and 50 % *cassoya* replacement resulted in better weight gain and final live weight. Improved feed conversion ratio observed in birds fed 50 % cassoya with enzyme supplementation could be attributed to improved enzymatic digestion and the rate of nutrient utilization (Agbede, 2002). Different result was obtained by Obiakonu and Udedibe (2006) that the ratio of growth and feed intake is poor when sun-dried cassava was used to replace maize. Increased feed intake was observed in birds offered *cassoya* diet with enzyme because birds eat to satisfy energy need. This observation is contrary to the report of Tahir *et al.* (2005) that multi-grains enzyme improved growth without showing any effect on feed consumption. Reduced growth observed in 100 % *cassoya* with enzyme could be as a result of reduced appetite due to gut filled sensation with fibre and inadequate substrate for degradation (Adeola and Olukosi 2008). Birds fed 0 % *cassoya* without enzyme recorded the highest feed intake compared to 0 % and 50 % *cassoya* with enzyme. This supports the work of Samarasinghe *et al.* (2000), who found out that feed intake decreased with the addition of feed enzyme due to bird fulfilling their nutrient requirement by taking less amount of feed. Carbohydrase enzyme improved *cassoya* diets on broiler chicken with better performance (Giacobbo *et al*., 2021) compared to proact enzyme in a previous experiment might be attributed to the fact that enzyme utilization should be based on its profile. This is in line with the report of Attia *et al.* (2008) that diet composition will determine the type of enzyme to be used for production.

The cost of the control diet was the most expensive compared to *cassoya* diet. Birds fed 50 % *cassoya* with enzyme supplementation had the least feed cost per unit gain in weight which showed a beneficial effect of enzyme supplementation on *cassoya*-based diet for broiler chickens and this showed that enzyme supplementation is economical (Alam *et al*., 2003: Altaf *et al.,* 2007).

Highest values obtained for duodenum villus height in the duodenum of birds fed 50% cassoya could be attributed to ability of the birds to consume and utilize more nutrients and this showed in the improved value recorded for growth performance. Higher values obtained for morphological parameters with the exception of ileum crepth depth and jejunum crepth depth could be attributed to efficient activity of enzyme. Previous findings confirmed that the increase in intestinal component resulted in increased villus surface which enhanced the total luminal villus absorptive area and subsequently resulted in adequate digestive enzyme action and higher transport of nutrients at the villus surface (Cera *et al*., 1988). Increased values were revealed in birds fed 0 % and 50 % *cassoya* with enzyme supplementation on duodenum villus height, duodenum villus height to crepth depth ratio, jejunum villus height, jejunum villus height to crepth depth ratio and ileum villus height. This was the major reason behind the improved performance observed. Increase in surface area as a result of increase in intestinal structure might have enhanced nutrient absorption and improved nutrient digestibility (Caspary, 1992). This result further agreed with the findings of Viveros *et al.* (1994) that enzyme supplementation increased the villi, crepth length, width and increased the relative number of the goblet cells. Reduction in jejunum crept depth as for broiler fed with enzyme may be related to low sensory activities. According to Hedemann *et al.* (2003) increase and decrease in cell turn over and rate of sensory activity is directly related to crepth depth and villi length. On the contrary, Iji *et al.* (2001) and Wu *et al.* (2004) reported that addition of xylanase to wheat-based diets had no effect on morphometric parameters of broilers. It can be inferred from this study that incorporation of exogenous multi-enzymes influenced the intestinal morphology of the broiler chickens (Giacobbo *et al*., 2021) and therefore, 50 % *cassoya* inclusion level with enzyme supplementation is recommended in poultry diet for finishers.

Conclusion

From this study, *cassoya* could replace 50 % maize in finisher broiler chickens diets for efficient growth response. Cassoya diet at 50 % inclusion level with enzyme supplementation in broiler finisher diet is therefore recommended for improvement of growth performance and gut health.

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Conflict of Interests

The authors declare that there is no conflict of interests.

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