NUTRITIONAL IMPLICATIONS OF *CASSOYA* DIET SUPPLEMENTED WITH MULTI-ENZYME ON HAEMATOLOGY, SERUM AND CARCASS CHARACTERISTICS OF A COMMERCIAL BROILER STRAIN

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Abstract: This study was conducted to evaluate the utilization of *cassoya*-based diets, (40:60 mixture of cassava root meal and full-fat soybean) supplemented with multi-enzyme for broiler chickens on haematological, biochemical and carcass and organ characteristics. The experiment involved the use of 300 day-old *ROSS 308* broiler chickens. The birds were allotted to 6 dietary treatments (T) for 42 days with 50 birds per treatment and 5 replicates, in a 3x2 factorial arrangement, T1 – T3 contained *cassoya* at 0, 50 and 100 % without enzyme while T4 - T6 had protease enzyme 10 g/tonne. Data on carcass characteristics were collected and subjected to Analysis of Variance in a Completely Randomized Design. Birds on enzyme supplemented diets recorded the highest values ($p<0.05$) for carcass weight and gut morphology. The mean values for final live weight ranged from 1112.20 g to 1738.60 g, highest values were obtained in birds fed 0 % and 50 % *cassoya* with enzyme supplementation while the least was obtained in birds fed 100 % *cassoya* without enzyme supplementation. *Cassoya* diet at 50 % level of inclusion with multi-enzyme supplementation in broiler starter and finisher diets is recommended for improved performance.

Keywords: Carcass; *cassoya*; enzyme; haematology; biochemical; multi-enzyme.

Introduction

The shortage of feed resources for livestock and poultry feeding has prompted various researches in the field of animal nutrition to discover novel feed resources that are cheap, nutritive and locally available (Amata, 2014; Chisoro *et al*., 2023). The practicability of using non-cereal grain feed resources as the basis for intensive poultry production is gradually increasing (Beriso, 2022). The mixture of cassava with full-fat soya helps to reduce its dustiness while also increasing its protein content (Amos *et al*., 2021). Enzyme supplementation in *cassoya*-based diet to be fed to poultry is required to facilitate nutrient availability and utilization while destroying the toxins and inhibitors in the feed (Alagawany *et al*., 2018). It can also reduce the excretion of nitrogen and phosphorus, among other elements that can pollute the environment, in poultry manure (Alagawany *et al*., 2018).

Haematological and serum parameters are good indicators of the functional status of animals and they can be used to assess their exposure to toxicants (Joshi *et al*., 2002; Malik *et al*., 2013). Changes in the haematology as well as serum biochemistry can also be used to determine stress due to environmental, nutritional and pathological factors (Ewuola *et al*., 2017; Aikpitanyi and Egweh, 2020).Proper utilization of feed is reflected in the carcass yield which is an indicator of nutrient utilization (Bamgbose and Niba, 1998). The effect of enzyme supplementation on carcass traits in poultry has been reported by many researchers (Eruvbetine *et al*., 2002; Alam *et al*., 2003; Wang *et al*., 2005; Bharathidhasan *et al*., 2009; Rougiere and Carre, 2010; Svihus, 2011 and Meremikwu *et al*., 2013). The objective of this study is to assess the nutritional effects of *cassoya* diets supplemented with multi-enzyme on haematology, serum biochemical indices and carcass characteristics of a broiler chickens.

Materials and Methods

Management of Experimental Animals

A total of three hundred day-old Ross 308 broiler chickens were purchased from AGRITED Nigeria limited. The poultry pen and the equipment were thoroughly washed and disinfected before the arrival of the chicks. The birds were raised on battery cage system. They were reared in two phases: starter phase (0-3 weeks) and finisher phase (4-6 weeks). Routine management and medication (drug and vaccines) programs were observed. Feed and water were supplied to the birds *ad libitum.*

Experimental Design

The three hundred day–old broiler chicks were randomly allotted to six dietary treatments. Each treatment group was further divided into five replicate groups of 10 birds each in a 3x2 factorial, using Complete Randomized Design.

Experimental Diet

The experimental diets consist of six dietary *cassoya* inclusion levels replacing 0 %, 50 %, and 100 % maize and full-fat soya with and without Ronoxyme® multigrains enzyme supplementation at 10 kg per ton. Tables 1 and 2 show the six experimental diets formulated.

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

	-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

Premix composition per 2.5kg feed supplied 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. FFSB - full fat soya bean.

Table 2: Percentage composition of experimental finisher diets (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

Premix composition per 2.5kg feed supplied 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. FFSB- full fat soya bean

Data Collection

Carcass Evaluation

At the end of the feeding trial, two birds per replicate were randomly selected, weighed and slaughtered for carcass evaluation. Prior to slaughtering, the sampled birds were fasted overnight. Live weight, dressed weight, dressing percentage, cut-up parts (thigh, drumstick, breast, back, wings, head, neck and shanks) and organs (gizzard, liver, lungs, kidney and abdominal fat) were excised and weighed. The weights of the cut-up parts and organs were expressed as percentages of the live weight.

Haematological and Serum Parameters

At the end of the study, 2.5 ml each of blood was collected from two birds per replicate through a jugular vein into the bottles containing ethylene diamine tetra acetate (EDTA). Haematological procedure was carried out according to Jain (1986) in determining the following parameters: Packed Cell Volume (PCV), White Blood Cell (WBC), Haemoglobin (Hb), Red Blood Cell (RBC), Mean Cell Haemoglobin Concentration (MCHC), Mean Cell Haemoglobin (MCH) and Mean Cell Volume (MCV).. Another 2.5 ml was collected in hypodermic syringe to determine serum metabolites (total protein, creatinine, globulin, albumin, uric acid and creatinine).

Statistical Analysis

All data generated were subjected to Analysis of Variance (ANOVA) using SAS statistical package (SAS, 1999). Means were separated using Duncan' Multiple Range Test of the software package. The experimental layout was 3x2 factorial arrangements in a randomized complete design.

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

Table 3 shows the main effects of *cassoya* inclusion and multi-enzyme supplementation on haematological indices of the finishing broiler chickens. The result indicated that the packed cell volume, haemoglobin, red blood cell, mean corpuscular haemglobin concentration and mean corpuscular volume were not significantly ($p>0.05$) influenced by *cassoya* inclusion levels. However white blood cell was significantly ($p<0.05$) affected by *cassoya* inclusion level. The values ranged from 6.98 to 8.24 X 10^3/L. The higher values were obtained in birds fed 50 % and 100 % *cassoya* inclusion while the least value was obtained in birds fed 0 % *cassoya* inclusion. Result of enzyme supplementation showed significant influence ($p<0.05$) on white blood cell, heterophil and lymphocytes. Higher values of 8.66 X 10^3/L, 34.70 % and 73.13 % were recorded for white blood cell, heterophil and lymphocytes respectively in birds fed enzyme supplementation diets. All other parameters were not significantly ($p>0.05$) affected.

Interaction effect of *cassoya* inclusion and multi-enzyme supplementation is presented in Table 4. There were significant differences ($p<0.05$) in white blood cell, heterophil and lymphocytes. White blood cell value ranged from 7.08 % to 9.40 X 10^3/L, the highest white blood cell values were obtained in birds Fed 50 % and 100 % *cassoya* with enzyme and least was obtained in 0 % *cassoya* without enzyme supplementation. Heterophil values ranged from 16.6 % to 34.6 %; highest value was obtained in birds fed 0 % *cassoya* without enzyme, followed by birds on 50 % *cassoya* with enzyme and 50 % *cassoya* without enzyme while the least was obtained in birds on 100 % *cassoya* without enzyme. Lymphocyte values ranged from 60.40 % to 75.30 % with higher values recorded for birds fed 50 % *cassoya* diet with enzyme while the least were obtained in those on diet without enzyme.

Table 3: Main effects of *cassoya* inclusion and multi-enzyme supplementation on haematological parameters of finishing broiler chickens

Supplementation	*Cassoya* inclusion				Enzyme		
Parameters	0%	50%	100%	SEM	-Enzyme	+Enzyme	SEM
Packed cell volume (%)	27.60	27.40	27.20	0.71	27.40	27.40	0.58
Haemoglobin (g/dl)	10.24	9.09	9.12	0.58	9.16	9.80	0.47
Red blood cell (x 10^{12}/l)	1.98	1.96	1.92	0.05	1.97	1.94	0.05
Mean corpuscular haemoglobin (pg)	46.76	46.37	46.84	0.37	46.61	46.69	0.31
Mean corpuscular haemoglobin concentration (g/dl)	33.49	33.18	33.51	0.22	33.44	33.34	0.18
Mean corpuscular volume (fl)	113.89	113.97	113.98	0.08	113.88	114.01	0.07
White blood cell (x 10^3/L)	6.98^b	8.24^a	8.40^a	0.36	7.09^b	8.66^a	0.25
Heterophil (%)	30.70	24.10	25.90	1.54	27.23^b	34.70^a	1.30
Lymphocyte (%)	65.50	72.40	70.60	1.87	64.87^b	73.13^a	0.26
Eosinophil (%)	4.30	4.30	3.90	0.31	4.07	4.27	0.31
Monocyte (%)	1.50	1.00	0.60	0.38	1.33	0.73	0.00
Basophil (%)	-	-	-	-	-	-	-

^{abc} Means on the same row having different superscript are significantly ($P<0.05$) different

Table 4: Interaction effect of *cassoya* inclusion and multi-enzyme supplementation on haematological parameters of finishing broiler chickens.

	-Enzyme			+Enzyme			
Parameters	0%	50%	100%	0%	50%	100%	SEM
Packed cell volume (%)	27.40	28.40	26.40	27.80	26.40	28.00	1.01
Haemoglobin (g/dl)	9.20	9.40	8.84	11.26	8.78	9.38	0.82
Red blood cell (x10 ^{12}/l)	1.98	2.04	1.88	1.98	1.88	1.97	0.08
Mean corpuscular haemoglobin (pg)	46.70	46.10	47.03	46.80	46.60	46.64	0.52
Mean corpuscular haemoglobin concentration (g/dl)	33.66	33.11	33.55	33.31	33.25	33.47	0.31
Mean corpuscular volume (fl)	113.72	113.92	114.02	114.05	114.02	113.94	0.11
White blood cell (x10^3)	6.30^{d}	7.08^{dc}	7.88^{bc}	7.66^{bc}	9.40^{a}	8.92^{a}	1.43
Heterophil (%)	34.60^{a}	31.60^{ab}	16.60^{d}	29.65^{bc}	31.03^{b}	26.43^{c}	2.17
Lymphocyte (%)	60.40^{c}	67.50^{c}	67.20^{c}	70.00^{ba}	75.30^{a}	74.00^{ba}	2.65
Eosinophil (%)	4.00	4.20	4.00	4.60	4.40	3.80	0.44
Monocyte (%)	2.20	1.20	0.60	0.80	0.80	0.60	0.54
Basophil (%)	-	-	-	-	-	-	-

^{abcdef} Means on the same row having different superscript are significantly (P<0.05) different

Table 5 shows the main effects of *cassoya* inclusion and multi-enzyme supplementation on blood serum metabolites of the finishing broiler chickens. The result revealed that total protein, aspartate alanine transferase, globulin, cholesterol and uric acid were significantly (p<0.05) influenced by *cassoya* inclusion. Total protein values ranged between 5.04 mg/dl and 5.84 mg/dl, with the highest value obtained in 50 % *cassoya* and least similar values in 0 % and 100 % *cassoya*, globulin values ranged between 1.89 mg/dl and 2.64 mg/d; the highest value was obtained in birds fed 100 % cassoya while the least was recorded in those on 0 % cassoya. Uric acid and cholesterol values ranged from 1.59 mg/dl to 2.23 mg/dl and 62.65 mg/dl to 85.94 mg/dl respectively. Highest values for uric acid and cholesterol were obtained in birds fed 100 % *cassoya*, while least similar values were obtained in birds fed 0 % and 50 % *cassoya*. Aspartate alanine transferase recorded the highest value in birds on 50 % *cassoya* while the least was obtained in 100 % *cassoya*; its mean values ranged between 18.3 u/l and 30.6 u/l. Enzyme supplementation revealed significant influence (P<0.05) on cholesterol and uric acid. The highest values were obtained in birds fed diet without enzyme. The values ranged from 64.47 mg/dl to 76.83 mg/dl and 1.43 mg/dl to 2.32 mg/dl respectively.

Interaction effect of *cassoya* inclusion and multi-enzyme supplementation on serum metabolites of the finishing broiler chickens is shown in Table 6. The result showed significant (p<0.05) effect on all the parameters with the exception of albumin. Total protein, globulin and cholesterol values ranged between 4.80 mg/dl and 6.38 mg/dl, 1.76 mg/dl and 2.97 mg/dl and 61.28 mg/dl and106.04 mg/dl respectively; the highest mean value for cholesterol was obtained in 100 % *cassoya* without enzyme supplementation, while the least was obtained in 0 % *cassoya* without enzyme. Birds fed 50 % *cassoya* with enzyme supplementation recorded the highest value for total protein and globulin. Aspartate amino transferase and alanine amino transferase recorded highest values in 50 % *cassoya* inclusion with enzyme supplementation, followed by 0 % *cassoya* without enzyme supplementation. The least similar values were obtained in 50 % *cassoya*, 100 % *cassoya* without enzyme and 100 % *cassoya* with enzyme supplementation. Their values ranged between 22.60 u/l and 63.20 u/l and 16 u/l and 45.20 u/l. Glucose mean values ranged between 215.60 and 268 mg/dl, birds on 0 % cassoya with enzyme and 50 % *cassoya* without enzyme had the highest similar values while those on 100 % *cassoya* without enzyme had the lowest value. Mean values for uric acid ranged between 1.06 mg/dl and 2.48 mg/dl. Birds fed *cassoya* diets without enzyme had the highest insignificant values while those on 50 % *cassoya* with enzyme depicted the least values. Creatinine values ranged from 0.42 mg/dl in birds fed 50 % *cassoya* without enzyme to 1.02 mg/dl in those placed on 0 % *cassoya* without enzyme while birds on 50 % without enzyme recorded the least value.

Table 5: Main effects of *cassoya* diets and multi-enzyme supplementation on serum metabolites of finishing broiler chickens

	Cassoya inclusion				Enzyme supplementation		
Parameters	0%	50%	100%	SEM	-Enzyme	+Enzyme	SEM
Total protein (mg/dl)	5.04^{b}	5.84^{a}	5.34^{b}	0.10	5.09	5.72	0.40
Globulin (mg/dl)	1.89^{c}	2.22^{b}	2.64^{a}	0.09	2.27	2.45	0.08
Albumin (mg/dl)	3.23	3.62	2.70	0.07	2.82	3.26	0.05
AST (u/l)	38.80	42.90	32.70	2.55	35.40	40.87	2.08
ALT(u/l)	24.00^{ab}	30.60^{a}	18.30^{c}	1.95	22.13	26.47	1.59
Cholesterol (mg/dl)	63.36^{b}	62.65^{b}	85.94^{a}	0.91	76.83^{a}	64.47^{b}	0.74
Glucose (mg/dl)	256.40	246.10	235.20	5.08	240.87	250.93	5.38
Uric acid (mg/dl)	1.81^{ab}	1.59^{b}	2.23^{a}	0.12	2.32^{a}	1.43^{b}	0.10
Creatinine (mg/dl)	0.81	0.70	0.59	0.09	0.63	0.71	0.08

^{abc} Means on the same row having different superscript are significantly (P<0.05) different

Table 6: Interaction effect of *cassoya* diets and multi-enzyme supplementation on serum metabolite of finishing broiler chickens

	-Enzyme			+Enzyme			
Parameter	0%	50%	100%	0%	50%	100%	SEM
Total protein (mg/dl)	4.80^{d}	5.30^{bc}	5.18^{c}	5.28^{bc}	6.38^{a}	5.49^{b}	0.80
Globulin(mg/dl)	1.76^{c}	2.09^{bc}	2.97^{a}	2.03^{bc}	2.97^{a}	2.35^{b}	0.13
Albumin(mg/dl)	3.04	3.21	2.21	3.25	3.39	3.13	0.09
AST (u/l)	50.80^{b}	22.60^{c}	32.80^{c}	26.80^{c}	63.20^{a}	32.60^{c}	3.60
ALT(u/l)	31.40^{b}	16.00^{c}	19.00^{c}	16.60^{c}	45.20^{a}	17.60^{c}	2.76
Cholesterol (mg/dl)	61.28^{c}	63.18^{bc}	106.04^{a}	65.44^{b}	62.12^{bc}	65.84^{b}	1.28
Glucose (mg/dl)	244.80^{abc}	262.20^{a}	215.60^{c}	268.00^{a}	230.00^{bc}	254.80^{ab}	5.78
Uric acid (mg/dl)	2.36^{a}	2.12^{a}	2.48^{a}	1.26^{c}	1.06^{c}	1.98^{b}	1.76
Creatinine (mg/dl)	1.02^{a}	0.42^{c}	0.46^{c}	0.6^{bc}	0.98^{ba}	0.56^{c}	1.33

^{abcdef} Means on the same row having different superscript are significantly (P<0.05) different

The main effects of *cassoya* inclusion and multi-enzyme supplementation on carcass characteristics of finishing broiler chickens fed *cassoya* diets are presented in Table 7. *Cassoya* inclusion revealed significant effect (p< 0.05) on final live weight, plucked weight, eviscerated weight, dressed percentages, shank, liver and intestine values. Higher similar significant values were obtained in birds fed 0 % and 50 % *cassoya* for final live weight 1890 g, 1719 g and plucked weight 1544 g and 1430 g respectively while the least value was obtained in birds offered 100 % *cassoya*. Birds fed 0 % *cassoya* recorded higher eviscerated weight value 1241.00 g followed by birds offered 50 % *cassoya* while the least value 826.50 g was obtained in birds that received 100 % cassoya. Similar (p<0.05) dress percentage values 71.85 % and 69.52 % were obtained in 0 % and 50 % *cassoya* while the highest was recorded in birds fed 100 % *cassoya*. Birds fed 100 % *cassoya* had the highest value for shank 4.7 %, head 3.69 %, liver 2.02 % and intestine 6.69 %; lowest mean values were obtained in 0 % and 50 % cassoya. Enzyme supplementation revealed higher significant (p<0.05) values for final weight 1772.67 g, plucked weight 1496 g, dressed weight 1268 g and eviscerated weight 1132.00 g while the least parameters were obtained in diets without enzyme supplementation.

Table 8 shows the interaction between *cassoya* inclusion and enzyme supplementation on carcass characteristics of finishing broiler chickens. Significant differences (p< 0.05) existed for final live weight, plucked weight, dressing weight, eviscerated, shank weight, head weight and liver weight. Final live weight mean values ranged from 1130 g to 2040 g, highest similar values were obtained in birds fed 0 % and 50 % *cassoya* with enzyme supplementation while the least was obtained in birds fed 100 % *cassoya* without enzyme. Mean values ranging (p<0.05) from 1058 g, 890 g 767 g were obtained for plucked weight, dress weight and eviscerated weight in birds fed 100 % cassoya without enzyme to 1658.00 g,1474.00 g and 1332.00 g in birds that received 0 % cassoya with enzyme. Head mean values ranged (p<0.05) from 2.96 to 3.82 % in birds fed 50 % *cassoya* with enzyme and the least was obtained in birds fed 100 % cassoya without enzyme. Shank and liver values ranged from 3.34 % and 1.65 % in birds fed 0 % *cassoya*

without enzyme to 5.03 % and 2.12 % obtained in birds fed 100 % cassoya without enzyme. Intestinal weight ranged between 3.20 and 6.81 %, birds on 50 % and 100 % *cassoya* without enzyme and *cassoya* with enzyme had higher values while the least was obtained on 0 % *cassoya* without enzyme. Birds on 50 % and 0 % *cassoya* had similar values.

Table 7: Main effects of *cassoya* diets and multi-enzyme supplementation on carcass characteristics of finishing broiler chickens

	Cassoya inclusion				Enzyme supplementation		
Parameter	0 %	50 %	100 %	SEM	-Enzyme	+Enzyme	SEM
Final live Weight (g/bird)	1890.00^{a}	1719.00^{a}	1220.00^{b}	47.09	1450.00^{b}	1769.30^{a}	39.10
Plucked weight (g/bird)	1544.00^{a}	1430.00^{a}	1149.00	40.62	1252.67^{b}	1496.00^{a}	44.59
Dressed weight (g/bird)	1358.00	1195.00	955.00	33.65	1070.67^{b}	1268.00^{a}	40.66
Eviscerated weight (g/bird)	1241.00^{a}	1059.00^{b}	826.5	30.07	952.33^{b}	1132.00^{a}	39.75
Dressing percentage (g/bird)	71.85^{b}	69.52^{b}	78.27^{a}	2.58	74.69	72.03	2.98
Cut part (% live weight)							
Neck	3.1	2.75	3.063	0.17	2.98	2.98	0.14
Shank	3.66^{b}	4.19^{ab}	4.70^{a}	0.33	4.24	4.19	0.70
Head	3.04^{b}	3.17^{b}	3.69	0.16	3.40	3.20	0.60
Drumstick	9.03	8.95	9.56	0.44	9.35	9.01	0.75
Thigh	10.22	10.45	9.28	0.48	9.49	10.49	0.77
Breast	16.69	17.11	15.57	0.81	15.84	17.07	0.96
Back	13.25	12.53	13.05	0.67	13.17	12.72	0.86
Wing	7.46	7.45	7.91	0.28	7.67	7.55	0.66
Organs weight (%liveweight)							
Gizzard	1.75	1.66	1.74	0.10	1.72	1.72	0.11
Liver	1.67	1.76^{ab}	2.016^{a}	0.09	1.86	1.77	0.11
Heart	0.43	0..45	0.50	0.04	0.48	0.45	0.07
Lung	0.31	0.44	0.45	0.56	0.42	0.46	0.08
Intestinal weight	4.06^{b}	5.47^{ab}	6.69^{a}	0.55	5.26	5.56	0.85
Spleen	0.11	0.155	0.14	0.02	0.12	0.15	0.06
Abdomial fat	1.02	1.192	0.74	0.02	0.81	1.07	0.60
Proventriculus	0.48	0.49	0.57	0.04	0.52	0.50	0.07

^{abc} Means on the same row having different superscript are significantly (P<0.05) different

Table 8: Interaction effect of *cassoya* diets and multi-enzyme supplementation on carcass characteristics finishing broiler chicken

	-Enzyme			+Enzyme			
Parameter	0%	50%	100%	0%	50%	100%	SEM
Final live weight (g/bird)	1740.00^{b}	1520.00^{c}	1090.0^{d}	2040.0^{a}	1918.00^{ab}	1350.00^{c}	67.73
Plucked weight (g/bird)	1430.00^{bc}	1270.00^{cd}	1058.0^{e}	1658.0^{a}	1590.0^{ab}	1240.00^{d}	57.44
Dressed weight (g/bird)	1242.00^{b}	1080.00^{c}	890.00^{d}	1474.0^{a}	1310.00^{b}	1020.00^{cd}	47.59
Eviscerated weight (g/bird)	1150.00^{b}	940.00^{c}	767.00^{d}	1332.0^{a}	1178.00^{b}	886.00^{cd}	42.53
Dressing percentage (g/bird)	71.38	71.05	81.65	72.25	68.30	75.55	3.69
Cut part (%live weight)							
Neck	3.03	2.84	3.07	3.21	2.67	3.06	0.24
Shank	3.34^{b}	4.36^{ab}	5.03^{a}	3.99^{ab}	4.02^{ab}	4.56^{ab}	0.47
Head	3.00^{b}	3.37^{ab}	3.82^{a}	3.08^{b}	2.96^{b}	3.56^{ab}	0.23
Drumstick	8.63	9.44	9.99	9.42	8.45	9.14	0.62
Thigh	9.89	9.61	8.98	10.56	10.80	10.11	0.67
Breast	16.38	15.56	15.59	17.01	18.41	15.80	1.14
Back	12.95	12.78	13.78	13.55	12.28	12.34	0.94
Wing	7.19	7.75	8.10	7.76	7.16	7.73	0.40
Organs weight (% live weight)	-	-	-	-	-	-	-
Gizzard	1.65	1.75	1.77	1.86	1.58	1.72	0.14
Liver	1.65^{b}	1.82^{ab}	2.12^{a}	1.69^{b}	1.70^{b}	1.91^{ab}	0.13
Heart	0.47	0.46	0.41	0.39	0.45	0.50	0.05
Lung	0.32	0.45	0.48	0.50	0.44	0.43	0.78
Intestinal weight	3.20^{b}	5.77^{a}	6.81^{a}	4.92^{ab}	5.17^{ab}	6.58^{a}	0.73
Spleen	0.09	0.14	0.13	0.13	0.17	0.14	0.03
Abdominal fat	1.10	0.97	0.62	0.93	1.42	0.87	0.25
Proventriculus	0.48	0.53	0.56	0.48	0.45	0.58	0.05

^{abcdef} Means on the same row having different superscript are significantly (P<0.05) different

Discussion

The haematology and serum biochemistry are the routine methods used for detection of health status of domestic animals (Malik *et al.,* 2013). Packed cell volume and haemoglobin values reported in this study were in line with the values reported by Bounous *et al.* (2000) 22-35 % and 7-13 g/dl. The effect of *cassoya* inclusion on white blood cell varied, birds fed 50 % and 100 % *cassoya* recorded higher values compared to those on control diets, however the values were within the normal range for chickens. This is an indication that the birds were in good health throughout the experimental period. White blood cell, heterophil and lymphocyte values were higher with enzyme supplementation; the values were within the reference range for healthy birds (Jain, 1993). Decrease in white blood cells is an indication of allergic condition and presence of antibody (Muhammad and Oloyede, 2009). Birds fed cassoya with enzyme supplemented diets had higher lymphocyte values which were within the normal values reported by (McDonald, 1996). Low lymphocyte value is an indication of stress which could be as a result of high fiber and anti-nutrient in diets, which often causes low blood carrying capacity with resultant growth impairment (Muhammad and Oloyede, 2009). It also corroborates the work of Hampton *et al. (*2002) that there were improvements in health of poultry birds as a result of carbohydrase enzyme supplementation.

In this study, *cassoya* dietary inclusion significantly affected the total protein and globulin, though the values were within the normal physiological range for chickens (Suchint *et al.,* 2004), with values 5-8 g/dl and 2.33-3.33 g/dl. Birds on 50 % *cassoya* had the highest total protein value which could be attributed to good protein reserve for tissue development. Higher serum protein is an indication of protein adequacy (Ahamefule *et al.,* 2006). Differences observed in blood globulin across the dietary treatments can be attributed to evaluation technique which is directly related to total protein and albumin. Birds fed *cassoya* with enzyme supplementation had the highest total protein and this trend shows the adequacy of protein in diet with enzyme activities. Awosanya *et al*. (1999) reported that there is a linear relationship between dietary protein and blood protein. Birds fed 50 % *cassoya* had the highest alanine amino transferase values which were also similar to those on 0 % *cassoya*, though values observed fall within the normal range for health chickens, which is indicative of absence of damage to liver cells (Monica, 1987). Aspertate amino transferase and alanine amino transferase were higher in birds fed 50 % *cassoya* with enzyme, though the values recorded in this study were lower to those in literature, implying that the livers of the birds were in good condition.

The highest cholesterol value was obtained in birds fed 100 % *cassoya*, probably due to increased lipid concentration as a result of enzyme action. This is further justified by the findings of Guyton and Hall (2006) who reported that one of the factors that affected cholesterol was changing from the degree of activation of specific enzyme which is directly responsible for lipid substrate metabolism. Creatinine, cholesterol and uric acid values showed that the birds reacted positively to the diet. Cholesterol and uric acid values were reduced in birds fed enzyme supplemented diet. Cholesterol level is an indication of emulsification process, depicting health benefit of the diets on the experimental birds. According to Gunarson (2006), fat metabolism can be assessed by measuring cholesterol level; higher levels indicate pothyroidism and hepatilipidosis. Cholesterol values obtained in this study ranged from 61.28 to 106.4 mg/dl, which is below the range 129-297 mg/dl reported for adult chicken by Clinical Diagnostic Division (1990). Variation could be linked to processes of lipid metabolism, nutrient profile and birds' age. Glucose values obtained ranged between 215 and 268 mg/dl which falls within the normal range 200-400 mg/dl reported by Mc Donald, (1996). This showed the benefit of the nutrient components to the birds and the importance of dietary energy to broiler chickens in this study. Uric acid is a function of protein quality, high levels indicate low quality protein. The reduced value obtained from birds on *cassoya* and enzyme supplementation compared to those on diet without enzyme suggests a better utilization and absorption of amino acid profile in the diet of birds fed enzyme, which also reflected in their performance. The highest creatinine value of 1.02 mg/dl was obtained in birds fed 0 % *cassoya* without enzyme while the least 0.42 mg/dl was recorded in 50 % *cassoya* without enzyme. This is an indication of balanced nutrient. The highest value obtained was in line with the value 0.9-1.85 mg/dl reported by Mitruka and Rawsley (1977). It is also in agreement with the earlier study that the lower the value of creatinine for a particular feed stuff, the better the protein quality (Ologhobo *et al.,* 2007). Furthermore, creatinine value is an indicator of muscle mass catabolism (Ladokun *et al*., 2008).

The values obtained for the carcass yield was similar to normal values in literature which show that *cassoya* inclusion had no detrimental effects on the carcass yield. Birds on 0 % and 50 % *cassoya* inclusion had similar higher values for final live weight, plucked weight and eviscerated weight; this could be attributed to good nutrient utilization and resultant effect of performance characteristics. Birds fed 100 % *cassoya* had the highest values of the head, shank, liver and intestinal weights, showing that carcass weight has indirect relationship to the cut part. The observation in this study is in partial agreement with the report of Borin *et al.* (2006) that the weight of cut part increased with an increase in cassava leaf meal. Variation in dressing percentage is a reflection of final live weight. Meanwhile when enzyme was supplemented, higher values were obtained for final live weight, plucked weight, eviscerated weight and dressed weight compared to those on diet without enzyme. This could be as a result of efficient digestibility and absorption of nutrients. Carcass characteristics follow the same trend with that of growth performance, birds on 0 % *cassoya* and 50 % *cassoya* with enzyme had higher final live weight, plucked weight, eviscerated weight and dressed weight compared to those on similar diet without enzyme which indicates the activities of enzyme in growth improvement. This contradicted the findings of Kidd *et al*. (2001) who reported insignificant effects of enzyme on carcass yield and internal organs. The liver weight of birds fed 100 % *cassoya* diet without enzyme was higher. The increment could be attributed to its function as detoxifier (Ameafule and Obioha, 2005). Liver has major role in detoxification; the values obtained suggest that there were no serious toxicity problems with the test diet. This is further justified by the

ALT and AST values obtained. Intestinal weight increased with increased inclusion levels of cassoya diet; which could be linked to high fiber level, resulting in increased retention time of digesta of fibrous diets (Amerah *et al*., 2009). Also, intestinal increase may be due to heavier muscles of the intestinal wall which is a direct response to the greater amount of feed that the animal would necessarily have to hold in gastro-intestinal tract. These observations were contrary to the findings of Omojola and Adeshinwa (2007) who reported that the inclusion of exogenous enzyme in broiler diets had no effect on the relative weights of kidney, gizzard, heart and the liver. Similarly, they contradict Shirluck *et al.* (1981) who reported that the cut part had linear relationship with carcass yield. Lower insignificant abdominal fat values were obtained with dietary inclusion in this study. This indicates the adequacy of crude protein in the diets; which is in line with the findings of Yalçin *et al*. (2010) that feeding broiler chickens diets containing 19.2 %, 16.6 %, and 15.5 % crude protein (low protein) led to an increase in total carcass fat deposition compared with chickens fed diets containing 22.9 %, 19.9 %, and 18.2 % crude protein, which were the standards recommended by NRC (1994) in the starter, grower and finisher phases respectively.

Conclusion

Cassoya diet at 50 % level of inclusion with multi-enzyme supplementation improved carcass yield. This study revealed that inclusion of *cassoya* up to 50 % level of inclusion had no detrimental effect on finisher broiler chickens.

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Conflict of Interests

The authors declare that there is no conflict of interests.

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