

Replacement Value of Cassava Root - Sandbox Seed Meal Mixture For Maize on Growth Performance, Blood Indices and Economics of Broiler Chickens

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Target Audience: Cassava farmers, broiler chicken rearers, animal nutritionists, animal physiologists, livestock feed companies

Abstract

This study determined the replacement value of cassava root – sandbox seed meal (CRSBSM) mixture for maize on growth performance, blood indices and economics of broilers. A total of 300 chicks with average body weight (101.08±0.02 g/bird) were randomly allotted in a completely randomized design into five treatments with three replicates of 30 birds each. Five diets were formulated where maize replaced CRSBSM at 0, 25, 50, 75 and 100 % representing T1, T2, T3, T4 and T5 respectively. Proximate composition and energy contents of sandbox seed and cassava root meal were determined, respectively. Results showed that sandbox seed meal is high in oil (15.49 %) and metabolizable energy (3440.95 Kcal/Kg), moderate in crude fibre (8.32 %) and crude protein (29.43 %), while cassava root meal has low crude protein (2.18 %), moderate crude fibre (6.14 %) and low metabolizable energy (2901.29 Kcal/Kg). Growth indices showed no significant ($p>0.05$) differences and protein efficiency showed significantly ($p<0.05$) deteriorating values. The total feed cost and total production cost significantly ($p<0.05$) decreased across treatments. The cost-gain ratio was significantly ($p<0.05$) better for birds in T2, T3 and T4. The blood chemistry was enhanced with increasing replacement levels. In conclusion, maize in broiler chicken diets could be replaced with CRSBSM up to 75% without deleterious effects on performance of broiler chickens.

Keywords: Blood; cassava; chicken; cost; growth; sandbox

Description of problem

Feed represents the biggest single cost that livestock farmers face and represents more than 55% of the total production cost [1, 2]. Longe [3] reported that the cost of ingredients could be as high as 80 % of the

total cost of production of broiler diets. The proportion of maize in monogastric diets ranges from 50 to 70%, which implies that the high cost of maize as being currently experienced due to low level of production and higher consumption rates by man and

agro-allied industries, will surely not only affect the cost of livestock feeds but its products [4].

Maize grain has remained the major source of energy in poultry feeds in Nigeria, its high cost has made it a major hindrance to animal production in developing countries [5, 6]. Several attempts have been made to reduce the cost of livestock products by replacing percentages of maize with agro - industrial by products such as wheat offal, maize offal, rice offal and other lesser unknown but cheap feedstuffs like cassava root meal, sandbox seed meal, etc. [7,8,9].

Cassava root meal which is essentially an energy source (2360Kcal/Kg), has a protein level of between 1 and 1.4 % which is of poor quality [10]. It is cheaper than maize, sorghum and millet. It is high in linamarin and lotaustralin. These anti-nutrients can impair digestion and can be detrimental to the animal's health. However, processing methods such as cooking, sun-drying, oven drying, roasting and ensiling or fermentation have been found to reduce the toxins to a tolerable level for livestock [11].

Another good alternative feedstuff to maize is Sandbox (*Hura crepitans*) seed meal. It is a shade tree with thorny trunk, commonly found on roadsides and villages in Nigeria. There have been reports of observations of some free ranging turkeys scrambling to pick and swallow whole seeds as they burst forth from dehiscing fruits. The dry matter of the seed (91 - 95%) is quite comparable to those of the conventional feedstuffs. The crude protein of 30.1% reflects a value that

although lower than that of soya bean and groundnut, its amino acid levels is compared favourably with most conventional feedstuffs [12]. The seed is also very high in energy 38.95-51.24 %, an attribute that could help in complementing the relatively poor energy level of cassava root meal. The relatively high protein level of sandbox seed meal can boast the poor crude protein content of cassava root meal. However, the anti-nutrients in sandbox seed meal include oxalate, tannins, alkaloids, saponins, flavonoids, cyanogenic glucosides and trypsin inhibitors [12].

This study was therefore designed to evaluate the growth performance, blood indices and economics of broiler chickens fed replacement levels of cassava root-sandbox mixture (CRSBSM) for maize in broiler chicken diets.

Materials and Methods

Study location

The study was carried out at the Teaching and Research Farm, University of Calabar. Calabar is located within the Tropical Rain Forest Zone of Nigeria, with an average humidity of 88 %; an average rainfall of 3,076 mm per annum, while its average (high) temperature is 33.01 °C (86.2 °F) and average (low) temperature of 22.5 °C (72.5 °F) with elevation of 32 meters (105 ft) above sea level [13].

Collection and preparation of test ingredients

The cassava variety of Tropical Manihot

Species (TMS) 3057 was purchased from the Crop Science Research Farm, University of Calabar. The fresh tubers were peeled and washed, chopped into small pieces and sun dried to constant weight for 7 days before being milled and stored in an air tight bag. Mature sandbox seeds were harvested from sandbox trees within Calabar Metropolis. The raw seeds after being obtained from broken pods were oven dried at 60°C (SAISHO S-196 model hot oven). Both the sandbox seeds and the cassava roots were milled in a meadows model 35 hammer mill and sieved through a mesh of 5mm. Their proximate composition was determined using standard AOAC methods.

Oil was extracted from the sandbox seed meal through mechanical means as described by Archibong *et al.* [14]. The mixture was prepared by mixing cassava root meal and sandbox seed meal at a ratio of 3:1 respectively to represent the experimental test ingredient/ mixture.

Experimental animals, management, diets and design

A total of three hundred (300), 7 days- old Abor acre broiler chicks were ordered from FIDAN farms, Ibadan- Nigeria and used for the experiment. Brooding lasted for two weeks before the commencement of the feeding trial. The chicks were randomly assigned to five dietary treatments of three replicates per treatment of 20 birds each in a completely randomized design (CRD). Five experimental diets for both starter and finisher phases were formulated to meet the

nutrient requirements of broiler chickens. The T1 which served as the control contained 0 % CRSBSM while T2, T3, T4 and T5 had 25, 50, 75 and 100 % of CRSBSM as replacement for maize. The feeding trial lasted for eight weeks, where the broiler chicks were fed starter diets for four weeks (0-4 weeks) and the finisher diets from the 5th - 8th weeks. Feed and water were given *ad libitum*. The birds were weighed at the beginning of the experiment and thereafter on a weekly basis. Daily feed intake was determined by weighing the feed offered and the leftover. The weight gain was calculated by subtracting the initial body weight from the current body weight and the value for weight gain was determined. Weight gain.

$$\frac{\text{New weight} - \text{initial weight}}{7 \text{ days}}$$

The feed conversion ratio was calculated as the ratio of the average daily feed intake to average daily weight gain.

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

Blood samples were collected from two birds per replicate at the end of the feeding trial through the wing vein of which about 2.5 ml of blood sample per bird were collected into sterilized bottles containing ethylene diamine tetra acetic acid (EDTA) as an anti-coagulant for the determination of haematological parameters. The second set of bottles that was without EDTA was used

for serum biochemical analysis; where the blood was allowed to stand for 2 hours at room temperature to obtain the serum, then centrifuged using the high speed Wintrobes Microhaematocrit reader to separate the cells. The serum indices analyzed included the serum total protein, globulin, albumin and urea acid through the methods described by Benzie and Strain [15]. Haematological indices determined were packed cell volume (PCV), red blood cell count (RBC), white blood cell count (WBC) and haemoglobin concentration (Hb). The improved Neubauer Haemocytometer method described by Jain [16] was used to estimate the red and white blood cells. Haemoglobin, mean corpuscular haemoglobin concentration (MCHC), mean corpuscular concentration (MHC) were determined according to the methods of Jain [16]; PCV was determined to Wintrobe Microhaematocrit method [17].

The cost analysis using appropriate formula were used to determine the economics of production based on the prevailing local market prices of feedstuffs in Calabar during the study.

Feed cos/Kg = sum of prices of ingredients/ Kilogram of feed

Total feed cost = Total feed intake × Feed cost/Kg/100

Total cost of feed consumed/Kg = Cost of feed/Kg(n) × Total feed consumed (Kg/bird)

Cost of feed/Kg live weight gain(N) = Total cost of feed consumed/Kg (N) / Total weight gain (g/bird).

Cost - gain ratio = Total cost of production / Total revenue

Statistical analysis

Data collected was subjected to one - way analysis of variance (ANOVA) using SAS [18], significant means were separated using Duncan's multiple range test [19].

Table 1: Gross composition of experimental starter diets

seed Ingredient	Replacement levels of maize with Cassava Root meal mixture (CRSBSM)				-Sandbox
	T1(0%)	T2(25%)	T3(50%)	T4(75%)	T5(100%)
Maize	54.00	40.50	27.00	13.50	0.00
CRSBSM	0	13.50	27.00	40.50	54.00
Soybean meal	33.00	33.00	33.00	33.00	33.00
Wheat offal	6.00	6.00	6.00	6.00	6.00
Fish meal	3.00	3.00	3.00	3.00	3.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Oyster shell	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
*Vit/min. pre.	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Determined analysis:					
Crude protein (%)	23.48	23.50	23.52	23.54	23.56
Crude fibre (%)	3.89	3.97	3.99	4.34	4.89
*ME (Kcal/Kg)	2980.09	2986.94	2989.67	2995.05	3004.50

*ME(Kcal/Kg) = 37x %CP+81.1 + %EE+ 35.5 x % NFE [20]

Table 2: Gross composition of experimental finisher diets

seed Ingredient	Replacement levels of maize with Cassava Root meal mixture (CRSBSM)				-Sandbox
	T1(0%)	T2 (25%)	T3(50%)	T4(75%)	T5(100%)
Maize	58.00	43.50	29.00	14.50	0
CRSBSM	0	14.50	29.00	43.50	58.00
Soybean meal	28.00	28.00	28.00	28.00	28.00
Wheat offal	8.00	8.00	8.00	8.00	8.00
Fish meal	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Oyster shell	1.00	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vit/min. prem	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Determined analysis:					
Crude Protein (%)	20.40	20.49	20.60	20.79	20.90
Crude fibre (%)	4.98	5.11	5.34	5.57	5.89
ME(Kcal/Kg)	3100.08	3109.80	3110.42	3160.76	3191.77

Results and Discussion

Proximate composition of maize, sandbox seed meal and cassava root meal

The result of proximate composition of the sandbox seed meal (SBSM) is represented in Table 3 and showed that SBSM was high in dry matter (81.90%), which is close to that of maize (87.18%) and cassava root meal (85.60%). The high dry matter content of the meal is an indication of its long storage capacity [12]. The ether extract of the SBSM (15.49%) was quite high, about 50 times the value for conventional oil seeds [12], quite higher than cassava root meal (3.94%) and maize (3.45%). An indication that SBSM is a good energy source in feeds, and can be used as a supplement in a low energy diet. The crude fibre content of SBSM (7.00%) and CRM (6.14%) are moderate when

compared to the low crude fibre content of maize (2.43%). Crude fibre is essential in feeds, as it helps in improving nutrient digestibility. However, it acts as a nutrient diluent when it is of high amount in diets [21]. The metabolizable energy values were 3440.15, 2901.20 and 3439.08 Kcal/kg for SBSM, CRM and maize respectively. SBSM and maize had numerically similar metabolizable energy values that were significantly ($p < 0.05$) lower than that of CRM. This observation is in agreement with the earlier reported values by Shaahu and Tiough [22]; Akinola and Ebhohon [23]; Archibong *et al.* [24].

Table 3: Proximate composition of maize, sandbox seed meal and cassava root meal

Parameter (%)	Maize	Sandbox seed meal	Cassava root meal	Sem
Dry matter	87.18	81.90	85.60	4.90
Crude protein	9.66b	29.43a	2.18c	0.43
Crude fibre	1.67c	8.32a	4.66b	0.64
Ether extract	3.94b	15.49a	3.45b	0.61
Ash	2.43c	7.00a	6.14b	0.56
NFE	82.30	39.76	83.57	6.82
ME (Kcal/Kg)	3434.09 ^b	3440.95 ^a	2901.29 ^c	21.82

^{a, b, c} Means on the same row with different superscripts are significantly different ($p < 0.05$)

Performance characteristics of broiler chickens fed experimental diets

The result of performance characteristics of broiler chickens fed graded levels of cassava root - sand box seed meal mixture as replacement for maize is presented in Table 4. Results showed no significant ($p > 0.05$) differences in the feed intake of broiler chickens, which is an indication of the acceptability of the diets. Each ingredient in the diets was included at the same level and received the same treatment. However, only the test ingredients cassava root meal - sand box seed meal mixture was used to replace maize. Therefore, any difference in the utilization of the diets could be attributed to the constituents of the cassava root meal-sand box seed meal mixture and maize.

There were also no significant ($p > 0.05$) differences in final live weight and daily weight gain excepts on birds fed diets with 100% CRSBSM (T5), which had significantly lower ($p < 0.05$) values. The feed conversion ratio also showed a similar trend with birds on diet 5 (100% CRSBSM) having the poorest value while other diets including the control had similar numerical

value s. This observation is an indication of poor utilization of diet by birds on this treatment (100% CRSBSM). This led to poor final live weight and weight gain values recorded for birds on this diet. This observation may be due to the high energy and high fibre contents of the diet with 100% CRSBSM. High energy diets are said to encourage poor growth performance as it not only affects feed consumption but can bind other nutrients making them unavailable for utilization by birds [21]. Also, high fibre and antinutritional factors in the test ingredient at the tissue level causes reduction in nutrients available for growth and maintenance and also causes decrease in the availability of nutrients by reducing the period of exposure of food to the digestive enzymes and absorptive surface, as a result of increase in the rate of passage, induce by fibre [25; 26].

Furthermore, Archibong *et al.* [24], reported that sandbox seed meal contains residual anti-nutritional factors (ANFs) such as oxalate, tannins, alkaloids, saponins, flavonoids, cyanogenic glucosides and trypsin inhibitors; likewise, cassava root

meal such as oxalate, phytate and hydrogen cyanide which was found to inhibit growth in poultry and increase excretion of cholesterol [26], especially that the CRSBSM was not so processed to totally eliminate the ANFs in this study. The protein efficiency ratio also showed a similar trend with the feed conversion ratio, final live weight and daily weight gain. The depressing effect was only

significant ($p < 0.05$) with birds fed diet with 100% CRSBSM. This showed poor utilization of protein, as equally reflected in the final weight and daily weigh gain values. The poor utilization of protein could also be attributed to the high oil and fibre contents of the diet (T5) with 100% CRSBSM having highest concentration of residual ANFs.

Table 4: Growth performance of broiler chickens fed diets containing replacement levels of cassava root - sandbox seed meal (CRSBSM) for maize

Parameter	T1	T2	T3	T4	T5	SEM
	0 %	25 %	50 %	75 %	100 %	
Initial Weight (g)	100.50	101.00	100.98	101.10	101.85	3.88
Final Weight (g)	2862.11	2921.30	2950.31	2900.12	2159.40	11.10
Daily feed intake (g)	110.42	109.32	107.88	101.49	96.65	6.09
Daily weight gain (g)	56.36 ^a	57.58 ^a	58.15 ^a	57.12 ^a	41.84 ^b	2.67
Feed conversion ratio	1.96 ^b	1.90 ^b	1.86 ^b	1.78 ^b	2.31 ^a	0.12
Daily protein intake (g)	24.27 ^a	24.08 ^a	23.85 ^b	22.51 ^b	9.30 ^c	1.11
Protein efficiency ratio	2.32 ^b	2.39 ^b	2.43 ^b	2.53 ^b	4.49 ^a	0.55

^{a, b, c} Means on the same row with different superscripts are significantly different ($p < 0.05$)

Table 5 shows the economics of production of broiler chickens fed experimental diets. The cost price per bag of feed was N287.15, N265.18, N247.13, N221.89 and N201.52 for diets T1, T2, T3, T4 and T5, respectively. The observation of decrease in feed cost per Kg could be attributed to the low cost of cassava meal and sandbox seed meal when compared to the cost of maize. The

proportion of maize in monogastric tropical diets ranges from 50 to 70 %, which implies increasing cost of maize, since there is so much demand for it; while sand box seed is from sandbox trees that are either cultivated as ornamental trees or grown wild, their usage as feed source in livestock feed is not popular; hence there is much demand for it, hence the low cost of the meal. The birds fed

diets T2, T3 and T4 had statistically similar values that were significantly ($p < 0.05$) higher than that of the control and birds fed T5 diet. It therefore means that diet T4 (75% CRSBSM) had the best economic advantage, since it encourages high low-cost feedstuff and at the same time encourages higher revenue.

Table 5: Effect of replacing maize with cassava root - sandbox seed meal mixture on economics of production of broiler chickens

Parameter	T1	T2	T3	T4	T5	SEM
	Replacement levels of CRSBM for maize					
	0 %	25 %	50 %	75 %	100 %	
Total feed intake (kg)	5.41	5.36	5.29	4.97	4.74	0.53
Cost/Kg diet(₦)	287.15 ^a	265.18 ^b	243.00 ^c	221.10 ^d	198.13 ^e	11.39
Cost/Kg weight gain(₦)	743.64 ^a	680.95 ^b	626.29 ^c	571.26 ^d	699.04 ^b	7.27
Total weight gain (Kg)	2.76	2.82	2.85	2.80	2.06	0.11
Total cost of feed (₦)	1553.65 ^a	1420.48 ^b	1284.52 ^c	1099.03 ^d	938.31 ^e	9.41
Other cost of production	500.00	500.00	500.00	500.00	500.00	0.00
Total cost of production (₦)	2053.65 ^a	1920.48 ^b	1784.52 ^c	1599.03 ^d	1438.31 ^e	11.69
sales/Kg (₦)	2500.00	2500.00	2500.00	2500.00	2500.00	0.00
Total Revenue (₦)	7155.28 ^b	7303.25 ^a	7375.78 ^a	7250.30 ^a	5398.50 ^c	19.93
Cost/gain Ratio	0.29	0.26	0.24	0.22	0.27	0.02

^{a, b, c} Means on the same row with different superscripts are significantly different ($p < 0.05$)

Haematological and serum biochemical indices of broiler chickens fed diets with replacement levels of cassava root-sandbox seed meal mixture

The result of haematological and serum biochemical indices of broiler chickens fed diets with replacement levels of cassava root-sandbox seed meal mixture is presented in Table 6. In terms of haematological parameters; the haemoglobin concentration, packed cell volume, red blood cell counts,

mean corpuscular volume and mean corpuscular haemoglobin had significant ($p < 0.05$) dietary effect; while the serum biochemical indices such as cholesterol, glucose, total protein, albumin, globulin and uric acid also recorded significant ($p < 0.05$) differences between dietary treatments. Most haematological parameters had higher numerical values up to 75% replacement level of CRSBSM for maize (T4), and were suppressed at the highest level of 100%. This

implies that the residual antinutrients in cassava root-sandbox seed meal mixture had antihaematopoietic effect on the broiler chickens. Compared to the control, haemoglobin increased across the dietary treatments with birds on T₅ (100% CRSBSM) having numerically lowest value (7.89 g/dl) than other treatments, while birds on T₁ had the highest value (9.43 g/dl). The haemoglobin values obtained fell within the normal range (7.40 – 13.10 g/dl) for healthy birds according to Mitruka and Rawnsley [27]; and could also be comparable to the range (8.04 – 12.03 g/dl) reported by Banjoko *et al.* [28].

The packed cell volume and red blood cell counts significantly ($p < 0.05$) decreased with replacement levels of CRSBSM for maize in the diets up to 75% level compared to the control. In this study, the packed cell volume ranged from 23.98 – 30.16 %, while red blood cell counts ranged from 1.22 – 1.63 $\times 10^{12}/L$. The values recorded in this study fell within the normal ranges for healthy birds [27; 28]. Furthermore, Onunkwo *et al.* [29] reported that packed cell volume is involved in the transport of oxygen and absorbed nutrients round the body delivering same to target cells. Thus, increased packed cell volume recorded in this study shows a better transportation of oxygen and absorbed nutrients, thereby preventing anaemia. These observations are in accordance with the findings of Banjoko *et al.* [28], who reported increased in the packed cell volume and haemoglobin as the inclusion level of bitter leaf meal increased in the diets of broiler

chickens. The findings of this study are in line with the reports of Opoola *et al.* [30] who stated an increase in packed cell volume and haemoglobin with supplementation of *vitamin C* in the laying hen diets. The difference could be attributed to the different test ingredients in the separate studies.

The white blood cells are involved in protecting the body against both infectious diseases and foreign invaders. The white blood cell counts ranged from 3.38 – 4.58 $\times 10^{12}/L$. Birds fed diet T2 (25% CRSBSM for maize) had the highest value ($4.58 \times 10^{12}/L$) for white blood cell counts which was slightly higher than those fed the control diet ($3.50 \times 10^{12}/L$). The values obtained in the present study were lower than the range ($9.20 - 31.00 \times 10^{12}/L$) reported by Mitruka and Rawnsley [27] for healthy birds. This may be due to the phytochemicals present in CRSBSM. Tokofai [31] stated that antinutrients can alter the distribution and occurrence of white blood cells, suggesting the ability of CRSBSM to act as an anti-immune stimulant. Also, the lower value ($3.38 \times 10^{12}/L$) of white blood cells obtained in the present study agrees with the findings of Owen and Amakiri [32], who reported that residual antinutrients in feedstuffs depressed white blood cell counts in birds. The reason could be attributed to the reduced production and re-distribution of white blood cells to peripheral blood into the tissues. The mean corpuscular volume (MCV) was significantly ($p < 0.05$) affected by the dietary treatments with birds on T₅ having the least value (16.44 fl) compared to birds on the

control which recorded the highest value (18.76 fl). Birds on T₁ and T₂ had statistically similar values. The values obtained were lower than the normal range (81.60 – 89.10 fl) reported by Wikivet English [33] for broiler chickens. A low MCV may indicate iron deficiency, chronic disease, haemoglobin disorder or bone marrow disorder [34]. The mean corpuscular volume values recorded in the present study shows that the birds were not suffering from iron deficiency, chronic disease, haemoglobin disorder or bone marrow disorder. There was no significant ($p>0.05$) difference in mean corpuscular haemoglobin concentration (MCHC) in the treatment groups with CRSBSM compared to the control group. However, the mean corpuscular haemoglobin concentration value was numerically higher in T₃ (50 %) diet than the other treatment groups. Tokofai *et al.* [31] reported that the slight increase in the mean corpuscular haemoglobin indicated that there were differences in corpuscle sizes, even if the blood samples had similar levels. MCH and MCHC are further guides to the investigation of anaemia [34]. The values of MCH and MCHC obtained in this study were slightly higher than the normal ranges (27.20 – 28.90 pg) for MCH and (32.41 – 33.37 %) for MCHC reported by Wikivet English [33] for broiler chickens. These variations may be attributed to the presence of antinutrients in CRSBSM. Moreover, the higher values of MCH and MCHC recorded in the present study indicates that the broiler chickens were not anaemic.

Heterophils were not significantly ($p>0.05$) influenced by increasing levels of CRSBSM in the diets. Birds on T₃ (50 %) recorded the highest numerical value (66.97 %) compared to T₅ (100 % CRSBSM) which recorded the lowest value (61.66 %). The value of neutrophils recorded in this study were slightly higher than the reference range (48.00 - 58.00 %) reported by Igene *et al.* [35] for broiler birds. This could be due to the higher level of CRSBSM and associated antinutrients in the diets. Lymphocytes values did not record any significant ($p>0.05$) difference between dietary treatments; and were observed to fluctuate with increasing levels of CRSBSM in the diets with birds on T₅ having the highest value (36.71 %). Lymphocytes are involved in the immune process, producing antibodies against foreign organisms, protecting against viruses and fighting cancer [27]. Lymphocyte values recorded in the present study were lower than the normal range (43.90 – 67.70 %) reported by Mitruka and Rawnsley [27], and reference range (38.00 – 46.00 %) reported by Igene *et al.* [35] for broiler chickens. The differences may be due to the strains and genotype of birds used as well as differences in test ingredients in the different studies. Values obtained for monocytes and eosinophils were within the normal range for healthy birds [27]. The low values of monocytes agree with the assertion that monocytes are present in small to moderate numbers in the blood

Table 6: Haematological and serum indices of broiler chickens fed diets containing cassava root - sandbox seed meal mixture

Parameter	T1 0 %	T2 25 %	T3 50 %	T4 75 %	T5 100 %	SEM
Haematological indices:						
Haemoglobin (g/dl)	9.43 ^a	9.41 ^a	9.37 ^a	8.10 ^b	7.89 ^b	0.98
Packed cell volume (%)	30.12 ^a	30.09 ^a	30.16 ^a	25.65 ^b	23.98 ^b	3.7
Red blood cell counts ($\times 10^{12}/L$)	1.56a	1.51a	1.63a	1.30b	1.22b	0.06
White blood cell counts ($\times 10^9/L$)	3.50	4.58	3.59	3.38	3.65	0.09
MCV (fl)	18.76 ^a	18.41 ^a	17.65 ^b	17.02 ^c	16.44 ^d	1.87
MCH (pg)	55.90 ^a	54.78 ^a	57.90 ^a	51.87 ^a	41.00 ^b	3.96
MCHC (g/dl)	56.00	55.88	53.90	53.05	52.98	4.32
Heterophils (%)	65.09	62.59	66.97	63.75	61.66	5.38
Lymphocytes (%)	31.32	31.54	30.67	34.87	36.71	1.88
Eosinophils (%)	3.21	2.88	3.00	2.89	3.11	0.32
Monocytes (%)	1.54	0.87	0.68	1.54	1.81	0.04
Serum biochemical indices:						
ALT (IU/L)	23.66	24.75	23.63	21.90	23.11	2.19
ALP (IU/L)	47.84	41.64	40.20	45.61	44.99	3.42
AST (IU/L)	139.65	141.78	149.83	151.89	154.81	11.96
Cholesterol (mg/dl)	95.09 ^c	99.85 ^d	109.54 ^c	114.21 ^b	119.87 ^a	4.77
Glucose (mg/dl)	157.86 ^b	159.00 ^b	161.00 ^b	189.65 ^a	194.04 ^a	4.89
Total protein (g/dl)	59.46 ^a	59.54 ^a	58.68 ^a	56.52 ^a	43.11 ^b	5.50
Albumin (g/dl)	36.56	36.50	36.00	34.01	30.05	1.17
Globulin (g/dl)	22.90 ^a	23.04 ^a	22.68 ^a	22.51 ^a	13.06 ^b	2.62
Uric acid (mg/dl)	59.76 ^b	60.34 ^b	60.99 ^b	63.56 ^a	63.99 ^a	4.51
Creatinine (mg/dl)	1.49	1.41	1.40	1.29	1.21	0.04

^{a, b, c} Means on the same row with different superscripts are significantly different ($p < 0.05$)

system [36]. For eosinophils, birds on the control diet (T₁) had the highest value (3.21 %) compared to the treatment groups. The eosinophils are known to protect the body against infection. This implies that birds on these treatments were well able to fight against infections. Generally, variations in avian haematological blood values are normal phenomenon, and depend in most cases on the physiological condition of the birds [37; 38].

Table 6 also shows result of serum biochemical indices of broiler chickens fed diets with CRSBSM. There were no

significant ($p > 0.05$) differences in most of the serum biochemical indices measured. The serum total protein level recorded a significant ($p < 0.05$) effect between dietary treatment; and was slightly decreased with increasing levels of CRSBSM with birds on T₂ (25 %) recording the highest value (59.46 g/dl) compared to other treatment groups. A similar trend was observed for albumin in the blood. The serum total protein is composed of albumin and globulin in the blood. Filipovic *et al.* [39] reported that blood proteins in birds serve as an important indicator in the evaluation of their health

status. The values of total protein, albumin and globulin recorded in the present study were far higher than the normal ranges reported by Wikivet English [33] as 4.63 – 4.81g/dl, 3.28 – 3.48g/dl and 1.15 – 1.53g/dl for total protein, albumin and globulin respectively. The high variations may be due to the protein content of the cassava root-sandbox seed meal mixture (CRSBSM). Okpe *et al.* [40] reported that the variation in total protein could be attributed to an improved digestion capacity conferred by the CRSBSM in the feed thereby making more protein available to the birds. This implies superiority of CRSBSM in protein balance in comparison with the control diet. Low levels of albumin and globulin indicate incidence of liver or kidney problem and could also be associated with the presence of infection [31]. The values of albumin recorded in the present study implies that the birds were not affected by any disease related to the liver or kidney. Dairo *et al.* [41] reported that albumin helps to prevent haemorrhage. This therefore implies higher blood clotting ability with improved albumin content.

Total cholesterol serves as a diagnostic index in conditions such as chronic obstructive jaundice, hepatitis, coronary heart disease and atherosclerosis. Hyperlipidaemia is one of the risk factors for coronary heart disease while cholesterol is the major lipid constituent of atherosclerotic plaque [42]. The values obtained for cholesterol in this study were outside the range reported by Owen *et al.* [43] as 3.30 - 4.50 mmol/L for cholesterol. These values were observed to

increase with the CRSBSM in the diets of birds; indicating that the plant might have contributed to some abnormal conditions like atherosclerosis due to the high oil content in sandbox seed meal, even though the birds did not manifest any obvious symptoms. Radwan *et al.* [44] reported that with high cholesterol levels, broilers tend to develop fatty deposits in their blood vessels. This eventually leads to difficulty in blood flow and lameness as well as sudden death of broiler chickens. The high level of cholesterol observed in birds on the dietary treatment implies that the birds did develop fatty deposits in their blood vessels. The elevated levels of cholesterol obtained in birds in this study were not in line with the findings of Ekpo *et al.* [42], who reported that bitter leaf meal reduces triglyceride biosynthesis and promotes the redistribution of cholesterol between lipoprotein molecules.

Result for Aspartate amino transferase (AST) and alanine amino transferase (ALT) did not show any significant ($p>0.05$) dietary effect in this study. Both AST and ALT are liver enzymes and are important in the determination of proper functioning of the liver [45]. An increase in the concentration of these enzymes may be because of damaged or diseased cells which denote the status of the liver function. Iheukwumere and Herbert [46], reported that the values of aspartate amino transferase and alanine amino transferase are normally low in the blood but become high when there is occurrence of liver damage by toxic substances. The values

of aspartate amino transferase and alanine amino transferase did not follow a particular trend. The values of aspartate amino transferase ranged between 139.65 and 154.81 IU/L and this was higher than the range reported by Okpe *et al.* [40] as 61.33-65.33 IU/L while that of alanine amino transferase ranged between 21.90 and 24.75 IU/L and this were higher than the range reported by Okpe *et al.* [40] as 12.00-12.80 IU/L. The variations may be due to the different test materials in the separate studies (bitter leaf meal and CRSBSM, respectively). The values of aspartate amino transferase obtained in the present study implies that CRSBSM was not toxic to liver cells. This was in agreement with the findings of Okpe *et al.* [40] who reported that the inclusion of bitter leaf meal in the diets of broilers may improve liver function. The serum glucose level was significantly ($p < 0.05$) different in all the treatment groups. The values (157.86 – 194.04 mmol/L) obtained were far higher compared to the range reported by Daramola *et al.* [47] as 10.33 – 13.50 mmol/L. This implies that the birds might have experienced some heat stress due to the high glucose levels in the blood, since cassava root – sandbox seed meal mixture is high in energy.

Conclusion and Application

The study demonstrated that

1. The expensive maize could be replaced with cassava root - sandbox seed meal mixture (CRSBSM) up to 75%.

2. Cassava root-sandbox seed meal at 75% replacement for maize will not affect growth performance and blood indices of broiler chickens.
3. CRSBSM recorded better economic returns to farmers.

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