



**Growth performance, nutrient digestibility, haematological and carcass characteristics of broiler chickens fed diets containing roselle (*hibiscus sabdariffa* L.) Seeds raw and fermented for varying durations**

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**Abstract**

A feeding trial was conducted to evaluate the growth performance, nutrient digestibility, haematological parameters and carcass characteristics of broiler chickens fed diets containing raw and fermented Roselle seeds fermented at different period. Two hundred and seventy Ross broiler chickens were used for this experiment following a completely randomized design (CRD). The broiler chicks were assigned to six dietary treatments with three replicates each with 15 birds per replicate and forty-five birds per treatment. Six experimental diets were formulated for broiler starter and finisher phases respectively. Treatment one (T1) served as the control diet (0% Fermented Roselle Seed (FRS)), while treatments T2, T3, T4, T5 and T6 contained fermented Roselle seeds for 24hrs, 48hrs, 72hrs and 96hrs, respectively. The result at the starter phase showed that final body weight, weight gain, feed conversion ratio and total feed intake were significantly ( $P < 0.05$ ) higher in birds fed the control diet compared to all the other dietary treatments. Feed conversion ratio was best in birds fed the control diet (1.66) compared to other dietary treatments. Total feed intake was significantly ( $P < 0.05$ ) higher in birds fed the control diet (1244.60g/bird). Feed cost/kg gain was best at diets containing fermented Roselle seed at 96hrs (₦158.16). At the finisher phase, final body weight, weight gain, feed conversion ratio and total feed intake increased linearly as the duration of fermentation increased. Birds fed diet containing raw Roselle seeds had the poorest feed conversion ratio (3.13). Feed cost/kg gain was lower in diets containing fermented Roselle seeds at 96hrs (₦187.84). The dressing percentage was higher with birds fed the control diet (80.90%). The haematological parameters showed significant ( $P < 0.05$ ) differences across dietary treatments except for WBC which showed no significant ( $P > 0.05$ ) differences across dietary treatment. Nutrient digestibility were significantly ( $P < 0.05$ ) different for dry matter, crude protein, crude fibre and ether extract except for nitrogen free extract. Based on the results of this study, it was concluded that 20% inclusion level of Roselle seed fermented for up to 96 hours can be incorporated in diets of broiler chickens without any adverse effect.

**Keywords:** Carcass, Growth, Haematology, Nutrient Digestibility, Roselle Seed.

**Introduction**

Prices of plant protein ingredients for livestock feeds have been on the increase in Nigeria. This has resulted in the increasing cost of livestock production and consequent increase in the cost of livestock products. The need to find alternative and cheaper ingredients to replace the expensive ones is inevitable since cost of feed accounts for 70-80% of the cost of poultry production in the country (Dashak and Nwanego, 2002).

Roselle (*Hibiscus sabdariffa*) seeds have been considered as a possible source of cheap feed which may be an option. Studies by Animal Production Research Centre (APRC) (1997) reported that Roselle seeds contain 28% crude protein, 19.9% ether extract, 5.5% ash and 18% crude fibre. In other studies, Dashak and Nwanego (2002) and Isidahomen *et al.* (2006) reported 35.19 and 25.92% crude protein respectively and 15% crude fibre in Roselle seeds. Roselle seeds also contain high amount

of minerals such as calcium, magnesium and phosphorus and can supplement other expensive conventional protein sources in the diet of poultry, thereby reducing the cost of production and the competition between man and livestock for these feed sources. In spite of the numerous advantages, Roselle seeds in their raw state are known to have bitter taste which is attributed to its anti-nutritional factors. The unprocessed seeds have been reported to contain tannin, hibiscin and hydroxyl flavone as major anti-nutritional factors (Mahadevan *et al.*, 2009). However, the most commonly reported anti-nutritional factors are total phenols, tannins and phytic acid, and these have been shown to have detrimental effects on the health and performance of animals (Diarra *et al.*, 2011; Kayembe, 2011). Effective utilization of Roselle seeds by poultry will necessitate processing to inactivate anti-nutritional factors (Soetan and Oyewole, 2009). Processing methods such as fermentation have been reported to be effective in doing this.

A viable option of optimizing the productivity of animals and minimizing cost of protein is by the use of non-conventional feedstuff such as Roselle seeds which is sold in Nigeria at less than two-fifth the cost of soybean and about half the price of groundnut cake, hence justifying the need to investigate its use in feeding broiler chickens. This study is aimed at evaluating the growth performance, nutrient digestibility, haematology and carcass characteristics of broiler chickens fed diets containing Roselle seed raw and fermented for varying durations.

## Materials and Methods

### Experimental Site

The experiment was carried out at the Poultry Unit, Department of Animal Science Teaching and Research Farm, Ahmadu Bello University, Zaria. Zaria is located in the Northern Guinea Savannah zone of Nigeria on longitude 11° 09' 01.78" N and latitude 7° 39' 14. 79' E at an altitude of 671mm above sea level. The climate is characterized by a well-defined dry and wet seasons. The

climate is tropical with annual temperature of 24.9°C and rainfall averages 1050mm (Ovimap, 2014).

### Sources and Processing of Roselle Seeds

The Roselle seeds used for this study were purchased from an open market in Yobe state during the harvest period. The Roselle seeds were sorted and thoroughly cleansed of dirt by winnowing and sieving to ensure clean grains.

### Processing Method

**Fermentation Method:** The cleaned Roselle seeds were soaked in 75 litres of water per batch of 25kg Roselle seeds for 8 hours. The soaked seeds were drained and placed in an air tight polythene bag and allowed to ferment for 24 hours, 48 hours, 72 hours and 96 hours. The Roselle seeds were spread on a tarpaulin sheet, sun dried for 3 days and crushed in a 1.5 mm sieve size hammer mill.

### Experimental Diets

Six experimental diets for broiler starter and finisher phases respectively were formulated as follows: Treatment 1 (Control diet) (0% RSM); Treatment 2 (Raw Roselle seeds diet) (0 hour fermented Roselle seed diet); Treatment 3 (24 hours fermented Roselle seeds diet); Treatment 4 (48hours fermented Roselle seeds diet); Treatment 5 (72 hours fermented Roselle seeds diet) and Treatment 6 (96 hours fermented Roselle seeds diet). Ingredients composition of the experimental starter and finisher diets are presented in Tables 1 and 3, respectively. Both starter and finisher diets were formulated to meet nutrient requirement standard for broiler chickens (NRC, 1994). The proximate analyses of the experimental diets are presented in Tables 2 and 4 for broiler starter and finisher diets, respectively.

### Experimental Design and Management of Birds

#### **Broiler Starter Phase (0-4 weeks of age):**

Two hundred and seventy (270) day- old Ross broiler chicks of mix-sex were used for the

experiment. After taking the initial weights, chicks were allocated to the experimental

**Table 1: Composition of Broiler Starter Diets Containing Roselle Seed Fermented for Different Periods (0-4 weeks of age)**

Ingredients (%)	Diets and Fermentation Periods (Hours)					
	(T1) Control	(T2) Raw (0)	(T3) 24	(T4) 48	(T5) 72	(T6) 96
Maize	56.75	47.75	47.75	47.75	47.75	47.75
Roselle seed	0.00	20.00	20.00	20.00	20.00	20.00
Soya bean meal	20.00	15.00	15.00	15.00	15.00	15.00
Groundnut cake	19.00	13.00	13.00	13.00	13.00	13.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.50
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.05	0.05	0.05	0.05	0.05	0.05
Vit-Premix	0.25	0.25	0.25	0.25	0.25	0.25
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>
<b>Calculated Analysis</b>						
ME/Kcals/kg	2911	2930	2937	2933	2940	2936
Crude Protein (%)	23.00	22.40	23.14	23.30	23.33	23.45
Crude Fibre (%)	4.29	3.98	3.98	3.98	3.98	3.98
Ether Extract (%)	3.74	7.31	7.31	7.31	7.31	7.31
Calcium (%)	1.32	1.31	1.31	1.31	1.31	1.31
Phosphorus (%)	0.87	0.82	0.82	0.82	0.82	0.82
Lysine (%)	1.30	1.32	1.32	1.32	1.32	1.32
Methionine (%)	0.54	0.56	0.56	0.56	0.56	0.56
Feed cost/kg (₦)	99.62	90.04	91.11	91.14	91.25	92.10

\*Biomix premix per Kg of diet: Vit A, 10,000; Vit D3, 1500 i.u; Vit E, 10mg; Vit K3, 1mg; Vit B1, 1.5mg; Vit B2, 4.5mg; Niacin, 150mg; Pantothenic acid 4.5mg; Vit B12, 0.015mg; Folic acid, 0.6mg; Biotin H2, 0.5mg; Cholin chloride, 175mg; Vit B6, 3mg; Manganese, 40mg; Iron, 20mg; Zinc, 30mg; Copper, 3mg; Iodine, 1mg; Cobalt, 0.2mg; Selenium, 0.2mg

**Table 2: Proximate Composition of Broiler Starter Diets Containing Roselle Seeds Fermented for Different Periods**

Parameters (%)	Diets and Fermentation Periods (Hours)					
	(T1) Control	(T2) Raw (0)	(T3) 24	(T4) 48	(T5) 72	(T6) 96
Crude protein	23.56	23.19	23.78	24.12	23.33	24.05
Ether extract	5.68	6.05	6.38	5.99	6.20	5.87
Crude fibre	5.89	5.39	5.66	5.08	5.36	5.77
Ash	8.12	8.20	7.98	8.41	8.28	7.97
Nitrogen free extract	56.75	57.17	55.20	56.40	56.83	56.34

**Table 3: Composition of Broiler Finisher Diets Containing Roselle Seed Fermented for Different Periods (4-8 weeks of age)**

Ingredients (%)	Diets and Fermentation Periods (Hours)					
	(T1) Control	(T2) Raw	(T3) 24	(T4) 48	(T5) 72	(T6) 96
Maize	59.00	57.00	57.00	57.00	57.00	57.00
Roselle seed	0.00	20.00	20.00	20.00	20.00	20.00
Soya bean meal	10.20	15.00	15.00	15.00	15.00	15.00
Maize offal	6.70	4.00	4.00	4.00	4.00	4.00
Groundnut cake	20.00	0.00	0.00	0.00	0.00	0.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.50	0.50	0.50	0.50	0.50	0.50
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.05	0.05	0.05	0.05	0.05	0.05
Vit-Premix	0.25	0.25	0.25	0.25	0.25	0.25
<b>Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>
<b>Calculated Analysis</b>						
ME/Kcals/kg	2950	3026.21	3029.24	3029.20	3025.29	3027.24
Crude Protein (%)	20.00	20.52	20.55	20.60	20.62	20.50
Crude Fiber (%)	4.79	3.05	3.05	3.05	3.05	3.05
Ether Extract (%)	3.80	6.72	6.72	6.72	6.72	6.72
Calcium (%)	1.22	1.19	1.19	1.19	1.19	1.19
Phosphorus (%)	0.83	0.76	0.76	0.76	0.76	0.76
Lysine (%)	1.10	1.13	1.13	1.13	1.13	1.13
Methionine (%)	0.70	0.74	0.74	0.74	0.74	0.74
Feed cost/kg (₹)	89.72	81.09	81.23	81.35	81.50	82.09

\*Biomix premix per Kg of diet: Vit A, 10,000; Vit D3, 1500 i.u; Vit E, 10mg; Vit K3, 1mg; Vit B1, 1.5mg; Vit B2, 4.5mg; Niacin, 150mg; Pantothenic acid 4.5mg; Vit B12, 0.015mg; Folic acid, 0.6mg; Biotin H2, 0.5mg; Cholin chloride, 175mg; Vit B6, 3mg; Manganese, 40mg; Iron, 20mg; Zinc, 30mg; Copper, 3mg; Iodine, 1mg; Cobalt, 0.2mg; Selenium, 0.2mg.

**Table 4: Proximate Composition of Broiler Finisher Diets Containing Roselle Seeds Fermented for Different Periods**

Parameters (%)	Diets and Fermentation Periods (Hours)					
	(T1) Control	(T2) Raw	(T3) 24	(T4) 48	(T5) 72	(T6) 96
Crude protein	20.11	21.04	20.19	21.21	20.61	20.36
Ether extract	5.66	5.79	5.80	6.14	5.52	6.09
Crude fibre	6.28	6.09	5.88	5.93	6.40	6.33
Ash	7.28	7.39	8.04	7.77	7.80	7.98
Nitrogen free extract	60.67	59.69	60.09	58.95	59.67	59.24



diets in a completely randomized design (CRD). There were 45 chicks per treatment and each treatment was replicated 3 times with 15 birds per replicate. The birds were raised on deep litter and managed using all necessary routine management practices. Birds were supplied with experimental diets and clean water *ad-libitum* throughout the period of the study. The experiment lasted for 4 weeks in which feed intake, weight gain and mortality were recorded..

### **Broiler Finisher phase (4-8 weeks of age):**

Before the beginning of the finisher phase, birds were fed a common diet for a week and those of averagely equal weights were used for the finisher phase. Two hundred and thirty four (234) broiler chickens at five weeks of age were used for the finisher phase. Each dietary treatment was fed to 39 birds in a completely randomized design and replicated three times consisting of 13 birds per replicate. Birds were fed with broiler finisher diet. Feed intake, weight gain and mortality were recorded.

### **Digestibility study**

Digestibility trial was carried out during the last week of the experiment (8 – 9 weeks of age). This was carried out by selecting 3 birds per replicate making a total of 9 birds per treatment. The birds were housed in metallic cages and allowed a period of 3 days to adjustment to the cage environment and were thereafter offered known amount of experimental diets. Total faecal outputs were collected for five days, weighed and oven dried at 65°C for 24 hours. The dried samples were then analysed for their nutrient contents using the method described by A.O.A.C (2005). Nutrient digestibility was calculated using the equation below;

$$\% \text{ Digestibility of Nutrient} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{Nutrient intake}} \times 100$$

Where: Nutrient intake (g) = Dry feed intake x Nutrient in diet (%)

$$\text{Nutrient output (g)} = \text{Dry faecal output} \times \text{Nutrient in faeces (\%)}%$$

### **Haematological Parameters**

At 9 weeks of age, three birds per replicate making a total of 9 birds per treatment were randomly selected and two millilitres (2.0mls) of blood was collected each from the wing web vein. The blood samples were collected into a labelled bottle containing Ethylene Diamine Tetra Acetic Acid (EDTA) and taken to the Clinical Pathology laboratory for analysis of haematological parameters which include Packed cell volume (PCV), haemoglobin (hb) content, white blood cells (WBC) counts, red blood cell (RBC) counts and leukocytes differential counts (Heterophil and lymphocytes). The haematological analysis was performed using a semi-automatic cell counter (Sysmex-F 820). Blood smears was ethanol-fixed and stained according to May-Grunwald-Giemsa technique. The blood smears was used to determine the differential blood count by immersion microscopy and quantified by immersion refractometry.

### **Chemical Analysis**

Samples of the fermented Roselle seeds at different levels of fermentation (24, 48, 72 and 96 hours) were taken to the Animal Science Biochemical Laboratory for proximate analysis using the method described by A.O.A.C. (2005).

### **Carcass Analysis**

At the end of the experiment, three birds from each replicate (nine birds per treatment) were selected based on average group weight and used for carcass analysis. The birds were starved of feed overnight so as to allow for the emptying of the crop and excretion of undigested feed. Each bird was weighed, slaughtered and eviscerated and cut into parts to obtain the dressed weight, breast weight, thigh weight, liver, heart and gizzard weight. The cut of parts were expressed as

percentages of dressed weight of birds slaughtered while the organ weights were expressed as percentages of the live weight.

### Data Analysis

All data obtained from the experiment were statistically analyzed using the General Linear Model procedure of Statistical Analysis System (SAS, 2008). Significant differences among means were compared using Dunnett's Test (Dunnett, 1955).

### Results and Discussion

#### Performance of Broiler Starter Chicks Fed Diets Containing Roselle Seeds Raw or Fermented for Varying Durations (0-4 weeks of age)

The performance of broiler chicks fed diets containing Roselle seeds raw or fermented for different periods are presented in Table 5. The result showed that there were significant ( $P < 0.05$ ) differences in total feed intake, feed conversion ratio, weight gain and final body weight. The birds fed the control diet had a higher value for final weight (794.33 g/bird) compared to birds fed diets containing raw Roselle seed and Roselle seeds fermented for 24, 48, 72 and 96 hours (545.33, 511.00, 622.00, 691.33 and 733.33 g/bird) respectively. Broiler chicks fed the control diet had higher total feed intake (1244.60 g/bird), while birds fed diets containing Roselle seeds fermented for 24 hours had the least feed intake (958.00 g/bird). There were significant ( $P < 0.05$ ) differences for feed conversion ratio. Feed conversion ratio was better for birds fed control diet and diet containing Roselle seeds fermented for 24, 48 and 96 hours (1.66, 1.89, 1.82 and 1.72, respectively) compared to other diets. Feed cost/kg gain was not significantly ( $P > 0.05$ ) different among the treatments. There were no mortality cases in birds fed T3, T4 and T6. However, birds fed T1, T2 and T5 had significant ( $P < 0.05$ ) mortality rate as compared to other treatments.

The higher weight gain and final weight observed in birds fed the control diet could be as a result of better feed utilization. There was

however a linear increase in final weight and weight gain as fermentation duration of Roselle seeds increased. This improved weight gain could be as a result of reduction in anti-nutritional factors present in fermented Roselle seed meal as duration of fermentation increased. This finding is in line with the report of Kwari *et al.* (2011) who reported improvement in growth performance of broiler chickens when Roselle seed was processed by soaking, cooking, sprouting or fermentation. The reduced weight gain observed in birds fed diets containing raw Roselle seed and Roselle seed fermented for 24 hours may be attributed to residual anti-nutritional factors in the Roselle seeds diets. This could be the reason for the poor performance of birds fed diet containing raw Roselle seeds. This also agrees with the findings of (Afolabi *et al.*, 1985) who reported reduced growth rate and egg production when raw Mucuna seeds meal was fed to broiler chicks and laying birds respectively. Effect of residual anti-nutritional factors was also observed after feeding soaked mango seeds to broiler chickens (Idris, 2012). The observed decrease in feed intake observed in bird fed T2 and T3 may be attributed to the texture of the feed that induced lower feed intake due to toughness of the seeds. This disagrees with the findings of Duwa *et al.* (2012) who fed diets containing sprouted and boiled Roselle seeds to broiler chickens and observed that intake was significantly ( $P < 0.05$ ) higher for birds fed processed Roselle seed, while birds on the control diet recorded the least feed consumption. The differences in feed intake could be as a result of the different processing methods used which may affects the texture of the feed. The feed conversion ratio which was better in birds fed the control diet and diets containing Roselle seed fermented for 96 hours compared to birds fed other dietary treatments agreed with the findings of Kwari *et al.* (2011). The authors reported similar outcome when they fed raw, soaked, sprouted and boiled Roselle seed meal to broiler chickens for 9 weeks. This could be as a result of better feed utilization. This result also

agreed with the report of Walter *et al.* (1984) who reported that fermentation improved palatability besides upgrading the nutrient content of fermented material. Feed cost/kg gain was higher in birds fed T3 (₦186.50), while birds fed diets containing Roselle seeds fermented for 96 hours had the least feed

cost/kg gain (₦158.16). The lower the feed cost/kg gain the better. The mortalities observed in this phase showed no particular trend. The mortalities recorded for treatment 1, 3 and 5 may therefore be as a result of low temperature between the months of December to February.

**Table 5: Effects of Diets Containing Roselle Seeds Raw or Fermented for Different Periods on Growth Performance of Broiler Chicks (0-4 weeks of age)**

Parameters	Diets and Fermentation Periods (Hours)						SEM
	(T1) Control	(T2) Raw	(T3) 24hrs	(T4) 48hrs	(T5) 72hrs	(T6) 96hrs	
Initial weight(g/bird)	43.23	43.23	43.21	43.23	43.23	43.23	1.16
Final weight (g/bird)	794.33 <sup>a</sup>	545.33 <sup>d</sup>	511.00 <sup>d</sup>	622.00 <sup>c</sup>	691.33 <sup>b</sup>	733.33 <sup>b</sup>	24.04
Weight gain (g/bird)	751.10 <sup>a</sup>	502.10 <sup>e</sup>	468.00 <sup>e</sup>	578.77 <sup>d</sup>	648.10 <sup>c</sup>	690.10 <sup>b</sup>	20.42
FCR	1.66 <sup>a</sup>	2.00 <sup>b</sup>	2.04 <sup>b</sup>	1.89 <sup>a</sup>	1.80 <sup>a</sup>	1.72 <sup>a</sup>	0.10
Daily feed intake (g/bird)	44.45 <sup>a</sup>	35.95 <sup>c</sup>	34.21 <sup>c</sup>	39.13 <sup>b</sup>	41.78 <sup>a</sup>	42.33 <sup>a</sup>	1.22
Total feed intake (g/bird)	1244.60 <sup>a</sup>	1006.60 <sup>d</sup>	958.00 <sup>d</sup>	1095.64 <sup>c</sup>	1170.00 <sup>b</sup>	1185.24 <sup>a</sup>	34.06
Feed cost/kg gain (₦)	165.02	180.43	186.50	172.76	164.76	158.16	0.02
Mortality (%)	4.44 <sup>c</sup>	2.22 <sup>b</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	6.67 <sup>d</sup>	0.00 <sup>a</sup>	0.24

<sup>abcde</sup>: Means on the same row with different superscripts are significantly different ( $P < 0.05$ ), SEM: Standard error of means, FCR: Feed conversion ratio,.

#### Performance of Broiler Finisher Chickens Fed Roselle Seeds Raw or Fermented for Varying Durations (4-8 weeks of age)

Table 6 shows the result of growth performance of broiler chickens fed diets containing Roselle seeds raw or fermented for varying durations at finisher phase. There were significant ( $P < 0.05$ ) differences in total feed intake, feed conversion ratio, weight gain and final body weight. The lower weight gain were recorded for birds fed diets containing raw Roselle seed and Roselle seeds fermented for 24 hours. Birds fed the control diet and diets containing Roselle seeds fermented for 96 hours recorded higher final body weight (2085.67 and 2048.33 g/bird, respectively), while the least final body weight was recorded in birds fed diet containing raw Roselle seeds (1600.33 g/bird). There were also significant ( $P < 0.05$ ) differences in feed conversion ratio. The values of feed conversion ratio for birds fed diets containing Roselle seed fermented for 96 hours and

control diet (2.29 and 2.30, respectively) were similar and significantly ( $P < 0.05$ ) better compared to values obtained for birds fed diets containing raw and Roselle seed fermented for 24 hours (3.13 and 3.11 respectively). There were significant ( $P < 0.05$ ) differences in total feed intake. Birds fed control diet recorded the highest total feed intake (2913.33 g/bird), while birds fed diets containing raw Roselle seed recorded the least feed intake (2445.24 g/bird). However, birds fed diet containing T1, T2, T4, T5 and T6 had significantly ( $P < 0.05$ ) higher mortality rates. The feed cost/kg gain was lower in bird fed diets containing Roselle seeds fermented for 96 hours (₦187.84) compared to the other dietary treatments.

The lower body weight observed in birds fed raw Roselle seeds diet, may be attributed to poor utilization of nutrients in the diet (Ologhobo *et al.*, 1993). This study agrees with the report of Kwari *et al.* (2010) who

observed decrease in final weight and average daily gain when raw Roselle seed diet was fed to broiler chickens. Feed conversion ratio was observed to be better in birds fed the control diet and diet containing Roselle seeds fermented for 96 hours (2.30 and 2.29, respectively). The values in this study disagree with the report of Duwa *et al.* (2012) who fed diets containing sprouted and boiled Roselle seeds to broiler chickens at finisher phase. The poor feed conversion ratio values in birds fed diet containing raw Roselle seeds and Roselle seeds fermented for 24 hours (3.11 and 3.13 respectively) might be as a result of the birds having energy deficiency problem and leading to high feed intake with lower body weight since birds eat to meet their energy requirements. Residual effects of anti-nutrients present in raw and Roselle seeds fermented for only 24 hours probably

gave rise to poor feed conversion ratio of the birds. The low feed cost/kg gain observed in birds fed diets containing Roselle seeds fermented for 96 hours (₦187.84) compared to birds fed the control diet (₦206.70) was in contrast to the report of Duwa *et al.* (2012) that there were no differences in feed cost/kg gain by birds fed processed Roselle seeds and birds fed the control diet, while birds fed diet containing raw Roselle seeds had the least cost and this is attributed to lack of processing cost. The high mortality rate observed in birds fed diet containing raw Roselle seed may be as a result of the presence of some anti-nutritional factors. McDonald *et al.* (1987) reported that higher concentration of anti-nutritional factors in the diet of monogastric animals may cause extensive scouring, distress, dullness, loss of appetite and extended cases leads to death.

**Table 6: Effect of Diets Containing Roselle Seeds Raw or Fermented for Different Periods on Growth Performance of Broiler Chicks (4-8 weeks of age)**

Parameters	Diets and Fermentation Periods (Hours)						SEM
	(T1) Control	(T2) Raw	(T3) 24hrs	(T4) 48hrs	(T5) 72hrs	(T6) 96hrs	
Initial weight (g/bird)	821.00	821.33	821.00	821.30	821.00	820.33	1.16
Final weight (g/bird)	2085.67 <sup>a</sup>	1600.33 <sup>d</sup>	1629.33 <sup>d</sup>	1892.00 <sup>c</sup>	1981.67 <sup>b</sup>	2048.33 <sup>a</sup>	24.04
Weight gain (g/bird)	1264.67 <sup>a</sup>	779.00 <sup>d</sup>	808.33 <sup>d</sup>	1070.70 <sup>c</sup>	1160.67 <sup>b</sup>	1228.00 <sup>a</sup>	20.42
FCR	2.30 <sup>a</sup>	3.13 <sup>c</sup>	3.11 <sup>c</sup>	2.59 <sup>b</sup>	2.36 <sup>a</sup>	2.29 <sup>a</sup>	0.10
Daily feed intake(g/bird)	104.00 <sup>a</sup>	87.33 <sup>d</sup>	89.89 <sup>c</sup>	99.07 <sup>b</sup>	98.04 <sup>b</sup>	100.40 <sup>b</sup>	1.22
Total feed intake (g/bird)	2912.33 <sup>a</sup>	2445.24 <sup>d</sup>	2517.00 <sup>c</sup>	2774.00 <sup>b</sup>	2745.00 <sup>b</sup>	2810.00 <sup>b</sup>	34.06
Feed cost/kg gain (₦)	206.70	254.50	253.03	210.90	192.85	187.84	1.24
Mortality (%)	8.88 <sup>b</sup>	15.50 <sup>c</sup>	0.00 <sup>a</sup>	8.88 <sup>b</sup>	8.88 <sup>b</sup>	8.88 <sup>b</sup>	0.24

<sup>abcd</sup>: Means on the same row with different superscripts are significantly different (P<0.05), SEM: Standard error of means, FCR: Feed conversion ratio.

#### **Haematological Parameters of Broiler Chickens fed Diets Containing Roselle Seeds Raw or Fermented for Varying Durations**

The haematological parameters of broiler birds fed raw or fermented Roselle seed is presented in Table 7. There were significant (P<0.05) differences in packed cell volume (PCV), total blood protein (TBP), red blood cells (RBC) count, haemoglobin (Hb) concentration, heterophils and lymphocytes.

There were no significant (P>0.05) for White blood cells (WBC) count among the treatments. Packed cell volume (PCV) value was significantly (P<0.05) higher in birds fed diets containing Roselle seeds fermented for 96 hours (31.00%), while birds fed the control diet had the lowest value (24.50%). The RBC count was found to be higher ( $5.30$  and  $4.73 \times 10^{12}/L$ ) in birds fed diets containing Roselle seeds fermented for 96 and 72 hours,



respectively, while birds fed the control diet were observed to have the least value (4.05).

There were no significant ( $P>0.05$ ) differences in white blood cells count. However birds fed diets containing Roselle seed fermented for 24 hours had higher white blood cell count ( $18.00 \times 10^9/L$ ), while birds fed the control diet had the least WBC count ( $11.85 \times 10^9/L$ ). Birds fed fermented Roselle seed diet had similar Hb values which were significantly ( $P<0.05$ ) higher than those fed the control diet. The highest Hb concentration was observed in birds fed diet containing Roselle seeds fermented for 96 hours (10.30g/dl), while the least value was observed in birds fed the control diet (8.15g/dl). Birds fed diets containing Roselle seeds fermented for 96 hours had the highest heterophil value (11.00%), while the least value was observed in birds fed diet containing Roselle seeds fermented for 48 hours (4.00%). There were significant ( $P<0.05$ ) differences in lymphocyte values. Birds fed diet containing Roselle seeds fermented for 48 hours had the highest value (94.00%), while birds fed diet containing fermented Roselle seeds for 72 hours had the least lymphocyte value (76.67%).

The observed differences in PCV, TBP, Hb, RBC count, Heterophils and Lymphocytes and non-differences in WBC count agree with the findings of Duwa *et al.* (2013) who conducted a study on the effect of Roselle seed meal on haematological and biochemical indices of broiler chickens. The highest WBC count observed in birds fed diet containing Roselle seeds fermented for 24 hours could be as a result of the body immune system producing antibodies to defend the body against foreign organisms. Roselle seeds fermented for 96 hours were observed to give higher values than the other dietary treatments in all the blood parameters evaluated. The PCV values (24.50-31.00 %) observed in this study are all within the normal range (24-31%) for healthy broiler chickens reported by Kwari *et al.* (2008). This indicated that the diets were adequate in nutrients for broiler chickens and the birds were not anaemic.

The values obtained in this study for TP (2.13-4.40 g/l) fall within the normal range (3.31 to 5.39 g/l) as reported by Mitruka and Rawnsley (1997). The values indicates nutritional adequacy of Roselle seeds fermented for varying durations in respect to protein. The RBC, WBC and Hb fall within the normal range  $2-4 \times 10^{12/L}$ ,  $3.9 - 31 \times 10^9/L$  and 7 -13g/dl, respectively as reported by Kwari *et al.* (2008). The haemoglobin concentration observed in this study ranged from (8.15-10.30g/dl) which falls within the normal range (7-13g/dl) recommended for healthy broiler chickens indicating that the birds had sufficient blood pigment for proper transportation of oxygen. The highest and least lymphocyte values of 94.00 and 76.67% were recorded for birds fed diets containing Roselle seeds fermented for 48 hours and Roselle seeds fermented for 72 hours respectively. The values recorded in this study were above the 40 to 48% reported by Bhatti *et al.* (2006). This implied that, all the treatment groups had adequate immune response status. The result also implied that fermentation at these durations predisposed the birds to infection as higher count than normal may mean that, the birds immune system may be combating some kind of infection as reported by Frandson (1986) and Adeyemo and Longe (2007).

#### **Nutrient Digestibility of Broiler Chickens Fed Diets Containing Roselle Seeds Raw or Fermented for Varying Durations**

Table 8 shows the result of dry matter, crude protein, crude fibre, ether extract and nitrogen free extract digestibilities by broiler chickens fed diets containing Roselle seeds raw or fermented for varying durations. There were significant ( $P<0.05$ ) differences in digestibility of dry matter, crude protein, crude fibre and ether extract. Dry matter digestibilities were higher in broiler chickens fed control diet and diet containing Roselle seeds fermented for 96 hours (87.55 and 84.51% respectively) and least in birds fed diet containing Roselle seeds fermented for



**Table 7: Effects of Diets Containing Roselle Seeds Raw or Fermented for Varying Durations on Haematological Parameters of Broiler Chickens (9 weeks of age)**

Parameters	Diets and Fermentation Periods (Hours)						SEM
	(T1) Control	(T2) Raw	(T3) 24hrs	(T4) 48hrs	(T5) 72hrs	(T6) 96hrs	
Packed cell volume (%)	24.50 <sup>b</sup>	28.00 <sup>a</sup>	27.33 <sup>a</sup>	27.00 <sup>a</sup>	28.33 <sup>a</sup>	31.00 <sup>a</sup>	2.13
Total protein (g/l)	3.30 <sup>a</sup>	3.06 <sup>b</sup>	3.20 <sup>a</sup>	2.13 <sup>b</sup>	2.67 <sup>b</sup>	4.40 <sup>a</sup>	0.61
Haemoglobin (g/dl)	8.15 <sup>b</sup>	9.30 <sup>a</sup>	9.06 <sup>a</sup>	8.97 <sup>a</sup>	9.40 <sup>a</sup>	10.30 <sup>a</sup>	0.70
White blood cell (x10 <sup>9</sup> /L)	11.85	13.57	18.00	15.37	14.83	15.87	3.47
Red blood cell (x 10 <sup>12</sup> /L)	4.05 <sup>b</sup>	4.67 <sup>a</sup>	4.57 <sup>a</sup>	4.60 <sup>a</sup>	4.73 <sup>a</sup>	5.30 <sup>a</sup>	0.37
Heterophil (%)	10.00 <sup>a</sup>	9.33 <sup>a</sup>	6.67 <sup>b</sup>	4.00 <sup>b</sup>	12.67 <sup>a</sup>	11.00 <sup>a</sup>	2.11
Lymphocyte (%)	79.50 <sup>c</sup>	86.33 <sup>b</sup>	89.33 <sup>a</sup>	94.00 <sup>a</sup>	76.67 <sup>c</sup>	87.50 <sup>a</sup>	2.36

<sup>abc</sup>: Means on the same row with different superscripts are significantly different (P<0.05), SEM: Standard error of means

24 hours (80.38%). Broiler chickens fed the control diet had significantly (P<0.05) higher crude protein digestibility value (90.86%) compared to other dietary treatments. The highest crude fibre digestibility was observed for broilers fed the control diet (90.27%), while birds fed the diet containing Roselle seeds fermented for 24 hours had the least value (85.22%). There were no significant (P>0.05) differences in digestibility of NFE. Ether extract digestibility was significantly (P<0.05) higher in birds fed the control diet (95.19%) compared to all the other dietary treatments.

The nutrient digestibility result showed that parameters analysed were similar in birds fed control diet and Roselle seeds fermented for 96 hours. This indicates that there is an improvement in nutrient digestibility as fermentation duration increased. This may be due to residual effect of anti-nutrient present in Roselle seed fermented for fewer hours. This agrees with the findings of Ready and Pierson (1999) that soaking before fermentation improves digestibility, nutritive value and flavors of Roselle seed, but in contrast to the report of Duwa *et al.* (2012) who reported significant differences in crude fibre levels when they fed roasted, boiled and soaked Roselle seed to broiler chickens.

**Table 8: Nutrient Digestibility of Broiler Chickens Fed Diets Containing Roselle Seeds Raw or Fermented for Varying Durations**

Parameters (%)	Diets and Fermentation Periods (Hours)						SEM
	(T1) Control	(T2) Raw	(T3) 24hrs	(T4) 48hrs	(T5) 72hrs	(T6) 96hrs	
Dry matter	87.55 <sup>a</sup>	82.16 <sup>b</sup>	80.38 <sup>b</sup>	85.44 <sup>a</sup>	82.81 <sup>a</sup>	84.51 <sup>a</sup>	2.44
Crude protein	90.86 <sup>a</sup>	87.56 <sup>a</sup>	85.27 <sup>b</sup>	89.66 <sup>a</sup>	88.54 <sup>a</sup>	88.94 <sup>a</sup>	1.84
Crude fibre	90.27 <sup>a</sup>	86.59 <sup>a</sup>	85.22 <sup>b</sup>	89.38 <sup>a</sup>	88.40 <sup>a</sup>	89.30 <sup>a</sup>	2.05
Ether extract	95.19 <sup>a</sup>	93.32 <sup>b</sup>	93.26 <sup>b</sup>	94.49 <sup>a</sup>	92.56 <sup>b</sup>	92.95 <sup>b</sup>	0.92
Nitrogen Free Extract	80.97	76.44	75.11	81.36	78.16	80.30	3.16

<sup>abc</sup>: Means on the same row with different superscript are significantly different (P<0.05), SEM: Standard error of means.



## **Carcass Characteristics and Organ Weight of Broiler Chickens fed Diets Containing Roselle Seeds Raw or Fermented for Varying Durations (9 weeks of age)**

Table 9 shows the carcass parameters of broiler chickens fed raw or fermented Roselle seeds. Live weight, dressed weight and dressing percentage were significantly ( $P < 0.05$ ) affected by raw or fermented Roselle seeds for varying durations in broiler finisher chickens. The live weight was higher in birds fed diets containing Roselle seeds fermented for 96 hours and the control diet (2033.33 and 2000.00 g/bird, respectively) but lowest in birds fed diets containing Roselle seeds fermented for 48 hours (1567.00 g/bird). Dressed weight were higher for birds fed control diet and birds fed diet containing Roselle seeds fermented for 96 hours (1618.33 and 1618.00 g/bird respectively) and lowest for birds fed diet containing Roselle seeds fermented for 48 hours (1217.33g/bird). Birds fed control diet had higher dressing percentage (80.92%) when compared to other dietary treatments. There were significant ( $P < 0.05$ ) differences in the values for heart, spleen, gizzard and liver. There were also significant ( $P < 0.05$ ) differences in the values for breast, thighs and drumsticks. Birds fed control diet and diet containing Roselle seeds fermented for 96 hours had higher percentage of breast, thighs and drumsticks compare to the other treatment groups.

The higher dressed weight and dressing percentages observed in birds fed the control diet and birds fed diet containing fermented Roselle seed for 96 hours (1618.33g and 80.92%) and (1618.00g and 79.59%), respectively is an indication that Roselle seed fermented for 96 hours improved carcass characteristics of the birds compared to birds fed raw Roselle seed and Roselle seed fermented for 24, 48 and 72 hours. This could be as a result of the reduced anti-nutrient in

Roselle seeds fermented for 96 hours. Birds fed diets containing Roselle seed fermented for 96 hours and the control diet had higher values for breast muscle, drumsticks and thighs, while birds fed diets containing raw Roselle seed had the least values. The low values of breast muscle, drumsticks and thighs observed in birds fed raw Roselle seed may be attributed to low feed consumption and poor utilization of feed by birds (Amaefule and Obioha, 2001). The organ weights which include spleen, heart, gizzard and liver were observed to be affected by dietary treatments. The higher weight of liver in birds fed diets containing raw and Roselle seed fermented for 24 hours is possibly as a result of high levels of toxic factors and the attempt by the liver to detoxify them. This agrees with the findings of Ukachukwu (2000) and Akinmutini, (2001) who reported that liver is the organ involved in detoxification and leads to stress on the liver to produce more enzymes to compensate for enzyme inactivation by anti-nutrients present in leguminous seeds. The higher values of gizzard weights by birds fed diets containing raw Roselle seed and Roselle seeds fermented for 24 hours may again indicate incomplete elimination of anti-nutrient in the diets or it may be attributed to high fibre content in raw and Roselle seeds fermented for 24 hours. Duwa *et al.* (2012) reported higher gizzard weight for birds fed boiled and soaked Roselle seed meal.

## **Conclusion**

Roselle seeds fermented for 96 hours at both starter and finisher phases resulted in improved growth performance, nutrient digestibility and haematological parameters of broiler chickens. It can therefore be recommended that roselle seeds fermented for 96 hours can be fed to broiler chickens at starter and finisher phases without any adverse effect on growth performance and haematological parameters.

**Table 9: The Effect of Diets Containing Roselle Seeds Raw or Fermented for Different Periods on Carcass Characteristics of Broiler Chickens (9 weeks of age)**

Parameters	Diets and Fermentation Periods (Hours)						SEM
	(T1) Control	(T2) Raw	(T3) 24hrs	(T4) 48hrs	(T5) 72hrs	(T6) 96hrs	
Live weight (g)	2000.00 <sup>a</sup>	1600.00 <sup>d</sup>	1567.00 <sup>d</sup>	1767.00 <sup>c</sup>	1835.00 <sup>b</sup>	2033.33 <sup>a</sup>	27.38
Dressed weight (g)	1618.33 <sup>a</sup>	1218.33 <sup>e</sup>	1249.33 <sup>d</sup>	1417.33 <sup>c</sup>	1450.00 <sup>b</sup>	1618.00 <sup>a</sup>	2.71
Dressing %	80.92 <sup>a</sup>	76.14 <sup>b</sup>	79.72 <sup>a</sup>	80.21 <sup>a</sup>	79.01 <sup>a</sup>	79.59 <sup>a</sup>	1.26
<b>Organ expressed as percentage of live weight</b>							
Heart %	0.32 <sup>d</sup>	0.44 <sup>a</sup>	0.43 <sup>a</sup>	0.40 <sup>b</sup>	0.36 <sup>c</sup>	0.37 <sup>c</sup>	0.01
Spleen %	0.05 <sup>b</sup>	0.10 <sup>a</sup>	0.08 <sup>a</sup>	0.05 <sup>b</sup>	0.08 <sup>a</sup>	0.07 <sup>b</sup>	0.01
Gizzard %	1.31 <sup>d</sup>	2.13 <sup>a</sup>	2.30 <sup>a</sup>	2.08 <sup>b</sup>	1.82 <sup>c</sup>	1.83 <sup>c</sup>	0.10
Liver %	1.67 <sup>b</sup>	2.00 <sup>a</sup>	2.00 <sup>a</sup>	1.73 <sup>b</sup>	1.50 <sup>c</sup>	1.40 <sup>c</sup>	0.06
<b>Cut parts expressed as percentage dressed weight</b>							
Drumstick (g)	10.58 <sup>b</sup>	7.96 <sup>e</sup>	8.49 <sup>d</sup>	8.97 <sup>c</sup>	8.96 <sup>c</sup>	11.20 <sup>a</sup>	0.08
Breast (g)	24.32 <sup>a</sup>	16.26 <sup>f</sup>	17.34 <sup>e</sup>	17.39 <sup>d</sup>	17.71 <sup>c</sup>	24.00 <sup>b</sup>	0.02
Thigh (g)	13.28 <sup>a</sup>	8.82 <sup>e</sup>	9.68 <sup>d</sup>	10.30 <sup>c</sup>	10.41 <sup>c</sup>	11.56 <sup>b</sup>	0.09

<sup>abcdef</sup>. Means on the same row with different superscripts are significantly different (P<0.05), SEM: Standard error of means

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