International Academic Research Consortium Journals (IARCJ)
International Journal of Agricultural Science and Technology
ISSN: 2360-9888. Volume 8, Number 1
Pages 90-109 (November, 2018)
www.iarcj.org, www.arcnjournals.org

Growth Performance, Carcass and Haematological Characteristics of Broiler Chickens Fed Toasted Sorrel Seed Meal as Replacement for Soybean Meal

[1]Ubua, J.A., [2]Ozung, P.O.* & [1]Aboluja, B.A.
[1]Department of Animal Science, Taraba State University, Jalingo, Nigeria
[2]Department of Animal Science, Faculty of Agriculture, Forestry & WRM, University of Calabar, Calabar, Nigeira

*Corresponding author's E-mails & mobile contacts: ozungpascal@unical.edu.ng; pascalozung@yahoo.com; ubua4u@gmail.com; +2348062246745; +2348037965335

***Abstract**: This study investigated the growth performance, carcass and haematological characteristics of broiler chickens fed dietary toasted sorrel seed meal as a replacement for soybean meal. A total of 120 day – old broiler chicks of Arbor acre plus strain were allocated to four dietary treatments designated as T_1, T_2, T_3 and T_4, with 0, 50, 75 and 100% replacement levels of toasted sorrel seed meal (TSSM) for soybean meal. There were 30 birds per treatment with two replicates of 15 birds each in a Completely Randomized Design (CRD) experiment. Growth performance characteristics (feed intake, body weight gain and feed conversion ratio) were monitored for 56 days. At the end of the feeding trial, the birds were slaughtered for the determination of carcass parameters. The data obtained was subjected to one- way ANOVA and the results showed decrease in growth performance characteristics with significant (P<0.05) effect of dietary treatments on the final weight gain (350 – 570 g/bird), average daily weight gain (11.14 – 19.00 g/bird) and FCR (1.77 - 2.37) at the end of the starter phase (0 - 4 weeks) as the replacement levels of TSSM for soybean meal increased across dietary treatments. The same trend was recorded in at the finisher phase (5 – 8 weeks), where significant (P<0.05) differences existed between treatments in the final weight gain (535.50 – 1521.00 g/bird), average daily weight gain (8.85 – 30.00 g/bird), average daily feed intake (52.45 – 89.10 g/bird) and FCR (2.62 – 5.92). However, the carcass characteristics showed significant (P<0.05) difference between treatments with the exception of dressing percentage. The breast and shanks were significantly (P<0.05) affected by dietary treatments while internal organs (% LW) and all haematological parameters recorded no significant (P>0.05) dietary effect. The 50% replacement level of TSSM for soybean meal appeared superior in terms of the feed intake, dressing percentage, most cut-up parts and internal organs of broiler chickens, when compared to the control diet. Replacement levels beyond 50% drastically reduced growth performance and carcass characteristics. The study therefore concludes that poultry farmers can replace soybean meal with 50% toasted sorrel seed meal in broiler chicken diets without fear of compromising growth and carcass characteristics.*

Key words: *Chicken, carcass, performance, sorrel, soybean*

INTRODUCTION

The protein quality of feed ingredients is determined by their essential amino acid profile as well as digestibility or bioavailability. The production of commercial feeds for farm animals has been conventionally based on the use of soybean meal and fishmeal as their main protein sources. This is due to their high protein content vis –a-vis biological value/ balanced amino acid profile (Nguyen, 2008). Alternative protein sources for livestock diets are necessary in order to reduce farmers' dependence on conventional sources of protein. The supply, availability and nutritional value are some of the necessary factors affecting the quest for suitable protein alternatives.

The poultry sector plays a vital role in improving the global food security status of consumers. Commercial and smallholder poultry enterprises are growing, thereby increasing the demand for poultry feeds. Soybean and fishmeal have traditionally been the main protein sources in poultry feeds, but with the growth of the poultry sector and the world's population, they are failing to meet the increasing demand (El-Sayed, 1987). Due to shortages and cost considerations, it is inevitable that more consideration is given to alternative protein sources or replacements to be utilized in poultry feeds in the near future. The high cost and lack of availability of commercial protein sources at times are known as some of the main limitations to efficient animal production. In livestock and poultry production, feed accounts for the largest single cost, making up approximately 60-80% of the total cost (FAO, 2003).

Soybean meal and fishmeal prices are on the increase for farmers. This implies that soybean meal and fishmeal will be less accessible. This makes the prospects of utilizing alternative sources of protein feasible, because they are locally available and easily accessible throughout most of the year. There is need therefore to supply the much needed average animal protein level of the ever growing population in Nigeria where it has been estimated that an average Nigerian consumes barely 45.4g of animal protein as against about 53.8g minimum recommended by the FAO for an adult (FAO, 1992).

Presently, Nigeria is not producing enough to meet the overall national demand for poultry products, though it is assumed that the country has the potential to meet the poultry requirements of the country (AgroNigeria, 2014). Considering the current school feeding programme by the Buhari administration with the poultry products alone, it is enough initiative to expand production capacities and the market opportunities for poultry producers (AgroNigeria, 2014). Lagos state alone for example will need about 800,000 eggs daily to implement the one egg per day per student programme (AgroNigeria, 2014). This therefore, requires holistic poultry production for sustainable and profitable enterprises to meet national demand. Increase in population of humans is leaving no hope of ever having surplus grains to compound economically viable livestock feed (Christopher *et al*., 1997; Onimisi, 2005).

The limited supply coupled with an increasing demand from the animal feed industry, results in high prices for conventional ingredients such as soybean and fishmeal. With the escalating cost of soybean meal and fishmeal, it is critical that all animal production systems reduce their reliance on these ingredients. With respect to Nigeria, the situation is exacerbated by the present decline in foreign reserve, high exchange rates and restrictions placed on access to foreign exchange for imported goods such as fishmeal.

Furthermore, there are growing environmental concerns about the use of wild fish to produce fishmeal. Hence, the growing interest in substitution of soybean meal and fishmeal with less expensive protein sources. The substitution of soybean meal and fishmeal in practical diets without reducing the performance would result in a more profitable production of farm animals.

Globally, many studies have been conducted to evaluate the substitution of high cost conventional feeds with low-cost, locally available plant and animal protein sources such as sorrel seed meal, locust bean meal, moringa leaf meal, bambara nut meal and watermelon seed meal, blood meal, meat meal, among others in practical diets for farm animal production. Current research efforts in most developing countries are therefore aimed at identifying potential feed sources that have little or no demand by humans, such that could be cheap and available for compounding livestock rations as it will reduce or remove the competition between man and livestock, and among livestock for feed sources. Some of such potential feed materials that are being investigated include by-products from garri processing industries and waste from groceries, cattle ranches, abattoirs, and poultry houses (Alawa and Umunna, 1993; Abdulmalik *et al*., 1994; Ozung, *et al*., 2017; Ozung *et al*., 2018).

Sorrel (*Hibiscus sabdarrifa*) is a very versatile plant similar to the coconut tree and can be found in almost all warm countries (Quezon, 2005). Sorrel is known by different synonyms and vernacular names such as Roselle, Zobo, Rosela, Omutete, Bissap, and Sour-Sour. Virtually all parts of the sorrel plant are important ranging from the leaves, flowers, calyces and the seeds. However, the sorrel seed is rich in nutrient value such as carbohydrates, proteins and lipids (Quezon, 2005). There are several reports on the chemical composition of sorrel seeds. APRC (1999) reported that sorrel seeds contain 28% crude protein, 19.9% ether extract, 5.5% ash and 18% crude fibre. In other studies, Dashak and Nwanegbo (2002) and Isidahomen *et al*. (2006) reported 35.19 and 25.92% CP respectively and 15% CF in sorrel seeds. The sorrel seed has relatively 9.9% moisture, 33.5g Protein, 18.3g total dietary fibre, 13.0g carbohydrate and 22.1% fat content (Hainida *et al*., 2008). In view of the nutrient profile of the seeds of this promising plant, this study was therefore designed to determine the effect of toasted sorrel (*Hibiscus sabdariffa*) seed meal on the growth performance, carcass and haematological characteristics of broiler chickens in a guinea savanna zone.

MATERIALS AND METHODS

Location of the study area

The study was carried out at the Poultry Unit of the Teaching and Research Farm of the Department of Animal Science, Taraba State University, Jalingo, Taraba State. It is located within the Guinea Savannah Zone. Jalingo lies between latitude 8°50$^{1'}$North of the equator and longitude 11°31^{1} East of the equator (Taraba State Diary, 2008). The area is characterized by tropical climate marked by dry and rainy seasons. The rainy season usually commences in the month of March and ends in October. The dry season then starts in late October and ends in March. The annual rainfall is between 1000 and 1500 mm with an average minimum temperature of 30^{0}C and maximum temperature of 38^{0}C depending on the season (Taraba State Diary, 2008).

Collection and processing of test ingredient

The sorrel seeds were sourced from markets in and around Jalingo metropolis for the study. The seeds were winnowed to remove chaff and unwanted particles while stones and other hazardous materials were carefully handpicked. The sorrel seeds were toasted manually by subjecting then to heat hot enough to toast but not to char with the use of firewood and metal pot. Thereafter the seeds were milled with the hammer mill to a coarse feed, which can easily be picked by the experimental birds.

Experimental birds and management

A total of one hundred and twenty (120) day – old broiler chicks of Arbor acres plus strain purchased from a reputable hatchery in Ibadan, Oyo State were used in this study. The chicks were randomly allocated into four (4) treatments of full fat soybean and replacement levels of sorrel seed meal. Poultry facilities were thoroughly washed and properly disinfected. Drinkers and feeders were installed 24hrs before arrival of the birds; the poultry house was also fumigated two (2) weeks before the arrival of the birds. Vaccination of the birds was carried out according to the recommended vaccination programme for broiler birds. Feed and water were provided *ad libitum* on a daily basis.

Proximate composition of Sorrel (*Hibiscus sabdariffa*) seed meal and experimental diets

The proximate analysis of sorrel seed meal and experimental diets (starter and finisher diets) was carried out using the procedures of AOAC (2001).

Experimental diets

Four experimental diets were formulated and designated as T_1, T_2, T_3 and T_4 respectively containing 0, 50, 75 and 100% replacement levels of sorrel seed meal for soybean meal as presented in Tables 1 and 2 for the broiler starter and finisher phases respectively.

Table 1: Composition of experimental diets (Starter phase, 0-4weeks)

	T_1	T_2	T_3	T_4
Ingredients	(0%)	(50%)	(75%)	(100%)
Maize	55.45	55.45	55.45	55.45
Toasted sorrel seed meal	0.00	12.50	18.75	25.00
Soybean (Full fat)	25.00	12.50	6.25	0.00
Fish meal	2.00	2.00	2.00	2.00
Maize bran	12.00	12.00	12.00	12.00
Bone meal	2.50	2.50	2.50	2.50
Salt	0.25	0.25	0.25	0.25
Premix	0.50	0.50	0.50	0.50
Limestone	2.00	2.00	2.00	2.00
Methionine	0.30	0.30	0.30	0.30
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated values:				

Crude Protein (%)	22.90	22.93	22.93	22.93
ME (Kcal/kg)*	2900.00	2907.00	2900.00	2900.00
Crude fibre (CF) (%)	3.40	4.90	4.92	4.97
Ether Extracts (EE) (%)	3.70	4.20	4.30	4.42
Ash (%)	3.20	3.00	3.20	3.20
NFE (%)	66.80	64.97	64.65	64.48

*Calculated based on Pauzenga (1985) equation:

Metabolizable energy (ME) = 37 × CP % + 81.8 × EE % + 35.5 × NFE %)

Premix composition: Vit. A=12,000,000IU, Vit. D3=2,500,000UI, Vit. C=30,000IU, Vit. K=2,000mg, Vit.B1=2,250mg, Vit. B2=6,000mg, Vit. B6=4,500mg, Vit. B12=15mcg, Niacin=40,000mg, Pantothenic Acid=15,000mg, Folic Acid=1,500mg, Biotin=50mcg, Choline Chloride=300,000mg, Manganese=80,000mg, Zinc=50,000mg, Iron=20,000mg, Copper=5,000mg, Iodine=1,000mg, Selenium=200mg, Cobalt=500mg, Antioxidant=125,000mg.

Table 2: Composition of experimental diets (Finisher phase, 5 - 8weeks)

	T_1	**T_2**	**T_3**	**T_4**
Ingredients (Kg)	**(0%)**	**(50%)**	**(75%)**	**(100%)**
Maize	65.15	65.15	65.15	65.15
Toasted sorrel seed meal	0.00	10.00	15.00	20.00
Soybean (full fat)	20.00	10.00	5.00	0.00
Fish meal	1.80	1.80	1.80	1.80
Maize bran	10.00	10.00	10.00	10.00
Bone meal	1.00	1.00	1.00	1.00
Salt	0.25	0.25	0.25	0.25
Premix	0.50	0.50	0.50	0.50
Limestone	1.00	1.00	1.00	1.00
Methionine	0.30	0.30	0.30	0.30

Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated values:				
Crude Protein (%)	19.00	19.20	19.31	19.40
*ME (Kcal/kg)	3000.00	3050.00	3060.00	3064.00
Crude fibre (CF) (%)	3.20	4.60	5.20	5.80
Ether extracts (EE) (%)	3.70	4.20	4.40	4.70
Ash (%)	2.03	2.06	2.08	2.09
NFE (%)	72.07	69.94	69.01	68.01

*Calculated based on Pauzenga (1985) equation:

Metabolizable energy (ME) = 37 × CP % + 81.8 × EE % + 35.5 × NFE %)

Premix composition: Vit. A=10,000,000IU, Vit. D3=2,000,000UI, Vit. C=20,000mg, Vit. K=2,000mg, Vit.B1=3,000mg, Vit. B2=5,000mg, Vit. B6=45,000mg, Vit. B12=10,000mg, Niacin=4,000mg, Pantothenic Acid=20mg, Folic Acid=300,000mg, Biotin=1,000mg, Choline Chloride=50mg, Manganese=300,000mg, Zinc=120,000mg, Iron=80,000mg, Copper=3,500mg, Iodine=1,500mg, Selenium=300mg, Cobalt=120mg, Antioxidant=120,000mg.

Experimental procedure

The chicks were brooded for one week during which time they were placed on the control diet for adaptation prior to commencement of the study. The birds were randomly allotted to four dietary treatments designated as T_1, T_2, T_3 and T_4, with thirty (30) birds per treatment while each treatment was further replicated twice with fifteen (15) birds per replicate in a Completely Randomized Design (CRD) and housed in a 1.2 m × 1.2 m pen per replicate. Standard vaccination practices were strictly adhered to as well as administration of medication and other management practices that ensure good health. Water was supplied *ad libitum*. The overall feeding trial lasted for 56 days from the starter to finisher phases.

Determination of growth characteristics

Feed intake

Feed intake was determined on daily basis as the difference between the quantity of feed fed the previous day and quantity left over the next morning.

Body weight

The initial body weight of the birds was taken at the start of the trial using digital measuring scale and subsequently live weight measurements were carried out on weekly basis. Body weight changes were calculated by difference; thereafter the average weekly and daily weight gain values were determined accordingly.

Feed conversion ratio (FCR)

The FCR was calculated as the ratio of feed intake to body weight gain.

Haematological parameters

Four blood samples per treatment (2ml each from 2 replicates) were obtained from the wing vein of the birds at the 8th week into Ethylene Diamine Tetra acetic acid (EDTA) bottles for hematological assay using standard laboratory methods (Ochei and Kolhathar, 2007). The haematological parameters determined were the Packed Cell Volume (PCV), Red Blood Cell counts (RBCs), White Blood Cell counts (WBCs), Haemoglobin concentration (Hb), while Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Volume (MCV) and Mean Corpuscular Haemoglobin Concentration (MCHC) were computed using appropriate formulae described by Svobodova *et al*. (1991).

Carcass evaluation

Carcass evaluation was done at the end of feeding trial (56th day), where four (4) birds per treatment (2 birds/replicate whose body weights were similar or closed to the average weight per treatment) were selected after all birds were fasted 24 hours for subsequent slaughtering and carcass evaluation. Each bird was weighed (live/slaughter weight) and slaughtered for effective bleeding. The slaughtered birds were defeathered after immersing in warm water (scalding). Each defeathered bird was eviscerated and the head and shanks removed before the dressed or eviscerated weight was taken, thereafter the primal cuts and internal organs were removed and weighed accordingly.

Dressing percent = $\frac{Eviscerated\ weight}{\text{Live weight}}$ x 100

Statistical analysis

All data obtained was subjected to one – way analysis of variance (ANOVA) for CRD using SAS (2000) while significant means were separated using Duncan's Multiple Range Test (DMRT) (Duncan, 1955).

RESULTS AND DISCUSSION

Proximate composition of the test ingredient (Toasted sorrel seed meal) and experimental diets

The result obtained for the proximate composition of the test ingredient, toasted sorrel seed meal (*H. sabdariffa*) is presented in Table 3. It shows that sorrel seed meal had 98.5% dry matter (DM), 33.85% crude protein (CP), 32.0%, crude fibre (CF), 11.5% ether extracts (EE), 8.1% ash and 14.55% Nitrogen free extracts (NFE). The results revealed high CP, which was within the 24 - 35.91% range reported for sorrel seed meal by previous workers (Samy, 1980; Rao, 1996; APRC, 1999; Dashak and Nwanegbo, 2002; Isidahomen *et al*., 2006; Kwari *et al*., 2011 and NIAS 2014). This showed that toasted sorrel seed meal possesses good CP content that can replace full fat soybean meal in animal diets. The CF was a little lower than the range (39 - 42%) reported by Rao (1996). The ash content was closed to values reported by Samy (1980) and Dashak and Nwanegbo (2002) with 7.0% and 10.09% respectively.

Table 3: Proximate composition and energy value of toasted sorrel seed meal

Parameter	% composition
Dry matter (DM)	98.50
Crude protein (CP)	33.85
Crude fibre (CF)	32.00
Ether extracts (EE)	11.50
Ash	8.10
Nitrogen free extracts (NFE)	14.55
*ME (Kcal/kg)	2,250.00

Each value is the mean of three separate proximate determinations

*Calculated based on Pauzenga (1985) equation: Metabolizable energy (ME) = 37 × CP % + 81.8 × EE % + 35.5 × NFE %)

The proximate composition and energy values of experimental diets at both the starter and finisher phases are presented in Table 4. The dry matter (DM) content of the broiler starter diets across the treatments ranged between 95.50 and 96.50%. The crude protein ranged between 22.65 and 24% across the treatments, which was in agreement with the recommended value of 24% for broiler starter diets (Olomu, 1995). This could be attributed to the adequate level of crude protein in the test ingredient (*H*. *sabdariffa*) and the protein contents of other feed ingredients. This was an indication that TSSM can be adequately used to replace soybean meal in broiler starter diets. The crude fibre (CF) ranged from 10.50 - 32.00% with highest level recorded in T_4 (100% replacement). Ether extracts had the range 10.00-11.50% across the treatments while ash content ranged between 4.70 and 8.30% with lowest and highest levels recorded in T_3 and T_1 respectively. The Nitrogen free extracts (NFE) showed a range of 23.50 - 46.70% across the treatments. However, the energy level (3,020.15 – 3,090.70Kcal/kg ME) across the treatments was similar to the energy requirement of 3,000kcal recommended for broiler starter diets reported by Olomu, (1995).

Table 4: Proximate composition and energy values of experimental diets

Parameter (%)	T_1 (0%)	T_2 (50%)	T_3 (75%)	T_4 (100%)
Starter diets:				
Dry matter	96.50	95.50	96.50	96.00
Crude protein	24.00	23.20	22.65	22.80
Crude fibre	10.50	19.50	25.50	32.00

Ether extracts	10.50	10.50	10.90	11.50
Ash	8.30	8.80	9.80	10.20
Nitrogen free extracts (NFE)	46.70	38.00	31.15	23.50
*ME (Kcal/Kg)	3,063.95	3,020.15	3,047.65	3,090.70
Finisher diets:				
Dry matter	93.50	95.50	94.50	95.50
Crude protein	22.10	20.25	21.30	20.50
Crude fibre	13.00	18.00	13.50	19.50
Ether extracts	11.50	10.00	11.50	9.00
Ash	4.30	9.40	4.20	4.70
Nitrogen free extracts (NFE)	49.10	42.35	49.50	46.30
*ME (Kcal/Kg)	2,889.05	2,801.40	2,867.65	2,861.15

*(ME= 37 x CP% + 81.8 x EE + 35.5 x NFE %) (Pauzenga, 1985)

The finisher diets had dry matter (DM) content ranging between 93.50 and 95.50% across dietary treatments. The range of crude protein (20.25 - 22.10%), was within the recommended value of 20% for broiler finisher birds (Olomu, 1995). This could be attributed to the high level of crude protein in the test ingredient (*H. sabdariffa*). This signifies that adequate quantity of sorrel will also be required to meet the crude protein need of broiler finishers. The crude fibre (CF) ranged from 13.00 - 19.50% with highest level recorded in T_4 (100% replacement). Ether extract ranged from 9.00-11.50% across the treatments while ash content was between 4.20 and 9.40%. The Nitrogen Free Extract (NFE) showed a range of 42.35 - 49.50% across the treatments. However, the energy level was between 2,801.40 and 2,889.05Kcal/kgME) across the treatments. The values were within the range of 2,800 – 3,000Kcal/kg ME recommended energy requirements for broiler finishers (NIS, 1989; Olomu, 1995). Generally, the diets were nutritionally adequate to support the growth performance of broiler chickens at both the starter and finisher phases.

Growth performance of broiler chickens fed dietary levels of toasted sorrel seed meal

The growth performance of broiler chickens fed dietary levels of toasted sorrel seed meal (TSSM) is presented in Table 5. There was no significant (P>0.05) difference in the average daily feed intake and values were 25.15, 25.45, 25.05 and 26.50 g/bird for 0, 50, 75 and 100% dietary levels respectively at the starter phase (Fig 1), These results agree with the findings of Duwa *et al*. (2012) reported, that there was no depression in average daily feed intake of broiler chickens at the starter phase fed replacement levels of boiled sorrel seed meal up to 60%. The feed conversion ratio of 1.37, 1.77, 2.18 and 2.37 for T_1, T_2, T_3 and T_4 respectively were obtained at the end of starter phase. This agrees with Duwa *et al*. (2012) that reported no significance difference (P>0.05) in feed conversion ratio of broiler starter chickens. The average final weight and daily weight were significantly (P<0.05) influenced by dietary treatments. The weight gain decreased marginally as the replacement levels of TSSM for soybean meal increases across treatments. This implies that toasted sorrel seed meal depresses weight gain in broiler chickens.

However, at the finisher phase all growth parameters were significantly (P<0.05) affected by dietary treatments. The final weight values were 1521, 1014, 661 and 535 g/bird; average daily weight gain values were 34.00, 20.50, 10.78 and 8.85 g/bird, while average daily feed intake values were 89.10, 75.15, 63.50 and 52.45 g/bird for 0, 50, 75 and 100% levels representing T_1, T_2, T_3 and T_4 respectively. All the growth performance parameters at the finisher phase were markedly depressed as the replacement levels of TSSM increased across diets (Fig. 2). This outcome confirms the reports of Duwa *et al*. (2012; 2013) and Wafar (2013) who reported decrease in feed intake and body weight gain as the replacement levels of sorrel seed meal increases. The depression of these growth parameters could be attributed to anti-nutritional factors such as tannin associated with sorrel seeds (*Hibiscus sabdariffa*). Tannin has been reported to cause poor palatability in high tannin diets due to its astringent property and it has the ability of binding dietary proteins and digestive enzymes into complexes that are not readily digestible (Melansho *et al*., 1987, Olomu, 1995; D'Mello and Devendra, 1995). Elkin *et al*. (1990) also reported depressed growth rate and reduced feed efficiency in poultry fed diets containing tannin.

Table 5: Growth performance of broiler chickens fed replacement levels of TSSM for SBM

Parameter	T_1 (0%)	T_2 (50%)	T_3 (75%)	T_4 (100%)	SEM
Starter phase (0-4weeks)					
Initial weight (g/bird)	38.00	39.00	39.00	38.00	-
Final weight (g/bird)	570.00^{a}	440.00^{b}	360.00^{b}	350.00^{b}	34.64^{*}
ADWG (g/bird)	19.00^{a}	14.32^{b}	11.46^{b}	11.14^{b}	7.60^{*}
Av. daily feed intake (g/bird)	25.15	25.45	25.05	26.50	1.14^{NS}
Feed conversion ratio (FCR)	1.37^{c}	1.77^{b}	2.18^{ab}	2.37^{a}	0.10*
Mortality (No.)	2	3	3	4	
Finisher phase (5-8weeks)					
Initial Weight (g/bird)	570.00	440.00	360.00	350.00	34.64
Final Weight (g/bird)	$1,521.00^{a}$	$1,014.00^{b}$	661.00^{c}	535.50^{c}	53.50*
ADWG (g/bird)	34.00^{a}	20.50^{b}	10.78^{c}	8.85^{c}	9.40*

Av. daily feed intake (g/bird)	89.10^{a}	75.15^{ab}	63.50^{bc}	52.45^{c}	5.62*
Feed conversion ratio (FCR)	2.62^{c}	3.66^{b}	5.89^{a}	5.92^{a}	4.16*
Mortality (%)	3.10	10.32	10.41	12.35	

$^{a, b, c...}$ Means within the same row bearing different superscripts differ significantly (P<0.05).

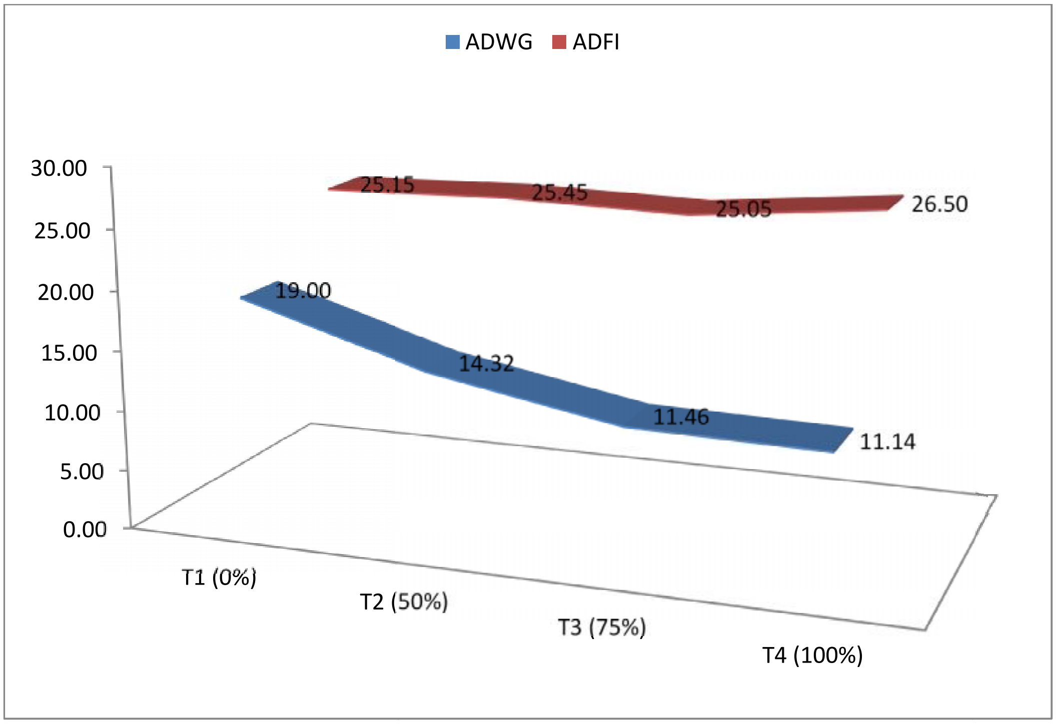

Figure 1: Relationship between ADFI & ADWG at the starter phase

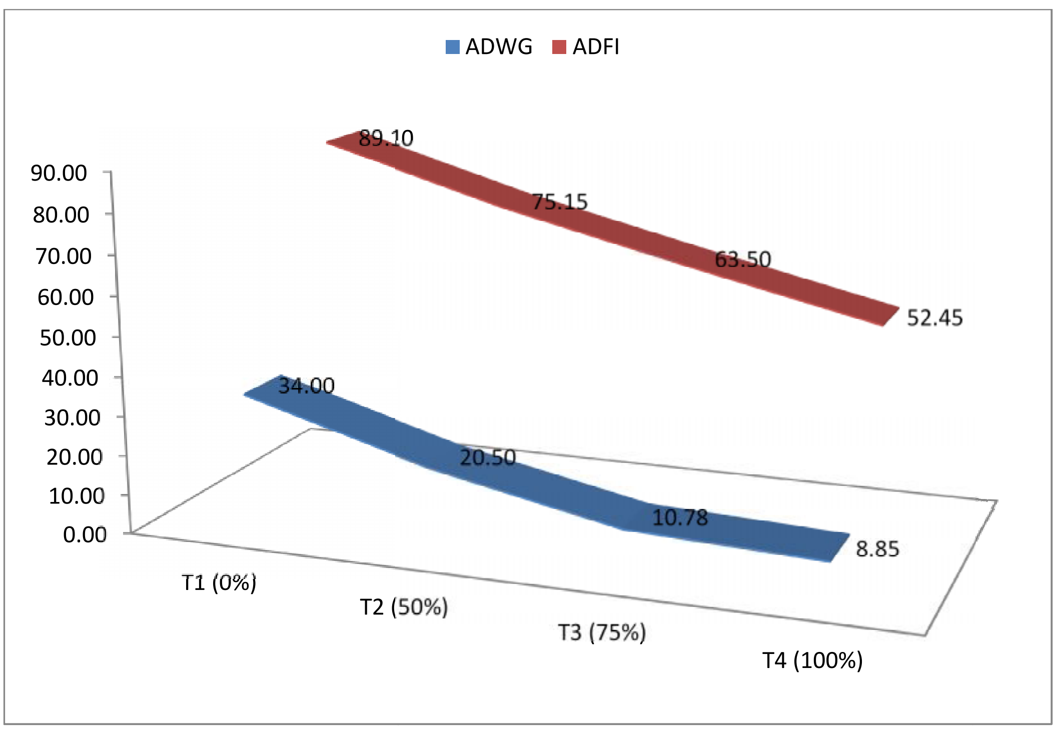

Figure 2: Relationship between ADFI & ADWG at the finisher phase

Haematological characteristics of broiler chickens fed replacement levels of TSSM for SBM

The result of haematological characteristics of broiler chickens fed dietary levels of toasted sorrel seed meal is presented in Table 6 above. The result showed no significant difference (P>0.05) in all the haematological parameters analyzed (RBC, WBC, Hb, PCV, MCV, MCH and MCHC) between the treatments. This result is not in agreement with the findings of Duwa *et al*. (2013) who reported significant effect (P<0.05) in the same haematological parameters of cockerels fed boiled sorrel seed meal up to 60% replacement level. The difference in results could be attributed to the method of processing the test ingredient (TSSM) and associated residual tannin levels. However, the result was similar to the normal ranges of haematological parameters for broiler chickens as presented by Simarak *et al*. (2004) and Wikivet (2013). This implies that TSSM replacement up to 75% has no adverse effect on the haematological characteristics vis – a-vis haematopoietic processes of broiler chickens.

Table 6: Haematological characteristics of broiler chickens fed toasted sorrel seed meal as replacement for soybean meal

Parameter	T_1 (0%)	T_2 (50%)	T_3 (75%)	T_4 (100%)	SEM
RBCs ($\times 10^{12}$/L)	2.75	2.50	2.75	2.00	0.31^{NS}
WBCs ($\times 10^{9}$/L)	96.50	90.75	89.75	77.25	3.61^{NS}
Hb (g/dl)	16.60	14.87	14.35	13.00	6.86^{NS}
MCHC (g/l)	448.00	449.50	459.00	467.00	7.40^{NS}
MCH (pg)	61.75	59.50	57.50	59.50	1.35^{NS}
MCV (fl)	137.35	132.50	125.25	127.00	3.50^{NS}
PCV (%)	37.25	33.25	31.25	28.00	1.92^{NS}

SEM = Standard Error of Means

NS= Not Significant (P>0.05)

RBCs = Red Blood Cell counts

WBCs = White Blood Cell counts

Hb = Haemoglobin concentration

MCHC = Mean Corpuscular Haemoglobin Concentration

MCH = Mean Corpuscular Haemoglobin

PCV = Packed Cell Volume

Carcass characteristics of broiler chickens fed replacement levels of TSSM for SBM

The carcass characteristics, cut-up parts and internal organs of broiler chickens fed dietary replacement levels of toasted sorrel seed for soybean meal are presented in Table 7. The carcass characteristics showed significant (P<0.05) differences in all the carcass parameters except the Dressing percentage. The live weight values were 1274.25, 1122.50, 845.50 and 696.50 g/bird for 0, 50, 75 and 100% replacement levels of TSSM respectively. The plucked weight was recorded as 1176.25, 1044.75, 794.25 and 636.00 g/bird for 0, 50, 75 and 100% replacement levels of TSSM respectively while eviscerated weight values were 1008.50, 848.75, 661.00 and 522.50 g/bird for 0, 50, 75 and 100% respectively. All the carcass parameters showed progressive decline in values across dietary treatments. This implies that the associated residual anti-nutrients in toasted sorrel seed meal adversely affected the carcass yield of broiler chickens in this study. This finding agrees with the report of Duwa *et al*. (2012 and 2013) who reported significant (P<0.05) depression of carcass characteristics of broiler chickens fed boiled sorrel seed meal up to 60% replacement level. However, there was no significant difference (P>0.05) in the dressing percentage of birds fed replacement levels of toasted sorrel seed meal across the treatments. This signifies that replacing soybean meal with toasted sorrel seed meal has no adverse effect on the dressing percentage of broiler chickens. This agrees with Kwari *et al*. (2010) who reported no significant difference in dress percentage of broiler chickens fed raw sorrel seed meal. The chart of carcass characteristics is presented in Fig. 3.

Among the cut up parts, the breast and shank (expressed as % LW) showed significant (P<0.05) differences between dietary treatments; while the head, wings, neck, drumstick, thighs, and back recorded no significant difference between treatments. This signifies that toasted sorrel seed meal can adequately replace soybean meal without adverse effect on these cut-up parts. This agrees with Duwa *et al*. (2012) who fed boiled sorrel seed meal up to 60% in broiler chickens. Kwari *et al*. (2010) also asserted that replacement levels of raw sorrel seed meal had no adverse effect on carcass cut-up parts.

For the internal organs, the results obtained showed that there were no significant (P>0.05) differences in the percentage weights across the dietary treatments except the caeca length. This result however, disagrees with Duwa *et al*. (2012), who reported significant difference in internal organs such as the gizzard, heart, lungs, liver, abdominal fat and the intestine. This could however be due to the different methods of processing the test ingredient (boiling and toasting). However, this agrees with Wafar (2013) who reported no significant difference with replacement level up to 20% of toasted sorrel seed meal in broiler finishers on the percentage weights of gizzard, heart, lungs, liver, small and large intestine length and weight. Therefore, it can be stated that replacement of soybean with toasted sorrel seed meal up to 100% had no adverse effect on the internal organs of broiler chickens.

Table 7: Carcass characteristics and internal organs of broiler chickens fed replacement levels of TSSM for SBM

Parameter	T_1 (0%)	T_2 (50%)	T_3 (75%)	T_4 (100%)	SEM
Live weight (g/bird)	1274.25[a]	1122.50[a]	845.50[b]	696.50[b]	64.36*
Plucked weight (g/bird)	1176.25[a]	1044.75[a]	794.25[b]	636.00[b]	61.08*
Eviscerated weight (g/bird)	1008.50[a]	848.75[a]	661.00[b]	522[b]	50.71*

Dressed Percentage (%)	79.50	80.00	78.00	75.00	0.75 ^{NS}
Cut-up Parts (% LW):					
Head	4.00	3.50	4.50	4.50	0.44^{NS}
Wings	11.00	11.00	11.50	12.00	0.56^{NS}
Breast	21.50^{a}	23.00^{a}	19.00^{ab}	18.50^{b}	1.06*
Neck	6.50	6.00	6.00	7.00	0.56^{NS}
Shanks	6.00^{b}	5.00^{b}	6.50^{b}	7.50^{a}	0.62*
Drumstick	12.50	12.00	12.50	12.00	0.36^{NS}
Thighs	14.50	14.50	13.50	14.50	0.50^{NS}
Back	17.50	17.00	16.50	17.00	0.36^{NS}
Internal Organs (% LW):					
Gizzard	3.50	3.00	4.00	3.50	0.36^{NS}
Heart	0.20	0.20	0.50	0.50	0.36^{NS}
Lungs	0.20	0.50	0.50	1.00	0.36^{NS}
Liver	2.00	1.50	2.00	2.00	0.24 ^{NS}
Abdominal fat	1.00	1.50	2.50	1.50	0.43^{NS}
Kidney	0.50	0.50	1.00	.50	0.43^{NS}
Small Intestine length (cm)	176.00	157.00	150.00	162.00	15.76^{NS}
Large Intestine length (cm)	9.50	7.50	8.00	8.00	0.79^{NS}
Small Intestine weight (%)	4.50	4.50	4.50	5.50	0.50^{NS}
Large Intestine weight (%)	0.31	0.20	0.24	0.29	0.14^{NS}
Caecal weight (%)	0.82	0.67	0.68	0.86	0.28^{NS}
Caecal length (cm)	31.00	30.00	26.50	26.50	1.06*

$^{a, b, c...}$ Means within the same row bearing different superscripts differ significantly (P<0.05)

SEM = Standard error of means

NS= Not Significant (P>0.05)

* = Significant Difference (P<0.05)

Table 7: Carcass characteristics and internal organs of broiler chickens fed replacement levels of TSSM for SBM

Parameter	T_1 (0%)	T_2 (50%)	T_3 (75%)	T_4 (100%)	SEM
Live weight (g/bird)	1274.25^a	1122.50^a	845.50^b	696.50^b	64.36*
Plucked weight (g/bird)	1176.25^a	1044.75^a	794.25^b	636.00^b	61.08*
Eviscerated weight (g/bird)	1008.50^a	848.75^a	661.00^b	522^b	50.71*
Dressed Percentage (%)	79.50	80.00	78.00	75.00	0.75^{NS}
Cut-up Parts (% LW):					
Head	4.00	3.50	4.50	4.50	0.44^{NS}
Wings	11.00	11.00	11.50	12.00	0.56^{NS}
Breast	21.50^a	23.00^a	19.00^{ab}	18.50^b	1.06*
Neck	6.50	6.00	6.00	7.00	0.56^{NS}
Shanks	6.00^b	5.00^b	6.50^b	7.50^a	0.62*
Drumstick	12.50	12.00	12.50	12.00	0.36^{NS}
Thighs	14.50	14.50	13.50	14.50	0.50^{NS}
Back	17.50	17.00	16.50	17.00	0.36^{NS}
Internal Organs (% LW):					
Gizzard	3.50	3.00	4.00	3.50	0.36^{NS}
Heart	0.20	0.20	0.50	0.50	0.36^{NS}
Lungs	0.20	0.50	0.50	1.00	0.36^{NS}
Liver	2.00	1.50	2.00	2.00	0.24^{NS}
Abdominal fat	1.00	1.50	2.50	1.50	0.43^{NS}
Kidney	0.50	0.50	1.00	.50	0.43^{NS}
Small Intestine length (cm)	176.00	157.00	150.00	162.00	15.76^{NS}
Large Intestine length (cm)	9.50	7.50	8.00	8.00	0.79^{NS}
Small Intestine weight (%)	4.50	4.50	4.50	5.50	0.50^{NS}

Large Intestine weight (%)	0.31	0.20	0.24	0.29	0.14^{NS}
Caecal weight (%)	0.82	0.67	0.68	0.86	0.28^{NS}
Caecal length (cm)	31.00	30.00	26.50	26.50	1.06*

[a, b, c…] Means within the same row bearing different superscripts differ significantly (P<0.05)

SEM = Standard error of means

NS= Not Significant (P>0.05)

* = Significant Difference (P<0.05)

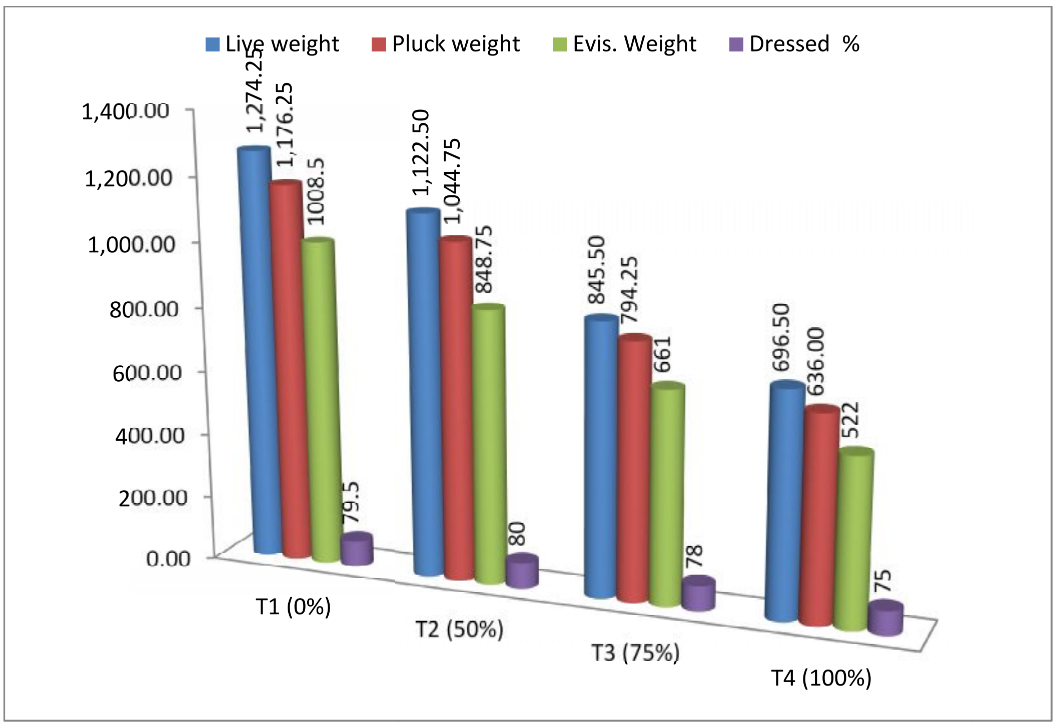

Figure 3: Carcass characteristics of broiler chickens fed replacement levels of TSS for SBM

CONCLUSION

Based on the results obtained in this study, it is therefore concluded that replacement of soybean meal with toasted sorrel (*Hibiscus sabdariffa*) seed meal (TSSM) up to 50% level had no adverse effect on the growth performance and carcass characteristics of broiler chickens. Levels beyond 50% will adversely affect these parameters, however without any adverse effect on haematological parameters. Thus, with the adoption of this replacement level (50% of TSSM) as an alternative plant protein source the heavy demand on soybean meal can be drastically reduced.

RECOMMENDATION

Based on the above conclusion, the replacement of soybean with toasted sorrel (*Hibiscus sabdariffa*) seed meal (TSSM) up to 50% level is hereby recommended for poultry farmers as an alternative plant protein source. Further researches should be encouraged on the test ingredient because it shows such great potentials that need to be harnessed. Combined treatment (boiling and toasting or drying) methods of the test ingredient could also be adopted for better results as this can significantly reduce the tannin level of the test ingredient in order to increase the replacement level to 75% or 100%. Finally, programmes should be created for small-scale poultry producers to produce chickens raised on sorrel seed meal based – diets.

REFERENCES

Abdulmalik, M.E., Aduku, O.A., Balogun, T.F., Ogundipe, S.O. and Adeyinka, I.A. (1994). Evaluation of Brewer's Sorghum Residues as Feed Ingredients in Rabbit Diets. *A Paper Presented at the 19th Annual Conference of Nigerian Society for Animal Production, University of Ibadan, Benin City,* 20th -24th March.

Agro Nigeria (2014). *AgroNigeria Magazine*. Special Edition, ISSN 1597-6386.

Alawa, J.P. and Umunna, N.N. (1993). Alternative Feed Formulation in Developing Countries: Prospects for Utilization of Agro-Industrial By-Products. *Journal of Animal Production Research* 13(2): 63-98.

A.O.A.C. (2001). Official methods of analysis, 14th edition association of the official analytical chemists' standard method, U.S.A.

APRC (1999). Animal Production Research Centre. The Nutrient Composition of Sudanese Animal Feeds. *Bulletin HI, Central Animal Nutrition Research Laboratory, Kuku, Khartoum. North, Sudan*.

Christopher, D., Pierre, C., and Claude, C., (1997). The Impact of Livestock and Fisheries on the Food Availability and Demand in 2020. *American Journal of Agricultural Economics* 79 *(Number 5, 1997);* 1471-1475.

D'mello, J.P.F and Devendra, C. (1995).*Tropical legumes in Animal nutrition*. United Kingdom, 96-133.

Dashak, D.A. and Nwanegbo, V. (2002). Chemical composition of the seeds and calyxes of (*Hibiscus sabdariffa*) grown in Jos North Local Government Area of Plateau State. *Journal of Natural Sciences,* 5: 32-34.

Duncan, D.B. (1955). *Multiple ranges and multiple F- test. Biometrics*, 42Pp.

Duwa, H., Oyawoye, E.O. and Njidda, A.A. (2012). Replacement Value of Boiled Sorrel Meal for Soybean in Broiler Diet in Semi-Arid Zone of Nigeria. *Pakistan Journal of Nutrition* 11 (6): 572-579.

Duwa, H., Saleh, B., Girgiri, A.Y. and Adegbolah, T.A. (2013). The Replacement Value of Sorrel Seed Meal for Groundnut Cake in Cockerels Diet. *International Journal of Advance Biological Research* 3(1): 36-39.

Elkin, R.G., Rogler, J.C. and Sullivan, T.W. (1990). Comparative Effects of Dietary Tannins in Ducks Chicks and Rats. *Poultry Science*, 69: 1685-1693.

El-Sayed, A-F.M. (1987). Protein and Energy Requirements of *Tilapia zillii*. Ph.D Dissertation, Michigan State University, East Lansing, Michigan, 147 Pp.

FAO (1992). Food and Agriculture Organization of the United Nations. The State of Food Security in the World, Progress Report on World Food Hunger; Rome

FAO (2003). Food and Agriculture Organization of the United Nations, FAOSTAT Agriculture Data.

Hainida, E., Amin, I., Normah, H., Moh'd, – Esa N., and Aminu, Z.A.B. (2008). Effects of defatted dried Roselle (H. sabdariffa L.) seeds powder on lipid profile of hypercholesterolemia rat. *Journal of the Science of food and Agriculture 88*: 1043-1050. http://apps.fao.org/page/collections?subset=agriculture; http://www.hort.purdue.edu/newcrop/duke_energy/hibiscus_sabdariffa.html.

Isidahomen, C.E., Kwari, I.D., Adejumo, E.O. and Igwebuike, J.U. (2006). Proximate composition, tannin content and amino-acid profile of differently processed sorrel (*Hibiscus sabdariffa*) seeds. *Journal of Research in Biological sciences*, 2: 37- 40.

Kwari, I.D, Igwebuike, J.U., and Diarra, S.S. (2010). Growth Performance and Carcass Measurements of Broiler Chickens fed Different Levels of Raw Sorrel (*Hibiscus sabdariffa*) Seed Meal. *Journal of Environmental Issues and Agriculture in Developing Countries* Vol.2 Nos. 2 & 3.

Melansho, H., Butter, L.G. and Carlson, D.M. (1987). Dietary tannins and salivary proline-rich protein interacting induction and defence-mechanisms. *Annual Reviews in Nutrition*, 7: 423 - 440.

NIAS (2014). Nigerian Institute of Animal Science. Listing of Ingredients for Commercial Feed mills in Nigeria. NIAS/RA/LFI-2014.

N.I.S. (1989). Nigerian Industrial Standards. Standards on Specification for Poultry Feed, Standard Organization of Nigeria.

Nguyen T.N. (2008). The Utilization of Soybean Products in Tilapia feed – A Review. *8th International Symposium on Tilapia in Aquaculture.*

Ochei, J. and Kolhatkar, A. (2007). *Medical Laboratory Science Theory and Practice,* 6th edition, McGraw – Hill Publishing Company Limited, New York, USA, 1338pp.

Olomu, J.M. (1995). *Monogastric Animal Nutrition. Principles and Practices*.

Onimisi P.A. (2005). Evaluation of Ginger waste meal as energy source in the diets of broiler chickens. M.Sc. *Thesis Submitted to the Department of Animal Science. Ahmadu Bello University, Zaria – Nigeria.*

Ozung, P. O., Oko, O. O. K. and Agiang, E. A. (2016). Chemical composition of differently treated forms of Cocoa POD Husk Meal (CPHM). *Asian Journal of Agricultural Sciences*, 8 (2): 5 – 9. DOI: 10.19026/ ajas.8.2912.

Ozung, P. O., Oko, O. O. K., Agiang, E. A., Eburu, P. O., Evans, E. I. and Ewa, C. E. (2017). Growth Performance and Apparent Nutrient Digestibility Co - efficients of Weaned Rabbits fed Diets containing different forms of Cocoa Pod Husk Meal. *Agricultural and Food Sciences Research,* 4(1): 8 – 19, DOI: 10.2448/journal.512.2017.41.8.19.

Pauzenga, U. (1985). Feeding Parent Stock. Zootechnica International, Pp. 22 – 24.

Quezon (2005). Roselle: The Dawn of a Sunrise Industry. Available Online: http://www.quezon.org/Roselle.

Rao, P.U. (1996). Nutrient Composition and Biological Evaluation of *H.* sabdariffa seeds. *Plant Foods for Human Nutrition.* 49: 27-34.

Samy, M.S. (1980). Chemical and nutritional studies on Roselle seeds (*H*. *Sabdariffa*), Zeith Ernahrungswisse 19: 47-49

SAS (2000). Statistical Analysis System. SAS/STAT Software. Changes and Enhancements Release 6.07, SAS Technical Report, SAS Institute Inc, Cary, New York, 229Pp.

Simarak, S., Chinrasri, O. and Aengwanich, W. (2004). Haematological, electrolyte and serum biochemical values of the Thai indigenous chickens (*Gallus domesticus*) in northern Thailand. *Songkalanakarin Journal of Science and Technology*, 26 (3): 425-430.

Svobodova, Z., Pravda, D. and Palackova, J. (1991). Unified methods of haematological examination. Research Institute of Fish Culture and Hydrobiology, Vodnany, Czech Republic, 31Pp.

Taraba State Diary (2008). Yearly publication by the Government of Taraba State Nigeria, P.14.

Wafar, J.R. (2013). Effect of replacing toasted Sorrel seed meal for Soybean Meal in broiler finisher diets *Journal of Animal Production Advances,* 3(8): 247-253.

Wikivet (2013). *Haematology*. Available at en.wikipedia/wiki/haematology