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Replacement Value of Boiled Sorrel Seed Meal for Soyabean in Broiler Diet in Semi Arid Zone of Nigeria

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Abstract: The effects of replacing boiled sorrel seed meal for soyabean in broiler diet was investigated in an eight week feeding trial. Five diets were fed to 200 day-old Anak-2000 broilers chicks in groups of 40 chicks per diet with 3 replicates of 10 chicks each in a completely randomized design. The diets consisted of a control based on soyabean meal as major protein source and 4 other diets, in which sorrel seed meal was replaced at 0, 15, 30, 45 and 60% respectively. Data were collected on the growth performance, nutrient digestibility and carcass characteristics. There was no significant ($p>0.05$) dietary effects on final weight and daily weight gain. Feed intake was significantly ($p<0.05$) higher in treatments receiving sorrel seed meal except for finisher phase where the control diet tend to be higher than treatments 1 and 2. Feed Conversion Ratio (FCR) was better for treatment 4 (45%) compare to other treatments on the starter diet while treatment 2 (15%) had better FCR on the finisher phase. The overall nutrient digestibility was positive except for crude fibre digestibility where treatment 3 (30%) had 45.11%. The result of the carcass characteristics shows that there were significant differences ($p<0.05$) for all the cut-parts observed. Treatment 5 had higher weight than the other treatment groups except for drumstick, breast muscle, feather weight, head, gizzard and spleen where treatment 4 was higher.

Key words: Soyabean, sorrel seed meal, processing, broilers, performance

INTRODUCTION

The persistent decline in the poultry industry and its consequences on the sub-optimal animal protein consumption by Nigerians is a dangerous signal to imminent animal protein malnutrition (Madubuike and Ekenyem, 2006). The high cost of animal protein has made the protein intake to fall below 10 g caput^{-1} compare to the recommended daily intake of 35 g (Marquisit, 1985; Njidda and Isidahomen, 2011). Esonu *et al*. (2002) had stated that more than 50% of the country's poultry farms have closed down and another 30% forced to reduce their production capacity because of shortage of feed. This feed shortage has been blamed on high cost of the conventional sources of ingredients which Opara (1996), Madubuike and Ekenyem (2006) have rated at 70-80% of total cost of poultry production. There is need to look for locally available and cheap sources of feed ingredients particularly those that do not attract competition between humans and livestock and for which Esonu *et al*. (2002) suggested leaf meals of some tropical legumes and browse plants. There is therefore the need to investigate the effect of these unconventional feed resources on the productive performance of animals.

Hibiscus sabdariffa is a popular plant (belonging to the family *Malvceae)* and is presently cultivated widely in the old and new world tropics and subtropics. The presumed origin is South East Asia in the region of India to Malaysia. It has long been cultivated in Africa. Probably, it was carried by slaves to the new world (Duke, 1999). *Hibiscus sabdariffa* is suitable for tropical climate with well distributed rainfall of 1500-2000 mm yearly, from sea-level to about 600 m altitude. The soil preparation should be deep, about 20 cm and seed rate (11-22 kg/ha) depending on the soil. Soil is drilled about 15 cm by 15 cm at beginning of rainy season and seeds planted at depth of about 0.5 cm. Broadcasting is not recommended (Duke, 2000). There are several reports on the chemical composition of sorrel seeds. Studies by 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 ether extract ranges between 19.90% (APRC, 1999) and 23.00% (Dashak and Nwanegbo, 2002; Isidahomen *et al*., 2006). The objective of the study was to investigate the replacement effect of sorrel seed with soyabean meal.

MATERIALS AND METHODS

Experimental site: The study was conducted at the Poultry Production Unit (PPU) of Borno State Ministry of Agriculture and Natural Resources Maiduguri. The farm had standard deep litter houses. The study area lies between Latitude 11°05' and 12" North and longitude

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Table 1: Composition of broiler starter diet containing varying levels of boiled sorrel seed meals

	T_1 (0%)	T_2 (15%)	T_3 (30%)	T_4 (45%)	T_5 (60%)
Maize	43.87	42.87	41.87	40.55	39.87
Soya bean (full fat)	35.38	30.07	24.77	19.76	14.15
Sorrel seed meal	0.00	5.31	10.61	15.94	21.23
Fish meal	7.00	8.00	9.00	10.00	11.00
Wheat offals	10.00	10.00	10.00	10.00	10.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Salt	0.30	0.30	0.3.0	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Crude protein (%)	22.99	22.88	22.93	22.96	22.90
ME (kcal/kg)	3000.50	2950.96	2901.52	2951.98	2902.50
Crude fibre (%)	3.62	4.37	4.80	5.39	5.98
Calcium (%)	1.10	1.20	1.21	1.26	1.31
Phosphorus (%)	0.93	1.06	0.08	1.01	1.04
Lysine (%)	1.38	1.57	1.76	1.95	2.14
Methionine (%)	0.41	0.47	0.54	0.60	0.67

*Bio-mix starter supplied/kg Vit A: 4,000,000.00 IU; Vit D_3 = 800,000.00 IU; Vit E = 9,200.00 mg; Niacin = 11,000.00 mg; B_1 = 720.00 mg; B_2 = 2000.00 mg; B6 = 1,200.00 mg; B_{12} = 600.00 mg; Pantothenic acid = 3,000.00 mg; Biotin = 424.00 mg; folic acid = 300.00 mg; choline chloride = 120,000.00 mg; cobalt = 80.00 mg; copper, 1,200.00 mg; Iodine = 400.00 mg; Iron = 8,000.00 mg; Manganese = 16,000.00 mg; Selenium = 80.00 mg; zinc = 12,000.00 mg; Anti-oxidant = 500.00 mg

13°05' and 14° East and had an altitude of 354M above sea level (Alaku, 1983). It is characterized by hot and dry climate and short duration of erratic rainfall (3-4) months per annum and a long period of dry season. Ambient temperatures are low in December to January ranging from 15-19°C and high in March to June, ranging from 33-44°C and low relative humidity ranging from 5-43.5% (Alaku, 1983).

Experimental birds and management: Two hundred (200) 7 days-old Anak 2000 broilers chicks were used for the study. The broiler chicks were individually weighed and randomly selected and allocated to the five replacement levels of full fat soybean by sorrel seed meal in broiler diets in a completely randomized design. Each treatment consisted of forty birds and was replicated four times with 10 birds per replicate. The sorrel seed meals were incorporated at 0, 15, 30, 45 and 60% levels of replacement for full-fat soybeans respectively as shown in Table 1 and 2. The birds were vaccinated against Gumboro, at two and five weeks of age while New castle disease vaccine (Lasota) was administered at three weeks of age. Antistress was given each time after administration of drugs. Each treatment received one of the diets and clean drinking water provided *ad libitum* and the birds were vaccinated against common poultry disease in Borno State of Nigeria. The experiment lasted for 8 weeks. Feed intake, weight gain, feed conversion ratio, carcass composition and blood parameters form the response criteria for the study.

Carcass analysis: At the end of the experiment (7 weeks) 64 chickens, three from each replicate was slaughtered to determine the carcass characteristics such as cut-up parts and organ weights.

Chemical analysis: The experimental diets were analyzed for Dry Matter (DM), Crude Protein (CP), Crude Fibre (CF), Ether Extract (EE), ash according to AOAC (2002).

Statistical analysis: Data obtained was subjected to analysis of variance. Where significant differences occurred, the means will be separated using Duncan multiple range F-test of the SAS (1988) options.

RESULTS

Proximate composition of the experimental diets: The proximate composition of the experimental diets of broiler starter and broiler finisher was presented in Table 3 and 4 respectively. The dry matter content of the feed was similar in both experimental diets. The Crude Protein (CP) ranged from 22.00-22.80% and 19.40-20.00% for both broiler starter and finisher experimental diets respectively.

The Ether Extract (EE) values ranged from 5-7.50% and 6.00-9.50% for broiler starter and finisher diets respectively. The Ether Extract (EE) percentage increased as the sorrel seed meal replacement level increased in both broiler starter and finisher diets. The Crude Fibre (CF) ranged from 7-9.40% and 7-8.90% for starter and finisher diet respectively. This was attributed to the level of fibre in sorrel seed meal. The ash percentage of both broiler starter and finisher was 3.00-3.90% and 2.50-3.00% and Nitrogen-free extract was 57.80-63.00% and 60.50- 65.10% respectively.

Table 2: Composition of broiler finisher diet containing varying levels of boiled sorrel seed meal

	Replacement levels of full fat soyabean by boiled sorrel seed meal				
Ingredients (%)	T_1 (0%)	T_2 (15%)	T_3 (30%)	T_4 (45%)	T_5 (60%)
Maize	52.52	52.02	51.52	50.52	48.52
Soyabean(full fat)	28.73	24.42	20.11	15.80	11.49
Sorrel seed meal	0.00	4.31	8.62	12.93	17.24
Fish meal	5.00	5.50	6.00	7.00	9.00
Wheat offals	10.00	10.00	10.00	10.00	10.00
Bone meal	3.00	3.00	3.00	3.00	3.00
Methionine	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25	0.25
Premix*	0.30	0.30	0.30	0.30	0.30
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Crude protein (%)	20.01	19.83	19.62	19.71	20.03
ME (kcal/kg)	3101.60	3054.95	3048.24	3050.84	3047.75
Crude fibre (%)	3.51	3.99	4.67	4.97	5.41
Calcium (%)	1.01	1.02	1.04	1.09	1.19
Phosphorus (%)	0.96	1.01	1.05	1.03	1.08
Lysine (%)	1.14	1.28	1.42	1.59	1.79
Methionine (%)	0.35	0.39	0.45	0.50	0.58

*Bio-mix Finisher supplied/kg; Vit. A 4,000,000.00 IU; Vit D_3 = 800,000.00 IU, Vit. E = 9,200.00 mg, Niacin = 11,000.00 mg Vit. B_1 = 720.00 mg, B_6 = 1200.00 mg; B_{12} = 6.00 mg; Pantothenic acid = 3,000.00 mg, Biotin = 2,400.00 mg, Folic acid = 300.00 mg, Choline Chloride = 120,000.00mg. Cobalt = 80.00 mg, Copper = 1,200.00 mg, Iodine = 400.00 mg Iron = 8,000.00 mg, Manganese = 16,000.00 mg, Selenium = 80,000.00 mg, Zinc = 12,000.00 mg, Anti oxidant = 500.00 mg

Table 3: Proximate composition of broiler starter mash containing varying levels of boiled sorrel seed meal

	Replacement levels of full fat soyabean by sorrel seed meal				
Parameter	T_1 (0%)	T_2 (15%)	T_3 (30%)	T_4 (45%)	T_5 (60%)
Dry matter	93.30	93.70	93.50	93.60	93.40
Moisture content	6.70	6.30	6.50	6.40	6.60
Crude protein	22.00	22.80	21.70	22.70	22.60
Crude fibre	7.00	8.00	8.90	9.10	9.40
Ether extract	5.00	5.50	6.00	6.50	7.50
Ash	3.00	3.20	3.50	3.90	4.00
Nitrogen Free Extract (NFE)	63.00	60.50	59.90	57.80	56.50

Table 4: Proximate composition of broiler finisher mash containing varying levels of boiled sorrel seed meal

	Replacement levels of full fat soyabean by sorrel seed meal				
Parameter	(Control 0%)	15%	30%	45%	60%
Dry matter	92.80	92.90	92.80	92.90	93.10
Moisture content	7.20	7.10	7.20	7.10	6.90
Crude protein	19.40	19.16	19.90	19.50	20.00
Crude fibre	7.00	7.50	7.80	8.40	8.90
Ether extract	6.00	9.50	8.70	8.60	10.00
Ash	2.50	2.50	2.50	3.00	3.50
Nitrogen free extract	65.10	60.90	61.10	60.50	57.60

Productive performances: The productive performances of broiler chickens fed boiled sorrel seed meal as a replacement for soyabean meal are presented in Table 5. The initial weight revealed no significant ($p>0.05$) difference among the replacement levels of full fat soyabean by sorrel seed meal. The values were: 125.00, 124.25, 126.50, 122.50 and 122.75 for the (0% control), 15%, 30%, 45% and 60% replacement levels respectively. The starter phase weight at 5 weeks revealed significant ($p<0.05$) difference among the replacement levels of full fat soyabean by sorrel seed meal. The values are: 856.00, 968.40, 970.00, 1014.80 and 1155.00 g/bird for the (control), 15%, 30%, 45% and 60% replacement levels respectively. Birds which were on 60% replacement value gave significantly ($p<0.05$) heavier weights than those fed on (0% control) diet, followed by 45%, 30% and 15% replacement level.

Data on the final body weight is presented in Table 5. There were significant ($p<0.05$) differences among the

Table 5: Productive performance of broiler chickens fed varying levels of boiled sorrel seed meal as a replacement for full fat soyabeans

	Replacement levels of full fat soyabean by sorrel seed meal					
Parameters	Control	15%	30%	45%	60%	SEM±
Initial weight g/bird	125.00	124.25	126.50	122.50	122.75	2.596
Weight at 5 weeks g/bird	856.00^{d}	968.40^{c}	970.00^{c}	1094.80^{b}	1155.00^{a}	2.285*
Final weight g/bird	1862.30^{e}	1967.50^{d}	1988.30^{c}	2063.50^{b}	2131.30^{a}	2.045*
Feed cost N/kg	36.65^{a}	34.98^{b}	33.30^{b}	31.66^{c}	30.15^{c}	0.356*
Mortality	2.00	1.00	1.00	1.00	2.00	
Mortality percentage	5.00	2.50	2.50	2.50	5.00	
Starter phase						
Daily weight gain g/bird	24.23^{d}	26.99^{d}	24.99^{d}	30.56^{b}	32.35^{a}	0.388*
Daily feed intake g/bird	68.46^{c}	70.10^{bc}	69.98^{bc}	75.12^{a}	71.70^{b}	1.045*
Feed conversion ratio	2.82^{a}	2.63^{b}	2.80^{a}	2.05^{c}	2.11^{c}	0.033*
Feed cost/kg gain	105.47^{a}	94.48^{b}	95.74^{b}	79.55^{c}	67.67^{d}	0.787*
Finisher phase						
Daily weight gain g/bird	40.60	42.38	43.50	41.20	42.98	0.861
Daily feed intake g/bird	90.50^{b}	84.10^{d}	87.60^{c}	91.15^{b}	95.31^{a}	0.467*
Feed conversion ratio	2.22	2.00	2.10	2.20	2.23	0.059
Feed cost/kg gain	79.10^{a}	67.37^{bc}	65.29^{c}	68.52^{b}	65.75^{c}	0.814*
Combine phase						
Daily weight gain g/bird	32.41^{c}	34.55^{b}	34.24^{bc}	35.88^{db}	37.69^{a}	0.595*
Daily feed intake g/bird	79.84^{b}	77.10^{c}	78.79^{bc}	83.14^{a}	83.51^{a}	0.554*
Feed conversion ratio	2.52^{a}	2.32^{b}	2.45^{a}	2.13^{c}	2.17^{c}	0.027*
Feed cost/kg gain	94.40^{a}	78.05^{b}	76.63^{b}	73.36^{c}	66.84^{d}	0.462*

^{a,b,c}Means within the same row bearing different superscript differ significantly ($p<0.05$). SEM = Standard Error of Means; NS = Not significant ($p>0.05$); *= Significant difference ($p<0.05$)

treatment in the final body weights. The values of the final weights were 1862.30, 1967.50, 1988.30, 2063.50 and 2131.30 g/bird for (0% control), 15%, 30%, 45% and 60%) respectively. Birds fed on 60% replacement level had the highest final body weight. The higher the percentages of the sorrel seed meal in place of soyabean meal the heavier the weights of the chickens. The result of the daily weight gain, daily feed intake, feed conversion ratio, feed cost N/kg, feed cost/kg gain and mortality are presented in Table 5. The results of mean daily weight gain (g/bird) at the starter phase ranged from 72.46-137.31, finisher phase ranged from 40.60-43.50 and overall combined ranged from 32.41-37.69 respectively. The results of the daily weight gain (g/bird) showed significant ($p<0.05$) difference in favour of birds fed on 60% replacement levels in starter and combined phase, but the finisher phase showed no significant ($p>0.05$) difference. The birds performance increased as the percentage of replacement of soyabean meal increased up to 60%. Therefore replacing 60% of the soyabean meal in broiler diets with processed (boiled sorrel seed meal) had no adverse effect on the weight gain.

The feed intake ranged from 68.46-75.12 at the starter phase, 84.10-95.31 at the finisher phase and overall (combined) ranged from 77.10-83.51. The results showed no depression of feed intake in replacing 60% of the soyabean meal with sorrel seed meal. The starter phase indicated significant ($p<0.05$) difference in 45% replacement of sorrel seed meal for soyabean meal in broiler diet. There were significant ($p<0.05$) differences among the treatments in feed intake in the combined phases of growth of the birds.

The feed conversion ratio in this study had a similar pattern with daily weight gain and final weight gain. The mean ranged from 2.05-2.82, 2.00-2.32 and 2.13-2.52 for starter phase, finisher phase and overall (combined) respectively.

The starter phase revealed significant ($p<0.05$) difference in birds fed on 45% and 60% replacement levels while the finisher showed no significant ($p>0.05$) difference and the overall (combine) showed significant ($p<0.05$) difference among all the replacement levels. The Feed Conversion Ratio (FCR) is a measure of the efficiency of the bird to convert feed consumed into meat. The lower the value of feed conversion ratio the better the feed efficiency. The result indicated significant ($p<0.05$) difference in the feed cost (Naira/kg) and feed cost per kg gain in the starter phase, finisher phase and combined phase.

The feed cost (Naira/kg) decreased with increasing level up-to 60% replacement of the boiled sorrel seed meal for soyabean meal. Diets in which soyabeans was replaced with 15%, 30%, 45% and 60% of boiled sorrel seeds were cheaper than the (control) diet. The highest feed cost (Naira/kg, Naira 36.65) were in (control) diets and the lowest (Naira 30.15) was the 60% replacement level of soyabean with boiled sorrel seed meal. However, best feed cost per kg gain (Naira 66.84) was obtained in 60% replacement level of full fat soyabean by sorrel seed meal (Naira 66.84) which was better than the other replacement levels.

Nutrient digestibility: The result of the nutrient digestibility is shown in Table 6. Generally, nutrients digestibility was high except for crude fibre which is in

Table 6: Nutrient digestibility of broiler chickens fed varying levels of boiled sorrel seed meal as a replacement for full fat soyabeans

	Nutrient digestibility (%)					
Parameter	T_1	T_2	T_3	T_4	T_5	SEM
Dry Matter (DM)	65.32^{c}	70.98^{b}	77.63^{a}	76.18^{a}	72.10^{b}	5.61*
Crude Protein (CP)	70.64^{c}	62.31^{d}	75.74^{ab}	74.93^{ab}	80.74^{a}	4.20*
Crude Fibre (CF)	55.82	50.19	45.11	59.64	55.86	2.38
Ether Extract (EE)	70.56^{b}	79.13^{a}	63.35^{c}	71.19^{b}	67.82^{c}	5.22*
Total ash	62.39^{b}	60.51^{b}	61.09^{b}	60.31^{b}	70.89^{a}	2.84*
Nitrogen Free Extract (NFE)	60.23^{b}	62.97^{b}	61.67^{b}	78.37^{a}	79.14^{a}	5.81*

^{a,b,c}Means within the same row bearing different superscript 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 of broiler chickens fed varying levels of sorrel seed meal as a replacement for full fat soyabeans

	T_1 (Control)	T_2 (15%)	T_3 (30%)	T_4 (45%)	T_5 (60%)	SEM
Carcass weight	1272.5^{c}	1385.00^{b}	1417.50^{b}	1692.50^{a}	1637.50^{a}	36.35*
Drumstick	159.14^{c}	207.14^{c}	199.85^{b}	244.44^{a}	239.19^{a}	5.13*
Thighs	122.25^{c}	123.02^{c}	36.04^{b}	156.81^{a}	120.91^{c}	3.87*
Wings	83.93^{ca}	78.09^{d}	87.23^{c}	100.28^{b}	112.95^{a}	2.16*
Breast muscle	173.69^{a}	114.84^{b}	170.93^{a}	184.72^{a}	139.66^{b}	9.42*
Feather weight	65.00^{b}	70.00^{a}	60.00^{c}	73.00^{a}	67.00^{b}	0.51*
Head	76.12^{b}	82.01^{a}	80.98^{a}	84.13^{a}	70.39^{bc}	4.68*
Neck	69.96	70.90	67.41	69.47	70.15	5.11
Gizzard	66.95^{d}	73.95^{c}	81.34^{b}	90.01^{a}	89.19^{a}	6.23*
Spleen	1.34^{b}	1.68^{b}	1.71^{b}	2.02^{a}	1.64^{b}	0.58*
Liver	55.96^{b}	57.79^{a}	53.65^{b}	40.88^{c}	60.65^{a}	4.30*
Intestine	83.31^{ab}	80.69^{b}	78.00^{b}	78.25^{b}	89.16^{a}	9.41*
Chest	141.44	142.00	149.55	140.65	149.02	14.12
Legs	59.50^{b}	70.04^{a}	61.76^{b}	63.51^{b}	70.04^{a}	7.87*
Heart	18.00^{a}	18.32^{a}	12.93^{b}	13.39b	14.88^{ab}	4.11*
Lungs	10.42^{c}	9.12c	14.82a	11.83b	14.37a	8.33*
Back	150.03^{b}	159.11^{a}	134.55^{c}	160.71^{a}	160.38^{a}	13.77*
Abdominal fat	86.26^{a}	74.72^{b}	75.97^{b}	84.36^{a}	87.76^{a}	15.68*

^{abc}Means within the same raw bearing different superscript differ significantly ($p<0.05$). SEM = Standard Error of Means; NS = Not significant ($p>0.05$); * = Significant difference ($p<0.05$)

the range of 45.11 to 59.64% for all the processing methods with the least (45.11%) for all the treatment groups.

Carcass components: The results of carcass characteristics are presented in Table 7. The carcass weight showed significant ($p<0.05$) difference in birds fed on 45% and 60% replacement levels of full-fat soyabean by boiled sorrel seed meal. The weight of cut-up parts of drumstick, thighs, wings and breast muscle indicated significant ($p<0.05$) difference in 45% and 60% replacement levels of full fat soyabean by sorrel seed meal.

DISCUSSION

Proximate composition of the experimental diets: The dry matter contents in the feed were similar in both experimental diets. The Crude Protein (CP) ranged from (22.00-22.80%) and (19.40-20.00%) for both broiler starter and finisher experimental diets. The values were within the range of (21-24%) and (18-20%) crude protein level for broiler starter and finisher diets reported by Kekeocha (1984) and Williamson and Payne (1978) who stated that success in rearing broilers for maximum weight gain was not only a function of the birds, good management and housing, but also upon the feed given to the chickens. The Ether Extract (EE) value range of (5-7.50%) for the experimental diets of broiler starter mash obtained in this study can favourably meet the fatty acids requirement of broiler starter diet. This observation agreed with the value of (5-7%) recommended by NRC (1996). The value of (6-10.00%) obtained in this study (Table 4) was higher than the recommended value (3.0-5.0%) for broiler finisher (Olomu, 1978).

The values of the Ether Extract (EE), increases as sorrel seed meal levels replaced full-fat soyabean increased in both starter and finisher diets. This shows that sorrel seed meal has high percentage of fat (22.3%) as reported by Samy (1999). The Crude Fibre (CF) range of 7-9.40% and 7-8.90% for starter and finisher diet obtained in this study for the replacement levels were higher than the range recommended by Olomu (1995). The Crude Fibre (CF) range of 7-8.90% in finisher diet was also higher than the 5.0% level reported by Olomu (1978). The ash and nitrogen free extract of the starter and finisher diets agreed with the range of 3.00-2.70 and 66.20-75.80% recommended by Olomu (1995). The values were adequate to provide the necessary minerals such as calcium and phosphorus needed for development of bones.

Productive performances

Starter phase (g/bird): There were significant differences among the birds fed on replacement levels of full fat soyabean by sorrel seed meal. Birds fed diets in which 60% of the soyabean was replaced by sorrel seed meal performed significantly better than the rest of the replacement levels. The starter phase weight in this experiment did not agree with findings of (NRC, 1984) who reported that broiler weights at 5 weeks were 1250.00 g and 1110.00 g for male and female birds.

Final weight gain (g/bird): There were significant differences among the birds fed on different levels of replacement of soyabean meal by sorrel seed meal in final body weight. These values were within the range of 1-3 kgs live weight of broiler chicken at age of 9-10 weeks reported by Asamoah (1982). Birds fed with 60% boiled sorrel seed meal replacing soyabean meal showed significant difference in the body weight compared to the birds fed on (control 0.0%) diet. The final body weight range from 1862.50-2131.30 g/bird obtained in this study was inferior to the standard (2495 g) reported by Olomu (1995). The difference noticed could be due to high ambient temperature (33- 40°C) which was reported to reduce feed intake and weight gain (Williamson and Payne, 1978).

Daily weight gain (g/bird): The results of daily weight gain showed improved performance in favour of birds fed with 60% replacement levels of full fat soyabean by sorrel seed meal in starter and combined phase but no significant difference in finisher phase. The birds performance over birds fed with (control) diets increased as the percentage of replacing soyabean meal increased up to 60%. Therefore, replacing 60% of the soyabean meal in broiler diets with processed (boiled sorrel seed meal) had no adverse effect on weight gain. The significant difference in body weight gain among the replacement levels could be attributed to levels of the limiting amino acids in sorrel seed meal and soyabean meal. These levels were adequate to meet the amino acid needs of the birds. The methionine level in all the diets probably improved the biological value of the feeds. Formulation to meet the amino acid needs of the birds rather than the general crude protein levels is important because it does not only reduce feed cost but it also results in improved feed conversion ratio (Day, 1983). Abasiekong and Tyopat (2000) recommended 2.4% of combined supplementation of both lysine and methionine for optimum performance in broiler chickens. The requirements of poultry for protein and amino acid also differ among breeds and strains (NRC, 1994) and age (Baeza and Leebereg, 1998 and Bartov, 1998). Chickens are sensitive to dietary balance in amino acid in terms of weight gain and feed efficiency.

Daily feed intake (g/bird): Daily feed intake showed that replacing 45% and 60% of the soyabean meal portion of broiler diets with processed (boiled) sorrel seed meal had no adverse effect on feed intake except in the starter phase where birds fed with 45% replacement levels of full fat soyabean by sorrel seed meal indicated significant difference. This observation agreed with the report of Olomu (1995) who stated that feed intake should be up to 160 g/bird/day.

In the finisher phase and the overall (combined), birds fed with 45% and 60% replacement indicated significant difference over the (control), 15% and 30% replacement levels. The mean value for the feed intake observed in this study for the finisher phase and overall (combined) agreed with the value of up to 160 g/bird/day reported by Olomu (1995), but was lower than the report of NRC (1984) which observed the range of 189-144 g for daily feed intake of male and female broilers well fed on balanced diets. The average performance could be attributed to combined supplementation of lysine and methionine used in the formulation of the experimental diet as reported by Abasiekong and Tyopat (2000) who recommended 2.4% of the combined supplement of methionine and lysine for optimum performance in broiler chickens.

Feed Conversion Ratios (FCR): The feed conversion ratio is the feed consumed per unit weight gain and therefore measures how efficient the birds convert feed consumed into meat. The conversion ratio revealed significant difference in birds fed on 45% and 60% boiled sorrel seed meal as replacement for full-fat soyabean. The feed conversion ratio recorded in this study did not agree with report of Pour-Rezza and Edriss (1997) who recorded FCR of 1.89-2.04 when some plant protein sources were used for broiler chickens diet.

The finisher phase showed no significant difference among all the replacement levels of full fat soyabean by sorrel seed meal. Since FCR is a measure of the efficiency of the bird to convert feed consumed into meat, the lower the value, the better the FCR. This agrees with the feed conversion ratio value of (2.50) recommended by (Olumu, 1995) but is higher than FCR of 1.89-2.04 reported by Pour-Rezza and Edriss (1997) when some plant protein sources were used for broiler chickens diet.

The Feed Conversion Ratio (FCR) in this study followed the same pattern with daily weight gain and final weight gain. It has been reported that formulation to meet the amino acid needs of the birds rather than the crude protein level tends to improve feed conversion ratio (Day, 1983). This may account for the similar Feed Conversion Ratio (FCR) recorded in the study.

Economic analysis: The mean live weight gain, daily weight gain, daily feed intake, feed cost (Naira/kg) and

feed cost/kg gain showed significant difference among all the replacement levels at the starter phase, finisher phase and the combined phase in birds fed on 45% and 60% boiled sorrel seed meal as replacement for full-fat soybean meal. The finisher phase indicated no significant difference. The feed cost N/kg decreased with increasing level up to 60% of the boiled sorrel seed meal for soyabean meal in broiler diet. Diets in which 15%, 30%, 45% and 60% of full-fat soyabean was replaced by sorrel seed meal were cheaper than the (control) diet. The highest feed cost (Naira/kg) of (Naira 36.65) was in (control) diet and the lowest (Naira 30.15) from diet with 60% replacement. However, the best feed cost per kg gain (Naira 65.75) was obtained in birds fed with 60% replacement and this was followed by 45% replacement (68.52) which was better than the other replacement levels of full fat soyabean by sorrel seed meal. Considering the weight gain per bird, diet with 60% replacement levels had the highest value followed by diet with 45% and the least value was recorded in (control) diet while the feed cost Naira/kg and feed cost/kg gain, decreased with increasing level of as sorrel seed meal. The result obtained in this study was desirable in broiler diet because the inclusion of boiled sorrel seed meal decreased the feed cost and cost per kg gain. This observation agreed with the report of Apata and Ojo (2000) that the high cost of feed was largely due to the exorbitant price and scarcity of conventional feed ingredients.

Nutrient digestibility: The result of the apparent digestibility of nutrients showed significant differences ($p<0.05$) among treatments. There seemed to be a numerical increase in values for all nutrients except for crude fibre. This is similar to the report of Nwokolo *et al.* (1985) and Njidda *et al.* (2006) that crude fibre and phytic acid found in most plant do not only resist digestibility by monogastric endogenous enzymes but are also the two common organic compounds known to sequester feed nutrients, rendering them unavailable for animal use.

Carcass characteristics: The carcass weight showed significant difference among the birds fed on 45% and 60% boiled sorrel seed meal as a replacement for full-fat soyabean significantly heavier than birds fed on (control) diet, 15% and 30% replacement levels. This agrees with carcass yields of 65-70% reported by Oluyemi and Roberts (1988). The weight of cut-up parts of drumstick (159.14 g-244.40 g) showed significant difference among the replacement levels. Thighs (120.91-156.8 g) and breast muscle (114.84 g-184.72 g) showed significant difference among the replacement levels. The wings (78.09 g-112.95 g) indicated significant difference among the replacement levels with birds fed on 60% replacement levels of full fat soyabean by sorrel seed meal having heavier weight. The value obtained in this study did not agree with 11.69, 12.95, 8.21 and 17.4 g for drumstick, thighs, wings and breast muscle reported by Oluyemi and Roberts (1988). The results on carcass characteristics in this study were similar to the observation of Rabo (2002) which suggest that the experimental birds fed with boiled sorrel seed meal did not develop adverse effects on the carcass and organs.

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