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Growth performance and carcass characteristics of broiler chickens fed four differently processed roselle seed meals *(Hibiscus sabdariffa)* as partial replacement for soybean meal

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Abstract

The constant increment in the prices of conventional protein feed sources have prompted the search for alternative locally feed resources with minimal competition between man and livestock without any deleterious effect on health of the animal. A 56-day feeding trial was conducted to determine the effect of feeding four differently processed roselle seed meals as partial replacement for soybean meal in broiler chicken's diet. One hundred and fifty (150), one day -old (Yammfy, +AA) broiler chicks were randomly allotted to five (5) dietary treatments comprising three replicates and ten chicks per replicate. The experimental diets were formulated with differently processed Roselle Seed Meal [DPRSM] in the diets of broiler chicks at 15% inclusion levels irrespective of the processing methods. The treatments were designated as T1, T2 T3, T4 and T5 as control diet (no roselle seed meal), fermented roselle seed meal (FRSM), boiled roselle seed meal (BRSM), lye roselle seed meal (LRSM) and enzyme roselle seed meal i.e (enzyme + raw roselle seed) (ERSM) respectively. Data obtained were subjected to Analysis of Variance [ANOVA] at 5% level of probability. Feed and water were supplied ad libitum for eight weeks of the experiment. Data were generated for final body weight, total feed intake, daily feed intake (DFI), total weight gain, daily weight gain (DWG), feed conversion ratio and carcass traits. Results of the analysis for growth performance revealed significant ($P < 0.05$) influence of differently processed roselle seed meal [DPRSM] on final weight gain, total weight gain, daily weight gain, total feed intake, daily feed intake and feed conversion ratio for starter phase. Birds fed control diets and fermented roselle seed meal recorded the higher ($P < 0.05$) final weight gain, total weight gain and daily weight gain. Also, birds fed control diets recorded the highest total feed intake and daily feed intake which were statistically similar to birds fed fermented roselle seed meal while bird on other processed roselle seed meal recorded the least statistically similar values of TFI% and DFI respectively. Birds fed fermented roselle seed meal recorded the best FCR while birds on boiled roselle seed meal recorded the least value. The result at the finisher phase revealed significant ($P< 0.05$) effect of processed Roselle seed on DWG and FCR while other growth parameters were not affected ($P>0.05$) for the treatment imposed. Birds fed control diet and fermented Roselle seed meal had the highest DWG (31.48g and 30.13g). Closely followed were birds fed boiled and lye roselle seed meal (27.94g and 28.78g) while birds fed enzyme roselle seed meal recorded the least value(26.40g). The best FCR was obtained with birds fed control diet, fermented and lye Roselle seed meal. However, the carcass measurements were significantly ($p< 0.05$) influenced for all the parameters measured except for liver, kidney lungs and shanks. Birds on control diets, fermented and lye processed Roselle seed meal recorded the highest of all

these parameters. It was concluded that fermented and lye roselle seed meal at 15% inclusion could be used to partially replace soybean meal in both starter and finisher broiler formulation as it compared favorably with soybean meal for better growth performance and without any detrimental effect on the experimental birds.

Keywords: Broiler chicken, Roselle seed, enzyme (Roxazyme G®), performance, carcass characteristics

Performance de la croissance et caractéristiques de la carcasse des poulets nourris à quatre repas de graines de roselle traitées différemment (hibiscus sabdariffa) comme remplacement partiel du repas du soja

Résumé

L'augmentation constante des prix des sources d'alimentation en protéines conventionnelles a suscité la recherche d'alternatives ressources alimentaires localement avec une concurrence minimale entre l'homme et le bétail sans effet délétère sur la santé de l'animal. Un essai d'alimentation de 56 jours a été effectué pour déterminer l'effet de l'alimentation de quatre repas de graines de roselle traitées différemment comme remplacement partiel du repas de soja dans le régime alimentaire du poulet de poulet. Cent cinquante (150), une journée de poulet-pous poussins de gril à cinq (5) traitements diététiques comprenant trois réplicats et dix poussins par réplication. Les régimes expérimentaux ont été formulés avec un repas de graines de roselle traité différemment [RGRTD] dans les régimes de poussins de poulets à gril à 15% de niveaux d'inclusion indépendamment des méthodes de traitement. Les traitements ont été désignés comme T1, T2 T3, T4 et T5 en tant que régime de contrôle (pas de repas de graines de Roselle), repas de graines de roselle fermentés (RGRF), repas de graines de roselle à la boue (RGRB), Repas de graines de Roselle (RGR) et graines de roselle enzymatique Repas, c'est-à-dire (enzyme + graines de roselle brut) (EGRB) respectivement. Les données obtenues ont été soumises à une analyse de la variance [ANOVA] à 5% de probabilité de probabilité. L'alimentation et l'eau ont été fournies publicitaires de Libitum pendant huit semaines de l'expérience. Les données ont été générées pour le poids final, l'apport alimentaire total, la consommation quotidienne d'alimentation (CQA), le gain de poids total, le gain de poids quotidien (GPQ), le ratio de conversion d'alimentation et les traits de carcasse. Les résultats de l'analyse des performances de la croissance ont révélé une influence significative ($p < 0,05$) de la farine de graines de roselle traitées différemment [FGRTD] sur le gain de poids final, le gain de poids total, le gain de poids quotidien, l'apport alimentaire total, l'apport d'alimentation quotidienne et le rapport de conversion d'alimentation pour le démarreur phase. Doits de contrôle de la Fed des oiseaux et repas de semences de roselle fermentés enregistré le gain de poids supérieur ($p < 0,05$), le gain de poids total et le gain de poids quotidien. En outre, les régimes de contrôle de la Fed des oiseaux ont enregistré l'admission totale totale d'alimentation et une prise d'alimentation quotidienne statistiquement similaire à celle des oiseaux nourris à la farine de graines de roselle fermentée tandis que l'oiseau sur un autre repas de graines de roselle transformé a enregistré respectivement les mêmes valeurs statistiquement similaires de TFI% et de DFI. Oiseaux Feed Fermenté RoselleSeed Repas enregistré le meilleur FCR tandis que les oiseaux sur la farine de graines de roselle bouillie ont enregistré la moindre valeur. Le résultat de la phase de finition a révélé un effet significatif ($P < 0,05$) des graines de roselle transformées sur DWG et FCR, tandis que d'autres paramètres de croissance n'ont pas été

affectés (p> 0,05) pour le traitement imposé. Un régime de contrôle de la commande des oiseaux et un repas de semences de roselle fermenté présentait le plus haut dwg (31,48 g et 30.13g). Suivi étroitement des oiseaux nourris à la farine de graines de la chaurée et de la lyeRoselle (27,94 g et 28,78 g) tandis que les oiseaux nourris à l'enzyme de graines de roselle ont enregistré la moindre valeur (26.40g). Le meilleur FCR a été obtenu avec un régime alimentaire de contrôle des oiseaux, fermenté et lyeRoselle Graine. Cependant, les mesures de la carcasse étaient significativement (p <0,05) influencées pour tous les paramètres mesurés à l'exception du foie, des poumons de reins et des tiges. Oiseaux sur les régimes de contrôle, fermenté et lonité Roselle Roselle Repas ont enregistré le plus haut de tous ces paramètres. Il a été conclu que le repas de graines de la Roselle fermenté et la lye à 15% d'inclusion pourrait être utilisé pour remplacer partiellement la farine de soja dans la formulation de chalameurs de démarrage et de finition, car elle comparée favorablement au farine de soja pour une meilleure performance de croissance et sans effet néfaste sur les oiseaux expérimentaux.

Mots-clés: poulet à gril, graines de roselle, enzyme (Roxazyme G^2), performances, caractéristiques de la carcasse

Introduction

The rising cost of feed resources in livestock production has created a serious alarm to meeting the demand for animal protein particularly in developing countries (Adejinmi *et al.*, 2000). Menegesha (2011) reported that inadequate animal protein are problems in Nigeria. Conventional protein feed ingredients such as soybean have become inadequate to meet the physiological needs of the animal on the account of unavailability of these ingredients because they are being competed for by man and livestock industry. In addition, feed alone accounts for 70 – 80% of cost of production. Protein as oneofthecriticalfeed ingredients forpoultry such as (soybeans, sesame, GNC) which are themain sources ofvegetable protein in intensive monogastric animal production have soared so high in the recent times. This makes poultry production to become unbearable and uneconomical for ration formulation in livestock nutrition. This therefore, necessitates the utilization of alternative feed ingredients. (Mariscal-Landı´*et al.*, 2004; Mukhtar, 2007). Similarly, Gura (2008) reported that the competition between feed-food and agrofuel is expected to escalate the prices of poultry feed which is propelling nutritionists to look inward for alternatives feed stuffs that are locally available to be incorporated into poultry diets without any negative effect on optimum performance. Several legumes have been investigated for their potential as alternative protein feedstuff in poultry nutrition such as roselle seeds. Roselle seeds for instance have been investigated for its nutritional value in poultry (Igoche, 2015). Roselle (*Hibiscus sabdariffa*) seed is a leguminous shrub well adapted to the Guinea and Sudan savannah vegetation's belts of Nigeria (Akanya *et al.*, 1997; Fasoyiro *et al.,*2005). The roselle seeds from Nigeria contain about 35.90% crude protein, 10.14% ether extract, 10.09% ash and 15-17% crude fibre (Dashak and Nwanegbo, 2002; Kwari *et al.*,2011). The seed is a potential source of protein for poultry (Ismail *et al.*, 2008; Diarra *et al.*, 2011). Roselle seed cake (RSC) is not consumed by humans; it is cheap and readily available and therefore poses no threat of scarcity. Unprocessed Roselle seeds have been reported to contain anti-nutritional factors which include total phenol, tannin and phytic acid. These factors have been shown to have detrimental effects on the health and performance of animals (Diarra

et al., 2011). Processing methods such as boiling water treatment, fermentation and ice water treatment have been reported to be effective to some extent. However, information on lye processing and the use of feed additives to improve utilization through reduction or elimination of anti-nutritional factors in these unprocessed seed for better performance are scarce. Friesen *et al*. (1992) reported that the use of enzyme as feed additives in livestock feed has reported a success as a way of improving the utilization of dietary nutrients and high fibre feedstuff by monogastric animals. Bedford and Schulze (1998) documented that supplementation of diets with exogenous enzyme reduced the adverse effects of some of these compounds especially those produced by carbohydrates and proteins. Application of enzyme had been used to improve fibre digestion and reduce viscosity of digesta (Atteh, 2001 and Oke *et al.*, 2016). This research seeks to evaluate four differently processed roselle seed meals as partial replacement for soybean meal as a way to ameliorate the competition between livestock industry and man for the limited protein source available.

Materials and methods

Experimental site

The experiment was conducted at the Poultry Unit, Livestock Teaching and Research Farm, Federal University Dutse, Jigawa State, Nigeria. Dutse is located on longitude 9.34° E and Latitude 11.76°N and has an elevation of 431.36 meters above sea level (Encarta, 2007). There is usually a hot diurnal temperature and comparatively cooler at nights during the last 2-3 months of the dry season which is followed by a wet season between the months of June and September (Wikipedia, 2013).

Processing of test ingredient

Roselle seeds were purchased in Dutse ultra-modern market, Jigawa State. The seeds were cleansed by winnowing and hand picking to remove stones and debris. The raw seeds were subjected to four (4) processing methods such as fermentation, boiling, lye and raw roselle supplemented with enzyme. Each of these processed Roselle seeds were incorporated in broiler diet at 15% inclusion levels in both starter and finisher of the experiment to replace soybean. The treatments were designated as T1, T2 T3, T4 and T5 as control diet (basal diet), fermented roselle seed meal, boiled roselle seed meal, lye roselle seed meal and enzyme roselle seed meal (enzyme + raw roselle seed), respectively. The processing methods adopted for the Roselle seeds are described below:

Lye-water method

Ash was sieved to remove charcoal and other impurities; hot water was poured over ash in a barrel and a brown liquid dripped at base of container which represents the lye water. Roselle seeds was placed in a muslin cloth and soaked in the lye water for 18 hours, thereafter, it was removed, sun-dried for seven days, crushed and left to be incorporated in the formulation. (Akande *et al.,* 2011

Hot water treatment

The cleaned roselle seeds were put inside aluminum tower pot containing 50 litres of clean water in a batch of 50 kg. It was allowed to boil for 30 minutes at 100°C and allowed to cool by spreading on jute bags until stable weight is attained at room temperature. Thereafter, it was dried, crushed and left to be incorporated in the formulation.

Fermented Roselle seeds (FRS)

The cleaned Roselle seeds were poured inside a drum of 50 liters of boiling water for 30 minutes at 100 °C. The boiled grains were drained, allowed to cool at room temperature and covered in a covered container for 48 hours. Thereafter, the product was sun-dried, crushed and left to be incorporated in the formulation.

Enzyme treatment

The clean raw Roselle seeds were crushed and mixed with enzyme from reputable manufactures and left to be incorporated in the formulation. The commercial enzyme (Roxazyme G®) used in this study is a blend of multi-enzymes consisting of endo – 1, 4 – β – xylanase (EC 3.2.1.8), endo – 1, 3 (4) – β – glucanase (EC 3.2.1.6) and endo – 1, 4 – β – glucanase (EC 3.2.1.4) produced by *Trichodermareesei.*

Experimental design and animal management

One hundred and fifty (150) day old' Yammfy, +AA' broiler chicks were randomly allotted to five (5) dietary treatments comprising three replicates and ten chicks per replicate. The experimental diets were formulated with differently processed Roselle seed Meal [PRSM] in the diets of broilers at 15% inclusion levels.The treatments were designated as T1, T2 T3, T4 and T5 as control diet (no roselle seed meal), fermented roselle seed meal, boiled roselle seed meal, lye roselle seed meal and enzyme roselle seed meal (enzyme + raw roselle seed) respectively. During brooding, temperature was controlled at 34.5°C for the first 0 to 2 days and then gradually reduced by 2 °C per week to a final ambient temperature of 27 °C at the last week of brooding. Feed and clean water were supplied *ad libitum*. The birds were reared intensively on deep litter (dried wood shavings) housing system. Normal vaccination program and medication schedule were strictly adhered to.

Experimental diets

Five experimental diets were formulated for both starter (Table 1) and finisher (Table 2) phases of the study. The experimental diets were formulated with 15% inclusion levels of differently processed roselle seed meal (PRSM) in the diets irrespective of the processing methodstomeet the NRC (1994) nutrient requirements for broiler chickens. The chicks were allocated to five different treatments designated as T1, T2, T3, T4 and T5 fed with diets containing 0% (control diet), 15% fermented roselle seed meal, 15% Boiled roselle seed meal, 15% lye roselle seed meal and 15% raw roselle seed meal supplemented with enzyme at 200 ppm respectively. The gross and proximate compositions of the experimental diets are presented in Table 1, 2, 3 and 4 while the proximate composition of the roselle seed is presented in Table 5.

Table 1: Composition of the experimental diets at starter phase (0-4) weeks (kcal/kg Diet)

Ingredients	T1	T2	T3	T4	T5
Maize	49.00	49.00	49.00	49.00	49.00
Fish meal	4.00	4.00	4.00	4.00	4.00
Soy bean meal	20.00	5.00	5.00	5.00	5.00
G/nut cake	8.60	8.60	8.60	8.60	8.60
Wheat offal	14.00	14.00	14.00	14.00	14.00
Bone meal	1.86	1.86	1.86	1.86	1.86
Oyster shell	1.50	1.50	1.50	1.50	1.50
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.30	0.30	0.30	0.30	0.30
Premix	0.30	0.30	0.30	0.30	0.30
Salt	0.25	0.25	0.25	0.25	0.25
Roselle seed	-	15.00	15.00	15.00	15.00
Total	**100**	**100**	**100**	**100**	**100**
Calculated analysis					
ME (Kcal/kg)	2,883	2,862	2,862	2,862	2,862
Crudeprotein (%)	23.00	22.00	22.00	22.00	22.00
Ether extra (%)	3.97	3.97	3.97	3.97	3.97
Crude fibre (%)	3.64	3.66	3.66	3.66	3.66
Calcium (%)	1.18	1.20	1.20	1.20	1.20
Phosphorus (%)	0.43	0.53	0.53	0.53	0.53
Lysine (%)	1.38	1.40	1.40	1.40	1.40
Methionine (%)	0.66	0.66	0.66	0.66	0.66

Composition of the premix supplied per 100kg of diet: premix vit A=8000IU, Vit E=21.6, Vit D3=i44iIU, VitB1 1.8mg, Vit . B2 Folic acid=100mg, Nicotinic acid=4000mg, Pantothenic acid=1500mg, 1=1750mg, Fe=40000mg, Zn= 50000mg, Mn=100mg, Boitin=6000mg, Vit. C=30000mg, Cu=1500mg, Co=200mg, Si=100mg

Table 2: Composition of the experimental diets at finisher phase (5-8) weeks (kcal/kg Diet)

Ingredients	T1	T2	T3	T4	T5
Maize	58.00	58.00	58.00	58.00	58.00
Fish meal	4.00	4.00	4.00	4.00	4.00
Soy bean meal	18.00	3.00	3.00	3.00	3.00
G/nut cake	8.00	8.00	8.00	8.00	8.00
Wheat offal	8.00	8.00	8.00	8.00	8.00
Bone meal	1.50	1.50	1.50	1.50	1.50
Oyster shell	1.50	1.50	1.50	1.50	1.50
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.30	0.30	0.30	0.30	0.30
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Roselle seed	-	15.00	15.00	15.00	15.00
Total	**100**	**100**	**100**	**100**	**100**
Calculated analysis					
Metabolizable energy **(kcal/kg Diet)**	2,986	2,965	2,965	2,965	2,965
Crudeprotein	20.46	20.00	20.00	20.00	20.00
Ether extra	4.02	4.13	4.13	4.13	4.13
Crude fibre	3.18	3.28	3.28	3.28	3.28
Calcium	1.09	1.11	1.11	1.11	1.11
Phosphurus	0.38	0.51	0.51	0.51	0.51
Lysine	1.27	1.83	1.83	1.83	1.83
Methionine	0.65	0.56	0.56	0.56	0.56

Composition of the premix supplied per 100kg of diet: vit A=1200IU, Vit E=1500, Vit D3=2500IU, Vit. B2 Folic acid=4000mg, Nicotinic acid=4000mg, Pantothenic acid=1500mg, 1=1750mg, Fe=40000mg, Zn=50000mg, Mn=100mg, Boitin=6000mg, Vit. C=30000mg, Cu=1500mg, Co=200mg, Si=100mg

Table 3: Proximate composition of the experimental diet (0-4 Weeks)

Parameters	T1	T2	T3	T4	T5
Starter Phase					
CP	22.43	23.14	23.48	22.68	22.70
EE	5.68	7.87	8.64	8.54	7.86
ASH	6.30	6.76	6.50	5.72	5.81
CF	6.43	6.62	6.89	6.72	6.93
NFE	50.40	49.62	47.86	48.16	47.84
DM	94.13	95.28	95.44	93.69	94.96
Finisher Phase					
CP	20.56	21.88	20.24	20.56	21.14
EE	8.06	9.84	9.91	10.11	9.56
ASH	7.01	7.43	7.86	6.98	7.44
CF	8.42	8.55	8.77	8.76	8.23
NFE	54.16	52.68	53.88	53.96	53.84
DM	94.56	96.24	96.70	94.24	95.83

Data collection and parameters measured

The birds were weighed at the beginning of the experiment and the initial weight was obtained. The final weight was taken at the end of the experiment by subtracting the initial weight from the final weight.

Daily feed intake was determined by the difference between daily feed offered and daily feed leftover and the total feed intake was obtained by cumulative addition of the daily feed intake.

Feed conversion ratio (FCR) was computed by dividing daily feed intake by daily weight gain as follows = Feed intake/weight gain

Carcass analysis

At the end of the eight weeks of feeding trial, two birds from each replicate were randomly selected, slaughtered, de-feathered and eviscerated. The live weight of the birds was taken prior to slaughtering and the dressed weight were also recorded. The cut parts such as head, neck, breast, back, thigh, drumstick, shank, spleen, kidney, lungs, gizzard, liver, heart and proventriculum were weighed using a sensitive electronic weighing scale and the weight was expressed as a percentage of live weight.

Proximate analysis

The proximate compositions of the diets were determined using the methods of AOAC (2012). The Kjeldahl procedure was used to determine the crude protein (CP) content. The dry matter was obtained first by eliminating the moisture content using the vacuum oven-dried method. The dry matter was obtained when the weight become constant and moisture was computed as moisture = 100-final weight of sample. Dry matter = 100-% moisture. The ashing procedure as described by Onu (2005) was used to determine the ash content. The defatting and boiling methods were used to determine the crude fibre while soxhlet fat extraction method was used to determine the ether extract (EE). The nitrogen – free extract (NFE) was obtained using the formula below: NFE = 100 - (% Moisture + % CP + % CF +% EE +% Ash). The energy value ME was calculated using the formula of Pauzenga (1985) as follows: ME (kcal/kg) = 37x % CP+81x % EE +35.5 x % NFE.

Data analysis

Data generated were subjected to one-way ANOVA using SAS (2009). Significant means at 5%

level of probability was separated using Duncan's Multiple Range Test of the same statistical package.

Statistical model

Yij = U+Ti +eij

Where;

Yij = the observed response

U = the overall mean

Ti = the fixed effect of ith treatment (n = fermented roselle seed meal, boiled roselle seed meal, lye roselle seed meal and enzyme roselle seed meal) the residual error.

Results

Proximate composition of roselle seed meal is presented in Table 4.Proximate composition of roselle seed meal revealed higher dry matter (DM) for boiled, lye and enzyme methods compared to fermented roselle seed. The proximate composition of the roselle seed meal for crude protein (CP) ranged between 34.27% for fermented roselle seed and 32.50% for enzyme roselle seed meal. The CP was similar for all the processing methods meanwhile, fermented method recorded higher numerical value. Ether extract (EE) and Crude fibre (CF) values for fermented roselle seed meal were numerically higher compared to values obtained for other processed methods. The crude fibre and EE were numerically higher in fermented while the lowest was recorded for enzyme roselle seed meal. The nitrogen free extract (NFE) decreases with the processing methods. Boiled roselle seed meal recorded higher value of NFE while enzyme roselle seed meal recorded the lowest value.

Table 4: Proximate composition of differently processed Roselle seed meal

	Raw	Fermented	Boiled	Lye	Enzyme
CP	32.50	34.27	33.48	33.44	33.60
EE	11.26	16.31	15.57	15.46	14.17
ASH	7.54	7.88	7.68	7.78	7.34
CF	10.17	12.49	11.60	11.12	10.82
NFE	48.17	45.83	43.11	43.86	40.18
DM	95.72	95.89	95.17	95.44	94.16

Crude protein, EE=Ether extract, CF= Crude fiber, NFE=Nitrogen free extra, DM=Dry matter

The growth performance of broiler starter chickens fed differently processed Roselle seed meal at starter phase is presented in Table 5. The results revealed a significant ($P<0.05$) influence of processed roselle seed meal on all the parameters measured. The final weight gain, total weight gain and daily weight gain were highly significant ($P<0.05$) for birds fed control diet and fermented roselle seed meal compared to other treatments that were statistically similar for these parameters. There were significant differences ($P<0.05$) in total feed intake, daily feed intake and feed conversion ratio. Birds fed control diet (T1) had significantly ($P<0.05$) higher values of total feed intake (1080.03g) and daily feed intake (38.57g) compared to other treatments. The values were statistically similar to those fed T2 (977.02g, 34.89g). Meanwhile, the lowest values of these parameters were recorded in birds fed boiled roselle seed meal T3, lye roselle seed meal T4 and enzyme roselle seed meal T5 respectively. The feed conversion ratio was significantly ($P<0.05$) influenced by the dietary treatments imposed on the birds. Birds fed fermented Roselle seed (T2) recorded the best feed conversion ratio with least similar values recorded for birds on other treatments. The feed cost in Naira per kilogram gain were significantly ($P<0.05$) better for birds fed fermented roselle seed meal (T2), boiled roselle seed meal (T3), lye roselle seed meal (T4) and enzyme roselle seed meal (T5) respectively compared to birds fed control diet (T1). Similar trend was observed in cost of feed consumed per kilogram in Naira.

The growth performance of broiler finisher chickens fed differently processed Roselle seed meal at finisher phase is presented in Table 6. The result showed a significant difference ($P<0.05$) in daily weight and feed conversion ratio. However, there was no significant differences ($P>0.05$) in the final weight gain, total weight gain, total feed intake and daily feed intake. Birds fed control diet (T1) and fermented roselle seed meal (T2) had the highest significant ($P<0.05$) daily weight gain. Similarly, birds fed boiled roselle seed meal (T3) and lye roselle seed meal (T4) were similar in daily weight gain while the lowest daily weight gain was recorded in birds fed enzyme roselle seed meal (T5). Birds fed T1, T2 and T4 recorded the best feed conversion ratio. Birds fed T1 and T2 had numerically higher values in final weight gain, total weight gain, total feed intake while the lowest values of all the parameters measured were recorded in enzyme roselle seed meal. The feed cost in naira per kilogram gain were significantly ($P<0.05$) better when birds were fed T2, T3, T4 and T5 respectively compared to birds on control diet (T1). Similarly, it was cheaper to produce a broiler chicken on T2, T3, T4 and T5 in terms of cost of feed consumed per kilogram naira.

Table 5: Performance of starting broiler chickens fed differently processed Roselle seed meal (0-4) weeks

Parameters (%)	T1	T2	T3	T4	T5	SEM
Initial weight (g/bird)	36.90	36.90	36.90	36.90	36.90	- -
Final weight (g/bird)	640.38 [a]	621.87 [a]	541.51 [b]	564.23 [b]	556.65 [b]	15.72
Total weight gain (g/bird)	603.48 [a]	584.97 [a]	504.61 [b]	527.33 [b]	519.97 [b]	0.89
Daily weight gain (g/bird)	21.55 [a]	20.90 [a]	18.02 [b]	18.83 [b]	18.56 [b]	0.58
Total feed intake (g/bird)	1080.03[a]	977.02[ab]	948.96[b]	937.85[b]	933.25[b]	15.72
Daily feed intake (g/bird)	38.57[a]	34.89[ab]	33.86[b]	33.49[b]	33.33[b]	20.27
Feed conversion ratio	1.80[ab]	1.67[b]	1.88[a]	1.78[ab]	1.80[ab]	0.13
Feed cost (#/kg) /gain	272.41 [a]	219.91 [b]	219.91 [b]	219.91 [b]	219.91 [b]	13.48
Cost of feed consumed (#/kg)	10.51 [a]	7.67 [b]	7.45 [b]	7.37 [b]	7.59 [b]	0.93

[abc] Means on the same row having different superscripts are significantly different ($P < 0.05$), SEM= standard error of mean

Table 6: Growth performance of broiler finisher chickens fed differently processed Roselle seed meal (5-8) weeks

Parameters	T1	T2	T3	T4	T5	SEM
Initial weight (g/bird)	560.65	560.85	560.65	560.65	560.85	- -
Final weight (g/bird)	1442.13	1404.59	1342.97	1366.41	1300.01	25.60
Total weight gain (g/bird)	881.35	843.74	782.32	805.76	739.16	52.1
Daily weight gain (g/bird)	31.48[a]	30.13[a]	27.94[b]	28.78[b]	26.40[c]	1.47
Total feed intake (g/bird)	2437.40	2308.42	2283.60	2280.82	2274.62	65.96
Daily feed intake (g/bird)	87.05	82.44	81.56	81.46	81.24	1.60
Feed conversion ratio	2.77[b]	2.74[b]	2.92[a]	2.83[b]	3.08[a]	0.34
Feed cost (#/kg)	276.05 [a]	223.55 [b]	223.55 [b]	223.55 [b]	231.55 [b]	14.17
Cost of feed consumed (#/kg)	24.03 [a]	18.43 [b]	18.23 [b]	18.21 [b]	18.81 [b]	1.01

[abc] Means on the same row having different superscripts are significantly different ($P < 0.05$), SEM= standard error of mean

Carcass characteristics of finisher broiler chickens fed differently processed roselle seed meal

The effect of differently processed roselle seed meal on carcass characteristics of broiler chicken is shown in Table 7. The result revealed that the parameters measured were significantly ($P<0.05$) different across the treatments except for liver, kidney and lung. The result showed that there existed significant ($P<0.05$) differences in final live weight, defeathered weight, dressing weight, thigh muscle, breast, drum stick, back and wings weights. Birds fed T1 had significantly ($P<0.05$) higher values of all these parameters measured followed closely were birds fed T2, T4 and T5 diet respectively while the lowest values were recorded in treatment T3. The liver value ranged between 2.11 for control diet and 1.77 for lye roselle seed meal whereas the kidney values were similar across the dietary treatments. Birds fed control diet, boiled roselle seed meal and lye roselle seed meal recorded the highest numerical value for lung. Closely followed were birds fed lye roselle seed meal while the least of the value was recorded for birds fed fermented roselle seed meal. The spleen, kidney, lung and shank weight were not significantly different across the treatment. However, there were significant ($P<0.05$) differences in proventriculus with the highest value (0.87%) obtained from birds fed fermented Roselle seed meal (T2) while the least (0.54) was recorded in birds fed boiled Roselle seed meal (T3).

Table 7: Carcass characteristics of finisher broiler chickens fed differently processed roselle seed meal

Parameters	Treatments					SEM
	T1	T2	T3	T4	T5	
Live weight (g)	1350.00^{a}	1325.00^{ab}	1200.00^{c}	1300.00^{ab}	1275.00^{ab}	28.93
Defeathered weight (g)	1150.00^{a}	1125.00^{a}	1060.00^{c}	1150.00^{b}	1175.00^{b}	38.95
Dressing percentage (%)	85.17^{ab}	87.59^{a}	81.13^{c}	84.59^{b}	84.39^{b}	1.36
Head (%)	3.44^{a}	2.91^{ab}	3.17^{ab}	3.02^{ab}	3.14^{ab}	0.19
Neck (%)	3.58^{a}	3.04^{ab}	2.89^{b}	2.82^{b}	2.67^{b}	0.29
Wing (%)	7.28^{a}	6.18b^{ab}	6.71^{ab}	5.48^{b}	6.20^{ab}	0.29
Breast (%)	14.77^{a}	12.77^{ab}	12.00^{ab}	10.46^{b}	12.14^{ab}	0.84
Thigh (%)	8.86^{a}	8.50^{a}	7.09^{b}	6.14^{bc}	6.87^{bc}	0.58
Drumstick (%)	8.55^{a}	6.92^{b}	7.38^{ab}	7.23^{ab}	7.35^{ab}	0.67
Back (%)	11.14^{a}	9.40^{ab}	9.67^{ab}	8.38^{b}	10.11^{ab}	0.80
Shank (%)	4.19	4.14	4.13	4.15	4.14	0.36
Spleen (%)	0.01	0.01	0.01	0.01	0.01	0.07
Liver (%)	2.11	2.00	1.88	1.77	1.97	0.17
Kidney (%)	0. 02	0. 02	0. 03	0. 03	0. 02	0.00
Lung (%)	0.59	0.52	0.59	0.58	0.59	0. 05
Gizzard	4.25^{a}	4.04^{a}	3.25^{b}	3.21^{b}	3.31^{b}	0.27

SEM=Standard error of mean

Discussion

The proximate composition of the differently processed roselle seed contained dry matter of 95.89 %. This result was higher compared to Maikano *et al.* (2014) who reported 91.39% for crushed roselle seed but in harmony with Onunkwo *et al.* (2019) that recorded (95.17%). The crude protein (CP) recorded (34.27%) regardless of the processing method employed were higher compared to (30.45%) reported by Onunkwo *et al.* (2019) and Igoche (2015) who reported (30.50%) when fed roselle seed cake. Similarly, it corroborated the works of Dashak and Nwanegbo (2002); Isadahomen *et al.* (2006) and Kwari *et al.* (2011) that roselle seed cake contain between 21.40 -38.75% CP. Ismail *et al.* (2008); Diarra *et al.* (2011) attested the seed is a potential source of protein for poultry. In addition, the higher CP observed in all the processing methods especially the fermented roselle seed agreed with the earlier report of Owosibo *et al.* (2018) who noted increased CP (22.44%) in fermented roselle seed meanwhile the recent findings were higher (34.27%). The numerically higher crude fiber observed for fermented roselle seed agreed with Mukhtar (2007) who reported (11.98%), Sanni (2015) reported (10.20%) and (11.87%) was observed by Owosibo *et al.* (2018) although the value here were higher than value (4.20%) obtained by Igoche (2015). The ether extract (EE) was in accordance with owosibo *et al.* (2018) who reported higher EE for fermented roselle seed in a feeding trial. This suggests the superiority and efficacy of fermented processing method over its counterpart to sustain life. Furthermore, higher nitrogen free extract (NFE) value recorded for boiled roselle seed which was similar to other treatments with the lowest numerical value in enzyme roselle seed correlates with the trend reported by Owosibo *et al.* (2018). The authors recorded a decreasing trend (Raw < Soaked < Boiled < Fermented) for Nitrogen Free Extract when roselle seeds were subjected to different processing methods. The metabolizable energy value of 2883kcal/kg agreed with the observed range (2880-3500kcal/kg) by these researchers (Isidahomen *et al*. (2006) Mukhtar, 2007 Diarra et al. (2011); and Kwari et al. (2011).

The significant and numerically higher final weight and total weight gain reported for birds fed control diet and fermented processed roselle seed meal compared to other treatments at the starter and finisher phases corroborates the earlier works of owosibe *et al.* (2018) and Maikano *et al.* (2013) who reported significant higher weight gain and final weight gain when finisher broilers were fed fermented roselle seed meal. The work is at variance with the findings of Kwari *et al*. (2011); Freitas *et al*. (2011) and Ashom *et al*. (2014). The researchers actually reported no significant difference in weight gain and final weight gain when birds were fed differently processed roselle seed meal. The better utilization potential of nutrients consistently displayed by fermented roselle seed meal and other roselle processed methods as compared with control diet showed there was increased bulkiness to meet their metabolic energy requirement resulting to better final weight gain. Since birds eat to satisfy their energy requirement. Moreover, the significantly higher values of total feed intake and daily feed intake observed at both phases for control and fermented roselle seed meal compared to other treatments suggested better digestibility of the feed (crude protein and crude fiber) and utilization of nutrients which translated to better weight gain observed. Similar reports were asserted by (Ashom *et al.*, 2014 and Owosibo *et al*., 2018) for broiler chickens when fed fermented roselle seed meal. Although, Ashom*et al.* (2014) reported highly significant feed intake for birds fed sprouted and boiled roselle seed compared to those on control and soaked roselle seed meal. This result was contrary to the finding of Duwa *et al.* (2012) who reported no significant difference in total feed intake and daily feed intake of broiler chickens at starter phase except for the control diet. The similarities observed in FCR of all processing methods of roselle seed meal at the starter phase except for boiled roselle seed meal and the superiority noticed in fermented and lye roselle seed meal at the finisher phase showed that the birds were more efficient in utilizing the feed which concomitantly led to better final weight gain regardless of the processing methods used. This affirms that the Lye, enzyme and fermented roselle were able to sustain life and maintain metabolic processes as the basal diet (soybean meal). This is in line with the findings of Angbulus *et al.* (2020) and Freitas *et al.* (2011). The authors observed improved FCR when fed broiler with fermented roselle seed supplemented with enzyme. Ravindran *et al. (*1999) also confirmed that enzyme supplementation significantly improved body weight, feed consumption, feed conversion ratio, dietary energy, and protein utilization. This agreed with report of Doma (1998) who reported that the lower the feed conversion ratio the better the diet in monogastric animals. It also corroborated the earlier findings of Owosibo *et al.* (2018) that reported poor utilization of soaked roselle seed meal when fed finisher broiler chickens which translated to lower final weight gain. This was consistent with Owosibo *et al.* (2018) who noted decreased FCR in birds fed fermented roselle seed but in contrast to the result obtained by Kwari *et al.* (2011) and Ashom *et al.* (2014) who reported higher FCR for birds on fermented and sprouts. Meanwhile, Duwa *et al.* (2012) reported no significance FCR in birds fed differently processed roselle seed meal. Consequently, the similar FCR recorded for Lye and enzyme roselle seed meal as compared to control diet which led to similar weight gain of these birds affirms that the Lye, enzyme and fermented roselle seed meal were able to sustain life and maintain metabolic processes as their counterparts (control diet). This also corroborated the earlier finds of Owosibo *et al.* (2018) who reported

lower final weight gain as a result of poor utilization of soaked roselle seed meal fed to finisher broiler chickens. The feed cost in naira per kilogram gains were significantly better for birds fed T2, T3, T4 and T5 respectively compared to birds on control diet (T1). Similar trend was observed in cost of feed consumed per kilogram in Naira. The most expensive diet to achieve a unit weight gain was the control diet while the least cost diet to achieve a kg weight gain were T2, T3, T4 and T5 respectively. The reduced cost per kilogram of compound diet with differently processed roselle seed when compared to diet containing soya is confirmatory to the fact that roselle seed is a cheap feed ingredient compared to soya bean. The cost of feed per kilogram weight gained by the broiler chicken from the current study reduced with the inclusion of roselle seed meal at both starter and finisher phases of the study. This implied that it was cheaper to produce a unit weight gain from 1 kg of roselle seed meal at these phases. Ismail *et al.* (2008); Diarra *et al.* (2011) and Owosibo *et al.*(2018) confirmed that Roselle seed is a potential source of protein for poultry which is cheap, readily available and not consumed by humans which poses no threat of scarcity. This add credence to the fact that roselle seed meal irrespective of the processed method employed could be used to replace soybean meal up to 15% inclusion levels without any deleterious effect on the growth performance as it competes well with control diet (soybean meal). The result was at variance with Angbulu *et al.* (2020) that it was cheaper to produce a unit weight gain from 1 kg of control diet than from 1kg roselle seed meal supplemented with enzyme. The significant difference observed in carcass characteristics of broiler chickens fed differently processed roselle seed meal in this study was at variance with Owosibo *et al.* (2017) who reported no influence of graded levels of raw roselle seed meal on carcass traits of broiler chickens. Also, a contrary view was observed by Ashom *et al.* (2014) on an insignificant difference in the carcass trait when fed roselle seed meal to broiler chickens. The report here was consistent with Owosibo *et al.* (2018) who reported significant difference in birds fed differently processed roselle seed meal. The superior live weight and thigh weight demonstrated by fermented, lye and enzyme roselle processed seed meal agreed with Owosibo *et al*. (2018) but differs with Ashom *et al.* (2014). The dress weight value (87.59%) recorded in this study was at close range with the one reported by Ashom *et al*. (2014) (88.76%). The drumsticks and thighs observed here were relatively lower compared to report of Ashom *et al.* (2014) and Owosibo *et al.* (2018). This difference observed could be attributed to the breed of the broiler chicken used in which that they cannot perform beyond their intrinsic genetic potentials. The weights of the wings, breast and back were extremely lower compared with report by Owosibo *et al.* (2018); Ashom *et al.* (2014) and Oluyemi and Robert (2000). The researchers reported 8.40, 19.83, 17.23% and 8.21, 17.40, 12.05% respectively.It was revealed that the spleen, kidney lung and shank were not significantly different across the treatment. This was contrary to the finding of Ashom *et al.* (2014) who reported significant difference in the weight of spleen, kidney lung and shank. However, the significance noted in gizzard weight across the treatments supports similar finding of Angbulu *et al.*(2020).

Conclusion

The results of this study showed that differently processed Roselle seed meal up to 15% poses no treat on all growth performance and carcass trait measured both at starter and finisher phase of the research. In fact, the differently processes roselle seed meal performed favourably

with the control diet in all parameters measured. It was noticed that Fermented roselle seed meal displayed superiority for all the growth performance measured. However, lye and enzyme roselle seed meal were also good to raise broiler chickens on as a replacement for soybean meal in typical broiler chicken's formulation. In view of this, it is therefore concluded that fermented and lye roselle seed meal could replace soybean meal up to 15% in broiler chicken's formulation for both starter and finisher phases.

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