

Performance and meat attributes of finisher broiler chickens administered aqueous extracts of dried calyx from roselle plant (*Hibiscus sabdariffa*)

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Abstract

The performance, carcass, organ characteristics and meat attributes of finisher broiler chickens administered varying concentrations of aqueous extract of dried calyx roselle plant were assessed in this study. Two hundred grams of dried calyx roselle plant was boiled in 2 litres of water for 10 minutes to obtain the flower extract. After boiling, the extract was obtained with the aid of a syringe and was applied into a litre of drinking water at varying mls. The concentrations were 0, 5, 10, 20, and 30 ml of two litres of aqueous calyx extract of roselle plant per litre of drinking water as treatments: T1, T2, T3, T4 and T5, respectively. The experiment lasted for four weeks of finisher phase. The live weight and water intake of finisher broilers were significantly different across the treatments. T4 (20 ml) improved liveweight (2308.17 ± 4.25 g) and water intake (30.62 ± 0.05 ml/bird/day). The carcass parameters were significantly different across the treatments. Carcass prime cuts: drumsticks, wing, thigh and breast were positively affected at treatments T4 (20 ml) and T5 (30 ml). The kidney, pancreas and heart significantly had the highest weight values at treatment T3 (10 ml). The lung and the spleen had higher weight values at treatment T4 (20 ml). Highest significant value of the liver (15.95 ± 0.21 g/kg liveweight) occurred at Treatment T5 (30 ml). The colour scores were significantly different across the treatments. The colour score increased as the level of the extract increased with treatment T5 (30 ml) having the highest colour score (6.00) while T1 (0 ml) had the least colour score (5.56). Treatment T4 (20 ml) had the highest percentage value ($50.57 \pm 3.81\%$) while treatment T3 (10 ml) had the lowest ($24.10 \pm 0.65\%$) percentage value for cooking loss. The extract supported the meat value of the broiler chicken but enhanced the colour intensity of the meat without undermined organ growth and function. However, histological study of the organs can provide further information on the extract's biological value.

Keywords: Broiler chickens, carcass, organ, organoleptic parameters, aqueous extract, calyx of roselle plant

Performances et caractéristiques de la viande de poulets à griller en finition ayant reçu des extraits aqueux de calice séché de plante roselle (*Hibiscus sabdariffa*)



Résumé

La performance, la carcasse, les caractéristiques des organes et les attributs de la viande de poulets à griller de finition auxquels ont été administrées des concentrations variables d'extrait aqueux de calice séché ont été évalués dans cette étude. Deux cents grammes de calice roselle séché ont été bouillis dans 2 litres d'eau pendant 10 minutes pour obtenir l'extrait de fleur. Après ébullition, l'extrait a été obtenu à l'aide d'une seringue et a été appliqué dans un litre d'eau potable à différents ml. Les concentrations étaient de 0, 5, 10, 20

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et 30 ml de deux litres d'extrait aqueux de calice de roselle par litre d'eau de boisson comme traitements: T1, T2, T3, T4 et T5, respectivement. L'expérience a duré quatre semaines de phase de finition. Le poids vif et la consommation d'eau des poulets de finition étaient significativement différents d'un traitement à l'autre. T4 (20 ml) a amélioré le poids vif ($2308,17 \pm 4,25$ g) et la consommation d'eau ($30,62 \pm 0,05$ ml/oiseau/jour). Les paramètres de la carcasse étaient significativement différents d'un traitement à l'autre. Les coupes principales de carcasse : les pilons, l'aile, la cuisse et la poitrine ont été positivement affectés aux traitements T4 (20 ml) et T5 (30 ml). Le rein, le pancréas et le cœur présentaient significativement les valeurs de poids les plus élevées au traitement T3 (10 ml). Le poumon et la rate avaient des valeurs pondérales plus élevées au traitement T4 (20 ml). La valeur significative la plus élevée du foie ($15,95 \pm 0,21$ g/kg de poids vif) s'est produite au traitement T5 (30 ml). Les scores de couleur étaient significativement différents selon les traitements. Le score de couleur a augmenté à mesure que le niveau de l'extrait augmentait avec le traitement T5 (30 ml) ayant le score de couleur le plus élevé (6,00) tandis que T1 (0 ml) avait le score de couleur le moins élevé (5,56). Le traitement T4 (20 ml) avait la valeur en pourcentage la plus élevée ($50,57 \pm 3,81$ %) tandis que le traitement T3 (10 ml) avait la valeur en pourcentage la plus faible ($24,10 \pm 0,65$ %) pour la perte de cuisson. L'extrait a soutenu la valeur de la viande du poulet à griller mais a amélioré l'intensité de la couleur de la viande sans nuire à la croissance et à la fonction des organes. Cependant, l'étude histologique des organes peut fournir des informations supplémentaires sur la valeur biologique de l'extrait.

Mots-clés : Poulets à griller, carcasse, organe, paramètres organoleptiques, extrait aqueux, calice de plante roselle

Introduction

Dietary protein played a major role in human diets, due to its role in cells and tissue growth and development. Based on short-term nitrogen balance studies, the Recommended Dietary Allowance of protein for a healthy adult with minimal physical activity is currently 0.8 g protein per kg body weight (BW) per day (Wu, 2016) and daily protein requirement of 52g by FAO (Oyedepi, 2021). Animal protein provides relative appropriate amino acids that match human amino acids requirements better than plant protein sources. The proteins are generally scored higher to be of better biological values than plant proteins. Therefore, adequate consumption of high-quality proteins from animal products is essential for optimal growth, development, and health of humans (Wu, 2016). FAO has recommended that one-third of the daily protein intake should be of animal origin (Oyedepi, 2021).

Unfortunately, the low level of animal protein consumption in Nigeria, as reported by the FAO, revealed that the diet of an average Nigerian contains 33 percent less than the recommended requirement (Odoemena *et al.*, 2020). Consequently, the shortfall in animal protein consumption can be made up for through sustainable poultry production especially broiler chickens. Generally, poultry has short generation interval, suffer no cultural taboo or religious discrimination, required limited land area for rearing and constitute no serious threat to the environment. However, the concern for food safety without compromising the performance of broiler chicken expected that broiler chicken should be reared to guarantee the healthy consumption of its products. The outbreak of various life-threatening diseases and ailments had been linked to what being consumed. Therefore, food items should be produced in a nutritionally

safe form. The increased problem of antibiotic resistance (Diarra *et al.*, 2007; Forgetta *et al.*, 2012; Furtula *et al.*, 2010), and presence of antibiotics residues in feed and environment (Carvalho and Santos, 2016; Gonzalez and Angeles, 2017), compromises human and animal health (Diarra *et al.*, 2010). Therefore, there has been consistent efforts to find the effective alternatives to prevention and control of spread of resistant bacteria through plant phytobiotic investigations (Diarra and Malouin, 2014). Black cumin seed (Khalaji *et al.*, 2011; Khan *et al.*, 2012; Abd El-Hack *et al.*, 2018), pawpaw seed (Bolu *et al.* 2009; Nwaoguikpe 2010), and mustard seed (Khandaker *et al.*, 2011) have all been reported to have a growth promoting effect on different species of poultry such as chicken and quail which serves varying purposes such as meat and egg production. Furthermore, the beneficial use of plant seeds and plant extracts in ruminant (Faniyi *et al.*, 2016; Hernandez *et al.*, 2017) is well documented. Consequently, plant parts or their extracts are of benefits to livestock performance. Feeding the broiler chickens with the diets containing antibiotic alternatives alleviated the negative effects of removing antibiotics from their diets (Yakhkeshi *et al.*, 2011). Licorice (*Glycyrrhiza glabra*) extract in drinking water can reduce abdominal fat and serum levels of low-density lipoprotein cholesterol and total cholesterol without any adverse effects on broilers performance and immune status (Khamisabadi *et al.*, 2015). Roselle is a tropical shrub belonging to the family *Malvacea* which produces red, dark red and green form of calyces. The chemical composition of the red calyces revealed that they are good sources of vitamin C, flavonoids, minerals, and antioxidants (Babalola *et al.*, 2001; Wong *et al.*, 2002). Roselle aqueous extract is an organic acid; it is usually processed into a sour tasting refreshing drink called Zobo in

Nigeria (Fasoyiro *et al.*, 2005). The acid content of the calyces increases during growth but decreases when it reaches maturity or ripens (Frimpong *et al.*, 2014). The roselle plant is considered an antiseptic, emollient, sedative, and tonic (Olaleye, 2007). It aids digestion, promotes kidney function, improves cardiovascular health and helps reduce fever (Fasoyiro *et al.*, 2005). Consequently, the roselle calyx has the potential of being used to supplement or replace synthetic antibiotics in drinking water of broiler as farmers are unrelently sourcing for alternative ways to improve the performance of broiler chickens (Asaniyan and Akinduro, 2020). Asaniyan and Akinduro (2020) reported that up to 10 ml level of the extract of dried roselle calyx in a litre of drinking water supported the health and wellbeing in terms of haematological and serum biochemistry parameters of broiler chickens. Therefore, this study tends to assess the performance and meat quality of finisher broiler chicken exposed to aqueous of dried calyx extract from roselle plant.

Materials and methods

The study was conducted at the Poultry Unit of the Teaching and Research Farm of College of Agriculture, Osun State University, Ejigbo Campus. The farm is located on latitude 7°54'N and longitude 4°18'E and 4°54'E at an altitude of 426m above the sea level. Ejigbo is located in the middle portion of 35km to the Northeast of Iwo, 30km from Ogbomoshos in the North and about 24km east.

Housing

The birds were raised in a standard deep litter system for 8 weeks (56 days). The poultry house and the necessary equipment used were fumigated and disinfected. On arrival of the birds, solution of glucose and vitamins was given to serve as anti-stress.

management and experimental procedure

One hundred and fifty Abor Acres day old

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broiler chicks were procured from a reputable hatchery. The chicks were randomly assigned to five treatments (30 birds per treatment) replicated three times with ten (10) birds per replicate in a completely randomized design experiment. These chicks were obtained from a reputable hatchery in Ibadan, Oyo state. They were brooded on deep litter system using 200watts electricity bulbs and coal pots for fourteen days. The necessary vaccination program: Newcastle Disease Vaccine (NDV intraocular), Gumboro (Infectious Bursa Disease) and Newcastle Disease Vaccine (NDV Lasota) were carried out at appropriate times. Anti-stress was also administered to the birds on arrival. The birds were reared up to four weeks and fed starter diet (Table 1); after which they were given aqueous extracts of

calyx and finisher diet (Table 1) for 4 weeks. Both routine (cleaning of pen, changing of water, and washing of feeders and drinkers) and occasional (medication and vaccination) management practices were thoroughly carried out with strict hygiene measures. Each of the five treatments represented the concentration of the dried calyx extract from roselle plant per litre of drinking water. The concentrations were 0, 5, 10, 20 and 30 ml per litre of drinking water for treatments T1, T2, T3, T4 and T5 respectively. The dried calyx from Roselle plant purchased from a local market was measured using a sensitive scale. The 200gram of the sample was boiled in 2litres of water for 10 minutes to obtain the flower extract. After boiling, the extract was obtained with the aid of a syringe and was applied into the drinking water.

Table 1: Gross composition of diets fed to the experimental broiler chicken

Ingredients	Composition	
	Starter (23% Crude protein)	Finisher(20% Crude protein)
Maize	50.00	50.00
Wheat offal	3.90	10.50
Brewer dried grain	5.00	10.00
Groundnut cake	10.00	12.00
Soyabean meal	24.50	13.00
Fish meal	3.00	-
Oyster shell	0.20	0.20
Bone meal	2.50	3.00
Methionine	0.25	0.35
Lysine	-	0.30
Premix	0.25	0.30
Salt	0.40	0.40
Total	100Kg	100Kg
Fibre level	4.34%	4.87%
Energy	2822.99MEkcal/kg	2717.38MEkcal/kg

Performance and meat evaluation parameters

The birds were weighed at the end of four weeks (starter phase) acclimatization period, which marks the beginning of the experiment. Subsequently, weekly body weight and feed consumption with water consumption were recorded. Weight gain, feed intake, feed conversion ratio (FCR)

and water intake were estimated to assess the performance of the birds. Weight gain was calculated as the final weight minus the weight at the end of 4th week, FCR as feed intake divided by weight gain and the water intake was the cumulative water consumption at the beginning of the fifth week. At end of the 8th week (end of fourth week of the trial), feed was withdrawn 12

hours prior to slaughtering. Three birds were selected randomly from each replicate for carcass, organ characteristics and meat evaluation. The birds were weighed, stunned, bled, and processed to obtain the cut-up parts and organs which are expressed as g/kg live weight. The thighs were removed for meat evaluation. Thigh muscles from the birds' carcass on treatment basis were boiled for 5 minutes at 100°C. ten trained panellists were used for the organoleptic quality assessment. A nine-point hedonic scale was used for the sensory evaluation of thighs organoleptic parameters; flavour, juiciness, tenderness, colour, odour, broth and general acceptability (Manhendraker, 1988). The cooking loss and thaw loss were also evaluated.

Statistical analysis

Data were subjected to one-way analysis of variance (ANOVA) using the Statistical Analysis System (SAS version 9.1, USA). Where significant differences were found, all means were compared and separated using the Duncan's multiple range test of the same statistical package.

Results and discussion

The performance of finisher broiler chickens exposed to aqueous extracts of dried calyx from roselle plant is presented in Table 2. Most of the parameters observed were not significantly ($p > 0.05$) different except in final live weight and water intake. The live weight values varied significantly ($P < 0.05$) across the treatments in which the birds in T4 (20ml) had the highest average live weight ($2,308.17 \pm 4.25\text{g}$) followed by those in T2 ($2,279.67 \pm 5.49\text{g}$), T1 ($2,231.46 \pm 35.75\text{g}$), T5 ($2,118.96 \pm 34.54\text{g}$) and T3 ($2,085.79 \pm 3.91\text{g}$) respectively. Specifically, T4 with the highest live weight value is significantly different from other treatments except treatment T2 of similar live weight. Also, the treatment T2 was not significantly

different from treatment T1 (0ml).

Similarly, treatment T3 with the least live weight value had similar live weight with treatment T5. Consequently, the treatments had unequal influence on the live weight of finisher broiler chickens. However, treatment T4 enhanced higher value of live weight above those broiler chickens under treatment T1 (0ml). Similarly, treatments T3 (10ml) and T5 with similar live weight that were of higher weight above T1 revealed the positive influence of the aqueous extracts of dried calyx from Roselle Plant on live weight. This tends to corroborate the assertion of Asaniyan and Akinduro (2020) on a related study that the dried calyx extracts from Roselle Plant supported the health and wellbeing of broiler chickens. However, the highest live weight exhibited under treatment T4 contradicted the report of Asaniyan and Akinduro (2020) that the extract inclusion above 10ml in a litre of drinking water could be detrimental to the health and wellbeing of finisher broiler chickens. Consequently, the detrimental impact of the extract if any, on the health and wellbeing of broiler chicken might possibly have something to do with the duration of chickens' exposure to the extract rather than its concentration in drinking water. Therefore, this could be investigated with layer chickens with the possibility of prolonging exposure to the extract. Furthermore, the broiler chicken under treatment T4 had water intake value like treatment T1 (control) and treatment T2. Also, treatment T5 with the least water intake value had similar value with treatment T3. However, the trend of water intake value per day across the treatment seems not to agree with the rule of thumb that chicken drinks water twice as much as their feed intake by weight; 1g of pure water is exactly 1ml. Notwithstanding, chicken under treatment T4 had the highest water intake value among the treatments

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aside treatment T1 (0ml) of which they are of similar value. Similarities in water intake value among the treatments showed equal response of the broiler chicken to the treatments. Meaning that 10ml of the extract per litre of drinking equally influenced water intake as with 30 ml of the extract per litre of drinking water. Similar experiences were recorded for treatments T4 and T1 and again T4 and T2. Therefore, the overview of live weight and water intake as performance parameters of significant; showed that the treatment tends to influence the parameters similarly in

bringing out treatment T4 (20 ml of the extract per one litre of drinking water) to be optimum extract concentration that favoured live weight and water intake. The feed intake, weight gain and feed conversion ratio (FCR) were not significantly ($P>0.05$) different across the treatment. This revealed that the treatments had equal influence on the feed intake, weight gain and feed conversion ratio as component parts of performance parameters. The carcass parameters of the finisher broiler chicken exposed to aqueous extracts of dried calyx from roselle plant is presented in Table 3.

Table 2: Performance of finisher broiler chicken exposed to aqueous extracts of dried calyx from roselle plant (*Hibiscus sabdariffa*)

Parameter	Concentration of the dried calyx extract per litre of drinking water				
	T1 (0 ml)	T2 (5 ml)	T3 (10 ml)	T4 (20 ml)	T5 (30 ml)
Live weight (g)	2231.46 ^b ±35.75	2279.67 ^{ab} ±5.49	2085.79 ^c ±3.91	2308.17 ^a ±4.25	2118.96 ^c ±34.54
Weight gain (g/bird/day)	39.80±16.35	39.93±11.97	38.07±12.04	39.29±11.83	46.54±14.05
Feed intake (g/bird/day)	44.74±8.03	45.32±7.66	40.61±7.56	44.79±7.80	47.18±8.24
Feed Conversion Ratio (FCR)	3.24±2.22	2.31±1.47	2.35±1.57	2.42±1.61	1.50±0.68
Water intake (ml/bird/day)	30.80 ^a ±0.01	30.48 ^b ±0.18	29.88 ^c ±0.07	30.62 ^{ab} ±0.05	29.72 ^c ±0.04

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

Table 3: Carcass characteristics (g/Kg live weight) of finisher broiler chicken exposed to aqueous extracts of dried calyx from roselle plant (*Hibiscus sabdariffa*)

Parameter	Treatment				
	T1 (0 ml)	T2 (5 ml)	T3 (10 ml)	T4 (20 ml)	T5 (30 ml)
Wings	71.75 ^b ±3.83	66.81 ^b ±1.90	71.19 ^b ±4.34	70.88 ^b ±3.07	97.41 ^a ±2.97
Drumstick	89.76 ^c ±5.44	92.95 ^{bc} ±1.95	101.11 ^{ab} ±1.79	103.22 ^a ±1.85	83.93 ^c ±2.83
Thigh	85.25 ^b ±2.01	92.66 ^a ±1.34	89.92 ^{ab} ±0.91	89.50 ^{ab} ±1.32	85.34 ^b ±1.36
Shank	38.43 ^{bc} ±0.95	35.68 ^c ±0.81	42.13 ^a ±1.27	39.22 ^{ab} ±0.66	40.24 ^{ab} ±0.79
Head	20.17 ^b ±0.73	19.67 ^b ±0.45	21.24 ^b ±0.65	21.24 ^b ±0.70	25.48 ^a ±0.54
Neck	34.33 ^b ±0.71	27.90 ^c ±0.95	34.29 ^b ±0.84	33.39 ^b ±0.73	38.36 ^a ±0.57
Breast	169.32 ^b ±0.80	185.74 ^a ±0.95	165.85 ^b ±1.01	184.69 ^a ±2.42	166.94 ^b ±1.60
Back	125.83 ^{ab} ±1.01	120.96 ^{ab} ±1.14	142.46 ^a ±21.65	107.25 ^b ±3.66	110.67 ^{ab} ±1.20

Mean±SEM

^{a,b,c} Means in the same row with different superscript are significantly different ($P<0.05$)

All the parameters were significantly ($P<0.05$) different across the treatments. Most of the parameters with highest weights among the treatments were significantly ($P<0.05$) different from treatment T1 (control, 0ml) except for back weight in treatment T3 (142.46 ± 21.65 g/kg live weight) with the highest weight similar to treatment T1 (125.83 ± 1.01 g/kg live weight). Treatment T5 had the highest weights for wings (97.41 ± 2.97 g/kg live weight), head (25.48 ± 0.54 g/kg live weight) and neck (38.36 ± 0.57 g/kg live weight) with treatment T2 having the least weight values for the wings (66.81 ± 1.90 g/kg live weight), head (19.67 ± 0.45 g/kg live weight) and the neck (27.90 ± 0.95 g/kg live weight). Treatments T4 (103.22 ± 1.85 g/kg live weight) and T5 (83.93 ± 2.83 g/kg live weight) had the highest and the least weight respectively for drumstick. Treatment T3 showed the highest weight for shank (42.13 ± 1.27 g/kg live weight) and back (142.46 ± 21.65 g/kg live weight) while treatments T2 (35.68 ± 0.81 g/kg live weight) and T4 (107.25 ± 3.66 g/kg live weight) presented least weights for shank and back respectively. Also, treatment T2 revealed thigh (92.66 ± 1.34 g/kg live weight) and breast (185.74 ± 0.95 g/kg live weight) to be of highest weights among the treatments; but the least weight values for the thigh (85.25 ± 2.01 g/kg live weight) and the breast (165.85 ± 1.01 g/kg live weight) were revealed by treatments T1 (control) and T3 respectively. The overview of carcass responses to the treatments especially at 20 and 30 ml per litre of drinking water showed that the carcass prime cuts; drumsticks, wing, thigh and breast were positively affected by the extracts. Therefore, the extract promoted the meat value of the finisher broiler chicken. The organ indices of finisher broiler chicken exposed to aqueous extracts of dried calyx from Roselle Plant (*Hibiscus sabdariffa*) is presented in Table 4. The results revealed

significant ($P<0.05$) differences across the treatments for all the organ indices. Therefore, the extracts had unequal influence on the organ indices.

Belly fat and proventriculus had the highest values of 3.13 ± 0.14 g/kg live weight and 4.05 ± 0.07 g/kg live weight respectively in T1 while treatments T2, T3, T4 and T5 with the same values for belly fat (0.00 ± 0.00 g/kg live weight) had the least value. Also, treatment T3 had the least value (2.74 ± 0.13 g / k g l i v e w e i g h t) f o r proventriculus. T1(0ml) having the highest weight of belly fat significantly different from other treatments with the least belly fat values showed that the extract tends to have the potential of limiting fat deposition in finisher broiler chicken (Kharmisabadi *et al.*, 2015). Similarly, the highest weight value of the proventriculus could be an indication of nutritional functionality of the organ as site for enzymatic digestion in chicken. However, the T1 (4.05 ± 0.07 g/liveweight) value of the proventriculus is similar in weight to treatment T5 (3.98 ± 0.03 g/kg live weight). Meaning that the extract sustain the functionality of the proventriculus, hence promoted feed digestion and its utilization as reflected in the low belly fat. Open gizzard (22.06 ± 0.63 g/kg live weight) and close gizzard (28.51 ± 0.69 g/kg live weight) were significantly ($P<0.05$) of highest values in treatment T2 while their least values were 25.95 ± 0.14 g/kg live weight (close gizzard) and 18.06 ± 0.17 g/kg live weight (open gizzard) in treatments T4 and T5 respectively. This showed that treatment T2 (5 ml extract) optimally supported the functionality of gizzard as muscular grinding organ in chicken. However, the situations in treatments T4 (20ml) and T5 (30ml extract) had no distinct compromising influence of high concentration of the extract on gizzard muscularization and functionality.

The kidney, pancreas, and heart

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significantly ($P < 0.05$) had the highest weight values 4.11 ± 0.13 g/kg live weight, 3.10 ± 0.06 g/kg live weight and 3.70 ± 0.15 g/kg live weight respectively in treatment T3 (10% extract) while their least weight values were recorded in treatments T1 (kidney (3.20 ± 0.21 g/kg live weight) and pancreas (1.40 ± 0.28 g/kg live weight)) and T5 heart (3.01 ± 0.02 g/kg live weight). The significant highest weight values of the kidney, pancreas, and heart in treatment T3 indicated that 10ml extract optimally supported renal, pancreatic and cardiac functions in finisher broiler chickens (Fasoyiro *et al.*, 2005) but absence of the extract in treatment T1 placed the finisher broiler chickens at disadvantage of benefiting from renal and pancreatic functions' enhancing potential of the extracts. However, the cardiac function of the finisher broiler chicken might not necessarily be compromised or limited at 30ml (treatment T5) extract concentration because of its similar statistical relationship with the other treatments. In treatment T4, lung and spleen were significantly ($P < 0.05$) of highest weight values of 5.01 ± 0.06 g/kg live weight and 1.01 ± 0.06 g/kg live weight respectively among the treatments. It implies that at 20% extract concentration, the lung and spleen functions were optimally sustained. The respiratory function of the lung and the capacity of the spleen to fight off bacteria and maintain blood purification and rejuvenation were not compromised. It is evident on the fact that no mortality was recorded throughout the study. The least values of the two organs were at treatment T1; with weight values of 4.05 ± 0.08 g/kg live weight and 0.69 ± 0.01 g/kg live weight for lung and spleen

respectively. Even though, mortality was not recorded across the treatments; the least values of the organs in treatment T1 (0 % extracts) could be attributed to inaccessibility of the finisher broiler chickens to the inherent benefits of the extracts. Liver significantly ($P < 0.05$) had the highest weight (15.95 ± 0.21 g/kg live weight) in treatment T5 while the organ had its least value (13.94 ± 0.29 g/kg live weight) in treatment T2. Even at treatment T5 (30ml extract), highest level of the extract in the study; liver as the organ of concern in blood filtration and body detoxification did not have its function compromised in the course of the study. The least weight value of the organ in treatment T2 (5ml extract) could be associated with the concentration level of the extract, which limited the benefits of the extract to liver growth significantly below the control treatment (T1, 14.93 ± 0.23 g/kg live weight). The general absence of mortality across the treatment throughout the study provided the evident of unequal and unharmed influence of the extract on the organ growth. Also, the physical appearances of the considered organs revealed relative proportionate weight with the live weight of the finisher broiler chickens without any abnormality. However, histological study of the organs might be necessary to further empirically establish the biological and health benefits of the extract of dried calyx of roselle plant. The meat palatability status of the finisher broiler chicken exposed to aqueous extract of dried calyx from roselle plant presented in Table 5 showed only the meat colour to be significantly ($P < 0.05$) different across the treatments.

Table 4: Organ Indices (g/Kg live weight) of finisher broiler chicken exposed to aqueous extracts of dried calyx from roselle plant (*Hibiscus sabdariffa*)

Parameter	Treatment				
	T1 (0 ml)	T2 (5 ml)	T3 (10 ml)	T4 (20 ml)	T5 (30 ml)
Belly fat	3.13 ^a ±0.14	0.00 ^b ±0.00	0.00 ^b ±0.00	0.00 ^b ±0.00	0.00 ^b ±0.00
Kidney	3.20 ^c ±0.21	3.30 ^c ±0.27	4.11 ^a ±0.13	4.00 ^{ab} ±0.03	3.53 ^{bc} ±0.24
Pancreas	1.40 ^c ±0.28	2.09 ^b ±0.01	3.10 ^a ±0.06	2.11 ^b ±0.07	1.41 ^c ±0.21
Heart	3.29 ^{ab} ±0.20	3.55 ^{ab} ±0.26	3.70 ^a ±0.15	3.43 ^{ab} ±0.09	3.01 ^b ±0.02
Lung	4.05 ^b ±0.08	4.31 ^b ±0.20	4.13 ^b ±0.14	5.01 ^a ±0.06	4.14 ^b ±0.11
Open gizzard	20.31 ^b ±0.49	22.06 ^a ±0.63	19.58 ^{bc} ±0.67	18.12 ^c ±0.17	18.06 ^c ±0.17
Close gizzard	28.51 ^b ±0.69	32.75 ^a ±0.38	27.39 ^b ±0.49	25.95 ^c ±0.14	27.94 ^b ±0.36
Liver	14.93 ^b ±0.23	13.94 ^c ±0.29	14.38 ^{bc} ±0.48	15.09 ^{ab} ±0.13	15.95 ^a ±0.21
Proventriculus	4.05 ^a ±0.07	3.33 ^b ±0.18	2.74 ^c ±0.13	3.62 ^{ab} ±0.28	3.98 ^a ±0.03
Spleen	0.69 ^c ±0.01	0.83 ^b ±0.03	0.83 ^b ±0.02	1.10 ^a ±0.06	0.75 ^{bc} ±0.02

Mean±SEM

^{a,b,c}Means in the same row with different superscript are significantly different (P<0.05)

Table 5: Palatability status of the finisher broiler chicken exposed to aqueous extract of dried calyx from roselle plant (*Hibiscus sabdariffa*)

Parameter	T1 (0 ml)	T2 (5 ml)	T3 (10 ml)	T4 (20ml)	T5 (30 ml)	SEM
Flavour	5.22	5.44	5.00	5.89	5.44	0.63
Juiciness	6.00	6.78	6.00	6.00	6.44	0.66
Tenderness	6.22	6.00	6.67	6.33	6.44	0.63
General acceptability	6.11	6.00	6.22	6.44	6.89	0.63
Colour	5.56 ^b	5.69 ^{ab}	5.72 ^{ab}	5.89 ^{ab}	6.00 ^a	0.48
Odour	5.78	7.11	6.11	6.78	6.89	0.61
Broth	5.67	5.78	5.89	6.22	6.56	0.57

^{a,b} Means in the same row with different superscripts are significantly different (P<0.05)

The colour scores increase as the level of the extract increased with treatment T5 (30ml extract) having the highest colour score (6.00) while T1 (0% extract) had the least colour score (5.56). The T5 score is similar to scores reported in treatments T4, T3 and treatment T2. Also, T1 had scores similar to treatments T2, T3 and T4. The anthocyanins, which are flavonoids are water-soluble natural pigments in the extract (Aishah *et al.*, 2013) might have impacted differently on myoglobin, a protein responsible for the bright red

appearance of the meat colour as a result of the extract's concentration differences across the treatments. Other palatability parameters: flavour, juiciness, tenderness, general acceptability, odour and broth were not significantly (P>0.05) influenced by the treatments. The cooking loss and the thaw loss as presented in Table 6 showed significant (P<0.05) difference across the treatments for cooking loss with treatment T4 (0ml) having the highest percentage value (50.57±3.81%) while treatment T3 had the lowest (24.10±0.65%).

Table 6: Cooking and thaw loss of meat from broiler chicken exposed to aqueous extract of dried calyx from roselle plant (*Hibiscus sabdariffa*)

Treatment	Cooking Loss (%)	Thaw Loss (%)
T1 (0 ml)	36.47 ^{ab} ±3.42	3.97±0.40
T2 (5 ml)	24.73 ^b ±9.88	2.83±0.61
T3 (10 ml)	24.10 ^b ±0.65	6.59±3.26
T4 (20 ml)	50.57 ^a ±3.81	3.66±0.48
T5 (30 ml)	32.97 ^{ab} ±5.45	2.45±0.85

^{a,b} Means in the same column with different superscripts are significantly different (P<0.05)

The T4 had similar cooking loss with treatments T5 (32.97±5.45%) and T1 (36.47±3.42%). Also, treatment T3 had similar value with treatments T2, T1 and T5. Cooking loss is the degree of shrinkage of meat during cooking because of loss of moisture and fat. Therefore, treatment T3 that is similar to treatment T2 (24.73±9.88%) had the lowest cooking loss percentage that optimally results in the highest cooking yield of the meat across the treatments (Huff-Lonergan, 2002). The treatments had no influence on thaw loss.

Conclusion

The aqueous extract of dried calyx of roselle plant optimally impact positively on the live weight and water intake of finisher broiler chicken at treatment T4, 20 ml per litre of drinking water. The extract supported lean meat development in the broiler chicken with the promotion of optimal growth of carcass prime cuts at 20 ml (Treatment T4) and 30 ml (Treatment T5) per litre of drinking water. The extract enhanced the colour intensity of broiler chicken meat with treatment T3 (10 ml) optimally promoted the meat yield. Also, the extract maintained organ growth and function.

Recommendation

There was no observed physical lesions on any of the organs. However, it might be necessary to carry out histological study on the organs to further establish the extract's biological value and safety. Also, the impact of prolonged exposure of chickens to the extract can be investigated with laying chickens.

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