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RESPONSE OF GROWING COCKERELS TO DIETS CONTAINING DIFFERENTLY PROCESSED SORREL (*HIBISCUS SABDARIFFA*) SEED MEAL

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ABSTRACT
The influence of feeding differently processed sorrel (*Hibiscus sabdariffa*) seed meal on the productive performance, haematology, blood chemistry and carcass measurements of growing cockerels was investigated. One hundred and eighty (180) Harco Black day– old cockerel chicks were purchased from a reputable hatchery and assigned to six (6) dietary treatments in groups of 30 birds each with three replications of 10 birds per replicate in a complete randomized block design. The differently processed sorrel seed meal replaced 50% of the soyabean portion of the diets as the main protein source in treatments 1 (control), 2, 3, 4, 5 and 6. Cockerels fed raw and sprouted sorrel seed meals were significantly ($p<0.05$) lighter than those fed soaked, boiled, soaked and boiled and fermented sorrel seed meals. There were no significant ($P>0.05$) differences among treatments for weight gain and feed conversion ratio. Red blood cells (RBC) count and packed cell volume (PCV) were better ($P<0.05$) in the fermented sorrel seed diet than all the other treatment groups while birds on sprouted sorrel seed meal diet recorded the highest values for haemoglobin concentration, mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) compared to all the other treatment groups. Results for serum biochemical indices showed that blood protein, blood albumin and blood globulin of cockerels were not adversely affected by feeding raw or differently processed sorrel seed meal. Results obtained from this study showed no clear differences in performance when raw or differently processed sorrel seed meal when fed at a ratio of 50:50 to cockerels as a major protein source.

Keywords: Growing cockerels, response, differently processed, sorrel seed meal

INTRODUCTION

Sorrel (*Hibiscus sabdariffa*) which is locally known as "yakuwa" in Hausa is known to have originated from West Africa and other tropical countries. In Nigeria, the cultivation is steadily expanding due mainly to increasing demand for its calyxes which are used for the preparation of "Zobo" drink and soup. Information on the feeding value of sorrel seeds to animals are scanty, however, Muktar (2007) reported that feed intake feed conversion ratio and body weight gain of broiler chickens decreased as the level of raw sorrel seeds increased in their diet although he reported no adverse effects on the weight of some internal organs like liver, pancreas and abdominal fats.

Purseglove (1969) have reported that sorrel seeds contain some anti-nutritional factors which Duke (1983) identified to include hibiscin, hydroxyl flavone (glossypetin) and tannins as the major ones. These anti-nutrients, particularly tannins are known to have detrimental effects on the health and growth of animals (Jansmon, 1993).

Although, Price *et al* (1980) and Bressani *et al* (1982) have reported that some of the anti-nutritional factors could be inactivated by heat treatment. Soaking in water is also one of the recommended ways of eliminating anti-nutritional factors in feedstuffs (Price et al; 1979). This study was designed to investigate the response of growing cockerels to diets containing differently processed sorrel seed meal.

MATERIALS AND METHODS

Experimental stock and management

One hundred and eighty (180) day-old cockerels were purchased from a reputable hatchery (The AVIANS, Ibadan - Nigeria) and used for the study. The chicks were brooded together for 4 weeks. During brooding, the chicks were fed commercial chick mash and clean drinking water *ad libitum*. All other conventional management practices were observed strictly.

At the end of the brooding period, the cockerels were individually weighed and allotted to six (6) experimental diets in groups of 30 birds each with 3 replications of 10 birds per replicate in a complete randomized block design. The experiment lasted for 12 weeks.

Experimental diets

The ingredients and analyzed chemical composition of the experimental diets (chicks and growers mashes) are presented in Tables I and II respectively. The differently processed sorrel seed meal replaced 50% of the soyabean portion of the diets as the main protein source in treatments 1 (control), 2, 3, 4, 5, and 6. The processing of sorrel seeds were as follows:

i) Raw sorrel seeds were thoroughly cleansed and milled and tagged 'raw sorrel seed meal' (RSSM);
ii) Sorrel seeds were soaked for 24 hours in a plastic container, washed and sun-dried for three days.

The dried seeds were milled and tagged 'soaked sorrel seed meal' (SSSM).

iii) Sorrel seeds were boiled for 30 minutes at 100 ^{o}C. The boiled sorrel seeds were sun-dried for 3 days and milled. This was tagged boiled sorrel seed meal (BSSM)

iv) Sorrel seeds were soaked for 24 hours and then boiled for 30 minutes at 100^{o}C. The seeds were washed, sun-dried for three days and milled. This was tagged 'soaked and boiled sorrel seed meal' (SBSSM).

v) Sorrel seeds were soaked for 24 hours and allowed to sprout for 2 days. The sprouted seeds were dried for 3 days, milled and tagged 'sprouted sorrel seed meal' (SPSSM)

vi) Sorrel seeds were boiled for 30 minutes at 100^{o}C, washed and kept in an air-tight container to ferment for three days. The fermented sorrel seeds were dried for 3 days, milled and tagged 'fermented sorrel seed meal' (FSSM).

PARAMETERS MEASURED

Performance

Feed consumption was recorded daily while the cockerels were weighed weekly to determine rate of gain. Feed conversion ratio (FCR) was calculated as the ratio of feed intake to weight gain.

Blood collection and analyses

During the last week of the experiment (week 16), blood samples were collected from four birds in each experimental group for determination of the haematological and biochemical indices. Blood samples were collected early in the morning from the brachial vein in two parts namely; in heparinized and non-heparinized test tubes. The heparinized blood samples were used for determination of the red blood cells (RBC) count, haemoglobin (Hb) concentration, packed cell volume (PCV) and white blood cells (WBC) count while the non-heparinized blood samples were allowed to stand at room temperature for clotting. Serum was obtained for the estimation of biochemical substances

Carcass measurements

At the end of the experiment, 3 birds from each experimental group were selected and for the carcass measurements. The birds were starved of feed overnight before slaughter the next morning. The fasted weight, slaughter weight, plucked weight and dressed weight were all recorded. Accordingly, all the cut-up parts and visceral organs were weighed/measured for each individual bird and recorded.

Statistical Analysis

Data collected were subjected to analysis of variance using Statistix (2003). Means were separated using least significant difference (LSD).

RESULTS AND DISCUSSION

Growth performance and Economics of Production

The growth performance characteristics of the cockerels are presented in Table III. Birds fed the raw (RSSM) and sprouted (SPSSM) sorrel seed meals had similar weight but they were significantly ($P< 0.05$) lighter at the end of the study period (16 weeks) than those of other treatments (soaked (SSSM), boiled (BSSM), soaked and boiled (SBSSM) and fermented (FSSM) sorrel seed meals). Overall weight gain of the birds showed that cockerels on soaked, boiled, and soaked and boiled gained significantly ($P< 0.05$) more weight than those on fermented sorrel seeds meal while those on raw and sprouted sorrel seed meals had the poorest ($P< 0.05$) overall mean weight gain. There were no significant ($P> 0.05$) differences among treatments for daily feed intake, daily weight gain and feed conversion ratio.

The mean final live weights (1331.05 to 1440.11g) obtained in this study were comparable to the 1357.03 to 1396.29g obtained by Diarra (2008) for the same breed of cockerels reared for 15 weeks but lower than the values (1550 to 1710g) obtained by Salami *et al*. (2004) although the birds used by these authors were raised up to 19 weeks while this experiment was terminated at 16 weeks of age.

Daily feed intake (64.15 – 69.55g/bird), daily weight gain (13.71 – 14.66g/bird) and feed conversion ratio (4.55 – 4.81) were inferior to the corresponding values of 77.92 – 78.77g/bird, 26.46 – 28.54g/bird and 2.64 – 2.92 obtained by Diarra (2008). The feed intake values were also lower than the value 110 – 115g/bird reported by Salami *et al*. (2004). The daily feed intake values were similar to the 65.18 – 68.75g/bird reported for cockerels by Fapohunda *et al*. (2008) although they also reported better daily weight gain (21.61 – 23.93g/bird) and feed conversion ratio (2.86 to 3.02).

The critical parameters in the interpretation of these results are the daily feed intake, daily weight gain and feed conversion ratio which were similar ($P> 0.05$) across the treatments. This gave an indication that performance of cockerels was not sacrificed as a result of partial replacement of soyabean meal with raw and processed sorrel seed meal.

Cost of feed (₦/kg) was averagely higher in the processed than the raw sorrel seed meal due to the cost of processing. However, cost per gain were significantly ($P< 0.05$) higher in the sprouted and fermented sorrel seed meal diets than in the soaked, boiled and soaked and boiled sorrel seed meal diets. The cost per gain was lowest ($P< 0.05$) in the boiled sorrel seed meal diet followed by the soaked, soaked and boiled and raw sorrel seed meal diets.

Haematological Parameters

Results of haematological parameters are presented in Table IV. Significant ($P< 0.05$) differences were observed among treatments for red blood cells (RBC) count, white blood cells (WBC) count, packed cell volume (PCV), haemoglobin (Hb) concentration, mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC). Red blood cells (RBC) count and packed cell volume were better ($P< 0.05$) in the fermented (FSSM) diet than the other treatment

groups. Birds on sprouted (SPSSM) sorrel seed meal diet recorded the highest (P< 0.05) values for haemoglobin (Hb) concentration, mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) compared to all the other treatment groups.

For differential counts, eosinophils, basophils and monocytes differ significantly (P< 0.05) among treatments but there was no clear trend in respect of the values for raw and the differently processed sorrel seed meals. No treatment effects (P> 0.05) were observed for mean corpuscular volume (MCV), neutrophils and lymphocytes levels. The RBC, WBC and PCV values obtained in this study were all within the normal ranges reported in literature for chickens (Swenson, 1970; Merck Veterinary Manual, 1986; Awoniyi *et al*., 2000). The results indicated that sorrel seed meal was not deleterious to blood formation. The values therefore suggest that the diets fed did not cause nutrient restriction which could lead to reduction of these parameters (Omoikhoje *et al*., 2004). Previously, Campbell *et al*. (2003) stated that when haematological parameters were within the normal range, it is an index of adequate nutritional status.

Serum Biochemical Indices

Results of serum biochemical indices of growing cockerels are presented in Table V. Total protein, blood albumin and globulin differed significantly (P< 0.05) among treatments. Total protein was significantly (P< 0.05) higher in the soaked and boiled (SBSSM) sorrel seed meal group than all the other treatment groups while albumin values were significantly (P< 0.05) higher in the boiled (BSSM), soaked and boiled (SBSSM), sprouted (SPSSM) and fermented (FSSM) groups compared to those in raw (RSSM) and soaked (SSSM) sorrel seed meal diets.

Blood globulin values were highest (P< 0.05) in the raw (RSSM) and soaked and boiled (SBSSM) sorrel seed meal fed groups followed by those on soaked (SSSM) and the lowest (P< 0.05) values were in the groups fed boiled (BSSM), sprouted (SPSSM) and fermented (FSSM) sorrel seed meal diets.

The total protein values (3.30 – 4.0 g/dl) were comparable to the 3.60g/dl and 4.0g/dl respectively reported by Swenson (1970) and Butler (1971) for non-laying adult chickens. The albumin levels (1.75 – 2.25g/dl) compared favourably to the normal range (1.70 – 2.0g/dl) reported by Fajimi *et al*. (1993), Olorede *et al*. (1995) and Onifade (1995) for chickens. The globulin levels (1.35 – 1.75g/dl) observed in this study were, however, lower than the normal range (2.0 – 2.90g/dl) given by the above authors.

Urea levels did not differ (P> 0.05) among treatments but creatinine and cholesterol values differ significantly (P< 0.05) among the treatment groups. Creatinine was lowest in the raw (RSSM) sorrel seed meal treated group but the value did not differ (P> 0.05) from that in the soaked (SSSM) sorrel seed meal diet. The value of creatinine was highest (P< 0.05) in the group fed fermented (FSSM) sorrel seed meal although the value did not differ (P> 0.05) from those of BSSM, SBSSM and SPSSM groups. Cholesterol levels were lowest (P< 0.05) in the RSSM and SPSSM fed groups compared to those on BSSM and FSSM fed groups. The blood urea, creatinine and cholesterol levels obtained in this study were lower than the values reported by Alabi *et al*. (2008) for broiler chickens.

Sodium (Na^+), potassium (K^+), chloride (Cl^-) and bicarbonate (HCO_3^-) levels all differ (P< 0.05) among the treatment groups. Sodium was significantly (P< 0.05) higher in the group fed SSSM diet than all the other groups while Potassium levels were higher (P< 0.05) in SBSSM and SPSSM fed groups compared to those fed RSSM, SSSM and FSSM diets. Bicarbonate level was higher (P< 0.05) in BSSM fed group than all the other treatments. Alkaline phosphate was significantly (P< 0.05) lower in SBSSM group compared to all other treatment groups while aspartate amino-transferase (ASAT) levels were higher (P< 0.05) in the groups fed BSSM, SBSSM and SPSSM diets than those on RSSM, SSSM and FSSM diets. For alkaline amino transferase (ALAT), the values were lower (P< 0.05) in the SBSSM and FSSM groups than the group fed BSSM. Total bilirubin (TB) and conjugate bilirubin (CB) values were higher (P< 0.05) in the RSSM and SSSM fed groups compared to those on BSSM, SBSSM, SPSSM and FSSM diets.

The results of the serum biochemical indices showed that blood protein, blood albumin and blood globulin were not adversely affected by feeding raw or differently processed sorrel seed meal as partial replacement for soyabean meal. Most blood proteins are formed in the liver and plasma protein synthesis is usually reduced in severe liver damage or prolonged protein deficiency (Dukes, 1975), a situation which can be vindicated by the results of this study. According to Bush (1991), the concentration of biochemical substances in the serum changes in abnormal conditions and therefore aids in disease diagnosis. Usually, total protein, albumin, urea, creatinine and cholesterol analyses are used for renal function test while sodium, potassium, chloride, bicarbonate, alkaline phosphate, aspartate amino transferase (ASAT), alkaline amino transferase (ALAT) and bilirubin analyses are used to assess the function of the liver.

Carcass and Some Organs measurements

The data of carcass and some organs measurements are presented in Table VI. There were no significant (P> 0.05) differences in slaughter weight, plucked weight and dressed weight. Carcass yield was best (P< 0.05) in T_4 (SBSSM) although it did not differ (P> 0.05) from T_1 (RSSM), T_2 (SSSM) and T_5 (FSSM). The lowest (P< 0.05) carcass yield was recorded in T_3 (BSSM) but it did not also differ (P> 0.05) from T_5 (SPSSM). Yield of shanks were best (P< 0.05) in T_1 (RSSM), T_2 (SSSM) and T_6 (FSSM) and lowest (P< 0.05) in T_5 (SPSSM). The yield of thighs were higher (P> 0.05) in T_2 (SSSM) and T_4 (SBSSM) followed by T_1 (RSSM), T_3 (BSSM) and T_5 (SPSSM) and the lowest (P< 0.05) was in T_6 (FSSM). Drumsticks were best (P< 0.05) in T_2 (SSSM) followed by T_4 (SBSSM) and T_6 (FSSM) and lowest (P< 0.05) in T_1 (RSSM), T_3 (BSSM) and T_5 (SPSSM). For breast yield, T_4 (SBSSM) was the best (P< 0.05) and significantly (P< 0.05) reduced in T_1 (RSSM), T_2 (SSSM) and T_3 (BSSM). The lowest (P< 0.05) breast yield were in T_5 (SPSSM) and T_6 (FSSM). Yield of backs and necks also showed significant (P< 0.05) differences among treatment groups.

There were no significant (P> 0.05) differences among treatments for yield of heads and wings. Liver, full gizzards and caeca also did not show significant (P> 0.05) differences among treatment groups.

Carcass yields obtained in this study were generally lower than the 65 – 70% reported by Salami *et al*. (2004) although the age at slaughter could be the reason because these workers slaughtered cocks at the age of 19 weeks as against the 16 weeks in the present experiment. Nwokoro and Bamgbose (1995) and Nwokoro and Tewe (1998) observed that cockerels reach their maximum weight at 17 weeks of age. The differences observed in the yield of legs, thighs, drumsticks, breasts, backs and necks could not be explained since they did not follow any pattern.

These results seem to suggest that feeding cockerels with raw or the differently processed sorrel seed meal as partial replacement for soyabean meal could be done without adverse effects on performance, blood parameters, carcass and organs measurements.

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Table I: Ingredients and analysed Chemical composition of chicks mash containing processed sorrel (*Hibiscus sabdariffa)* seed meal.

	Variously processed sorrel seed meal based diets					
Ingredients (%)	RSSM	SSSM	BSSM	SBSSM	SPSSM	FSSM
Maize	53.00	53.00	53.00	53.00	53.00	53.00
Soyabean	10.00	10.00	10.00	10.00	10.00	10.00
Sorrel seeds meal	10.00	10.00	10.00	10.00	10.00	10.00
Wheat offals	16.00	16.00	16.00	16.00	16.00	16.00
Fish meal	6.00	6.00	6.00	6.00	6.00	6.00
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00
Premix*	2.50	2.50	2.50	2.50	2.50	2.50
Salt (NaCl)	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00	100.00
Chemical composition (%)						
Crude protein (CP)	21.03	20.99	21.10	20.96	20.88	21.04
Crude fibre (CF)	4.50	4.43	4.38	4.33	4.38	4.40
Ether extract (EE)	5.37	5.23	5.12	5.17	5.17	5.25
Ash	3.63	3.23	3.14	3.16	3.18	3.63
Calcium (Ca)	1.53	1.47	1.55	1.38	1.52	1.23
Phosphorus (P)	0.96	0.94	0.92	0.93	0.97	0.92
ME (Kcal/kg)**	2724.76	2735.73	2719.78	2724.51	2719.33	2720.40

* *Vitamin – Mineral Premix (BIO – MIX) Supply the following per Kg: Vitamin. A 4000Iμ; Vit. D_3, 8, 000IU; Vit. E, 9,000mg; Niacin, 12, 000mg; Vit. 3_1, 1, 5000mg;Vit. B_3, 4, 000mg;Vit. B_6, 12,000mg; Vit. B_{12}, 6mg;Vit. K_3,800mg; Pantothenic acid, 3,000mg; Biotin, 24mg;Folic acid, 300; Choline Chloride, 120, 000mg;Cobalt, 80mg; Copper, 1,200mg; Iodine, 400mg; Iron, 8, 000mg; Manganese,16, 000mg; Selenium, 80mg; Zinc, 12, 000mg; Anti-oxidant; 500mg.*

**Metabolizable Energy (ME) = 37 X % CP + 81 X % EE + 35.5 X % NFE (Pauzenga, 1985).

Notations

RSSM = Raw Sorrel Seed Meal
SSSM = Soaked sorrel seed meal
BSSM = Boiled and sorrel seed meal
SBSSM= Soaked and boiled sorrel seed meal
SPSSM= Sprouted sorrel seed meal
FSSM = Fermented sorrel seed meal

Table II: Ingredients and analysed Chemical composition of growers experimental diets containing processed sorrel (*Hibiscus sabdariffa)* seed meal

	Variously processed sorrel seed meal based diets					
Ingredients (%)	RSSM	SSSM	BSSM	SBSSM	SPSSM	FSSM
Maize	55.00	55.00	55.00	55.00	55.00	55.00
Soyabean meal	8.00	8.00	8.00	8.00	8.00	8.00
Sorrel seeds meal	8.00	8.00	8.00	8.00	8.00	8.00
Wheat offals	20.00	20.00	20.00	20.00	20.00	20.00
Fish meal	4.00	4.00	4.00	4.00	4.00	4.00
Blood meal	2.00	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00	2.00
Premix*	0.50	0.50	0.50	0.50	0.50	0.50
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30
Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Total	100.00	100.00	100.00	100.00	100.00	100.00
Chemical composition (%)						
Crude protein	18.27	18.27	18.27	18.27	18.27	18.27
Crude fibre	16.43	16.43	16.43	16.43	16.43	16.43
Ether extract	6.09	6.09	6.09	6.09	6.09	6.09
Ash	3.53	3.53	3.53	3.53	3.53	3.53
Calcium	1.25	1.25	1.25	1.25	1.25	1.25
Phosphorus	0.73	0.73	0.73	0.73	0.73	0.73
ME (Kcal/kg)**	2816.88	1816.88	2816.88	2818.88	2818.88	2818.88

* *Vitamin – Mineral Premix (BIO – MIX) Supply the following per Kg: Vitamin. A 8000Iμ; Vit. D_3, 16, 000IU; Vit. E, 5,000mg;Vit. K_3,2000mg; Thiamine B_1,1, 5000mg; Rebloflavin B_2, 4, 000mg; Pyridoxine, B_6, 1500mg; Niacin, 16, 000mg; Vit. B_{12}, 1,mg; Pantothenic acid, 5,000mg; Folic acid, 5,000mg; Biotin, 20mg; Choline chloride, 200mg; Antioxidant, 125mg; Manganese, 80mg; Zinc, 50mg; Iron, 20mg; Copper, 5mg, iodine, 12mg; Selenium, 200mg;Cobalt, 200mg.*

**Metabolizable Energy (ME) =37 X % CP + 81 X % EE + 35.5 X % NFE (Pauzenga, 1985).

RSSM = Raw Sorrel Seed Meal
SSSM = Soaked sorrel seed meal
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SBSSM = Soaked and boiled sorrel seed meal
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Table III: Performance and economic analysis of cockerels fed variously processed sorrel (*Hibiscus sabdariffa*) seed meal

	Variously processed sorrel seed meal based diets						
Parameters	RSSM	SSSM	BSSM	SBSSM	SPSSM	FSSM	SEM
Initial live weight at 4 weeks (g)	231.45	232.15	230.00	230.00	225.95	223.21	4.38^{NS}
Final live weight at 16 weeks (g)	1336.51^{b}	1437.34^{a}	1440.11^{a}	1438.64^{a}	1331.05^{b}	1406.55^{a}	42.56*
Overall weight gain (g)	1105.06^{c}	1205.19^{a}	1210.11^{a}	1208.64^{a}	1105.10^{c}	1183.34^{b}	24.66*
Daily feed intake (g)	64.15	68.11	65.50	68.29	65.80	69.55	3.45^{NS}
Total feed intake for 84 days (g)	5388.60	5721.24	5502.00	5736.36	5527.20	5842.20	-
Mean daily weight gain (g)	13.86	14.35	14.41	14.66	13.71	14.92	0.74^{NS}
Feed conversion ratio (Feed gain)	4.63	4.77	4.55	4.66	4.81	4.67	0.25^{NS}
Cost of feed (N/kg)	63.49	63.71	64.05	64.28	63.94	64.17	-
Feed cost (N/kg) gain	309.61^{ab}	302.44^{b}	291.22^{c}	305.08^{b}	319.80^{a}	316.81^{a}	3.45
Mortality	0	01	00	00	02	01	-

a, b, c, = Means within the same row bearing different superscripts differ significantly (P< 0.05)
* = Significant (P< 0.05)
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SEM = Standard Error of Means

Notations
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Table IV: Haematological components in cockerels fed variously processed sorrel (*Hibiscus sabdariffa*) seed meal

Parameters	Variously processed sorrel seed meal based diets						
	RSSM	SSSM	BSSM	SBSSM	SPSSM	FSSM	SEM
Red blood cells (RBC) Count ($x10^6mm^{3)}$)	2.99^c	3.28^b	3.01^c	2.87^d	3.34^b	3.59^a	0.046*
White blood cells (WBC) count ($10^3/mm^3$)	4.84^c	4.73^d	5.10^a	4.91^b	4.81^c	4.83^c	0.037*
Packed Cell Volume (PCV) %	27.56^b	29.60^b	28.80^b	27.80^b	30.60^b	33.80^a	1.32*
Haemoglobin (Hb) Concentration (g/dl)	5.61^b	5.54^b	5.86^b	5.58^b	8.22^a	5.70^b	0.63*
Mean corpuscular volume (MCV) (fl)	94.80	91.94	96.18	95.70	92.62	94.98	3.90^{NS}
Mean corpuscular haemoglobin (MCH) (Pg)	17.20^b	16.87^b	19.61^b	19.20^b	24.97^a	20.70^b	1.39*
Mean corpuscular haemoglobin concentration (MCHC) (%)	14.80^c	14.75^c	20.54^b	19.94^b	26.62^a	21.77^b	2.85*
Differential Counts							
Neutrophils (%)	30.40	30.80	30.80	31.20	31.80	33.20	1.31^{NS}
Eosinophils (%)	5.40^{bc}	5.20^{bc}	6.20^{ab}	5.80^b	6.80^a	4.80^c	0.31*
Basophils (%)	0.00^b	0.00^b	0.60^a	0.00^b	0.60^a	0.60^a	0.02*
Monocyles (%)	8.80^b	9.60^{ab}	10.40^a	8.60^b	9.00^b	9.00^b	0.52*
Lymphocytes (%)	51.60	52.60	52.60	54.80	53.00	52.20	2.03^{NS}

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Table V: Serum biochemical indices in cockerels fed variously processed sorrel (*Hibiscus sabdariffa*) seed meal

Parameters	Variously processed sorrel seed meal based diets						
	RSSM	SSSM	BSSM	SBSSM	SPSSM	FSSM	SEM
Total Protein (g/dl)	3.45^b	3.30^b	3.60^b	4.00^a	3.60^b	3.55^b	0.082*
Albumin (g/dl)	1.75^b	1.75^b	2.25^a	2.25^a	2.20^a	2.20^a	0.073*
Globulin (g/dl)	1.70^a	1.55^b	1.35^c	1.75^a	1.40^c	1.35^c	1.04*
Urea (mmol/L)	4.40	4.50	4.05	4.45	4.40	4.60	0.30^{NS}
Creatinine (Mmol/L)	45.00^c	46.50^{bc}	48.50^{ab}	48.00^{ab}	49.00^{ab}	53.00^a	2.78*
Cholesterol (Mmol/L)	3.35^b	3.50^{ab}	3.80^a	3.55^{ab}	2.90^b	3.85^a	0.15*
Sodium (Na^+) (Mmol/L)	141.50^b	145.00^a	142.50^b	141.50^b	143.00^b	143.00^b	0.51*
Potassium (K^+) (Mmol/L)	4.08^b	4.05^b	4.45^{ab}	4.95^a	4.85^a	3.85^b	0.31*
Chloride (Cl^-) (Mmol/L)	107.00^b	110.00^a	107.00^b	105.00^c	103.00^d	109.00^a	0.40*
Bicarbonates (HCO^-3) (Mmol/L)	19.30^b	19.50^b	24.00^a	19.40^b	19.00^b	20.00^b	0.21*
Alkaline Phosphate (IU/L)	256.11^a	254.00^a	258.00^a	226.00^b	260.00^a	259.00^a	8.51*
Aspartate Amino Transferase (ASAT) (IU)	88.50^b	89.00^b	95.50^a	97.50^a	97.50^a	89.00^b	2.31*
Alkaline Amino Transferase (ALAT) (Mmol/L)	8.00^{ab}	8.00^{ab}	10.00^a	6.00^b	8.00^{ab}	6.00^b	1.04*
Total Bilirubin (TB) (Mmol/L)	7.00^a	7.50^a	5.00^b	5.50^b	4.00^b	5.00^b	0.55*
Conjugate Bilirubin (CB)l (Mmol/L)	3.50^a	4.00^a	2.50^b	2.50^b	2.00^b	2.50^b	0.23*

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Table VI: Carcass and some organ measurement of cockerels fed variously processed sorrel (*Hibiscus sabdariffa*) seed meal

Parameters	Variously processed sorrel seed meal based diets						
	RSSM	SSSM	BSSM	SBSSM	SPSSM	FSSM	SEM
Live weight at 16 weeks (g)	1498.00	1500.00	1600.11	1550.32	1550.31	1675.11	60.62^{NS}
Slaughtered weight (g)	1449.11	1450.00	1525.21	1475.60	1450.18	1600.41	57.74^{NS}
Plucked weight (g)	1338.23	1350.13	1400.00	1400.82	1350.23	1475.36	54.85^{NS}
Dressed weight (g)	952.15	973.23	990.00	1019.32	973.48	1074.50	41.79^{NS}
Carcass yield (%)	64.81^{ab}	64.74^{ab}	61.83^{c}	65.67^{a}	62.76^{bc}	64.17^{ab}	0.49*
Body components as percentage of Liveweight (%)							
Head	3.11	3.21	2.89	3.18	3.04	3.08	0.065^{NS}
Legs (shanks)	5.11^{a}	5.09^{a}	4.81^{b}	4.87^{b}	4.62^{c}	5.08^{a}	0.086*
Wings	8.88	9.14	8.54	8.84	8.62	8.55	0.22^{NS}
Neck	5.21^{ab}	5.38^{a}	4.58^{b}	4.83^{b}	5.189^{ab}	5.68^{a}	0.21*
Thighs	10.41^{b}	11.04^{a}	10.22^{b}	11.02^{a}	10.54^{b}	9.36^{c}	0.23*
Drumstick	10.11^{c}	11.09^{a}	10.03^{c}	10.69^{b}	10.19^{c}	10.61^{b}	0.11*
Breast	14.67^{b}	14.86^{b}	14.61^{b}	15.54^{a}	13.54^{c}	13.51^{c}	0.33*
Back	13.66^{a}	13.49^{ab}	13.97^{ab}	10.95^{c}	13.76^{ab}	14.38^{a}	0.64*
Full gizzard	3.91	4.63	4.26	4.26	3.88	3.57	0.36^{NS}
Liver	2.26	2.37	1.97	2.35	1.91	2.10	0.20^{NS}
Heart	0.56^{a}	0.57^{a}	0.41^{b}	0.59^{a}	0.45^{b}	0.42^{b}	0.021*
Intestine	5.68^{a}	5.84^{a}	5.34^{ab}	4.80^{bc}	5.23^{ab}	4.58^{c}	0.17*
Caeca	0.73	0.74	0.75	0.68	0.69	0.62	0.06^{NS}

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