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INFLUENCE OF DIETARY SUPPLEMENTATION OF TERMINALIA ARJUNA STEM BARK ON GROWTH PERFORMANCE, CARCASS EVALUATION, OXIDATIVE STRESS AND CAECAL MICROBAL COUNT OF GUINEA FOWL

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Abstract: A 90 days experiment was carried out to determine the influence of dietary supplementation of *Terminalia arjuna* stem bark on growth performance, carcass evaluation, oxidative stress and caecal microbal count of guinea fowl using 350 one-day-old guinea fowl (Lavender variety) of mixed sex (male and female) was randomly divided into five groups with seven replicates with ten birds each. Standard basal diet was compounded to meet the nutritional requirement of birds according to the Nutritional Research Council guidelines in 1994. Birds in group A (control) received a standard basal diet presented in Table 1, while the other group B, C, D and E were fed same diet fortified with *Terminalia arjuna* stem bark powder at 100 g, 200 g, 300 g and 400 g per kilogram diet in that order. Animals had unlimited access to fresh clean water, feed and a completely randomized experimental design was adopted. Tannins, saponins, alkaloids, flavonoids, triterpenoids, steroids and phenolic compounds were the phyto-components present in *Terminalia arjuna* stem bark powder at 207.3 mg/g, 56.41 mg/g, 82.55 mg/g, 532.5 mg/g, 96.82 mg/g, 34.79 mg/g and 200.8 mg/g respectively. Average daily weight gain and average daily feed consumption values which varied from 16.44 - 19.51 g and 43.19 - 44.58 g increasing the level of *Terminalia arjuna* stem bark increased these parameters ($p<0.05$). Conversely, feed conversion ratio decreased as the level of *Terminalia arjuna* stem bark powder increased in the diet. Dry matter, crude protein, crude fibre, ether extract, nitrogen free extract, dressing percentage, total antioxidant capacity, superoxide dismutase, catalase, malondialdehyde and glutathione reductase were significantly ($p<0.05$) except for weights of internal organs ($p>0.05$). Supplementation of *Terminalia arjuna* stem bark powder in the diet of guinea fowl decreased the population of *Staphylococcus aureus, Escherichia coli, Pseudomonas spp, Proteus spp and Streptococcus faecalis* count whereas triggers the proliferation of *Lactobacillus spp* in the caecum. In conclusion, *Terminalia arjuna* stem bark powder can be supplemented up to 400 g/kg diet without causing any negative effect on the performance and health status of guinea fowl.
Keywords: Broilers; Growth; *Terminalia arjuna*; Phytocomponents; Performance

1 INTRODUCTION

Terminalia arjuna is a perennial, evergreen and deciduous tree that belongs to the family Combretaceae which can grow up to 30 m tall and comprises of nearly 200 species widely distributed globally [1,2]. The truck is characterized with buttressed shape with wide spreading crown, leaves are green in colour while the stem bark has a smooth and pinkish green appearance [3]. The plant is found in some parts of Africa, America and Asia including India [1]. The plants have been reported to contain several minerals and phytocomponents such as, tannins, alkaloids, polysteroids, saponins, glycosides, flavonoids, triterpenoids and phenolic compounds which have medicinal properties [4, 5]. Leaves and stem bark have been reported to possess: anti-atherosclerotic, anti-cancer, anti-dabetic, anti-inflammatory, antioxidant, antibacterial, anti-mutagenic, cardio-protective, antiviral, gastro-protective, immune-stimulatory, antifungal, cytotoxic, hepato-protective, osteogenic, hypoglycemic, analgesic activities [6].

Traditionally, decoction of *Terminalia arjuna* stem bark has been effective in the treatment of cold, fever, cough, snake bite, asthma, anaemia, stomach disorder, urinary disease, dislocation of bones, ulcer amongst others [7, 8]. Alcohol extracts from *Terminalia arjuna* stem bark can be used to improve heart pumping, heart rate, and blood pressure [9]. It has also been reported to suppress the activities of some pathogenic organisms in the gastro-intestinal tract of animals and neutralize the activities of free radicals in the body [10, 11].

Research n previous studies has shown that the supplementation of phytogenic compounds in feed at different concentrations could have a positive influence on growth of birds [12], exert positive effect on the activities of intestinal enzymes [13], modulate feed intake [14, 15], boost the immunity of birds as well as neutralize the activities of free radicals [16, 17]. However, there are discrepancies in some of the results due to level of supplementation in animal diet, specie and part of plants utilized as well as the preparation procedure of the phytogenics [18]. In view of the numerous potentials in *Terminalia arjuna* stem bark, this experiment was designed to determine the effect of dietary supplementation of *Terminalia*

arjuna stem bark on the general performance of guinea fowl. This research will help to provide a natural and sustainable way to improve animal's health and development.

2 MATERIALS AND METHODS

2.1 Description of Investigation Area, Experimental Duration and Ethical Approval

The experiment was carried out at the Poultry Section of Sumitra Research Institute, Gujarat located between 28o 20' N and 75o 30' East India. The study lasted for 90 days between the months of January to March, 2024. The experimental techniques were approved by the Research Committee at the department of Animal husbandry according to the guidelines of Animal Research and Management.

2.2 Collection of Terminalia Arjuna Stem Bark and Processing Method

Fresh and mature Terminalia arjuna stem bark was collected from different trees in Orathur village in Gujarat and sent to the taxonomy department of Sumitra Institute in Gujarat for a detailed inspection before a registration number (FH/009/2023) was ascribed to the sample. Thereafter, samples were cut into smaller pieces to reduce their surface area and spread on flat plastic tray and dried under shade for sixteen days. On the seventeenth day, dried samples of Terminalia arjuna stem bark was sent to the laboratory and grinded into powder using an electric blender. Powdered samples were collected into an air tight, labeled plastic bucket and another 500 grams was sent to the laboratory to examine their various phyto-components.

2.3 Preliminary Preparation before the Arrival of Birds

A deep litter system was used for the experiment. Pens were thoroughly washed and disinfected. Each replicate measuring 3ft by 4ft by 1.5 ft (length/width/height) was demarcated using a ply wood and wood shavings was spread in each area to absorb fecal droppings and prevent contact with the cemented floor. Plastic drinkers, aluminum feeders were thoroughly washed and 200 Watt bulbs was installed to supply heat and illumination to birds. Tarpaulins were used to cover the sides of the open sided pen to retain heat during brooding period.

2.4 Management of Experimental Birds, Diet and Design Adopted

A total of 350 one-day-old guinea fowl (Lavender variety) of mixed sex (male and female) were purchased from a commercial farm in Gujarat and randomly divided into five groups with seven replicates with ten birds each after their average initial body weight gain was taken using a digital scale. Group A (control) received a standard basal diet presented in Table 1, while the other group B, C, D and E were fed same diet fortified with *Terminalia arjuna* stem bark powder at 100 g, 200 g, 300 g and 400 g per kilogram diet in that order. Birds were placed on glucose with vitamins for 3 days after arrival, vaccination schedule was adhered to according to the template designed by Sumitra Research institute, Gujarat as presented in Table 2. The experiment lasted for 90 days and a completely randomized design was adopted. Guinea fowl had unlimited access to fresh clean water and feed. Plastic watering troughs was washed daily and wood shavings was turned daily with a disinfected rake to prevent dampness of the litter material. Performance variables examined during the experimental period includes; initial body weight, final body weight, weight gain which was estimated as the difference between the final body weight and the average initial body weight (expressed in grams), total feed consumption (in grams), average daily weight gain and average feed consumption was calculated as weight gain and feed consumed divided by the duration of experiment (ninety days) (expressed in grams).

2.4.1 Evaluation of carcass parameters

At the end of the trial (90th day), two birds were randomly selected per replicate for carcass examination. Prior to the slaughtering, selected birds were only offered water for 10 hours and their body weight was recorded. A clean sharp knife was used to cut the jugular vein in the neck region and blood was allowed to properly drain completely. Slaughtered birds were immersed in hot water and feathers were removed manually, thereafter weights of internal organs were weighed using a digital sensitive scale and expressed in percentage of dressed weight. Dressing percentage was calculated as dressed weight divided by live weight multiplied by one hundred.

2.4.2 Nutrient digestibility assessment

At the end of the trial (90th day), two birds were randomly selected per replicate and moved to specially constructed metabolic cage measuring 400 cm by 320 cm by 100 cm (L×w×h) to ease the collection of faecal droppings throughout the five days collection period. Birds were allowed three days adjustment period, on the fourth day, a known quantity of feed was served to birds and their excreta was collected daily per replicate. Collected samples were weighed and oven dried at 70°C for 5 hours. Dried samples from each replicate was bulk together at the end of the experiment before they were sent to Sumitra Research laboratory for proximate evaluation. Percentage digestibility of each parameter was calculated as:
Nutrient input minus Nutrient output divided by Nutrient input multiplied by hundred

2.4.3 Ceacal microbial examination

At the end of the trial (90th day), two birds were randomly selected per replicate (same birds used for carcass evaluation) and caecal material was collected into a labeled sterile sample bottle followed by the addition of 10 percent peptone solution. Laboratory count of microbes was carried out at the department of microbiology, Sumitra Research institute, Gujarat using Labrat® commercial kit (Model HH/Gj008/11, China).

2.5 Quantification of Phyto-components in Terminalia Arjuna Stem Bark

Gas chromatography-mass spectrometry (Model AAD/300E, Netherlands) was used for the quantitative assessment of phyto-components in Terminalia arjuna stem bark. Concentrations of each compounds were captured at different optical density on the equipment as described previously by [35].

2.6 Laboratory Assessment of Experimental Diet

Assessment of experiment diet was done using standard laboratory procedures described by [19].

2.7 Statistical Technique Adopted

All data obtained on growth performance, carcass assessment, oxidative stress and caecal microbial count were subjected to one -way analysis of variance using SPSS (version 20). Significant differences among the groups were subjected to comparisons using the Duncan multiple range test of the same software. All differences were considered to be statistically significant when $p < 0.05$.

3 EXPERIMENTAL RESULTS

Gross and ingredient composition of experimental diet showed that starter, growers and finishers mash contained crude protein (24.47 %, 21.02 % and 19.11 %), crude fibre (3.98 %, 4.05 % and 4.44 %), ether extract (4.11 %, 5.00 % and 5.23 %), calcium (1.36 %, 1.52 % and 1.66 %), phosphorus (0.64 %, 0.71 % and 0.82 %) and metabolizable energy [(2871.0, 2692.7 and 2761.3 kcal/kg)] respectively.

Vaccination schedule for Guinea fowl reared for 90 days is presented in Table 2. Before the administration of oral vaccines, drinking water was withdrawn from birds for 6 hours to ensure they are very thirsty before giving them their required vaccines.

Phyto-components in Crataeva nurvala stem bark presented in Table 3 revealed that flavonoids (532.5 mg/g), tannins (207.3 mg/g) and phenolic compounds (200.8 mg/g) were the major compounds followed by triterpenoids (96.82 mg/g), alkaloids (82.55 mg/g), saponins (56.41 mg/g) and steroids (34.79 mg/g) respectively.

Growth indices of guinea fowl fed diet supplemented with Crataeva nurvala stem bark powder (Table 4) showed that average body weight gain of birds in group B (basal diet + 100 g Crataeva nurvala stem bark powder per kg diet), group C, D and E (basal diet with 200 g, 300 g and 400 g per kg diet) were similar ($p>0.05$) but significantly higher ($p<0.05$) than those in control (group A). Average total feed consumption were higher in groups fed diet supplemented with Crataeva nurvala stem bark powder (group B, C, D and E) compared to control (group A). Increasing the supplementation of Crataeva nurvala stem bark powder in the diet (100 - 400 g per kg diet) significantly decreased ($p<0.05$) the feed conversion ratio.

Carcass characteristics of guinea fowl fed diet supplemented with Crataeva nurvala stem bark powder (Table 5). Dressing percentage of birds fed 300 g Crataeva nurvala stem bark powder per kg diet (group D) was comparable ($p>0.05$) to those which received 400 g Crataeva nurvala stem bark powder (group E). Similarly, animals in group B and C were had similar ($p>0.05$) values but higher than those in group A. Values obtained for neck, drum stick, head, wing, back, breast, thigh, liver, gizzard and heart were not affected with the treatment ($p>0.05$).

Nutrient digestibility of guinea fowl fed diet supplemented with Crataeva nurvala stem bark powder presented in Table 6 showed that dry matter, crude protein, ether extract and nitrogen free extract values follow similar trend. Birds fed diet supplemented with 100 g and 200 g Crataeva nurvala stem bark powder per kilogram diet group B and group C were similar ($p>0.05$) to those who received 300 g and 400 g Crataeva nurvala stem bark powder per kilogram diet but significantly higher ($p<0.05$) than those fed diet A (control). Conversely, crude fibre values were higher ($p<0.05$) in group A compared to the other treatments.

Oxidative stress indices of guinea fowl fed diet supplemented with Crataeva nurvala stem bark powder (Table 7). Total antioxidant capacity, superoxide dismutase, catalase and glutathione reductase values varied from 0.45 - 1.25 ng/mL, 0.31 - 0.88 U/mL, 0.32 - 0.71 mg/dL and 0.16 - 0.38 mg/dL. These parameters were higher among birds in group B, C, D, E and lowest in group A ($p<0.05$). Malondialdehyde values (0.27 - 0.72 nmol/mL) were higher among birds given group A (control), intermediate in group B (100 g Crataeva nurvala stem bark powder/kg diet) and lowest in group C (200 g Crataeva nurvala stem bark powder/kg diet), group D (300 g Crataeva nurvala stem bark powder/kg diet) and group E (400 g Crataeva nurvala stem bark powder/kg diet) ($p<0.05$).

Caecal microflora of guinea fowl fed diet supplemented with Crataeva nurvala stem bark powder (Table 8). Staphylococcus aureus count varied from [(2.14 - 3.72 (Log10 CFU)], Escherichia coli, Pseudomonas spp, Proteus spp, Streptococcus faecalis and Lactobacillus spp values were within
[(1.97 - 3.09 (Log10 CFU)], [(1.39 - 2.66 (Log10 CFU)], [(0.98 - 2.21 (Log10 CFU)], [(0.80 - 1.62 (Log10 CFU)] and [(2.03 - 4.56 (Log10 CFU)] respectively. Staphylococcus aureus)], Escherichia coli, Pseudomonas spp, Proteus spp and Streptococcus faecalis values of birds fed group B and C was similar ($p>0.05$) to those which received group D and E but significantly lower ($p<0.05$) than group A (control). Conversely, Lactobacillus spp count was higher among birds in group B, C, D and E compared to group A ($p<0.05$).

Table 1 Gross Composition of Experimental Diet Fed to Guinea Fowl for 90 days

Ingredients	Starter mash: 1-4 weeks	Growers mash: 5-8 weeks	Finisher mash: 9-12 weeks
	Content (%)	Content (%)	Content (%)
Maize	53.50	52.00	54.00
Wheat bran	4.00	8.50	9.00
Soya bean meal	33.5	30.5	28.0
Fish meal	2.00	2.00	2.00
Limestone	2.00	2.00	2.00
Bone meal	4.00	4.00	4.00
Lysine	0.20	0.20	0.20
Methionine	0.20	0.20	0.20
*Mineral and Vitamin Premix	0.25	0.25	0.25
Common salt	0.35	0.35	0.35
Total	100.0	100.0	100.0
Determined analysis			
Crude protein (%)	24.47	21.02	19.11
Crude fibre (%)	3.98	4.05	4.44
Crude fat (%)	4.11	5.00	5.23
Calcium (%)	1.36	1.52	1.66
Phosphorus (%)	0.64	0.71	0.82
Metabolizable energy (Kcal/kg)	2871.0	2692.7	2761.3

Starter mineral and vitamin premix contained the following: Vit A = 13,000,000 IU, Vit D3 = 2,000,000 IU, Vit E = 35,000 mg, Vit K_3 = 3,500 mg, and thiamine (B_1) = 4,200 mg. B_2 6,000 mg, niacin = 45,000 mg, calcium pantothenate = 10,000 mg, Vit. B_6 6,500 mg, Vit B_{12} = 30 mg, folic acid = 1,500 mg, Biotin = 50 mg, choline chloride = 350,000 mg, manganese = 100,000 mg, iron = 90,000 mg, zinc = 100,000 mg, copper = 7,500 mg, iodine = 1,000 mg, cobalt = 200 mg, selenium = 200 mg, and antioxidant = 200 mg.; Growers' mineral and vitamin premix contained the following: Vit A = 8,500,000 IU, Vit D3 = 1,500,000 IU, Vit E = 20,000 mg, Vit K_3 = 1,200 mg, and thiamine (B_1) = 2,000 mg. B_2 3,000 mg, niacin = 29,000 mg, calcium pantothenate = 10,000 mg, Vit. B_6 3,000 mg, Vit B_{12} = 20 mg, folic acid = 2,500 mg, Biotin = 60 mg, choline chloride = 250,000 mg, manganese = 100,000 mg, iron = 50,000 mg, zinc = 60,000 mg, copper = 8,000 mg, iodine = 1,800 mg, cobalt = 400 mg, selenium = 80 mg, and antioxidant = 120 mg.; Finisher mineral and vitamin premix contained the following: Vit A = 12,500,000 IU, Vit D3 = 2,500,000 IU, Vit E = 40,000 mg, Vit K_3 = 2,000 mg, and thiamine (B_1) = 3,000 mg. B_2 5,500 mg, niacin = 55,000 mg, calcium pantothenate = 11,500 mg, Vit. B_6 5,000 mg, Vit B_{12} = 25 mg, folic acid = 1,000 mg, Biotin = 80 mg, choline chloride = 500,000 mg, manganese = 120,000 mg, iron = 100,000 mg, zinc = 80,000 mg, copper = 8,500 mg, iodine = 1,500 mg, cobalt = 300 mg, selenium = 120 mg, and antioxidant = 120 mg.

Table 2 Vaccination Schedule for Guinea Fowl Reared for 90 days

Days	Vaccines	Dose	Method of administration
8	Lasota (Izovac)	First dose	Water
14	Gumboro (IBV) - Izovac	First dose	Water
22	Lasota vaccine (Abic)	Second dose	Water
30	Gumboro - Izovac	Second dose	Water
60	Fowl pox (Izovac)	First dose	Wing web

Table 3 Phyto-Components in *Crataeva Nurvala* Stem Bark

Variables	Concentration (mg/g)
Triterpenoids	96.82
Flavonoids	532.5
Steroids	34.79
Tannins	207.3
Alkaloids	82.55
Phenols	200.8
Saponins	56.41

Table 4 Growth Indices of Guinea Fowl Fed Diet Supplemented with *Crataeva Nurvala* Stem Bark Powder

Variables	A	B	C	D	E	SEM
Number of birds/group	50.0	50.0	50.0	50.0	50.0	-
Duration of experiment	90.0	90.0	90.0	90.0	90.0	-
Average initial body weight (g/b)	43.16	43.14	43.12	43.11	43.05	0.02
Final body weight gain (g/b)	1522.6^{b}	1779.4^{a}	1786.3^{a}	1790.4^{a}	1799.3^{a}	69.56
Average body weight gain (g/b)	1479.44^{b}	1736.3^{a}	1743.2^{a}	1747.3^{a}	1756.3^{a}	68.11
Average daily weight gain (g/b)	16.44^{b}	19.29^{a}	19.37^{a}	19.41^{a}	19.51^{a}	0.01
Average total feed consumption (g/b)	3887.5^{b}	4001.2^{a}	4006.7^{a}	4011.2^{a}	4012.1^{a}	124.6
Average daily feed consumption (g/b)	43.19^{b}	44.46^{a}	44.52^{a}	44.57^{a}	44.58^{a}	0.02
feed conversion ratio	2.62^{a}	2.30^{b}	2.30^{b}	2.29^{b}	2.28^{b}	0.01

Values followed by different letters were significantly different ($p<0.05$); A: standard basal diet only (control); B, C, D and E: Standard basal diet supplemented with 100 g, 200 g, 300 g and 400 g *Crataeva nurvala* stem bark powder per kg respectively; SEM: standard error of mean

Table 5 Carcass Characteristics of Guinea Fowl Fed Diet Supplemented with *Crataeva Nurvala* Stem Bark Powder

Variables	A	B	C	D	E	SEM
Live weight	1500.3^{c}	1852.1^{b}	1858.7^{b}	2000.2^{a}	2100.3^{a}	73.12
Dressed weight	1044.3^{c}	1377.1^{b}	1380.7^{b}	1420.2^{a}	1420.7^{a}	62.08
Dressing percentage	67.60^{c}	70.35^{b}	70.38^{b}	74.74^{a}	74.75^{a}	0.03
Head (%)	2.01	2.08	2.11	2.13	2.18	0.01
Neck (%)	4.72	4.88	4.96	4.98	4.99	0.02
Wing (%)	9.74	10.03	10.05	10.11	10.13	0.01
Drumstick (%)	8.57	8.87	8.92	9.01	9.05	0.18
Back (%)	14.44	15.73	15.88	16.07	16.22	0.22
Breast (%)	24.85	25.67	26.01	26.09	26.17	0.47
Thigh (%)	12.76	13.24	13.50	13.72	13.78	0.13
Liver (%)	2.03	2.11	2.13	2.15	2.19	0.01
Gizzard (%)	3.02	3.17	3.30	3.46	3.51	0.02
Heart (%)	0.31	0.35	0.37	0.38	0.39	0.13

Values followed by different letters were significantly different ($p<0.05$); A: standard basal diet only (control); B, C, D and E: Standard basal diet supplemented with 100 g, 200 g, 300 g and 400 g *Crataeva nurvala* stem bark powder per kg respectively; SEM: standard error of mean

Table 6 Nutrient Digestibility of Guinea Fowl Fed Diet Supplemented with *Crataeva Nurvala* Stem Bark Powder

Variables in %	A	B	C	D	E	SEM
Dry matter	68.97[b]	84.67[a]	85.51[a]	86.83[a]	86.92[a]	3.18
Crude protein	59.08[b]	70.80[a]	72.33[a]	74.15[a]	75.06[a]	3.03
Crude fibre	49.85[a]	38.90[b]	38.66[b]	38.02[b]	37.74[b]	0.16
Ether extract	34.57[b]	45.83[a]	46.75[a]	47.22[a]	47.50[a]	0.12
Nitrogen free extracts	62.86[b]	73.22[a]	74.15[a]	74.66[a]	75.08[a]	2.75

Values followed by different letters were significantly different ($p<0.05$); A: standard basal diet only (control); B, C, D and E: Standard basal diet supplemented with 100 g, 200 g, 300 g and 400 g *Crataeva nurvala* stem bark powder per kg respectively; SEM: standard error of mean

Table 7 Oxidative Stress Indices of Guinea Fowl Fed Diet Supplemented with *Crataeva Nurvala* Stem Bark Powder

Variables	A	B	C	D	E	SEM
Total antioxidant capacity (ng/mL)	0.45[b]	1.06[a]	1.11[a]	1.23[a]	1.25[a]	0.02
Superoxide dismutase (U/mL)	0.31[b]	0.74[a]	0.81[a]	0.85[a]	0.88[a]	0.12
Catalase (mg/dL)	0.32[b]	0.61[a]	0.65[a]	0.68[a]	0.71[a]	0.01
Malondialdehyde (nmol/mL)	0.72[a]	0.41[b]	0.37[b]	0.35[b]	0.27[c]	0.06
Glutathione reductase (mg/dL)	0.16[b]	0.31[a]	0.33[a]	0.35[a]	0.38[a]	0.08

Values followed by different letters were significantly different ($p<0.05$); A: standard basal diet only (control); B, C, D and E: Standard basal diet supplemented with 100 g, 200 g, 300 g and 400 g *Crataeva nurvala* stem bark powder per kg respectively; SEM: standard error of mean.

Table 8 Caecal Microflora of Guinea Fowl Fed Diet Supplemented with *Crataeva Nurvala* Stem Bark Powder

Variables (Log_{10} CFU)	A	B	C	D	E	SEM
Staphylococcus aureus	3.72[a]	2.93[b]	2.88[b]	2.56[b]	2.14[b]	0.15
Escherichia coli	3.09[a]	2.42[b]	2.08[b]	2.00[b]	1.97[c]	0.13
Pseudomonas spp	2.66[a]	1.95[b]	1.74[b]	1.51[b]	1.39[b]	0.06
Proteus spp	2.21[a]	1.84[b]	1.72[b]	1.44[b]	0.98[c]	0.02
Streptococcus faecalis	1.62[a]	1.00[b]	0.96[c]	0.85[c]	0.80[c]	0.01
Lactobacillus spp	2.03[b]	4.00[a]	4.21[a]	4.40[a]	4.56[a]	0.15

Values followed by different letters were significantly different ($p<0.05$); A: standard basal diet only (control); B, C, D and E: Standard basal diet supplemented with 100 g, 200 g, 300 g and 400 g *Crataeva nurvala* stem bark powder per kg respectively; SEM: standard error of mean

4 DISCUSSION

The medicinal properties of plants can be attributed to the presence of phyto-components or phytochemicals which have been suggested to possess antimicrobial, antiviral, antifungal, anti-helminthic, anti-cancer, antioxidant, anti-diabetic, gastro-protective, antibacterial, hepato-protective, immune-stimulatory, cytotoxic activities amongst others [19, 20]. These chemical compounds have no withdrawal period and their concentrations in plants are influenced by geographical location, age of plant, specie and processing methods [21, 22]. Results on *Crataeva nurvala* stem bark powder showed that flavonoids, phenolic compounds and tannins were the major compounds in the sample, this suggests that the samples have hypolipidemic, antioxidant, antimicrobial, anti-inflammatory, antidiarrheal, gastro-protective and immune-stimulatory properties [23, 24]. A synergy with the other phytochemicals helps to enhance performance and support the overall health of birds [25].

Average body weight gain value which varied from 1479.1 - 1756.3 g/b was similar to the outcome of a research by [26, 27] who discovered that the average weight gain of broilers fed diet supplemented with *Moringa oleifera* leaf ranged from 1400.2 - 1788.5 g/b. This result was higher than those reported by [28] who found out that average weight gain of guinea fowl fed on dietary Neem (*Azadirachta indica*) leaf powder varied from 1220.0 - 1266.2 g/b. The impressive body weight gain among birds *Crataeva nurvala* stem bark powder suggests that it was able to stimulate the production of pancreatic enzymes, lipase, amylase, protease in the intestine to modulate feed digestion and feed absorption leading to better feed efficiency and increased weight gain. Average total feed consumption range recorded in this experiment with the dietary supplementation of *Crataeva nurvala* stem bark powder 3887.5 - 4012.1 g/b was similar to the outcome of a study by [29,

30] who discovered that the total feed consumption of broilers fed diet supplemented with probiotic varied from 3900.8 - 4337.6 g. This result was lower than those reported by [31, 32] who found out that total feed consumption of birds fed phytogenics varied from 4200.9 - 4855.6 g. Increasing the level of *Crataeva nurvala* stem bark powder supplementation in the diet of guinea fowl increased the total feed consumption, this result indicates that *Crataeva nurvala* stem bark powder improved the palatability of feed. This result aligns with the notion that phytogenic feed additives could positively influence the aroma and flavor of feed, thus increasing intake in birds [33, 34]. Increasing *Crataeva nurvala* stem bark powder levels in the diet decreased feed conversion ratio. This result suggests that the improved feed conversion ratio was reinforced by an increase in feed digestion [35]. According to [36, 37], improved feed conversion and feed conversion ratio is associated with intestinal health including efficient gut microbiota as key factor.

Dressing percentage and relative weight of neck was affected ($p<0.05$) by the levels of *Crataeva nurvala* stem bark powder in the diet of birds. Dressing percentage in group A was 67.60 % which later increased to 74.75 % in group E supplemented with 400 g Crataeva nurvala stem bark powder per kg diet. The dressing percentage range recorded in this experiment 67.60 - 74.75 % was similar to the result of a study by [38] who reported a dressing percentage range of 74.95 - 77.05 % when broilers were fed diet supplemented with mango leaf powder. The result obtained suggests that the dietary addition of medicinal plants, especially *Crataeva nurvala* stem bark powder used in this study can positively influence the meat yield of animals [39]. Weights of head, neck, wing, thigh, drum stick, back, liver and heart were not significantly affected by the dietary supplementation of Crataeva nurvala stem bark powder. This result suggests that there was no organ damage in the system of birds, implying that birds were able to tolerate the concentrations of phyto-components in Crataeva nurvala stem bark powder. Result obtained is in consonance with the reports of [40].

The supplementation of *Crataeva nurvala* stem bark powder in the diet of guinea fowl influenced ($p<0.05$) dry matter, crude protein, crude fibre, ether extract and nitrogen free extract digestibility. Increasing Crataeva nurvala stem bark powder levels increased dry matter, crude protein, ether extract and nitrogen free extract digestibility of guinea fowl. Dry matter range (68.97 - 86.92 %) recorded in this study was similar to the results of a study by [41] who reported a dry matter range of 69.07 - 86.11 % for growing quails fed diet supplemented with Rhamnus prinoides leaf extract. Crude protein, ether extract and nitrogen free extract in the control (group A) was 59.08 %, 34.57 % and 62.86 % and increased to 75.06 %, 47.50 % and 75.08 % respectively in group E. The result obtained is in agreement with the reports of [42] when Neem (Azadirachta indica) kernel meal was supplemented in the diet of Japanese quails. High nitrogen free extract, crude protein and ether extract digestibility among guinea fowl fed diet supplemented with *Crataeva nurvala* stem bark powder was strongly associated with stimulation of intestinal enzymes and healthy gut flora giving room for efficient feed absorption [43]. It is important to note that supplementing *Crataeva nurvala* stem bark powder at 400 g per kg diet can modulate the activities of enzymes without causing any deleterious effect on the health of birds.

Total antioxidant capacity, superoxide dismutase, catalase and glutathione reductase were higher among birds fed with Crataeva nurvala stem bark powder compared to the control group, conversely, melondialdehyde was higher in control relative to the other groups. This result suggests that Crataeva nurvala stem bark powder have antioxidant properties to neutralize the activities of free radicals. According to [41, 43], phytogenics contains loaded with antioxidants which aid to mitigate oxidative damage by scavenging free radicals which are capable of causing damage to the body. The lower levels of melondialdehyde among birds fed group B, C, D and E not only improves the health conditions of bird but also enhances the quality of meat by reducing lipid peroxidation [41]. It is important to note that the increased production of total antioxidant capacity, superoxide dismutase, catalase and glutathione reductase in group B, C. D and E neutralizes the activities of melondialdehyde by scavenging radicals [21]. Result obtained in this study is in agreement with the reports of [44, 45] who recorded an oxidative stability in meat of birds fed with phytogenic feed additives.

Maintaining a healthy gut is important to make sure that nutrient are efficiently absorbed at an optimum rate and the gastro intestinal tract can provide protection against pathogenic organisms [23, 48]. The result obtained in this experiment shows that population of *Staphylococcus aureus, Escherichia coli, Pseudomonas spp, Proteus spp* and *Streptococcus faecalis* were significantly inhibited as the level of *Crataeva nurvala* stem bark powder increased in diet of birds giving room for the rapid proliferation of Lactobacillus spp. These result provides insights on the positive influence of Crataeva nurvala stem bark powder to bind the receptors of pathogenic organisms, preventing them from attaching itself to the intestinal wall before they are excreted (dead) out of the digestive system (antimicrobial activity) [36, 49]. A balance in the population of intestinal flora promotes the overall health and performance of birds [34]. It is important to note that birds in group A can easily be susceptible to the attack of opportunistic pathogens due to the porous nature of the experimental diet [25, 51]. Result obtained in this study confirms the earlier reports of [46, 50] when Forsythia suspensa extract and berberine was fed to birds at different concentrations. [47, 51, 52] also confirm that supplementing herbal essential mixture and organic acid significantly suppressed that activities of Escherichia coli in the gut of laying birds.

5 CONCLUSION

Crataeva nurvala stem bark powder is rich in numerous phytocomponents with tremendous medicinal properties. Some of these chemical compounds helps to activate the activities of enzymes to give room for optimum absorption of digested

nutrient as well as neutralizing the activities of free radicals. It was concluded that *Crataeva nurvala* stem bark powder can be supplemented up to 400 g/kg in the diet of guinea fowl without compromising their performance and heath state.

CONFLICT OF INTEREST

The authors have no relevant financial or non-financial interests to disclose.

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