

Effect of Supplemental Fresh Forage Feeding on Egg Production, Egg Characteristics, Blood Profile, and Organoleptic Attribute of Pearl Guinea Fowls

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Abstract

Investigation on the impact of supplemental fresh forage feeding, including Moringa oleifera (MO), Talinum triangulare (TT), Boerhavia diffusa (BD), and a combination of TT and BD in a 1:1 ratio, was conducted using pearl Guinea fowls. Sixty Guinea hens and 15 males were completely randomised into 5 treatments and 3 replicates. Each replicate with 4 hens and 1 cock received different forage treatments including zero-forage inclusion (control), MO, TT, BD, and TT+BD. Egg production, haematology, biochemical profile, carcass characteristics, and organoleptic attributes were assessed. Data collected were analysed with the General Linear Model procedure of the Statistical Analysis System (version 7). The dietary treatments significantly influenced the consumption of the basal diet, forage, and water intake. However, there was no substantial impact on hen-day egg production, egg weight, feed conversion ratio (FCR), and shell thickness. Birds supplemented with BD showed higher final body weight and weight gain. Eggs from forage-supplemented birds exhibited richer yolk colour, increased fertility, and marginally lesser hatchability compared to the control group. Haematological and biochemical characteristics remained relatively unaffected, except for a few parameters. Organoleptic attributes, except for meat tenderness, were not significantly ($P > 0.05$) different among the treatments. Tenderness was notably higher in birds supplemented with TT+BD. In conclusion, supplementing Guinea fowl diets with selected forages, particularly BD and TT+BD, had several positive effects. It improved body weight, egg production, yolk colour, and meat tenderness without detrimental consequences. These findings suggest that these fresh forages can be beneficial for enhancing intensive Guinea fowl production.

Keywords: Boerhavia, Fresh Forage Feeding, Guinea Fowl, Moringa, Talinum.

Introduction

Guinea fowl production is gradually gaining momentum in recent times in Ghana and other West African countries. This production gains have mainly been driven by increase in demand by consumers for the eggs and meat of the bird. The bird is resistant to many of the diseases that affect chickens (Teye and Adam, 2000; Śmiecińska *et al.*, 2022). The Guinea fowl is known for its lean but gamey taste that is considered a delicacy by consumers. The gamey taste of the meat and tasty eggs with yellowish yolk has been mainly due to the scavenging characteristics of the birds (Jacob and Pescatore, 2022) which are predominantly reared on the extensive system (free range) of production and therefore depend on fresh forages as major feed resource due to Guinea fowls' special ability to utilize forages that are consumed effectively (Ponte *et al.*, 2008). Effective use of forages has the tendency to reduce feed costs which in recent times have been escalating making the cost of production very high (Kusi *et al.*, 2015; Adams *et al.*, 2022) and thus eroding the profitability of commercial farms. Increased demand for Guinea fowl meat globally has led to the establishment of some intensive commercial farms which are now fed on formulated diets (Shoyombo *et al.*, 2021). Formulated diets for Guinea fowls devoid of forages could affect meat taste, egg characteristics, and reproductive performance compared to those reared under the extensive system of production. Organic agriculture is being promoted due to the health concerns of consumers (Brzozowski and Marzourek, 2018; Das *et al.*, 2020). Phytochemicals in leaves have had mixed outcomes of negative effect where Anti-nutritional factors (ANF) depress productive performance. However, positive effects from Alkaloids are known to promote healthy and productive performance of birds depending on the kind of phytochemicals present and the concentrations in the plant (Lakshmi *et al.*, 2020; Mnisi *et al.*, 2023). Many forage plants have been incorporated into poultry diets as dried meals and sometimes in fresh forage form (Tufarelli *et al.*, 2018) similar to scavenging exploration on free range production. Supplementary fresh forage feeding was therefore carried out to determine their effects on productive performance, haematology, and biochemical profile, carcass characteristics, and sensory attributes of the pearl Guinea fowl under intensive production to enhance meat egg and meat quality and acceptability.

Materials and Methods

Experimental Birds and Design

Fifteen (15) males and Forty-five (45) females of Guinea fowl at 23 weeks old were obtained from the Olympio Hatchery, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana for the study. There were five treatments and three replicates in a completely randomized design. Each replicate had four (4) hens and one (1) male per replicate making a total of fifteen (15) birds per treatment. The treatments were supplementary fresh forages such that the control had no forage supplementation and was designated as CO, Fresh *Moringa olerifera* leaves, *Talinum triangulare*, *Boerhavia diffusa*, and combined *Talinum triangulare* and *Boerhavia diffusa* were used for the supplementation and designated respectively as MO, TT, BD, and TT+BD. The leaves selection for the experiment was on the premise of availability and observed consumption by local free-ranging Guinea fowls. All treatments were served with a common basal layer diet (Table 1) *ad libitum*.

Preparation of Experimental Treatments

Fresh and tender leaves (≤ 45 days old) of *Moringa oleifera*, *Talinum triangulare*, and *Boerhavia diffusa* were harvested daily. Moringa leaves were harvested from the moringa plantation at the Department of Animal Science, AAMUSTED, Mampong, Ashanti, Ghana. *Talinum* and *Boerhavia* forages were also obtained from the Crops and Soil Sciences Nursery at AAMUSTED, Mampong. The harvested leaves were cleaned of dirt, weighed and rinsed in clean water before been given to the birds as supplementary feed (As is). Leaves with broader sizes (*Talinum triangulare* and *Boerhavia diffusa*) were chopped into smaller units for easy uptake by the birds after weighing. *Talinum triangulare* and *Boerhavia diffusa* were mixed up in a ratio of 1:1 with the aid of electronic scale and fed to the respective birds. All supplementary leaves were fed *ad libitum*. The basal experimental diet which was fed to all the birds is shown in Table 1.

Table 1: Composition of the Experimental Basal Diet

Feed Ingredient	Level of Inclusion %
Maize grain	58.00
Tuna Fishmeal	6.50
Fishmeal anchovy	5.00
Wheat bran	17.50
Soybean meal	6.70
Oyster shells	5.20
Dicalcium Phosphate	0.50
*Premix	0.35
Salt	0.25
Total	100
Calculated Nutrient Composition	
Crude Protein (%)	17.03
Crude Fibre (%)	3.72
Ash (%)	11.27
Ether Extract (%)	3.03
Metabolisable Energy (Kcal/kg)	2671.78

*Premix contains contained the following per kilogram of diet: Fe 100 mg, Mn 110 mg, Cu 20 mg, Zn 100 mg, Se 0.2 mg, Co 0.6 mg, Senoquin 0.6 mg, retinal 2000mg, cholecalciferol 25 mg, α - tocopherol 25 mg, menadione 1.33 mg, cobalamin 0.03 mg, thiamin 0.83 mg, riboflavin 2 mg, folic acid 0.33 mg, biotin 0.03 mg, pantothenic acid 3.75 mg, niacin 23.3 mg, pyridoxine 1.33mg.

Parameters Measured

Feed and Water Intake

Weekly feed intake (Basal diet and forage) was calculated by subtracting feed left over from the amount of feed supplied in the previous week and the resulting feed divided by the number of birds to obtain weekly feed consumption per bird. Weekly feed consumed was summed up to obtain total feed intake for the experimental period. Daily water intake was calculated by subtracting water left over from the amount of water given in the previous day. This was summed up to obtain weekly water intake. Weekly water intake for the weeks was added to obtain water intake for the study period.

Hen-Day Egg Production

Hen-day egg production was determined for daily egg production according to the equation.

$$\text{Hen-day egg production} = \frac{\text{Number of eggs collected a day}}{\text{Number of layers alive}} \times 100\%$$

Hen-day egg production for the study period was calculated as the average of the respective hen-day egg production for the experimental period.

Egg Characteristics

Egg weight (g) was determined by weighing individual eggs collected daily with the use of A&D Weighing EK-6000i electronic balance. The length and width of the eggs were taken using a digital Vernier caliper. The destructive method was applied to measure internal and external egg characteristics (Dong *et al.*, 2019). These included yolk colour and shell thickness. The Roche colour fan was used to measure the yolk colour after carefully matching the egg yolk with the colour on the fan and recording the colour number corresponding to the egg yolk. Eggshell thickness was measured with the digital Vernier caliper. Measurement was taken at 3 different planes after carefully removing the tissue lining of the shell. The average value was recorded as the shell thickness.

Feed Conversion Ratio (FCR)

Feed conversion ratio was determined for daily average feed intake and average egg mass (Clark *et al.*, 2019).

$$\text{Feed Conversion Ratio} = \frac{\text{Feed intake}}{\text{Egg mass}}$$

Egg mass was calculated by multiplying the average egg weight by number of eggs laid in a week (Lei *et al.*, 2018). The mean FCR for the study period was determined by an average of the weekly FCR.

Body Weight Gain

The initial body weight of the respective replicates was measured at the start of the experiment such that the body weights of birds among the replicates were similar. At the end of the experimental period (12 weeks), the body weight of birds in each replicate was measured as the final body weight. The mean body weight gain of the birds was calculated by subtracting the average weight of the birds at the start of the experiment from the average weight at the end of the study.

$$\text{Body weight gain} = \frac{\text{Final average body weight} - \text{Initial average body weight}}{\text{Number of birds}} \text{ by Youssef } \textit{et al.} \text{ (2021)}$$

Carcass Characteristics

The carcass characteristics were determined at the end of the twelfth week (35 weeks old). After an overnight fast (except for water), three (3) female birds per treatment were taken randomly, weighed individually as the live weight, and then sacrificed using electrical stunning before the severance of the jugular vein for proper bleeding. They were then singed in hot water (85°C) for 30 seconds, manually plucked, washed, and allowed to drain on wooden tables. Evisceration was performed by a ventral cut and visceral as well as thoracic organs were removed (Winter and Malinovsky, 1954; El-Tazi, 2014). The heart, liver, kidney, blood, feathers, intestine (full and empty), gizzard (full and empty), head, neck, and shanks were weighed individually and expressed as a percentage of carcass weight. The dressed carcasses were refrigerated for a few days. The dressing percentage was calculated as follows:

$$\text{Dressing percentage} = \frac{\text{dressed weight}}{\text{live weight}} \times 100\%.$$

Haematological and Biochemical Characteristics

Blood analysis was carried out to determine the effect of phytochemicals in the supplementary fresh leaves fed to Guinea fowls on haematology and biochemical characteristics. Blood samples from free-range Guinea fowls were compared to the blood characteristics of the dietary treatments. The birds taken for the blood profile were weighed and their body temperature was measured with a Thermo Trace Infrared Thermometer gun (model 15041). The blood samples were taken by inserting a sterilized 5 ml syringe into the right-wing vein of each bird and drawing 4 ml of blood which 2 ml was immediately discharged into sterilized vacutainer test tubes containing Ethylene Diamine Tetra Acetic Acid (EDTA) after the area was disinfected with cotton wool dampened with methylated alcohol spirit. The blood sample in each tube was shaken to uniformly mix with the EDTA to prevent coagulation. The samples were analysed for red blood cells, White Blood Cells, Platelets, Haemoglobin, Packed Cell Volume, Lymphocytes, Mean Corpuscular Haemoglobin/Mean Cell Haemoglobin, mean cell volume, and Mean Corpuscular Haemoglobin Concentration, using three-part Rayto Haematology Auto Analyser.

The remaining 2 ml of the blood sample was dispensed gently into plain vacutainer tubes without EDTA and kept in a vacuum flask with ice cubes for blood biochemical analysis. Total lipid and protein parameters such as total cholesterol, triglycerides, high-density lipoprotein, low-density lipoprotein as well as total protein, albumin, and globulin respectively were determined. The analysis was carried out at the A.B.C Medical Diagnostic Services Laboratory at Agona in the Ashanti region using a Mindray BA 88A semi-auto Chemistry analyser. The chemical used for the analysis was the ELITech brand.

Reproductive Parameters

Eggs collected from the respective treatments were assessed for external characteristics (misshaped and shell strength) and set in the incubator at the hatchery unit of the Animal Science Department, AAMUSTED. Fertility as

a measure of the percentage of fertile eggs of the total eggs set in the incubator was determined after 10 days of incubation using the candling technique procedure as described by FAO (2002). Hatchability was determined as a percentage of keets that are hatched from the fertile eggs. Keets quality characteristics including hatch weight, body length, shank length, and body condition score were taken on the hatch day.

Sensory/Organoleptic Analysis

The breast muscle of one frozen carcass each per treatment was harvested from which eight pieces each per treatment were cut and then 10g weight taken. The eight pieces each per treatment of the meat were then mixed with 2 g of common salt and 200 ml of clean water. These were then cooked concurrently on five separate gas cylinders at a cooking temperature range above 100 °C for 20 minutes. After cooking, the pieces of meat were placed and properly sealed individually in aluminum foil and labeled according to the meat sample. The pieces of the labeled meat were placed according to five treatments: CO (control), MO (*Moringa oleifera*), TT (*Talinum triangulare*), BD (*Boerhavia diffusa*), and TT+BD respectively.

Eight taste panelists consisting of four males and four females between the ages of twenty-five and thirty-five old were used to score colour, flavour, toughness, tenderness, and juiciness of the meat, according to the guidelines of Cross *et al.* (1978) and Wołoszyn *et al.* (2020). All the participants were trained in making inferences and recording the observational score for each sample. The panelist had a waiting period of 10 minutes between the meat sample tasting and the crossover effects of tasting meat samples were reduced by rinsing the mouth with water.

Five-point descriptive scales were used to evaluate aroma intensity (1 = extremely bland to 5 = extremely intense), overall juiciness (1 = extremely dry to 5 = extremely juicy), overall tenderness (1 = extremely tough to 5 = extremely tender), muscle fibre and overall tenderness (1 = extremely tough to 5 extremely tender), and overall flavour intensity (1 = extremely bland to 5 = extremely intense). Overall acceptance was calculated as the summation of the individual parameter score with the highest score of 30 from the 6 parameters. The panelist used the RAL-classic colour-coded chart to differentiate the colours of the meat samples (Maryland Metrics).

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis Systems (SAS) (2008) computer software (Gamst *et al.*, 2008). Differences among treatments were separated at a 5% significant level by the Duncan multiple range test. The statistical model used was defined as:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \varepsilon$$

Where,

Y represents the response variable being measured (e.g., egg production, haematology, biochemical profile, carcass characteristics, or organoleptic attributes).

β_0 is the intercept term, representing the baseline or average response when all the explanatory variables are zero.

β_1 , β_2 , β_3 , β_4 , and β_5 the coefficients associated with the explanatory variables X_1 , X_2 , X_3 , X_4 , and X_5 , respectively.

X_1 represents the first treatment, *Moringa oleifera* (supplemental fresh forage feeding).

X_2 represents the second treatment, *Talinum triangulare* (supplemental fresh forage feeding).

X_3 represents the third treatment, *Boerhavia diffusa* (supplemental fresh forage feeding).

X_4 represents the fourth treatment, a combination of *Talinum triangulare* and *Boerhavia diffusa* (supplemental fresh forage feeding).

X_5 represents the control treatment (no supplemental fresh forage feeding).

ε represents the random error term.

Results and Discussion

Proximate Composition of Basal Diet and Forages

The proximate composition of the basal diet and supplementary forages is shown in Table 2. The proximate composition results were similar to the calculated composition of the basal diet. The proximate composition of the

basal diet showed that crude protein and metabolizable energy (17.41 % and 2768.34 kcal kg⁻¹ respectively) were within the recommended nutrient required levels of the pearl Guinea fowl layer which ranged between 17-19 % and 2750-2900 kcal kg⁻¹ for crude protein and metabolizable energy respectively as reported (NRC,1994; Nahashon *et al.*, 2007).

The proximate composition of selected fresh leaves had higher moisture contents with *T. triangulare* having the highest moisture (92.2 %), followed by *B. diffusa* (88.03 %), combined *T. triangulare* and *B. diffusa* (73.09 %) and *M. olerifera* (72.46 %). The high moisture content of the leaves indicates a relatively shorter shelf-life of fresh plant and as a result, long storage would lead to spoilage owing to its susceptibility to microbial attack (Beegum *et al.*, 2014). Moringa with the highest dry matter had the highest nutrient composition relative to the other selected leaves. The crude protein of Moringa fresh leaves (10.59%) and metabolisable energy content (868.48 kcalkg⁻¹) were 75 %, 63 %, and 41 % higher than the *Talinum*, *Boerhavia* and the combined leaves (TT+BD) respectively. The proximate composition of the *B. diffusa* is marginally higher than the crude protein of 2.26 %, 82.22 % moisture, and 0.96 % ash but had relatively higher carbohydrate (10.56 %), ether extract (1.61 %) and crude fibre of 2.40 % (Ujowundu *et al.*, 2008). Abou-Elezz *et al.* (2012) reported 75 % moisture, 22.75 % crude protein and 27.63 % NDF for moringa leaves. These results were relatively higher compared to the values obtained in this present study. However, the results obtained showed the superiority of the Moringa plant as nutritious relative to the other forages used. The proximate composition of the combined leaves (TT+BD), appears to have had a synergetic effect on the nutrients as the combination gave a nutrient composition that is higher than their individual nutrient content. The combined leaves treatment was the closest nutrient content to that of Moringa fresh leaves.

Oluwatoyin *et al.* (2012) reported a low moisture content (22.6 %) and ash (1.0 %) but relatively higher crude protein (2.99 %), ether extract (0.65 %), carbohydrate (71.56 %), crude fibre (1.20 %) for *T. triangulare* as compared to values obtained in this present study. Variations in values of the proximate composition obtained are attributed to differences in edaphic factors, age of plant used, and processing procedures (Ahmed *et al.*, 2013).

Table 2: Proximate composition of basal diet and experimental supplementary forages

Parameters	Basal Diet CO	Forages			
		MO	TT	BD	TT+BD
Moisture Content (%)	12.00	72.46	92.20	88.03	73.09
Crude Protein (%)	17.41	10.59	2.67	3.99	6.19
Crude Fat (%)	3.68	1.39	0.33	0.43	0.75
Crude Fibre (%)	4.14	2.61	0.71	1.10	2.55
Ash (%)	10.68	2.58	1.63	1.65	3.61
Nitrogen Free Extract (%)	52.09	10.37	2.46	4.80	13.81
*Metabolisable energy (kcalkg ⁻¹)	2768.34	868.48	211.88	350.8	773.73

* Metabolisable energy (ME kcal/kg) was calculated according to the formula derived by Pazenga (1985); ME kcal/kg = (37 x % CP) + (81.8 x % EE) + (35 x % NFE). CO = Control, MO = *Moringa oleifera*, TT = *Talinum triangulare*, BD = *Boerhavia diffusa*, and TT+ BD = combination of *Talinum triangulare* and *Boerhavia diffusa*

Effect of Supplementary Selected Fresh Leaves on Productive Performance

The pearl Guinea fowls for dietary treatments had no comparative weight advantage over the others as evidenced by similar ($P = 0.275$) initial body weights (Table 3). Mean feed intake of basal diet and supplementary forage were significantly different among treatments. Guinea fowls fed supplemental *Boerhavia* (BD) had the highest ($P = 0.037$) basal diet intake as compared to that of *Talinum* (TT) and the combined forages (TT+BD) but not Moringa (MO) and the control (CO). Feed intake of the basal diet was lower as compared to 10,878 g/bird as reported by Nahashon *et al.* (2007). This lower value could be attributed to the supplementary forage feeding of the birds. Guinea fowls fed supplemental MO, TT, and TT+BD had similar ($P > 0.05$) feed intake. Guinea fowls showed preference for the *Talinum* fresh leaves by recording the highest consumption (1106.1 g) which was significantly different ($P < 0.001$) from that of 1012.3 g of *Boerhavia* fresh leaves which is also higher ($P < 0.001$) than *Moringa* fresh leaves (903.9 g) with MO been significantly higher than forage intake (808.7 g) of the combined leaves (TT+BD). The differences in forage consumed by the Guinea fowls could be attributed to the moisture level in the respective leaves which has an effect on the level of fibre in the leaves. Birds usually prefer the very tender parts of leaves to the fibrous ones which are less digestible but intake is also regulated by the bulkiness and energy concentration of the forage (Downs

et al., 2022). The higher moisture in leaves apart from augmenting birds to split leaves into small sizes for consumption also facilitates digestion by bacteria in the digestive tract of the bird. These beneficial bacteria ferment digestible fibre to promote gut health through “competitive exclusion” to get rid of pathogenic organisms from the intestines which ultimately improves nutrient utilization and productive performance (Esmail, 2012; Bonsu *et al.*, 2012). *Talinum* leaves comparatively had the highest moisture and lowest crude fibre (92.2 %; 0.71 % CF) followed by *Boerhavia* (88.03 %; 1.1 % CF), *Moringa* (72.46 %; 2.61 % CF), and the combined leaves (73.09 %; 2.55 % CF) (Table 2). The moisture level of the leaves had an inverse relationship with crude fat content. Water intake was significantly ($P < 0.001$) higher but similar for Guinea fowls fed the control diet (20621 ml), Birds supplemented with BD (20436 ml) and TT (19902 ml) forages than the water consumption of birds supplemented MO (18489 ml) that was also significantly ($P = 0.001$) higher than 16829 ml of the combined leaves (TT+BD) (Table 3). Water intake is a reflection of feed intake such that the more the feed intake the higher the water consumption in the ratio of 2 water: 1 feed (Manz *et al.*, 2019). Other factors that affect water intake include the prevailing weather conditions, the chemical composition of basal diet and forage, and the moisture content of the feed (Meyer-Rochow *et al.*, 2021). The highest water intake by Guinea fowls fed the control diet indicates that the supplementary selected forages had an effect on the overall water intake on the birds fed the forages as relatively lower water intakes were recorded. Phytochemicals present in leaves can influence water intake but based on results obtained, it appears not to have had an observable impact on water consumption of the birds in this study. Final body weight was significantly different ($P < 0.007$) among dietary treatments. Guinea fowls fed supplementary *Boerhavia diffusa* had the highest ($P < 0.007$) final body weight (2483 g) as compared to the other treatments which recorded similar final body weights. This is attributed to increased feed intake that probably might have been stimulated by the certain phytochemicals in the *Boerhavia* leaves like flavonoids, alkaloids, and glycosides (Salem *et al.*, 2022) which boost appetite for feed intake. It has been reported to have antioxidant and antibiotic properties and these are vital for intestinal modulation for better feed utilization (Ali *et al.*, 2021). Weight gained by layers that are producing eggs is an indication that nutrient uptake was enough for eggs and excess channeled to body weight. Hen-day egg production (HDEP) was not significantly influenced by supplementary forage feeding; however, birds fed the supplemented forages had values above that of the control birds numerically. External and internal egg characteristics were not significantly different among dietary treatments except for egg yolk colour which significantly differed. Mean egg weight among dietary treatments was within the range (34.0 g and 45.7 g) as reported by Karsli *et al.* (2013) except egg weight of the control (32 g) which was relatively lower. The egg yolk colour intensity was similar for eggs laid by the combined leaves (TT+BD), TT, and MO but more intense ($P < 0.001$) than that of BD. Birds on the control had the lowest ($P < 0.001$) egg yolk colour intensity. Plant leaves generally contain xanthophylls and carotenoids which are tetraterpene pigments exhibiting yellow, orange, and red colours produced in the plastids of plant cells (Sun *et al.*, 2022) that enhance egg yolk colour when consumed by the birds (Pirgozliev *et al.*, 2022). Plant leaves fed to layers therefore have the tendency to increase the egg yolk colour positively and have been the basis of forage feeding in layers producing table eggs for an enhanced egg yolk colour.

Table 3: Effect of supplementary selected fresh forages on productive characteristics of Guinea fowls

Parameters	CO	MO	TT	BD	TT+BD	SEM	L.S.D	P-Value
Initial body weight (g)	1888	1957	1833	1929	1872	74.3	124.4	0.275
Final body weight (g)	2142 ^b	2145 ^b	1992 ^b	2483 ^a	2050 ^b	39.5	234.0	0.007
Basal diet intake (g)	9148 ^{ab}	8874 ^{abc}	8711 ^{bc}	9620 ^a	8165 ^c	273.1	860.6	0.037
Forage intake (g)	0.0	903.9 ^c	1196.1 ^a	1012.3 ^b	808.7 ^d	13.00	40.96	<0.001
Water intake (ml)	20621 ^a	18489 ^b	19902 ^{ab}	20436 ^a	16829 ^c	488.2	1538.4	0.001
Mean HDEP (%)	53.3	55.8	56.8	67.1	63.2	9.87	21.99	0.625
FCR	3.73	3.27	3.5	3.29	3.41	0.187	0.416	0.164
BWG (g)	254 ^b	188 ^b	158 ^b	555 ^a	178 ^b	110	245.1	0.024
Mean egg weight (g)	32.0	39.0	40.3	41.6	39.4	2.51	7.15	0.077
MET (mm)	0.567	0.603	0.637	0.643	0.54	0.039	0.122	0.33
Albumin height (mm)	3.76	3.81	3.96	4.05	3.74	0.233	0.734	0.846
Egg width (mm)	46.18	42.67	45.23	46.6	43.42	1.68	5.295	0.433
Egg length (mm)	50.40	48.30	50.40	47.00	49.70	4.28	13.47	0.974
Yolk colour	5.00 ^c	10.67 ^{ab}	12.33 ^a	9.00 ^b	12.67 ^a	0.816	2.573	<0.001

^{a, b, c} : Values in the same row with different superscript letters are significantly different ($P < 0.05$), L.S.D = least significant

difference, SEM =Standard errors of means. CO = Control, MO = *Moringa oleifera*, TT = *Talinum triangulare*, BD = *Boerhavia diffusa*, and TT+ BD = combination of *Talinum triangulare* and *Boerhavia diffusa*, FCR=Feed conversion ratio, BWG=Body weight gained, MET=Mean eggshell thickness.

Haematology and Biochemical Characteristics

The body weights of Guinea fowls randomly taken and used for the blood profile were significantly different ($P = 0.001$). Body weight of birds fed the supplementary BD, MO, TT+BD and the Control had similar body weight but heavier than that of TT which was also similar to TT+BD with the free ranged Guinea fowls having the least weight (818 g) (Table 4). The body temperature of the Guinea fowls measured did not differ ($P = 0.394$) among the dietary treatments and were within the normal body temperature of 41.5 ± 1.0 °C (Bell, 1949; Shepherd, 1984; Mitchell *et al.*, 2005; Abioja and Abiona, 2021), an indication of a normal body state devoid of ill health. All the haematological parameters (Hb, RBC, PLT, WBC, MCHC, PCV, HCT, Lymph) did not differ significantly ($P > 0.05$) except the mean corpuscular volume (MCV) ($P < 0.023$) and mean corpuscular haemoglobin (MCH) ($P = 0.05$) which differed significantly (Table 4). MCV was higher for Guinea fowls supplemented with BD and the control as compared to that of MO, TT, and TT+BD which recorded similar values. MCH value was higher ($P \leq 0.05$) for birds supplemented with BD as compared with that of TT, TT+BD, and FR but not CO, and MO. The blood profile of the free-range Guinea fowl was similar ($P > 0.05$) or lower ($P \leq 0.05$) as compared to the dietary treatments. WBC levels were not significantly ($P > 0.05$) influenced by forage supplementation however number of cells was numerically higher for birds that had forage supplementation including those on FR. Digestible fibre promotes the activities of beneficial microbes including lactobacillus which stimulates different subsets of Th-2 Cytokines to increase the production of WBC (Keerthi *et al.*, 2021). MCV measures the average size and volume of the RBC and gives an indication of good transport of oxygen to cells for metabolic function (Paul *et al.*, 2020).

Table 4: Effect of supplementary fresh forage on haematological parameters

Parameters	CO	MO	TT	BD	TT+BD	FR	SEM	L.S.D	P-Value
Body weight (g)	2568 ^a	2002 ^a	1647 ^b	2588 ^a	2033 ^{ab}	818 ^c	226.1	696.6	0.001
Temperature (°C)	41.73	40.73	42.03	41.67	41.77	41.4	0.423	1.305	0.394
RBC /L	1.30	1.37	1.33	1.36	1.36	1.46	0.057	0.175	0.055
Hb g/dL	12.97	13.30	12.70	12.53	13.17	13.43	0.470	1.448	0.141
HCT %	26.10	26.73	25.63	23.63	26.57	28.6	1.059	3.264	0.106
Lymph %	71.33	67.67	71.33	68.00	72.67	67.33	2.269	6.991	0.438
Monocytes %	4.00	4.33	4.33	3.33	4.00	4.33	0.861	2.652	0.954
Monocytes $\times 10^9$ L	0.399	0.47	0.452	0.398	0.476	0.528	0.159	0.347	0.958
Neutrophil %	21.00	23.67	21.33	23.33	20.00	23.33	1.171	3.607	0.256
Neutrophil $\times 10^9$ L	1.86	2.70	2.22	2.71	2.55	2.81	0.351	1.08	0.413
MCHC g/dL	49.68	49.75	49.54	49.36	49.55	49.48	0.197	0.607	0.772
MCH pg	99.74 ^{ab}	97.07 ^{abc}	95.70 ^c	100.48 ^a	96.52 ^b	95.86 ^c	1.162	3.581	0.050
Basophile %	3.33	3.00	2.67	3.00	1.33	1.67	0.981	3.024	0.647
Basophil $\times 10^9$ L	0.446	0.323	0.251	0.353	0.153	0.238	0.125	0.386	0.656
Eosinophil %	1.33	1.33	1.00	2.33	2.33	2.00	0.491	1.512	0.302
Eosinophil $\times 10^9$ L	0.052	0.159	0.049	0.267	0.224	0.234	0.072	0.223	0.204
MCV fl	200.77 ^a	195.12 ^b	193.17 ^b	203.58 ^a	194.82 ^b	195.31 ^b	2.040	6.286	0.023
PCV	33.8	34.60	34.1	34.67	34.35	35.38	0.424	1.307	0.221
PLT $\times 10^9$ L	7.67	12.00	9.67	10.33	9.33	10.00	1.622	4.997	0.598
WBC $\times 10^9$ /L	9.13	11.3	10.27	11.57	12.60	12.00	1.565	4.821	0.672

^{a, b, c} :Values in the same row with different superscript letters are significantly different ($P < 0.05$), L.S.D =least significant difference, SEM =Standard errors of means. CO = Control, MO= *Moringa oleifera*, TT = *Talinum triangulare*, BD = *Boerhavia diffusa*, and TT+BD = combination of *Talinum triangulare* and *Boerhavia diffusa*, FR= Free Range Guinea fowl, Red Blood Cell (RBC), White Blood Cell (WBC), Platelets (PLT), Packed Cell Volume (PCV)/Haematocrit (HCT), Lymphocytes(LYM), Mean Corpuscular Volume/Mean Cell Volume (MCV), Mean Corpuscular Haemoglobin (MCH), Haemoglobin (Hb) and Mean Corpuscular Haemoglobin Concentration (MCHC).

Reduced MCV might indicate chronic inflammatory disorders and iron deficiency while increased MCV count could be Vitamin B12 deficiency, underactive thyroid, and or liver disease. MCV values obtained are within the recommended range of 80-100 fl (Soslau, 2020). Hematological values obtained are relatively higher for Hb, MCH, MCHC, lymphocytes, and WBC as compared to 11.81 g/dL, 73.77 pg, 33.63 %, 34.82 %, and 2.57×10^9 L respectively but had similar values to PCV (33.47 %) and MCV (209.1 fL) as reported by Obesse et al. (2018).

RBC values obtained ($1.30 - 1.46 \times 10^{12}$ L) were marginally lower to 1.77×10^{12} / L, as reported by Obesse et al. (2018) but were within the recommended range of $1.10 - 2.65 \times 10^{12}$ L (Oyewale and Ogwuegbu, 1986; Pandian et al., 2012).

The biochemical characteristics of the blood (Glucose, Albumin, Globulin, Basopil, Eosinophil, total protein, Triglycerol, urea, Bilirubin, Cholesterol, Sodium, and Calcium) were all not significantly ($P > 0.05$) influenced by the supplementary forage feeding except chloride content which was significantly ($P = 0.013$) influenced by the supplemental forages (Table 5). The blood chloride was higher in Guinea fowls reared on the free range as compared to that of Guinea fowls on the control, TT, BD, TT+BD but similar to that of MO. Improper processing or storage of forages can lead to microbial growth and fermentation. During these processes, certain bacteria can produce organic acids that contain chloride ions. If birds consume spoiled or fermented forages, it can introduce higher chloride levels into their system (Barboza et al., 2009). It could also be attributed to diverse sources of water to the free-range birds that can be high in chloride ions. Biochemical values obtained for globulin, total cholesterol, and urea are relatively higher as compared to values reported by Obesse et al. (2018) but had lower values recorded for total protein, albumin, potassium, calcium, and sodium.

Supplementary Forages on Reproductive Performance of Guinea Fowls

Table 5: Effect of supplementary selected fresh forages on biochemical characteristics of Guinea fowls

Parameters	CO	MO	TT	BD	T+BD	FR	SEM	L.S.D	P-Value
Blood Glucose	16.33	15.80	16.97	15.07	13.80	17.00	1.017	3.133	0.269
Albumin g/L	14.23	12.07	14.47	15.73	9.13	10.67	2.222	6.845	0.329
Total Protein g/L	36.6	39.5	31.3	36.3	25.7	27.2	3.91	12.05	0.145
Globulin g/L	22.4	27.4	16.8	20.6	16.5	15.7	3.44	10.58	0.203
Total Cholesterol mmol/L	4.03	3.53	3.43	3.17	2.87	2.83	0.728	2.242	0.846
HDL Cholest. mmol/L	1.63	1.67	1.73	1.90	1.33	1.33	0.378	1.164	0.867
LDL Cholest. Mmol/L	1.121	0.721	0.986	0.924	0.765	0.860	0.227	0.700	0.824
Triglycerol mmol/L	2.47	1.59	2.17	2.03	1.68	1.9	0.498	1.536	0.825
D Bilirubin mol/L	17.9	2.0	7.8	6.9	4.6	8.4	3.44	10.59	0.091
T Bilirubin mol/L	70.6	7.6	21.8	58.1	12.6	47.3	22.65	69.78	0.323
Urea mmol/L	2.43	1.73	2.07	1.80	2.20	2.50	0.384	1.185	0.646
Calcium mmol/L	11.73	12.83	10.53	13.50	13.37	20.73	2.244	6.915	0.085
Sodium mmol/L	134.3	135.3	131.7	136.7	135.0	138.3	2.87	8.860	0.693
Chloride mmol/L	104.00 ^b	110.00 ^{ab}	107.67 ^b	106.67 ^b	108.67 ^b	115.33 ^a	1.753	5.402	0.013
Potassium mmol/L	3.03	3.00	3.37	3.23	3.37	3.03	0.486	1.497	0.984

^{a, b, c} :Values in the same row with different superscript letters are significantly different ($P < 0.05$), L.S.D =least significant difference, SEM =Standard errors of means. CO = Control, MO= *Moringa oleifera*, TT = *Talinum triangulare*, BD = *Boerhavia diffusa*, and TT+BD = combination of *Talinum triangulare* and *Boerhavia diffusa*, FR= Free Range Guinea fowl

Presented in Table 6 is the effect of supplementary fresh forages on the reproductive performance of Guinea fowl meat. Supplementary forages influenced ($P < 0.05$) reproductive performance. Fertility of the eggs was higher ($P < 0.001$) for birds supplemented with TT (74 %) relative to BD (62 %) which was also higher ($P < 0.001$) than that

of eggs of MO. The fertility of eggs laid from MO-supplemented forage was also higher ($P < 0.001$) than the control (CO) and the combined leaves (TT+BD). Hatchability was higher ($P < 0.001$) for eggs laid from the control (78 %) than for birds fed supplementary TT (72 %) which was in turn higher than that of BD (60 %) and MO (59 %), with the least ($P < 0.001$) hatchability (50 %) observed from eggs laid by TT+BD supplemented forage. Good nutrition promotes fertility and hatchability positively among other factors. Certain phytochemicals present in forages, such as phenolic compounds and flavonoids, exhibit robust antioxidant properties in both laboratory tests (*in vitro*) and living organisms (*in vivo*), aiding in the promotion of reproductive processes (Saini *et al.*, 2016). Although the HDEP was not different among dietary treatments, there was a significant variation in egg fertility, and is attributed to the phytochemicals in the supplemented forages in different forms and quantities which might have contributed positively to the production of viable eggs. Guinea fowls have the peculiar challenge of pair-bonding where some Guinea hens are not married and thus produce infertile eggs. This has been one of the major factors for poor fertility among Guinea fowls. The ratio of Guinea cocks to Guinea hens (1:4) falls within the appropriate range for successful mating (Giri *et al.*, 2014; Atawalna *et al.*, 2022), however, some Guinea hens were still observed to continuously lay infertile eggs and affirming the pair-bonding. According to Hamidu (2021), ensuring adequate embryo quality and providing favorable incubation conditions are crucial factors for achieving successful hatching of eggs (Guinea keets). These elements significantly impact the hatchability of the fertile eggs of birds. The study conducted by Yamak *et al.* (2015) also highlights the correlation between fertility and hatchability in Guinea fowls where fertility and hatchability were 58.46 % and 80.53 % respectively which are marginally below some treatment values and also above other values obtained in this study.

Guinea keets characteristics (hatch weight, body length, and shank length) were all significantly ($P < 0.05$) influenced by supplementary forage. Guinea keets that hatched from dietary treatment that had TT were significantly ($P < 0.05$) higher for hatch weight, body length, and shank length. The improved hatchability and Guinea keet characteristics observed in this study can be attributed to the immunostimulatory effects and anti-stress properties present in *T. triangulare* leaves. The immunostimulatory effects enhance the immune system of the developing embryo and Guinea keets, safeguarding them against infections, diseases, and other health conditions (Saeed *et al.*, 2020). Consequently, this leads to enhanced hatchability and overall characteristics. It is worth noting that stress has a detrimental impact on the hatchability and development of guinea keets. However, the phytochemicals found in *T. triangulare* leaves potentially possess anti-stress properties (Arunprasath *et al.*, 2018). These properties help mitigate the adverse effects of stress on the embryos and keets, resulting in improved hatchability and enhanced characteristics, as observed in this study.

Table 6: Effect of supplementary fresh forages on reproductive performance of Guinea fowl meat

Parameters	CO	MO	TT	BD	TT+BD	SEM	L.S.D	P-Value
Fertility (%)	43.0 ^d	51.7 ^c	74.1 ^a	61.8 ^b	40.1 ^d	2.47	7.79	<.001
Hatchability (%)	78.39 ^a	59.31 ^c	72.45 ^b	60.13 ^c	50.17 ^d	1.687	5.316	<.001
Hatch weight (g)	29.09 ^{ab}	25.94 ^b	31.87 ^a	27.33 ^{ab}	27.84 ^{ab}	1.29	3.725	0.034
Body length (cm)	14.43 ^a	13.19 ^c	14.53 ^a	13.61 ^{bc}	13.93 ^{ab}	0.23	0.665	0.001
Shank length (cm)	2.37 ^b	2.39 ^b	2.59 ^a	2.39 ^b	2.41 ^b	0.0538	0.1555	0.047

^{a, b, c} :Values in the same row with different superscript letters are significantly different ($P < 0.05$), L.S.D =least significant difference, SEM =Standard errors of means. CO = Control, MO= *Moringa oleifera*, TT = *Talinum triangulare*, BD = *Boerhavia diffusa*, and TT+BD = combination of *Talinum triangulare* and *Boerhavia diffusa*

Supplementary Fresh Forages on Carcass Characteristics of Guinea Fowls

Table 7 presents the effect of dietary inclusion of supplementary fresh forages on carcass characteristics of pearl Guinea fowl as compared to the control diet with no fresh forage supplement. The live weight of birds randomly taken for the carcass characteristics was significantly ($P < 0.05$) different among treatments. Birds fed supplementary BD had the highest live weight (2770 g/bird) with that of TT+BD supplemented forage recording the least live weight (1613 g/bird) but similar to that of the live weights of birds fed with supplementary TT and MO.

Due to the significant live weight values recorded for the dietary treatments, the weights of organs were expressed as a percentage of the live weight to compensate for the differences in body weight. Selected forages supplementation did not significantly ($P > 0.05$) influence weight of organs (de-feathered weight, full intestine, full

gizzard, empty gizzard, heart, liver, kidney, shank, and dressing percentage of live weight) except empty intestine and neck percent of live weight which was influenced ($P = 0.018, 0.026$ respectively). Guinea fowls fed supplementary BD had the highest mean empty intestine percent live weight of 5.29 %, with the other treatments recording similar values of the empty intestine percent live weight. The differences observed are attributed to the high feed and forage intake of birds fed the supplementary BD fresh forage which might have increased the size and weight. Empty gizzard weight was not significant but numerically higher for birds that had supplementary fresh forage as compared to the control which is from the fibre level in the forage which increases the mechanical muscular activity of the gizzard resulting in marginal weight increase (Karasov and McWilliams, 2005; Sekh and Karki, 2022).

The non-significant but numerically higher empty gizzard weight observed in birds that had supplementary fresh forage compared to the control can be attributed to the fibre content present in the forage. Fresh forages typically contain higher levels of dietary fiber, including both soluble and insoluble fibers. The presence of fibre in the diet has been known to stimulate the mechanical muscular activity of the gizzard in poultry (van Wyk, 2022). The gizzard is a muscular organ responsible for grinding and breaking down food particles in birds. The mechanical action of the gizzard helps in the breakdown of feed and enhances the digestion and absorption of nutrients. When birds consume fresh forages with higher fibre content, it increases the workload on the gizzard due to the presence of indigestible components such as cellulose and lignin. The gizzard responds to this increased mechanical activity by exerting more force and muscular contractions during digestion, which can result in a marginal increase in gizzard weight. It is important to note that the observed increase in empty gizzard weight is not statistically significant, indicating that the difference between the groups may be small or affected by other factors. However, the numerical increase suggests that the inclusion of supplementary fresh forage stimulates the gizzard's activity and potentially contributes to its development and function. The non-significance difference observed also suggests that the forages supplemented were not fibrous.

Overall, the higher empty gizzard weight observed in birds that had supplementary fresh forage compared to the control can be attributed to the fibre level in the forage, which increases the mechanical muscular activity of the gizzard, resulting in a marginal weight increase. This finding highlights the role of dietary fibre in influencing the digestive processes and organ development in poultry (Tejeda and Kim, 2021).

Neck weight and visceral fat were also significantly ($P < 0.05$) influenced by the different supplementary fresh forages. Birds supplemented with MO had the heaviest neck (4.22 % live weight), as compared to the other treatments which had similar ($P > 0.05$) values. Proteins are essential for muscle growth and development, and *Moringa oleifera* leaves are known to contain relatively high levels of protein (Sahay *et al.*, 2017). The higher protein content in the diet supplemented with *M. oleifera* leaves may have provided the necessary building blocks for muscle protein synthesis, resulting in increased neck muscle development and subsequently higher neck weight.

M. oleifera leaves contain bioactive compounds such as flavonoids, polyphenols, and phytochemicals, which have been shown to have antioxidant and anti-inflammatory properties (Ma *et al.*, 2022; Milla *et al.*, 2021). These compounds may have contributed to improved muscle health and reduced oxidative stress, leading to better muscle development in the neck region.

Birds fed the control diet which had no supplementary forage accumulated the highest ($P = 0.014$) proportion of visceral fat (5.08 % live weight), as compared to birds that had fresh forage supplementation which had similar ($P > 0.05$) values of visceral fat.

The significant difference observed in the proportion of visceral fat between birds fed the control diet with no supplementary forage and birds that had fresh forage supplementation can be attributed to several factors, including the nutrient composition of the diets and the physiological responses of the birds to different feeding regimes.

The control diet, which lacked supplementary forage, may have provided a different nutrient profile compared to the diets with fresh forage supplementation. It is possible that the control diet contained higher levels of energy-dense ingredients, such as grains or fats, which are known to contribute to increased fat deposition in animals (Leeson and Summers, 2005; Her *et al.*, 2017). The higher proportion of visceral fat observed in birds fed the control diet (5.08 % of live weight) may be a result of the increased availability of energy from the diet, leading to higher fat accumulation in the visceral region.

On the other hand, birds that had fresh forage supplementation had similar values of visceral fat, indicating that the inclusion of fresh forages in the diet did not significantly affect fat deposition in the visceral region. This could be attributed to the composition of the fresh forages, which typically contain higher amounts of fibre, water, and lower energy content compared to concentrated feed ingredients (Bhattarai *et al.*, 2019). The higher fibre content in fresh forages may have contributed to increased gut motility and reduced nutrient absorption, thereby limiting the deposition of fat in the visceral region.

Furthermore, fresh forages, particularly those with higher fibre content, can promote satiety and reduce energy intake in birds (Medawar *et al.*, 2023). Birds consuming diets with fresh forage supplementation may have consumed fewer calories compared to those on the control diet, resulting in reduced fat deposition in the visceral region. It is important to note that fat deposition in poultry is a complex process influenced by various factors, including genetics, age, sex, and management practices (Hocquette *et al.*, 2010; Yamak *et al.*, 2018). The observed differences in visceral fat accumulation between the control diet and fresh forage supplementation should be interpreted within the context of this specific study and the factors mentioned above.

The higher proportion of visceral fat in birds fed the control diet without supplementary forage compared to birds with fresh forage supplementation may be attributed to the different nutrient composition of the diets (Zhao and Kim, 2017) and the potential influence of energy-dense ingredients in the control diet (Rahim *et al.*, 2011; Parmar *et al.*, 2022).

Table 7: Effect of supplementary fresh forage on carcass characteristics of pearl Guinea fowls (Expressed as a percentage of the live weight of the bird)

Parameters	CO	MO	TT	BD	TT+BD	SEM	L.S.D	P-Value
L wgt (g/bird)	2477 ^{ab}	2204 ^{abc}	1783 ^{bc}	2770 ^a	1613 ^c	227.1	715.7	0.026
ST Wgt (%)	97.31	97.61	96.81	97.44	96.97	0.312	0.982	0.400
DFwgt (%)	92.7	82.2	92.6	95.0	89.7	5.36	16.9	0.518
FI wgt (%)	6.21	5.55	5.31	6.25	5.21	0.365	1.151	0.200
EI wgt (%)	4.01 ^b	3.82 ^b	3.63 ^b	5.29 ^a	3.43 ^b	0.327	1.030	0.018
FG wgt (%)	2.36	2.37	2.91	2.17	3.44	0.374	1.177	0.179
EG wgt (%)	1.38	2.27	1.61	2.11	1.68	0.261	0.823	0.175
HT wgt (%)	0.319	0.349	0.415	0.403	0.348	0.027	0.085	0.137
Nk wgt (%)	3.02 ^b	4.22 ^a	2.83 ^b	3.23 ^b	2.97 ^b	0.265	0.835	0.026
Liver wgt (%)	1.45	1.99	1.43	1.25	1.44	0.252	0.794	0.356
Kid wgt (%)	0.041	0.045	0.049	0.038	0.055	0.006	0.018	0.321
Sk wgt (%)	1.75	1.89	2.16	1.80	1.93	0.126	0.398	0.253
Visceral fat (%)	5.08 ^a	3.07 ^b	2.20 ^b	1.71 ^b	1.60 ^b	0.614	1.936	0.014
Dressing (%)	72.78	72.18	73.75	74.24	72.37	0.902	2.844	0.462

^{a, b, c}: Values in the same row with different superscript letters are significantly different ($P < 0.05$), L.S.D = least significant difference, SEM = Standard errors of means. CO = Control, MO = *Moringa oleifera*, TT = *Talinum triangulare*, BD = *Boerhavia diffusa*, and TT+BD = combination of *Talinum triangulare* and *Boerhavia diffusa*, Wgt = Weight, L = live, ST = slaughtered, DF = De-feathered, FI = full intestine, EI = Empty intestine, FG = full gizzard, EG = Empty gizzard, HT = heart, Nk = Neck weight, Kid = Kidney, Sk = Shank.

Effect of Supplemental Forage Feeding on Organoleptic Attributes of Guinea Fowl Meat

Table 8 represents the subjective score on colour, flavour, juiciness, toughness, and tenderness of the Guinea fowl meat as influenced by supplementary feeding of selective forages. Guinea fowl meat is characterized by a darker colour and a unique flavour. It has a proper texture that is attributed to its white muscle fibres, which correspond in quantity to the muscles of chickens but in size to those of geese (Bernacki *et al.*, 2012a).

The result obtained showed that the colour, flavour, juiciness, and toughness of the meat were not significantly ($P < 0.05$) influenced by the feeding of the forages indicating that the panel could not discriminate meat from the control and that supplemented with forages on these parameters. But tenderness of the meat was significantly ($P < 0.05$) desirable in meat of birds fed the diet that had the combined TT and BD than all other treatment groups. Tenderness of meat is considered as the most important organoleptic attribute of meat (Seabra *et al.*, 2001), age of

birds was the same and thus variation in tenderness score could be due to the supplementary forage. Different types of forages can have an effect on meat tenderness and a variety of leaves could better promote tenderness depending on the degree of fibre present and nutrients in the forage. High fibre forage makes meat less tender (tough) while less fibrous forage makes the meat tender (Kumar *et al.*, 2022). This tenderness meat may be due to the disruption of the muscle structure by the intracellular proteolytic system and also may influence the role of the calpain system which is a calcium-dependent cysteine protease found in most eukaryotes (Warner *et al.*, 2022). The overall acceptance score of the meat was significantly ($P = 0.045$) higher for the meat of birds fed supplementary combined leaves (TT+BD) as compared to the meat acceptance of birds fed supplementary MO and TT but not BD and the control (CO). Supplementary feeding of the combined forage might have provided birds with a variety of phytochemicals and nutrients which might have influenced the overall meat acceptance.

Table 8: Effect of supplementary fresh forages on sensory/organoleptic evaluation of Guinea fowl meat

Parameters	CO	MO	TT	BD	TT+BD	SEM	L.S.D	P-Value
Colour	3.75	3.12	3.25	3.38	4.12	0.577	1.172	0.419
Flavour	3.62	3.50	3.62	3.75	4.50	0.628	1.275	0.524
Juiciness	3.75	2.50	3.50	3.62	3.75	0.566	1.149	0.164
Toughness	3.12	3.12	3.75	3.50	4.12	0.479	0.972	0.198
Tenderness	3.75 ^{cd}	3.25 ^{bc}	3.38 ^c	4.38 ^a	5.00 ^a	0.420	0.854	<.001
Overall acceptance	18.00 ^{ab}	15.50 ^b	17.50 ^b	18.62 ^{ab}	21.50 ^a	1.317	3.782	0.045

^{a, b, c} :Values in the same row with different superscript letters are significantly different ($P < 0.05$), L.S.D =least significant difference, SEM =Standard errors of means. CO = Control, MO= *Moringa oleifera*, TT = *Talinum triangulare*, BD = *Boerhavia diffusa*, and TT+BD = combination of *Talinum triangulare* and *Boerhavia diffusa*

Conclusion

The research concludes that supplementary fresh forage feeding had no adverse effect on egg production and egg characteristics, reproduction performance, haematological and biochemical characteristics, and carcass and meat quality. Fresh *Boerhavia diffusa* and *Talinum triangulare* gave relatively better productive performances and can be used as supplementary feeding for guinea fowls under intensive commercial production. Cost-benefit assessment and how much feed can be replaced by fresh forages need further studies to elucidate.

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Contribution by Authors

Equal contribution. All authors declared that ‘written informed’ consent was obtained from the approved parties for publication of this article and accompanying images.

Conflict of Interests

There is no conflict of interest.

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