Impact of *Cordyline fruticosa* leaf meal supplemented diet on growth performance, egg production, egg quality, and some heamatological indices of laying hen

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Abstract

At Sumitra Research Institute in Gujarat, India, research was carried out to ascertain the impact of *Cordyline fruticosa* on the growth performance, egg quality, production, and some heamatological indices of laying hens. 500 – 35 weeks Lohmann brown birds with an initial weight of 1717 grams were randomly distributed into five treatments with five replicates (20 hens per replicate). The basal diet was formulated according to the requirements of the birds. Hens in treatment 1 (control group) were fed basal diet only. The other experimental groups were fed the same diet with the addition of *C. fruticosa* meal at 10, 20, 30, and 40 g respectively in treatments 2, 3, 4, and 5. Birds were given free access to feed and clean water and a completely randomized design was adopted throughout the 90-day experimental period. Results showed that average weight gains and average daily feed intake followed a similar trend, birds fed *C. fruticosa* meal had higher body weight compared to the control in this order treatment 5 (T5) (1270.0 g), 4 (1263.0 g), 3 (1233.6 g), 2 (1230.0 g) and 1 (983.1 g) ($p < 0.05$) respectively. The treatment influenced the average daily feed intake, feed conversion, and mortality rate ($p < 0.05$). Hen day egg production and hen house egg production were higher in T5 (72.98%, 65.90%), T4 (72.72%, 69.85%), T3 (72.88%, 69.83%), intermediate in T2 (60.09%, 51.00%) and lower in T1 (51.19%, 41.85%). Eggshell strength, eggshell thickness, egg weight, albumen weight, yolk weight, yolk index, and haugh unit were significantly ($p < 0.05$) different among the treatments. Pack cell volume, haemoglobin, red blood cell, white blood cell, heterophil, and lymphocyte count were influenced by the treatment. However, values fall within the established range for healthy laying hen. It was concluded that *Cordyline fruticosa* meal can be fed to laying hens up to 40 g kg^{-1} diet without having any negative effect on their performance and health status.

Keywords: antibiotics, *Cordyline fruticosa* meal, laying hens, phytochemicals, food safety.

Impacto da dieta suplementada com farinha de folhas de *Cordyline fruticosa* no desempenho de crescimento, produção de ovos, qualidade dos ovos e alguns índices hematológicos de galinhas poedeiras

Resumo

No Sumitra Research Institute em Gujarat, Índia, foram realizadas pesquisas para determinar o impacto da *Cordyline fruticosa* no desempenho do crescimento, na qualidade dos ovos, na produção e em alguns índices hematológicos de galinhas poedeiras. Aves Lohmann Brown com 500 – 35 semanas e peso inicial de 1.717 gramas foram distribuídas aleatoriamente em cinco tratamentos com cinco repetições (20 galinhas por repetição). A dieta basal foi formulada de acordo com as necessidades das aves. As galinhas do tratamento 1 (grupo controle) foram alimentadas apenas com dieta basal. Os demais grupos experimentais foram alimentados com a mesma dieta com adição de farinha de *C. fruticosa* em 10, 20, 30 e 40 g respectivamente nos tratamentos 2, 3, 4 e 5. As aves tiveram livre acesso à ração e água limpa e foi adotado delineamento inteiramente casualizado durante todo o período experimental de 90 dias. Os resultados mostraram que o ganho médio de peso e o consumo médio diário de ração seguiram uma tendência semelhante, as aves alimentadas com farinha de C. fruiticosa tiveram maior peso corporal em comparação com o controle nesta ordem tratamento 5 (T5) (1270,0 g), 4 (1263,0 g), 3

(1.233,6 g), 2 (1.230,0 g) e 1 (983,1 g) (p < 0,05), respectivamente. O tratamento influenciou o consumo médio diário de ração, a conversão alimentar e a taxa de mortalidade (p < 0,05). A produção de ovos no dia da galinha e a produção de ovos no galinheiro foram maiores no T5 (72,98%, 65,90%), T4 (72,72%, 69,85%), T3 (72,88%, 69,83%), intermediária no T2 (60,09%, 51,00%) e menor em T1 (51,19%, 41,85%). A resistência da casca, a espessura da casca, o peso do ovo, o peso do albúmen, o peso da gema, o índice de gema e a unidade haugh foram significativamente (p < 0,05) diferentes entre os tratamentos. Volume celular, hemoglobina, hemácias, leucócitos, contagem de heterófilos e linfócitos foram influenciados pelo tratamento. No entanto, os valores estão dentro da faixa estabelecida para galinhas poedeiras saudáveis. Concluiu-se que a farinha de *Cordyline fruticosa* pode ser fornecida a galinhas poedeiras com até 40 g kg^{-1} de dieta sem causar qualquer efeito negativo no desempenho e no estado de saúde.

Palavras-chave: antibióticos, farinha de *Cordyline fruticosa*, galinhas poedeiras, fitoquímicos, segurança alimentar.

1. Introduction

Globally, antimicrobial resistance is a serious threat to human beings and animals due to the misuse of antibiotics in animal feed (Daniel, 2020; Singh et al., 2022). This prompted the European Union and other countries in 2009 to place a ban on the use of antibiotic growth promoters to promote food safety and livestock sustainability (Agubosi et al., 2022; Jenny, 2022). According to the World Health Organization in 2015, about 600 million people worldwide became ill after consuming contaminated food out of which 420,000 people died including 125,000 children under the age of five (Melina; Liliana, 2021).

The use of herbs and their extracts have been considered as one of the potential alternatives to antibiotics in animal production due to their non-toxic effect, no drug residue, and withdrawal period (Basharat, 2020). One of the useful underexplored medicinal plants is *Cordyline fruticosa* which is widely distributed in Australia, Europe, America, and Asia including India (Annisa et al., 2012; Dahlia et al., 2013). The plant belongs to the family Asparagaceae which consists of over 480 species, and it is an evergreen, perennial monocotyledonous shrub having diverse leaf colours with tuber-like rhizomes (Hossain et al., 2012; Fuedjaou et al., 2016).

Investigation of the phytochemical components in *C. fruticosa* leaves suggests that they are a valuable source of different classes of biologically active compounds such as phenols, alkaloids, flavonoids, saponins, terpenoids, and tannins at various concentrations with numerous pharmacological properties (antimicrobial, antifungal, antiviral, antioxidant, hepato-protective, immunostimulatory, anti-inflammatory amongst others) (Fouedjou et al., 2014; Ding et al., 2019). In folk medication, the infusion of *C. fruticosa* leaf was used in the treatment of pyrexia, arthritis, toothache, gastrointestinal disease, skin infections, cough, bronchitis, tooth decay, malaria, stomach cramps, and dysentery (Hemaiswarya et al., 2009; Elfita et al., 2019). They have also achieved the potential to inhibit the activities of *Escherichia coli*, *Streptococcus* spp, *Staphylococcus* spp, *Micrococcus* spp, *Bacillus* spp, and *Salmonella* spp capable of altering the intestinal flora of birds (Cox et al., 2000; Cox; Wright, 2013).

Previous studies have revealed that the utilization of plant extracts in the diet of birds is capable of promoting the growth of birds (Wen et al., 2019), promoting the secretion of endogenous enzymes (pepsin, trypsin, amylase) and reducing the transit time of digestion (An et al., 2018), promoting the proliferation of beneficial bacteria in the gut (Ahmed et al., 2015; Alagbe, 2021), stimulating the immune system of birds thereby reducing mortality (Muritala et al., 2021), improving palatability and modulating the fatty acid in the meat of animals (Hashemipour et al., 2013). However, most outcomes of these research have not been consistent due to variations in the age of plant used, dose or concentration administered, processing or extraction technique adopted, and geographical location amongst others (Endarin et al., 2016; Singh et al., 2021). There is also a dearth of information on the dietary supplementation of *C. fruticosa* leaf meal in laying hens. Evaluating its effects on hens will help to establish a tolerable level and promote food safety and livestock sustainability.

The essence of this research was to determine the impact of *Cordyline fruticosa* leaf meal on the growth performance, egg production, and quality as well as some haematological indices of laying hens.

2. Materials and Methods

2.1 Experimental site and ethical approval

The research was conducted at Sumitra Institute's poultry unit situated between 23o 13' N and 72o 41' E. The study was done according to the guidelines and requirements of procedures that had been authorized by the ethics council of the Institute (BN/006C/2020).

2.2 Collection and processing of Cordyline fruticosa leaf meal

Fresh and matured leaves of *C. fruticosa* were harvested from the biological garden of Sumitra Institute, Gujarat, India, in the month of January 2024. Harvested leaves were sent to the Department of Taxonomy for proper identification and authentication where a voucher number AG/09D/2004 was assigned to it. Leaves were air-dried under a roof for 12 days until a constant weight was achieved, and then ground with an electronic blender stored in labeled zip lock nylon bags, and transferred to the Sumitra research laboratory for further examination.

2.3 Animal care and experimental design

500 – 35 weeks Lohmann brown birds with an initial weight of 1717 g were purchased from a reputable hatchery in Gujarat and transferred to the Poultry section of Sumitra Institute, India and randomly distributed into five treatments with five replicates (20 hens per replicate). Birds were raised in a specially constructed galvanized battery cage with automated nipple drinkers and feeders in a semi-sided pen and equipped with fluorescent lamps to provide light for 16 hours per day and to increase feed intake/laying. Before the beginning of the experiment, cages were properly disinfected with Morigad at the rate of 2 mL to 10 L of water. Birds in treatment 1 were fed a regular diet (layers mash) while those in treatment 2, 3, 4, and 5 were fed a regular diet supplemented with *C. fruticosa* leaf meal at 10, 20, 30, and 40 g kg^{-1} diet respectively. The feed used in this trial was consistent with the recommendation by Nutritional Research Council in 1994 as shown in (Table 1). Hens had free access to water and feed was provided twice a day (6:00 and 14:00). They were cared for according following commercial management techniques and the whole experiment lasted for 90 days adopting a completely randomized design.

Table 1. Gross composition of standard diet expressed in dry matter basis.

Feed ingredient used	The amount used expressed in kg^{-1}
Corn	50.00
Wheat offal	10.00
Soya bean meal	30.00
Bone meal	3.00
Limestone	6.00
Lysine	0.20
Methionine	0.25
*Mineral/Vitamin Premix	0.25
Salt	0.30
Total	100.00
Analyzed values	
Crude protein (%)	17.85
Crude fibre (%)	6.33
Ether extract (%)	4.06
Ash (%)	8.77
Metabolizable energy expressed in kcal/kg^{-1}	2708.4

Note: 2.5 kg of layer premix contained to 1 ton of feed is made up of Thiamine, 3000 mg, riboflavin, 6000 mg, pyridoxine, 3500 mg, cyanocobalamin, 1000 mg, niacin, 25,000 mg, Pantothenic acid, 12,000 mg, folate, 500 mg, biotin, 1000 mg, Retinyl acetate, 10,000 iu., cholecalciferol, 2,000,000 iu., tocopherol, 20,000 iu., ascorbic acid, 52,000 mg, Manganese, 8200 mg, Iron, 6,200 mg, Zinc, 300 mg, Copper, 200 mg, Cobalt, 150 mg, Iodine, 200 mg, Selenium, 100 mg, choline chloride, 50,000 mg. Source: Author, 2024.

2.4 Parameters measured

2.4.1 Growth performance

Feed consumed was estimated as the difference between the feed offered and the leftover (remnants)

Average daily feed intake = Total feed intake divided by the number of experimental periods

Average daily weight gain = Total weight gain divided by the number of experimental periods

Feed conversion ratio = Average daily feed intake divided by the average daily weight gain

2.4.2 Egg production estimation

Eggs were collected three times a day from each replicate at 0800, 1200, and 1600 hours. The sum of the three collections along with the number of birds alive on each day was recorded and computed at the end of the period. Hen-day egg production (HDP) and hen-housed egg production (HHP) were calculated using the formula below:

% HDP = total number of eggs produced/total number of hens present on that day multiplied by 100

% HHP = total number of eggs produced/number of hens originally housed multiplied by 100

2.4.3 Egg quality analysis

At the end of the experiment, egg analyzer TM (Model GT08-12A, China) was used to examine the eggshell strength, eggshell thickness, yolk weight, yolk length, and yolk colour from twenty eggs randomly selected from each replicate. Egg weight was carried out using a Smeg digital stainless scale. Orka's digital haugh tester (Model TD-0029F, China) was used to measure the height of albumen while the haugh unit was estimated manually using the formula below:

$$\text{Haugh unit} = 100 \times \log (H - 1.7 \times W0.37 + 7.6)$$

Where H: height of albumen (mm); W: egg weight (g)

2.4.4 Phytochemical evaluation of *Cordyline fruticosa* leaf meal

The laboratory procedures recently published by (Alagbe, 2024) were used for the determination of total phenols, tannins, alkaloids, saponins, flavonoids, and steroids. Plants were examined at different optical densities for quantification using gas chromatography-mass spectrometry at 460 nm, 506 nm, 350 nm, 610 nm, 602 nm, and 410 nm respectively. GC/MS Tripod (Model 81W-009C, China) was used and maintained to an inlet temperature of 406 ℃, scan rate of 12,000 amu/seconds, mass range (2.00 - 1,500 amu), filament emission current (400 µA) and pressure range of 120 psi to obtain an accurate result.

2.4.5 Proximate evaluation of experimental diet

Near infra-red kit (Model: TNOP NIRSTM, Netherlands) was used to analyze the experimental diet. 300 g of sample was placed in a collection tray after putting on the start button and the kit was operated according to the manufacturer's recommendation. The result was obtained within 60 sec and printed out from the visual display unit. To ensure precision in results, optical band, data resolution, and wavelength were maintained at 9.00 nm, 0.6 nm, and 2600 nm respectively.

2.4.6 Blood analysis

At the end of the trial, 2 mL of blood samples were collected from the wing vein of ten randomly selected birds per treatment into a labeled sample bottle with anticoagulant (ethylene diamine tetra acetic acid) and placed in an ice pack before it was sent immediately to Sumitra research laboratory, Gujarat for further evaluation. Parameters examined include pack cell volume, red blood cell, haemoglobin, white blood cell, heterophils, and lymphocytes. Samples were analyzed using a DXH 560 AL haeamtology analyzer (Model HA/003C, China) and maintained at an ambient temperature of 18 - 32 ℃ and humidity of 80% to ensure accuracy in the result.

2.5 Data analysis

Data obtained (growth performance, egg production egg quality, and heamatological parameters) were analyzed using the general linear model procedures of Statistical Analysis Systems software (SAS) with the model containing treatments. Differences between treatment means were separated using *Tukey's* test (SAS, 2001). Significant differences were declared at $p < 0.05$.

3. Results

Phyto-constituents analysis of *C. fruticosa* leaf meal (Table 2 and Figure 1) showed that flavonoid had the highest concentration of 1007.5 mg/g followed by phenol (672.81 mg/g), terpenoid (560.2 mg/g), tannin (402.7 mg/g), alkaloid (201.5 mg/g), saponin (102.9 mg/g) and steroid (35.10 mg/g) respectively.

Table 2. Phyto-constituents in *Cordyline fruticosa* leaf meal.

Constituent's	Concentrations expressed in mg/g^{-1}
Phenols	672.81
Tannins	402.7
Alkaloids	201.5
Flavonoids	1007.5
Saponins	102.9
Steroids	35.10
Terpenoids	560.2

Source: Author, 2024.

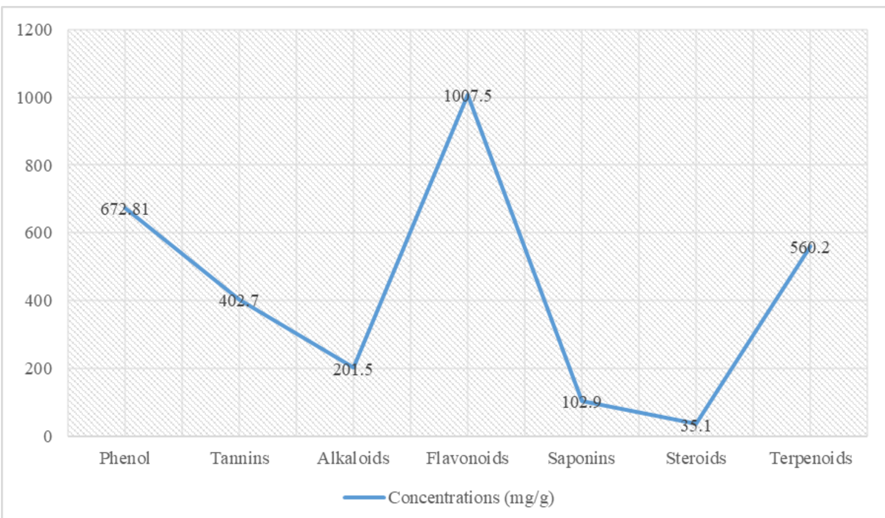

Figure 1. Composition of phyto-constituents of *Cordyline fruticosa* leaf meal. Source: Author, 2024.

As revealed in Table 3, the growth performance of laying hens fed a diet supplemented with *C. fruticosa* leaf meal. The average daily weight gain of hens fed *C. fruticosa* leaf meal at 10 kg (treatment 2), 20 g *C. fruticosa* leaf meal/kg^{-1} diet (treatment 3), and 30 g/kg^{-1} (treatment 4) was similar ($p > 0.05$) to those fed 40 g/kg^{-1} in treatment 5 but significantly higher ($p < 0.05$) than those in the control in treatment 1 (no *C. fruticosa* leaf meal). Average daily feed intake among all the treatments was influenced ($p < 0.05$) by the supplementation of *C. fruticosa* leaf meal in the diet of hens. The only mortality was recorded among birds in treatment 1 with 1.22% ($p < 0.05$). Average weight gain, average daily weight gain, total feed intake, and average daily feed intake values fell between 983.1 – 1270.0 g, 10.92 – 14.11 g, 10912 – 11209 g, and 121.4 – 124.5 g correspondingly.

Table 2. Growth performance of laying hens fed diet supplemented with *Cordyline fruticosa* leaf meal.

Indices	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	*P-value*
Average initial body weight	1717 ± 0.01	1717±0.01	1717±0.01	1717±0.01	1717±0.01	0.003
Average final body weight	2700.0^{b}±2.01	2943.0^{a}±2.04	2950.0^{a}±1.88	2980.0^{a}±1.82	2987.0^{a}±1.02	0.506
Average weight gain	983.1^{b}±0.03	1230.0^{a}±0.05	1233.6^{a}±0.03	1263.0^{a}±0.03	1270.0^{a}±0.04	0.112
Average daily weight gain	10.92^{b}±0.08	13.58^{a}±0.07	13.70^{a}±0.09	14.00^{a}±0.06	14.11^{a}±0.08	0.174
Total feed intake	10912^{b}±7.19	11203^{a}±9.67	11205^{a}±8.02	11208^{a}±5.92	11209^{a}±6.00	0.161
Average daily feed intake	121.4^{b}±3.08	124.4^{a} ±3.19	124.5^{a} ±3.21	124.5^{a} ±2.60	124.5^{a}±3.72	0.284
Feed conversion ratio	2.41^{a}±0.74	2.03^{b}±0.52	2.03^{b}±0.40	2.02^{b}±0.55	2.02^{b}±0.61	0.117
Mortality (%)	1.22±0.09^{a}	-	-	-	-	0.0001

Note: (-) not determined. Means on the same row having different superscripts are significantly different ($p < 0.05$); T1; treatment 1 (control): basal diet without *C. fruticosa* leaf meal; T2: basal diet with 10 g *C. fruticosa* leaf meal/kg^{-1} diet; T3: basal diet with 20 g *C. fruticosa* leaf meal/kg^{-1} diet; T4: basal diet with 30 g *C. fruiticosa* leaf meal/kg^{-1} diet; T5: basal diet with 40 g *C. fruticosa* leaf meal/kg^{-1} diet. Source: Author, 2024.

Egg production of hens supplemented with *C. fruticosa* leaf meal presented in (Table 3) revealed that hen day egg production and hen house egg production followed a similar trend. Values obtained were higher in hens-fed treatment 3 (20 g/kg^{-1}), treatment 4 (30 g/kg^{-1}) and treatment 4 (40 g/kg^{-1}), intermediate in treatment 2 (10 g/kg^{-1}), and lower in birds-fed control diet (treatment 1) ($p < 0.05$). The reported values also took the form of 51.19 to 72.98% and 41.85% to 65.90% respectively.

Table 3. Egg production of hens fed diet supplemented with *Cordyline fruticosa* leaf meal.

Indices	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	*P value*
Hen day egg production	51.19^{c} ± 10.4	60.09^{b} ± 8.77	72.88^{a}± 9.48	72.72^{a} ± 11.3	72.98^{a} ± 10.9	0.021
Hen-housed egg production	41.85^{c} ± 7.08	51.00^{b} ± 9.83	69.83^{a}± 9.00	69.85^{a} ± 8.82	65.90^{a} ± 9.10	0.042

Note: Means on the same row having different superscripts are significantly different ($p < 0.05$); T1; treatment 1 (control): basal diet without *C. fruticosa* leaf meal; T2: basal diet with 10 g *C. fruticosa* leaf meal/kg^{-1} diet; T3: basal diet with 20 g *C. fruticosa* leaf meal/kg^{-1} diet; T4: basal diet with 30 g *C. fruticosa* leaf meal/kg^{-1} diet; T5: basal diet with 40 g *C. fruticosa* leaf meal/kg^{-1} diet. Source: Author, 2024.

As presented in Table 4, egg quality parameters of hens fed a diet supplemented with *C. fruticosa* leaf meal. Eggshell strength, thickness, eggshell, egg weight, albumen height, albumen weight, yolk weight, yolk colour, yolk height, and haugh unit values show similarities in their trend. Hens fed diet supplemented with *C. fruticosa* leaf meal at 20 g/kg^{-1} (treatment 3), and 30 g/kg^{-1} (treatment 4) were similar to those fed treatment 5 (40 g/kg^{-1}). The obtained values fell between 3.08 – 4.79 kg/cm^{2}, 0.22 – 0.45 mm, 7.11 – 9.61 percent, 47.42 – 53.85 g, 4.77 – 8.01 mm, 21.06 – 28.14 g, 16.38 – 22.18 g, 6.41 – 11.09, 39.80 – 43.75 mm, 40.10 – 45.92 mm and 71.35 – 87.60 respectively.

Table 4. Egg quality parameters of hens fed diet supplemented with *Cordyline fruticosa* leaf meal.

Indices	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	*P value*
Eggshell strength (kg/cm^2)	$3.08^b \pm 0.04$	$3.51^b \pm 0.02$	$4.50^a \pm 0.03$	$4.78^a \pm 0.05$	$4.79^a \pm 0.04$	0.112
Eggshell thickness (mm)	$0.22^b \pm 0.01$	$0.29^b \pm 0.00$	$0.41^a \pm 0.02$	$0.43^a \pm 0.01$	$0.45^a \pm 0.01$	0.153
Eggshell (%)	$7.11^b \pm 0.03$	$7.31^b \pm 0.03$	$9.45^a \pm 0.03$	$9.50^a \pm 0.03$	$9.61^a \pm 0.03$	0.168
Egg weight (g)	$47.42^b \pm 5.60$	$49.60^b \pm 4.41$	$53.00^a \pm 3.82$	$53.09^a \pm 4.03$	$53.85^a \pm 4.00$	0.421
Albumen height (mm)	$4.77^b \pm 0.18$	$5.00^b \pm 0.22$	$7.77^a \pm 0.32$	$7.90^a \pm 0.45$	$8.01^a \pm 0.28$	0.172
Albumen weight (g)	$21.06^b \pm 0.10$	$21.33^b \pm 0.05$	$27.91^a \pm 0.08$	$28.06^a \pm 0.06$	$28.14^a \pm 0.06$	0.160
Yolk weight (g)	$16.38^b \pm 1.12$	$17.10^b \pm 1.10$	$22.10^a \pm 1.49$	$22.15^a \pm 1.03$	$22.18^a \pm 1.00$	0.988
Yolk colour	$6.41^b \pm 0.02$	$10.90^b \pm 0.01$	$10.98^a \pm 0.03$	$11.05^a \pm 0.02$	$11.09^a \pm 0.01$	0.291
Yolk length (mm)	$39.80^b \pm 5.31$	$40.20^b \pm 5.40$	$43.32^a \pm 5.81$	$43.40^a \pm 5.05$	$43.75^a \pm 5.69$	0.166
Yolk height (mm)	$40.10^b \pm 3.48$	$40.67^b \pm 3.50$	$45.80^a \pm 2.61$	$45.88^a \pm 3.00$	$45.92^a \pm 2.84$	0.128
Yolk index (%)	$0.25^b \pm 0.06$	$0.40^a \pm 0.02$	$0.42^a \pm 0.22$	$0.44^a \pm 0.36$	$0.45^a \pm 0.50$	0.0001
Haugh unit	$71.35^b \pm 4.16$	$71.33^b \pm 4.03$	$87.10^a \pm 4.00$	$87.15^a \pm 3.91$	$87.60^a \pm 3.88$	0.122

Note: Means on the same row having different superscripts are significantly different ($p < 0.05$); T1; treatment 1 (control): basal diet without *C. fruticosa* leaf meal; T2: basal diet with 10 g *C. fruticosa* leaf meal/kg^{-1} diet; T3: basal diet with 20 g *C. fruticosa* leaf meal/kg^{-1} diet; T4: basal diet with 30 g *C. fruticosa* leaf meal/kg^{-1} diet; T5: basal diet with 40 g *C. fruticosa* leaf meal/kg^{-1} diet. Source: Author, 2024.

As reported in Table 5, haematological parameters of hens fed diet supplemented with Cordyline fruiticosa leaf meal. Red blood cell count [2.07 to 2.96 ($\times 10^{12}$/L)], haemoglobin concentration (8.04 to 11.83 g/dL), pack cell volume (28.06 to 32.10 percent), white blood cell count [12.18 to 16.14 ($\times 10^9$/L)], heterophils (28.03 to 36.03 percent) and lymphocytes (59.40 to 73.33 percent) correspondingly.

Table 5. Haematological parameters of hens fed diet supplemented with *Cordyline fruticosa* leaf meal.

Indices	Treatment 1	Treatment 2	Treatment 3	Treatment 4	Treatment 5	Ref. values	*P value*
Red blood cell*	$2.07^b \pm 0.01$	$2.14^b \pm 0.00$	$2.88^a \pm 0.01$	$2.90^a \pm 0.00$	$2.96^a \pm 0.01$	2.00 – 4.00	0.021
Haemoglobin (g/dL)	$8.04^c \pm 0.03$	$9.03^b \pm 0.02$	$11.40^a \pm 0.01$	$11.80^a \pm 0.00$	$11.83^a \pm 0.02$	6.50 -15.00	0.005
Pack cell volume (%)	$28.06^b \pm 3.95$	$29.14^b \pm 4.12$	$31.92^a \pm 5.00$	$32.06^a \pm 4.14$	$32.10^a \pm 5.03$	26.0 – 36.0	0.110
White blood cell**	$12.18^b \pm 2.11$	$15.32^a \pm 1.96$	$15.77^a \pm 2.04$	$16.03^a \pm 2.00$	$16.14^a \pm 1.84$	9.0 – 21.00	0.017
Heterophils (%)	$28.03^c \pm 4.00$	$30.18^b \pm 3.91$	$35.84^a \pm 2.91$	$36.00^a \pm 3.03$	$36.03^a \pm 3.69$	18.0 – 40.0	0.402
Lymphocytes (%)	$59.40^c \pm 12.5$	$66.87^b \pm 10.8$	$71.44^a \pm 11.5$	$72.86^a \pm 12.7$	$73.33^a \pm 12.0$	40.0 – 87.0	0.071

Note: *Red blood cell (x10^{12}/L). **White blood cell (x10^9/L). Means on the same row having different superscripts are significantly different ($p < 0.05$); T1; treatment 1 (control): basal diet without *C. fruticosa* leaf meal; T2: basal diet with 10 g *C. fruticosa* leaf meal/kg^{-1} diet; T3: basal diet with 20 g *C. fruticosa* leaf meal/kg^{-1} diet; T4: basal diet with 30 g *C. fruticosa* leaf meal/kg^{-1} diet; T5: basal diet with 40 g *C. fruticosa* leaf meal/kg^{-1} diet. Source: Author, 2024.

4. Discussion

Phyto-constituent profile of the *Cordyline fruticosa* leaf meal showed that it contains numerous compounds with pharmacological properties (Musa et al., 2021; Adewale et al., 2021). Phenols function as local intestinal antioxidants which can reduce cellular oxidative damage in birds (Phil, 2021; Ojediran et al., 2024). Many Phyto-constituents have antimicrobial activities for instance, tannins, flavonoids, terpenoids, and alkaloids develop their actions against pathogenic bacteria's by interacting with their cell membrane thus causing a conformational change in their membrane structure leading to the leakage of ions (Phil, 2021; Alagbe et al., 2022).

Reports by Manu (2022) have shown that saponins can improve the permeability of the gut walls of animals leading to improved absorption of minerals and nutrients in the body. Flavonoids and tannins have also been suggested to lower gut inflammation, modulate cytokine production from macrophages, and support the development of acquired immunity (Stephanie, 2022; Alagbe, 2024). Alkaloids and steroids possess hepato-protective, analgesic, and antimalarial properties (Singh et al., 2022). Results on phenol (672.81 mg/g^{-1}) and flavonoid (1007.5 mg/g^{-1}) concentrations obtained in this study were higher than the values reported by Elfita et al. (2021). However, the result conforms with the report of Shihabudeen et al. (2010). The discrepancies in their outcome could be attributed to the processing or extraction method adopted, specie as well as geographical location (Shittu; Alagbe, 2020; Alagbe et al., 2020; Shittu et al., 2021).

Outcome on growth performance showed that dietary supplementation of *C. fruticosa* leaf meal at 10 g/kg^{-1} diet (treatment 2), 20 g *C. fruticosa* leaf meal/kg^{-1} diet (treatment 3), 30 g/kg (treatment 4) and 40 g/kg (treatment 5) resulted in a significant increase in average final body weight of hens compared to the control (treatment 1). This suggests that the *C. fruticosa* leaf meal has the potential to enhance the growth of birds, in particular the feed conversion ratio. The synergy of Phyto-constituents in *C. fruticosa* leaf meal in the diet can increase the activities of endogenous enzymes and influence uptake and transepithelial transport thus improving nutrient digestion and absorption in the body of birds (Stephanie, 2022). The findings of the present study (1717.0 – 2987.0 g) were similar to those of Cabuk et al. (2006), who revealed that the final body weight of hen fed diet supplemented with herbal essential oil was between 1888 – 2000 g.

It also confirms the earlier reports of Botsoglou et al. (2000) who recorded an average final weight of 1833 – 2300 g when laying hens were fed a diet supplemented with rosemary, oregano, saffron, and α-tocopheryl acetate. Similarly, there was arousal in the appetite of birds fed *C. fruticosa* leaf meal compared to the control treatment which suggests that it contains a pleasant aroma and triggers the increased secretions of enzymes which optimizes digestion and degradation of metabolic products as well as the absorption and metabolic conversion of supplied feed nutrients (Adewale et al., 2021; Alagbe et al., 2022).

The results obtained align with the reports of Olgun & Yildiz (2014) when laying hens were fed a diet supplemented with an essential oils mixture. A similar observation was made by Akbarian et al. (2011) who supplemented laying hen's diet with ginger root extract. No mortality was recorded among birds fed *C. fruticosa* leaf meal which suggests that it contains some vital bioactive compounds with therapeutic properties such as antibacterial, antioxidant, anti-inflammatory, immune-stimulatory, and antimicrobial amongst others which also resulted in a significant improvement in their feed conversion ratio (Singh et al., 2022). The outcome of this result confirms the earlier reports of Bozkurt et al. (2014) who examined the effect of herbs and essential oils on the performance of hens.

Dietary supplementation of *C. fruticosa* leaf meal also resulted in a significant increase in hen-day egg production and hen-housed egg production. This confirms that it can efficiency of the feed conversion ratio which translates into more egg production. According to Nuraini et al. (2007), the feed conversion of birds can be used as an index to ascertain the extent of egg production, birds with low values make more efficient use of feed to produce eggs. The current study was in line with the reports of Sosin-Bzducha & Krawczyk (2012); Merina et al. (2018) and Muhammad et al. (2021) who reported similar results on response to various levels of plant extracts in diets in laying chickens. In contrast, Santoso & Fenita (2016) noted non-significant results on hen day production and hen-housed production of laying hen-fed Sauropus androgynous leaf extract at 45 g/kg^{-1} diet.

Eggshell strength, eggshell thickness, egg weight, eggshell, albumen height, albumen weight, yolk weight, yolk colour, yolk height, yolk length, and haugh unit were positively influenced as the level of *C. fruticosa* leaf meal increased in the diet of laying hens. The result indicates that *C. fruticosa* leaf meal could contain some essential minerals such as Calcium, Phosphorus, Potassium, Magnesium, and Manganese which could ensure good eggshell quality, as well as xanthophylls which may influence the yolk colour of eggs (Ebenebe et al., 2013; Durmus et al., 2004).

According to Alagbe (2024), and Ojediran et al. (2024), most medicinal plants possess both nutritional and pharmacological properties. Odunsi et al. (2002); Oluyemi and Roberts (2000), reported that a yolk index in hens between 0.30 - 0.55% is an indication of the good internal quality of eggs especially from birds fed leaf meal-based diets. Nobakht & Moghaddam (2012) also noted a positive correlation between Haugh unit, yolk, and albumen. Therefore, an increase in egg weight translates to an increase in albumen and yolk weight. This might explain the increase in albumen weight in groups fed diets supplemented with Cordyline fruiticosa leaf meal relative to the control in treatment 1. Results obtained in this current study is in agreement with the findings of Abdel-Wareth (2013) when thyme and oregano were supplemented in the diet of laying hens.

Haematological indices are tools used to ascertain the health status of an animal as well as their nutritional status (Daniel et al., 2024; Ma et al., 2005). Pack cell volume values obtained in this study were within the normal range (26.0 – 36.0%) cited by Abdulkarim et al. (2011); Agubosi et al. (2022). Pack cell volume is used to diagnose polycythemia, anemia, dehydration, and other health conditions in animals (Daniel; Alagbe, 2023; Muritala et al., 2022). Red blood cell and haemoglobin values were within the normal values [(2.00− 4.00 ($\times10^{12}$/L)] and (6.50 – 15.0 g/dL) reported by Sayiedpiran et al. (2011) and Özek et al. (2011). Red blood cell carries oxygen and deliver them to the different body tissues from the lungs to the heart and other parts of the body (Alagbe, 2022; Alagbe, 2023). Low red blood cell and haemoglobin count may indicate bone marrow damage, hemorrhagic infections, metabolic disorders, chronic inflammation, and vitamin 12 deficiency (Musa et al., 2021).

Red blood cell, haemoglobin, and packed cell volume values were higher among birds fed 20 g *C. fruticosa* leaf meal per kg diet in treatment 3, 30 g *C. fruticosa* leaf meal/kg^{-1} diet (treatment 4), and 40 g *C. fruticosa* leaf meal per kg diet (treatment 5) relative to other treatments. However, values were within the established range reported in the Merck Veterinary manual (2001), this result suggests that the laying hens were healthy. White blood cell values are responsible for fighting infections via the production of antibodies (Anuore, 2024; Antruejo et al., 2011). White blood cell, heterophils, and lymphocyte values recorded in this experiment were within the normal range [(9.00 – 21.00 ($\times10^{9}$/L)]; 18.00 – 40.0% and 40.0 – 87.00 respectively reported by Najaf et al. (2010) and Sayiedpiran et al. (2011).

White blood cell count in laying hens fed treatment 2, and treatment 3 were similar ($p > 0.05$) to those in treatment 4 and treatment 5 but significantly higher ($p < 0.05$) than those in treatment 1. Conversely, heterophil and lymphocyte count follow a similar pattern as values were higher in birds fed treatment 3, treatment 4, and treatment 5, intermediate in treatment 2 and lower in treatment 1 ($p < 0.05$). Low white blood count suggests deficiencies in minerals and vitamins, bacteria or viral infections, liver disease, and enlarged spleen (Omokore; Alagbe, 2019; Agubosi et al., 2022). Lymphocytes are immune cells capable of defending the body against pathogens and infections (Daniel et al., 2024).

5. Conclusions

In conclusion, dietary supplementation of *Cordyline fruticosa* leaf meal is therefore regarded as an option not only to improve growth performance, egg quality, and blood parameters but also to alleviate the risk of antimicrobial resistance in both birds and human being. *Cordyline fruticosa* leaf meal can be supplemented with up to 40 g/kg^{-1} diet without causing any deleterious effect on the health status of laying hens.

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7. Authors' Contributions

John Olujimi Alagbe: designed the work, data collection, statistical analysis, and writing of the manuscript.

8. Conflicts of Interest

No conflicts of interest.

9. Ethics Approval

Yes, applicable. The study was accepted by the Ethics Committee of the Sumitra Institute, India (BN/006C/2020).

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