Effect of fringed rue (*Ruta chalepensis*) leaf as feed additives on growth performance and carcass characteristics of broiler chickens

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Abstract

Ruta Chalepensis (fringed rue) has been used for therapeutic and aromatic purposes. However, using this plant as a natural additive in animals is scarce. A seven-week study was conducted to determine and elucidate the effects of fringed rue as a feed additive on broiler chickens growth performance and carcass characteristics. The average weight (40.08±0.42g) of 144 unsexed, day-old broiler chickens was arranged in a completely randomized design into four treatment groups. Each treatment group was divided into three replicates of twelve birds. Four treatments feed containing ground fringed rue leaves at different levels of T1 (basal diet+ the antibiotics Flavomycin at 1g kg^{-1}); T2 (basal diet+ 60g kg^{-1}, T3 (basal diet+120g kg^{-1}), and T4 (basal diet+180g kg^{-1}. DM Intake was considerably high (P<0.05) in the T3 group than in the antibiotics control group broilers. As a result, T3 groups have better improvement (P<0.05) in final body weight, BW gain, and ADG compared to the antibiotics control in all phases. There were high improvements (P<0.05) in dressing percentage, breast, thigh muscle, and drumsticks for chickens fed T3 and T2 than in the antibiotics control group. Generally, supplementation of fringed rue up to 120 g kg^{-1} has no adverse effects on broiler chickens.

Keywords*:* Broilers; Carcass characteristics; Fringed rue (*Ruta chalepensis*), Growth performance

Introduction

The extensive practice of adding broiler diets with antibiotic growth promoters was primarily motivated by the compounds' positive effect on production performance. However, the exacerbated utilization of antibiotics in subtherapeutic dosage as growth promoters has led to increased microbial resistance and accumulation of antibiotic residues in animal products that affect the end-user or consumer health environment. This situation increased interest in natural alternatives (Hafeez *et al.*, 2016). This situation required most countries to ban or limit antibiotic growth promoter (AGP) in poultry feeds and launch *"antibiotic-free"* labeled feeds (Hafeez *et al.*, 2016). Nonetheless, the major concern related to rearing broilers without antibiotic growth promoters in the feed is poor production performance and the incidences of certain diseases leading to higher production costs (Khan *et al.*, 2013). To alleviate the situation, interest in non-antibiotic feed additives that could help to eliminate the continuous use of AGPs has grown in recent decades. Several products based on probiotics, prebiotics, medicinal plants or phytogenics sources, and organic acids claim to improve broiler chicken productivity and health.

Medicinal plants or phytogenic feed additives (PFA) are compounds of plant origin (spices, herbs, plants, and products derived thereof) has been incorporated into animal feeds to enhance livestock productivity by improving digestibility, nutrient absorption, and elimination of pathogens residents in the animal gut that enhance performance feed conversion ratio, carcass meat safety, and quality in animals (Dhama *et al*., 2015) and poultry (Gobezie 2022). PFA's principal method of action is the suppression of potential infections and the positive modulation of the gut flora. Antimicrobial, antiviral, anticoccidial, fungicidal, and antioxidant activities are found in medicinal plants (Parham, *et al.,* 2020). The antimicrobial effects of PFA are primarily attributed to their phenolic and flavonoid components and their action on pathogenic cells. The content of active substances in these products can vary greatly depending on what part of the plant is used (seeds, leaves, roots or rhizome, bark, flowers, or buds), the harvest season, and geographical origins (Yonatan *et al.,* 2016).

Fringed rue (*Ruta chalepensis* L.) is a widely known medicinal herb belonging to the Rutaceae family. Fringed rue is a native evergreen subshrub of the Mediterranean region, but it is widely distributed in many parts of the world in temperate and tropical countries. Fringed rue is used in the traditional medicine of many countries for treating fever, rheumatism, convulsions, and other nervous disorders and for its analgesic and antipyretic properties (Bailly, 2023).

In Ethiopia, fringed rue is typically acknowledged as the herb of grace and is locally known as "*Tena Adam*" which literally means Adam's health, signifying the plant's medicinal value to humankind. It is used to cure inconsolable crying newborns, diarrhoea, intestinal diseases, earache, heart discomfort, hemorrhoids, and influenza in Ethiopian folk medicine. In addition, a culinary application of the leaves of fringed rue is accustomed to flavor sour milk and cheese, coffee, and tea. Due to its strong smell, the fresh plant is an excellent insect repellant. Some studies reported that fringed rue's chemical and active compounds are flavonoids, quinoline alkaloids, acridones, coumarins, chalepensin, and umbelliferone (Park and Lee, 2015; Loizzo *et al.,* 2018). Even though fringed rue has medicinal value in humans, no study has been conducted as a natural feed additive and supplementation for farm animals. Therefore, the present study aims to evaluate the effect of fringed rue leaf as feed additives on broiler chicken's growth performance and carcass characteristics.

Materials and methods

Experimental site

The feeding trial was carried out at the Poultry Farm, Wolaita Sodo ATVET College, Ethiopia. The study area is located 332 km Southwest of Addis Ababa, and at 39°30'E longitude and 09°36' N latitude and within the altitude range of 1500 to 2900 meter above sea level.

Preparation of fringed rue

A height of 50-60 cm fringed rue was collected from the university forage sites. The leaf part was detached, rinsed with tap water, and air-dried in the shade. The dried plant was ground using mortar and pestle, sieved through a 5 mm mesh screen, and stored over a desiccant at 4°C until used for laboratory analysis and incorporation into the basal diets.

Fig 1 The *Ruta chalepensis* leaf and its preparation process

Fig 2 Experimental pen preparation and Cobb-500 broiler chicken

Table 1. Nutrient composition of treatment diet and fringed rue leaf

Ingredients	**Starter feed**	**Finisher feed**	
Corn	47.50	51.0	
Wheat middling	10.0	11.0	
Soybean meal (44%CP)	30.5	28.56	
Niger seed cake	8.00	6.0	
Limestone	2.56	2.0	
Lysine	0.5	0.5	
Methionine	0.14	0.14	
*Vit-Min Premix	0.5	0.5	
Salt	0.3	0.3	
Nutrient composition			**Fringed rue leaf**
DM%	88	90	94.40
Crude protein %	21	18	34.38
Crude fat	10.2	8	5.99
Crude fiber	4.9	5.5	7.63
Energy Kcal/kg	3050	3250	3024.79
Calcium	0.74	0.65	3.18

***** Supplied per kg of diet: Vitamin A 12,000 IU, vitamin D_3 3,000 IU, vitamin E 40 mg, vitamin K_3 3 mg, vitamin B_1 2 mg, vitamin B_2 6 mg, vitamin B_6 5 mg, vitamin, B_{12} 0.02 mg, niacin 45 mg, biotin 0.075 mg, folic acid 2 mg, pantothenic acid 12 mg, manganese 100 mg, zinc 600 mg, iron 30 mg, copper 10 mg, iodine 1 mg, selenium 0.2 mg, cobalt 0.1 mg.

Experimental diets

The trial used conventional maize and soybean meal-based broiler diets free of coccidiostat and antibiotics. The diets had metabolizable energy (ME) of 3050 kcal/kg DM and 21% CP for the starter phase (1-21 days) and ME of 3250 kcal/kg DM and 18% CP for the finisher phase (22- 49 days). The treatment groups were fed a basal diet supplemented with fringed rue leaf at 0% T1 (basal diet+ the antibiotics Flavomycin at 1g kg^{-1}), T2 (basal diet+ 60g kg^{-1} fringed rue, T3 (basal diet+120g kg^{-1} fringed rue) and T4 (basal diet+180g kg^{-1} fringed rue).

Ethical consideration

The experimental chicks were treated or managed according to an experimental animal protocol approved by the Ethics Commission of the Wolaita Sodo University (reference number WSU/41/14/1023).

Experimental design

A total of 144 unsexed day-old Cobb-500 broiler chicks with an average weight of 40.08±0.42 g (Mean±SD) were randomly assigned into four dietary treatment groups (T1, T2, T3, and T4), with three replications per treatment arranged in a completely randomized design (CRD).

Experimental chickens and management

A seven weeks feeding trial was conducted to determine and elucidate the effects of fringed rue as a feed additive on broiler chickens. The chicks were reared in a deep litter housing system covered with sawdust as a litter material at a depth of 10 cm. The house had portioned into 12 pens with a dimension of 150cmx150 cm. Before the commencement of the experiment, the room, waterer, feeder, and other utensils were thoroughly washed, cleaned, and sprayed with disinfectant chemicals, and the room was fumigated by mixing potassium permanganate (KMnO4) powder with 10% formalin solution. The bulbs were hanged just above the chicks' level at the center of each pen, and the temperature was maintained at 35^0C during the first week and then incrementally lowered each week until it reached an ambient temperature of 24^0C. The chicks were vaccinated against Newcastle disease (NCD) and infectious bursa disease and were administered according to the vaccine company National Veterinary Institute (NVI) protocol.

Growth performance measurement

Daily records of the amounts of feed offered and refused for each pen were kept. Dry matter intake (DMI) was determined by subtracting the amount of refused feed from the amount of feed offered and was expressed on a dry matter basis. The daily and total feed consumption was multiplied by the dry matter content to estimate DM intake. Body weights of the birds were taken as a group at the beginning of the experiment and weekly until the end of the trial using a bench balance with a sensitivity of 0.001 grams (Xianghai, model ACS-C). The average body weight gain (BW gain) was calculated by dividing the difference between two consecutive weights by the number of chickens. The average daily gain (ADG) was calculated by dividing the final BW change by the number of experimental days. The feed conversion ratio (FCR) was determined by dividing the average feed intake by the average BW gain.

Carcass characteristics measurement

At the termination of the study, two chickens were selected randomly from each replication to undergo a carcass examination. Before slaughter, the broiler chickens were weighed on a highly sensitive balance (Xianghai, model ACS-C, with a sensitivity of 0.001 grams) after fasting for 12 hours. Exsanguinations were carried out, the jugular vein was severed, and the broilers' feathers were plucked by hand. The cut of the eviscerated carcass and the non-edible offal were determined. The breasts, wings, drumsticks, thighs, and back were used to evaluate the carcass yield/weight. The amount of carcass weight to slaughter weight, multiplied by 100, was used to compute the dressing percentage. The separated and weighed parts of the eviscerated carcass include the breast, wings, thighs with drumsticks, and back. The giblets (heart, gizzard and liver) were weighed in grams. The fat around the proventriculus, gizzard, abdominal wall and cloacae was collected and weighed.

Chemical analysis

Fringed rue leaf samples were ground using a Wiley mill (Thomas® Wiley Cutting Mill) to pass through a 1 mm screen for proximate analysis at National Veterinary Institute in the animal nutrition laboratory. The fringed rue leaf and feed offered and refusal was sampled and analyzed for DM.

Chemical composition of fringed rue

Proximate analysis was conducted at National Veterinary Institute in the animal nutrition laboratory, Bishoftu. The results of the chemical composition of fringed rue leaf are given in Table 1.

Statistical analysis

The collected data were subjected to the analysis of variance test for each parameter using the general linear models (GLM) procedures of SAS Version 9.3. Duncan's Multiple Range Test was used to separate between group means at a 5% level of significance. The statistical model used was:

$$Yi= \mu+\alpha+\varepsilon_{ij}$$

Where: Y_{ij}= the dependents variables observed of the fringed rue supplementation i and the replication, j within the level of the treatment

μ = overall mean effect

αi= the effect of i^{th} fringed rue supplementation at (0, 60, 120, and 180 g kg^{-1})

e_{ij}= the random error variation of the ij^{th} (mean 0 and variance σ)

Result and Discussion

DM Intake and Feed Conversion Ratio

The DM intake of chickens fed with different levels of fringed rue leaf as feed additives is presented in Table 2. A highly significant difference (P<0.001)was observed in the broiler's daily and total DM intake among treatments during the starter, finisher, and entire experimental period. The total and daily DM intake increased (P<0.05) in the T3 group than in the antibiotics control (T1), T2, and T4 group during the starter, finisher, and entire period (P<0.05). This improvement in DM intake might be due to fringed rue compounds like, alkaloids, flavonoids, phenols, furocoumarins, coumarins, saponins, and amino acids. Phenolic compounds originated from aromatic plants may improve the flavor and palatability of the feed by stimulate saliva secretions and bile and enhance enzyme activities thus increase the feed intake.

Even though no farm animal experiment is conducted on fringed rue to contrast the current findings, other herbs and plants are considered for comparison. For instance, Daramola *et al.* (2019) reported improved daily and total feed intake of broilers fed with 2% bitter leaf meal Moringa leaf meal and blending of both bitter leaf meal and Moringa leaf, respectively. Similarly, this finding also agrees with Khaligh *et al.* (2011), who reported differences among treatments in average daily and total feed intake of broilers fed with 10g kg^{-1} thyme, rosemary leaf, anise, cinnamon, and garlic. However, the findings of this study differ from those of Alhajj *et al.* (2015), who claimed that adding 1 and 2 g kg^{-1} of anise to a broiler's diet had no impact on feed intake. The inconsistent reports may be explained by variances in the amount of primary and secondary metabolites in various medicinal plants and distinct parts of the plants used, as well as environmental factors, including soil type, climate, and harvesting time.

The FCR was not affected (P>0.05) when using fringed rue as feed additives on broiler chicken. Similar experiments showed that adding thymol, cinnamaldehyde, and commercially prepared essential oil to broiler chicken did not affect feed intake and FCR (Ren *et al.*, 2019). When used as a feed additive, a rue helps broiler chickens perform similarly to antibiotic growth promoters (AGP) and may improve broiler digestibility by increasing enzyme activity and mucus production in the gut.

An increase in dry matter intake (DMI) and body weight gain among different treatment diet groups without a significant difference in feed conversion ratio (FCR) or similar to the antibiotics control group. Meaning the treatment diets perform similar with the antibiotics control group regarding in growth promoting effect. In addition, the treatment diet groups containing fringed rue were more palatable than the antibiotics control diet due to the fringed rue aroma, which affects the stimulation of saliva and digestive enzymes and can lead to an increase in DM intake and body weight gain (as seen in Table 3). However, suppose the broilers are consuming more feed solely because of its palatability and not because it contains more nutrients or energy. In that case, there may not be a significant difference in FCR compared to the antibiotics control group (Yang *et al.*, 2015).

Growth performance

There were highly significant differences (P<0.001) in final body weight, BW gain, and ADG of broiler among treatments during starter, finisher, and the entire periods as shown in Table 3. The initial BW of the day-old chick had no significant differences (P>0.05) among the treatment. The final body weight and growth of chickens fed fringed rue as a feed additive improved considerably (P<0.05) over the antibiotics control group. During the overall growing period, there was a (3.3% -10.5%) and (3.3-11.29%) increase in BW and ADG in the fringed rue additive group compared to the antibiotics control group. In addition, the DM intake was higher in broilers fed with 120 g kg^{-1} fringed rue.

Table 2. Effect of fringed rue additives on DMI and FCR of broiler chicken

Parameters	Phases	Dietary Treatments T_1	T_2	T_3	T_4	SEM	P- Value
	Starter	979.87^d	1045.48^b	1101.48^a	1011.87^c	3.66	<0.001
DMI g/birds	Finisher	3589.75^d	3962.91^b	4103.47^a	3744.05^c	19.95	<0.001
	Entire	4569.63^d	5008.39^b	5205.20^a	4755.93^c	18.48	<0.001
	Starter	46.66^d	49.78^b	52.46^a	48.18^c	0.35	<0.001
DMI g/birds/day	Finisher	128.20^d	141.53^b	146.55^a	133.71^c	1.42	<0.001
	Entire	93.26^d	102.21^b	106.22^a	97.06^c	0.75	<0.001
	Starter	1.79	1.78	1.81	1.79	0.01	0.400
FCR	Finisher	1.87	1.93	1.93	1.89	0.02	0.126
	Entire	1.85	1.9	1.91	1.86	0.01	0.083

*****Mean values within the same row having different superscript letters are significantly different (P<0.05); T1 (basal diet+ the antibiotics Flavomycin at 1g kg^{-1}); T2 (basal diet+ 60g kg^{-1} fringed rue, T3 (basal diet+120g kg^{-1} fringed rue) and T4 (basal diet+180g kg^{-1} fringed rue); FCR= Feed conversion ratio; SEM = standard error mean; p=probability value.

Table 3. Effect of *fringed rue* additives on growth performance of broiler chicken

Parameter	Phases	Treatments T_1	T_2	T_3	T_4	SEM	P-value
IBW (g)		39.67	40.08	40.67	39.92	0.29	0.176
FBW(g)	Starter	586.83^d	626.5^b	647.92^a	605.93^c	4.38	<0.001
	finisher	2504.53^d	2674.89^b	2764.45^a	2587.12^c	23.83	<0.001
BWG(g)	Starter	547.17^d	586.42^b	607.25^a	566.02^c	4.39	<0.001
	finisher	1918^c	2048.67^{ab}	2116.67^a	1981.3^{bc}	22.6	0.001
	overall	2464.87^d	2634.81^b	2723.78^a	2547.2^c	23.61	<0.001
ADG(g)	Starter	26.06^d	27.92^b	28.91^a	26.95^c	0.21	<0.001
	finisher	68.49^c	73.15^{ab}	75.59^a	$70.75b^c$	0.81	0.001
	overall	50.3^d	53.77^b	55.98^a	51.98^c	0.48	<0.001

*****Mean values within the same row having different superscript letters are significantly different (P<0.05); T1 (basal diet+ the antibiotics Flavomycin at 1g kg^{-1}); T2 (basal diet+ 60g kg^{-1} fringed rue, T3 (basal diet+120g kg^{-1} fringed rue) and T4 (basal diet+180g kg^{-1} fringed rue); FCR= Feed conversion ratio; SEM = standard error mean; p=probability value.

According to Khan *et al*. (2012), the improved growth results seen in broilers fed a diet supplemented with fringed rue may be due to an increase in the production of digestive enzymes and an improvement in the way the liver processes nutrients. The antibacterial action of the fringed rue or natural growth promoters component may inhibit the growth of pathogenic bacteria in the gut while promoting the development of beneficial bacteria (Rashid *et al.,* 2020). However, higher inclusion of fringed rue with 180 g kg^{-1} did not produce linear BW and BW gain results with the DM intake. In the current study, fringed rue leaf increased BW gain without affecting FCR, similar to Azzam *et al.* (2020) on broiler chickens fed 1,000-3,000 mg kg kg^{-1} *Rumex nervosus* leaves improve BW and BW gain in female broiler chickens. *Moringa oleifera* leaves, on the other hand, have been shown to boost BW and BW gain without influencing FCR (Khan *et al*., 2017).

Furthermore, El-Tazi *et al.* (2014) indicated that 0, 0.5, 0.75, and 1.0% of black pepper (*Piper nigrum* L.) to broiler feed resulted in better body weight and gain. However, Amad *et al.* (2011) reported that supplementing a phytogenic compound including thyme and star anise at 150, 750, and 1,500 mg kg^{-1} in the diet did not alter body weight and gained favorably compared to the antibiotics control diet and had no beneficial production outcomes as supplementation increased. Medicinal plants or active compounds in the chicken feed may increase appetite and feed intake, increase endogenous digestive enzyme synthesis, promote immunity, and have antiviral, antibacterial, anthelminthic, and antioxidant properties. Furthermore, isoprene derivatives, flavonoids, glucosinolates, and other herbal metabolites may impact the poultry gut's physiological and chemical function (Reda *et al.*, 2021). Moreover, the fringed rue in the broiler chicken diet might have improved the production and activities of digestive enzymes.

Table 4. Effect of fringed rue *additives* on carcass and visceral organs of broiler chicken

	Dietary treatments					
Parameters (g)	**T_1**	**T_2**	**T_3**	**T_4**	SEM.	P-value
Slaughter weight(g)	2415.67^d	2646.67^b	2792.00^a	2521.67^c	17.82	<0.001
Dressing weight(g)	2280.67^d	2486.00^b	2619.00^a	2362.33^c	24.27	<0.001
Dressing %	70.62^b	71.47^a	71.82^a	71.10^{ab}	0.24	<0.001
carcass weight(g)	1706.00^d	1891.67^b	2005.33^a	1793.00^c	13.53	<0.001
Breast(g)	503.33^d	602.00^b	662.67^a	561.33^c	7.51	<0.001
Drumsticks(g)	238.00^d	298.33^b	336.33^a	268.00^c	6.04	<0.001
Thighs(g)	265.00^d	318.33^b	356.33^a	285.67^c	3.87	<0.001
Back	189.67^c	226.67^b	255.33^a	201.67^c	6.04	<0.001
Liver(g)	46.67^c	48.67^c	57.00^b	65.00^a	1.59	<0.001
Gizzard(g)	36.67^c	35.67^c	49.67^b	60.00^a	1.98	<0.001
Heart(g)	11.00	11.33	13.00	10.67	1.25	0.580
Abdominal fat (g)	99.00^a	62.67^b	46.67^c	40.67^c	3.51	<0.001

***Mean values within the same row having different superscript letters are significantly different (P<0.05); T1 (basal diet+ the antibiotics Flavomycin at 1g kg^{-1}); T2 (basal diet+ 60g kg^{-1} fringed rue, T3 (basal diet+120g kg^{-1} fringed rue) and T4 (basal diet+180g kg^{-1} fringed rue); FCR= Feed conversion ratio; SEM = standard error mean; p=probability value

Effect of fringed rue on carcass characteristics

The results showed that dietary treatments significantly affected (*P*<0.001) slaughter weight, dressing percentage, commercial carcass component, and giblet parts except for heart weight (*P*>0.05), as shown in Table 4. The dressing percentage and carcass weight were highly affected (*P*<0.001) by treatment and higher in both T3 and T2, followed by T4 and T1 (antibiotics control) (P<0.05).

The improvement in most carcass parameters could be attributed to the active compound in fringed rue, such as flavonoids, which can alter feed intake, metabolism, and uptake by enhancing the synthesis of digestive enzymes, leading to higher body weight growth and dressing percentage. These findings agree with those of Kadhim (2018), who studied the effects of dietary Marjoram (*Origanum vulgare*) on broiler chicken. Dietary treatments significantly affected the breast, drumsticks, thighs, and back (P<0.001). The birds fed T3 had particularly (*P*<0.05) higher breast weight, drumsticks, thighs, and back, followed by T2, T4, and T1 in all phases. This result agrees with Natasa *et al.* (2016), indicated broilers with phytobiotics in feed produced more meaty carcasses than antibiotics control broilers. Furthermore, Ukoha and Onunkwo (2016) found that a meal with 3 and 5 g kg^{-1} turmeric powder resulted in a greater dressing percentage and broiler breast weights. The presence of essential compounds flavonoids in the medicinal plants may be related to the increased breast weight, which prevents lipid oxidation, allowing high amounts of lean cut to accumulate in the organs and proportions of the organs, reducing the risk of hyperlipidemia in consumers and increasing acceptability. The current result differs with Alabi *et al.* (2017), who reported no influence of aqueous *Moringa oleifera* leaf extract on the weight of the breast meat, thighs, wings, and drumsticks. The treatments had a significant effect on the weight of the liver and gizzard (P<0.001). Their weight was substantially higher (*P*<0.05) in the T4 group than in the T3 group. T2 and T1 (antibiotics control group) are, however, comparable (*P*>0.05). This indicates that their weight grows with the amount of fringed rue in their diet increases, which may be related to the liver's detoxification (protection against toxins and free radicals) process as the amount of fringed rue in their diet increases. Medicinal plants or herbs contain large amounts of flavonoids, phenolic acids, tannins, and other hepatoprotective effects (Albert, 2018; Salam *et al.*, 2014). As a result, fringed rue should be fed at an acceptable dosage (60-120 g kg^{-1}) to avoid affecting broiler metabolic activity and production. Yet, in this study, the liver weight ranged from 2.01% to 2.57% of the overall carcass weight, which is still within the acceptable liver weight range.

The enlargement of the gizzard could be due to the response of broiler chickens to metabolic activity. According to Svihus (2011), the increasing size of the gizzard was an effort by broilers to improve nutritional digestibility through prolonged retention time and grinding and mixing the diets with digestive enzymes. This finding contradicts the findings of Al-Sagan *et al.* (2020), who found no change in the weight of broiler gizzards fed diets containing 1.6% and 3.2% fennel seed powder. The dietary treatment groups showed that the abdominal fat weight was highly affected (*P*<0.001). The fringed rue as a feed additive in T3 and T4 had significantly lower abdominal fat (*P*<0.05) than the antibiotics control and T2 broiler chickens. The abdominal fat content of broilers decreases when the dietary supplementation of fringed rue level increases (*P*<0.05). The reduction in abdominal fat could be attributed to fringed rue active compounds such as acridones, coumarins, chalepensin, and umbelliferone, which have the potential to inhibit hepatic fatty acid synthase activity and increase oxidation of fatty acids (stimulated glycogenesis), resulting in an effective reduction in fat storage (Loizzo *et al*., 2018; Park and Lee 2015). This result agrees with El-Tazi *et al*. (2014), broilers supplemented with 1% black pepper had significantly lowered abdominal fat percentage than the antibiotics control group.

Conclusion

This study found that supplementing broiler chicken meals with up to 120 g kg^{-1} fringed rue leaf increase live body weight, and weight gain. Consequently, the dressing percentage and significant carcass cuts have improved due to their digestive stimulating and antibacterial properties or activities. Therefore, fringed rue leaf supplementation should be considered a possible natural growth promoter for broiler chicken production.

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References

1) Alabi, O.J., Malik, A.D., Ngambi, J.W., Obaje, P., Ojo, B.K., 2017. Effect of aqueous Moringa Oleifera (Lam) leaf extracts on growth performance and carcass characteristics of Hubbard broiler chicken. Brazilian Journal of Poultry Science, 19: 273–279.
2) Albert, N., 2018. Improving poultry health with the hepatoprotective effects of herbal extracts. International Poultry Production, 26 (7): 17–19.
3) Alhajj, M.S., Alhobaishi, M., GerElNabi, A.R., Al-Muffarrej, S.I., 2015. Immune responsiveness and performance of broiler chickens fed a diet supplemented with high levels of Chinese star anise fruit (Illicium verum Hook. F). Journal of Animal and Veterinary Advances, 14: 36–42.
4) Al-Sagan, A., Khalil, S., Hussein, E.S., Attia, Y., 2020. Effects of Fennel Seed Powder Supplementation on Growth Performance, Carcass characteristics, meat quality, and economic efficiency of broilers under thermo neutral and chronic heat Stress conditions. Animals, 10 (2): 206.
5) Amad, A., Männer, K., Wendler, K.R., Neumann, K., Zentek, J., 2011. Effects of a phytogenic feed additive on growth performance and ileal nutrient digestibility in broiler chickens. Poultry Science, 90: 2811–2816.
6) Azzam, M., Mohammed, M., Qaid, Saud, I., Al-Mufarrej, A., Al-Garadi, H., Albaadani, A., 2020. Rumex nervosus leaves meal improves body weight gain, duodenal morphology, serum thyroid hormones, and cecal microflora of broiler chickens during the starter period. Poultry Science, 99 (11): 5572–5581.
7) Bailly, C., 2023. Ruta angustifolia Pers. (Narrow-Leaved Fringed Rue): Pharmacological Properties and Phytochemical Profile. Plants, 12 (4), 827.
8) Daramola, O.T., 2019. Medicinal plants leaf meal supplementation in broiler chicken diet, effects on performance characteristics, serum metabolite and antioxidant status. Animal Research International, 16(2), 3334–3342.
9) Dhama, K., Latheef, S.K., Mani, S., Samad, H.A., Kartik, K., Tiwari, R., Khan, R.U., Alagawany, M., Farag, M.R., Alam, G.M., Laudadio, V., Tufarelli, V., 2015. Multiple beneficial applications and modes of action of herbs in poultry health and production – A review. International Journal of Pharmacology, 11: 152–176.
10) El-Tazi, M.A., Mukhtar, M.A., Mohamed, K.A., Tabidi, M.H., 2014. Effect of using black pepper as natural feed additive on performance and carcass quality of broiler chicks. Global Advanced Research Journal of Agricultural Science, 3(4): 113−118.
11) Gobezie E.. 2022. Effect of Neem (Azadirachta indica) leaf powder on the growth performance and carcass quality of Broiler Chicken – A Review. Journal of Livestock Science 13: 152-158 doi. 10.33259/JLivestSci.2022.152-158
12) Hafeez, A., Männer, K., Schieder, C., Zentek, J., 2016. Effect of supplementation of phytogenic feed additives (powdered vs. encapsulated) on performance and nutrient digestibility in broiler chickens. Poultry Science, 95(3): 622–629.
13) Kadhim, M.J., 2018. Influence of different levels of rosemary leafs powder supplementation on some productive traits of broiler chicken Ross strain. Journal of University of Babylon for Pure and Applied Sciences, 26 (8): 77–83.

14) Khaligh, F., Sadeghi, G., Karimi, A., Vaziry, A., 2011. Evaluation of different medicinal plants blends in diets for broiler chickens. Journal of Medicinal Plants Research 5 (10): 1971–1977.
15) Khan, I., Zaneb, H., Masood, S., Yousaf, M.S., Rehman, H.F., Rehman, H., 2017. Effect of Moringa oleifera leaf powder supplementation on growth performance and intestinal morphology in broiler chickens. Journal of Animal Physiology and Animal Nutrition, 101: 114–121.
16) Khan, R.U., Naz, S., Nikousefat, Z., Tufarelli, V., Javdani, M., Qureshi, M.S., Laudadio, V., 2012. Potential applications of ginger (Zingiber officinale) in poultry diets. World's Poultry Science Journal, 68 (2): 245–252.
17) Khan, S.H., Anjum, M.A., Parveen, A., Khawaja, T., Ashraf, N.M., 2013. Effects of black cumin seed (Nigella sativa L.) on performance and immune system in newly evolved crossbred laying hens. Veterinary Quarterly, 33: 13–19.
18) Loizzo, M.R., Falco, T., Bonesi, M., Sicari, V., Tundis, R., Bruno, M., 2018. Ruta chalepensis L. (Rutaceae) leaf extract: chemical composition, antioxidant and hypoglicaemic activities. Natural Product Research, 32(5): 521–528.
19) Natasa, G., Kristina, S., Branislav, B., Marija, B., Jelena, J., Vesna, D., Radmila, M., 2016. Effects of phytobiotics on Cobb broiler production results, meatiness and chemical composition. Meat Technology, 57(2): 89–94.
20) Parham, S., Kharazi, A.Z., Bakhsheshi-Rad, H.R., Nur, H., Ismail, A.F., Sharif, S., RamaKrishna, S., Berto, F., 2020. Antioxidant, Antimicrobial and Antiviral Properties of Herbal Materials. Antioxidants, 9 (12):1309.
21) Park, J.H., Lee, H.S., 2015. Inhibitory effects of quinoline isolated from Ruta chalepensis and its structurally related derivatives against α-amylase or α-glucosidase. Journal of Applied Biological Chemistry, 58: 5–8.
22) Rashid, Z., Mirani, Z.A., Zehra, S., Gilani, S.M.H., Ashraf, A., Azhar, A., Al-Ghanim, K.A., Al-Misned, F., Al-Mulahim, N., Mahboob, S., Galani, S., 2020. Enhanced modulation of gut microbial dynamics affecting body weight in birds triggered by natural growth promoters administered in conventional feed. Saudi Journal of Biological Sciences, 27 (10): 2747–2755.
23) Reda, F., El-Saadony, M.T., El-Rayes, T.K., Farahat, M., Attia, G., Alagawany, M., 2021. Dietary effect of licorice (Glycyrrhiza glabra) on quail performance, carcass, blood metabolites and intestinal microbiota. Poultry Science, 100 (8): 101266.
24) Ren, H., Vahjen, W., Dadi, T., Saliu, E.M., Boroojeni, F.G., Zentek, J., 2019. Synergistic effects of probiotics and phytobiotics on the intestinal microbiota in young broiler chicken. Microorganisms, 7 (12): 684.
25) Salam, S., Sunarti, D., dan Isroli, 2014. The effect of black cumin (Nigella sativa) grinding supplementation on aspartate aminotransferase (AST), alanine aminotransferase (ALT) and liver weight on broiler. Journal Peternakan Indonesia, 16: 40–45.
26) Svihus, B., 2011. The gizzard: Function, influence of diet structure and effects on nutrient availability. World's Poultry Science Journal, 67: 207–224.
27) Ukoha, O.A., Onunkwo, D.N., 2016. The Effect of Turmeric (Curcuma longa) on Growth Performance of Broiler Chickens. International Research Journal of Agricultural and Aqua Science, 3: 131–135.
28) Yang, C., Chowdhury, M. A., Huo, Y., Gong, J. 2015. Phytogenic compounds as alternatives to in-feed antibiotics: potentials and challenges in application. Pathogens (Basel, Switzerland), 4(1): 137–156.
29) Yonatan, K., Berhan, T., and Etalem, T., 2016. Effect of supplementing natural feed additives: black cumin, fenugreek and turmeric on the growth performance and economic efficiency of broiler chickens. Advances in Biological Research, 10 (5), 335–344.