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Effects of clove oil as a substitute for antibiotic growth promoters on broiler growth performance

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Abstract

The goal of the current study was to assess how clove (*Syzygium aromaticum*) oil promotes broiler growth. A total of 50 chicks were split into 5 groups at random. As a control group, Group I received basal feed devoid of clove oil and antibiotics. Avilamycin was administered at a rate of 15 ppm in feed as a standard growth promoter to Group II, which functioned as the standard control group. Clove oil was administered to Groups III, IV, and V at doses of 200, 400, and 800 mg/kg feed, respectively. The duration of this study was 42 days. Weekly body weight (BW), weekly and total body weight gain (BWG), weekly and total feed consumption (FC), feed conversion ratio (FCR), and livability were all measured for each bird in the various experimental groups. In comparison to birds in the control group, poultry fed with clove oil at 400 and 800 mg/kg food and avilamycin antibiotic demonstrated significantly higher body weight and body weight gain at the end of the experiment. Birds treated with clove oil also displayed dose-dependent increases in body weight and weight gain. It showed that when it comes to enhancing broiler performance, clove oil supplementation has comparable effects to standard antibiotic avilamycin supplementation. The total amount of feed consumed by the birds from birth to the sixth week of life was not significant and did not alter amongst the various experimental groups, indicating that the addition of clove oil had no negative impact on the birds' feed intake. When compared to birds in the control group, the overall feed conversion ratio (FCR) at the end of the trial was considerably improved in birds supplemented with clove oil at 200, 400, and 800 mg/kg food and the common antibiotic avilamycin. This suggests that clove oil has a positive effect on feed utilization. Furthermore, the FCR of birds fed with conventional antibiotics and clove oil (200, 400, and 800 mg/kg diet) was nearly same. The current study's findings showed that clove oil has the potential to replace conventional antibiotic growth promoters in broiler diets and can be utilized as a safe, natural growth promoter with no negative health consequences.

Keywords: Broiler, clove oil, antibiotic growth promoter, body weight gain, FCR

Introduction

Over the past ten years, India's poultry production has increased dramatically, although this growth has mostly been confined to the country's big and small-scale organized poultry sectors. However, there are certain obstacles to the growing market for healthy poultry feeding products, such as insecticides and pesticides. Human negative effects may result from the proliferation of antibiotic-resistant bacteria and the spread of antibiotic growth promoter (AGP) residues in meat and eggs ^[1]. Consumer demand for poultry products from "Raised Without Antibiotics" or "No Antibiotics Ever" flocks has increased as a result of stricter laws on the use of antibiotic growth promoters ^[2]. The creation of substitutes for antibiotics in commercial chicken farming has since attracted a lot of attention.

Essential oils (EOs), which are produced as secondary metabolites from a variety of plants, are one such substitute. They had been effectively employed as a residue-free dietary antibiotic substitute ^[3]. By promoting the release of endogenous digestive enzymes and balancing the gut microbial environment, the active ingredients of essential oils enhance poultry growth performance ^[4]. Clove oil boosts the production of endogenous antimicrobial peptides in the gut and strengthens the immune system ^[5]. Clove and its essential oil have been shown to

enhance growth performance metrics in chicken, including body weight, body weight gain, feed consumption, and feed conversion ratio [6, 7, 8]. Therefore, the current study was designed to assess the growth-promoting effects of clove oil, particularly in broiler chicken, at 200, 400, and 800 mg/kg feed for 42 days.

Materials and Methods

Experimental Birds

Day-old Vencobb broiler chicks were used in the current investigation. Chicks were purchased from Shakti Hatcheries Pvt. Ltd, Anand, Gujarat. Broiler chicks were kept under conventional management conditions in the brooder house of the Poultry Research Station (PRS), College of Veterinary Science & Animal Husbandry, Anand (Gujarat). Chicks were weighed individually and had their wings banded on the day of arrival. The chicks were weighed and then divided into 5 treatment groups at random. Chicks were raised in a well-ventilated brooder house utilizing normal management and health care procedures in a deep litter system. Electric lights were utilized to produce enough artificial light at night and bukharies were also used. The Veterinary College, Anand's Institutional Animal Ethical Committee (No. IAEC/2019/VPT/308) sanctioned the experiment. The birds were shielded from diseases with vaccination, including infectious bursal disease and Ranikhet disease.

Feeding and Watering Management

The feed manufacturing facility of PRS, Anand produced broiler starter and finisher feed. Every bird was fed broiler feed based on their age, which was 1-28 days for starters and 29-42 days for finishers. To create several treatment diets, clove oil was first combined with vegetable oil and then combined with basal diet. For the duration of the experiment, weighed amounts of various treatment diets were provided twice a day. Three to four times a day, the feed was mixed and stirred in the feeder, and every safety precaution was taken to reduce feed waste. For the duration of the trial, all experimental birds were provided with unlimited access to clean, fresh, and cool drinking water.

Housing Management for Broilers

The birds were maintained at brooder house of the Poultry Research Station (PRS), College of Veterinary Science and Animal Husbandry, Anand Agricultural University, Anand. All organic debris, including dust, feathers, trash, and dung, were removed from the brooder house. The whole brooder house was cleaned with a detergent solution. After that, side walls were whitewashed with a lime solution. The electric lamps in the brooder were turned on 12 hours before to the chicks' placement in order to reach a temperature of 95 °F. Chicks were weighed individually and received their wings banded on the day of arrival. Then chicks were divided into five treatment groups at random. Chicks were raised in a well-ventilated brooder house utilizing normal management and health care procedures in a deep litter system. Electric lamps were used to offer adequate artificial light during the night, while bukharies were utilized to keep the surroundings warm.

Experimental Design

Five groups of 10 chicks each were randomly selected from a total of 50 chicks. Groups were assigned numbers from I to V. Group I was given a basal diet devoid of clove oil and a conventional antibiotic as a control. Group II was administered avilamycin antibiotic at a rate of 15 ppm in feed

as a growth booster and functioned as the standard control. Clove oil was administered to the remaining groups III, IV, and V at doses of 200, 400, and 800 mg/kg of feed, respectively. During the manufacture of broiler diets, clove oil and avilamycin antibiotic were combined in the basal diet using a mixer according to the dose rates specified for treatment groups. The duration of this study was 42 days. To assess the growth-promoting effects of clove oil in broiler chickens, a number of parameters were examined.

Body Weight (BW) and Body Weight Gain (BWG)

Every week, the birds' body weight was measured using a digital weighing balance in the morning before feeding at day old (BW₀), first (BW₁), second (BW₂), third (BW₃), fourth (BW₄), fifth (BW₅), and sixth (BW₆) weeks of age. Weekly body weight gain (BWG₀₋₁, BWG₁₋₂, BWG₂₋₃, BWG₃₋₄, BWG₄₋₅, BWG₅₋₆) and overall body weight gain (BWG₀₋₆) were computed by deducting the live body weight of the prior week from the current week. "Weekly body weight gain (g) = Current week body weight (g) - Previous week body weight (g)".

Feed Consumption (FC)

Over the course of the entire experiment, the measured amount of feed provided to birds on a group basis each day was noted. The remaining feed was gathered, weighed, and recorded for each group at the conclusion of the week. By deducting the leftover feed from the total amount of feed provided over the course of seven days, the feed consumption was determined. First (FC₁), second (FC₂), third (FC₃), fourth (FC₄), fifth (FC₅), and sixth (FC₆) feed consumption as well as total feed consumption (FC₀₋₆) were computed.

Feed Conversion Ratio (FCR)

The amount of feed a bird has to consume in order to gain one kilogram of live body weight is known as the feed conversion ratio. It is a crucial instrument for assessing birds' feed conversion efficiency. Each week's total body weight and total feed consumption were calculated independently each group. The following formula was used to determine the feed conversion ratio: $FCR = \frac{\text{Total feed consumption (kg)}}{\text{Total live body weight (kg) at a particular age}}$

Livability

It was computed using the recorded deaths that took place at various stages.

Statistical Analysis

Using SPSS statistical software (version 20.0), a completely randomized design test and one-way analysis of variance (ANOVA) were used to compare the means of different growth promoting effect parameters. Duncan's multiple range test was used to examine significant differences ($p < 0.05$) between the various experimental groups. Every data has been presented as mean $\pm$ S. E.

Results and Discussion

Body Weight (BW)

Table 1 shows the specifics of the mean body weight (g) values of broilers in the several experimental groups that were recorded at weekly intervals (BW₀, BW₁, BW₂, BW₃, BW₄, BW₅, and BW₆).

It observed from the Table 1 that during initial weeks, body weights of birds were non-significant among the different groups. However, from 4th week onwards, birds supplemented

with clove oil @ 400 and 800 mg/kg (group IV and V) and avilamycin @ 15 ppm (group II) in diet showed significantly higher body weight as compared to birds of control group. Birds supplemented with clove oil @ 400 and 800 mg/kg in

diet helps to improve body weight as compared to birds of control group and this was statistically at par with antibiotic treatment. This clearly indicated that the clove oil was beneficial in improving the body weight of broilers.

Table 1: Effect of dietary supplementation of clove oil for 42 days on weekly body weight (g) of broiler birds (Mean $\pm$ S. E.; n=10)

Groups	Weekly body weight (g)						
	BW ₀	BW ₁	BW ₂	BW ₃	BW ₄	BW ₅	BW ₆
I	45.84 $\pm$ 1.09	170.8 $\pm$ 5.32	419.8 $\pm$ 13.43	842.7 $\pm$ 27.50	1194.1 $\pm$ 43.78 ^a	1758.6 $\pm$ 40.24 ^a	2191.7 $\pm$ 27.63 ^a
II	48.63 $\pm$ 1.00	172.1 $\pm$ 8.22	437.3 $\pm$ 19.08	845.3 $\pm$ 35.42	1361.8 $\pm$ 56.02 ^b	1955.2 $\pm$ 42.96 ^b	2389.7 $\pm$ 52.25 ^b
III	46.63 $\pm$ 1.38	152.5 $\pm$ 4.93	413.1 $\pm$ 14.70	844.2 $\pm$ 28.30	1297 $\pm$ 36.28 ^{ab}	1834.9 $\pm$ 31.04 ^{ab}	2330.1 $\pm$ 42.77 ^{ab}
IV	47.31 $\pm$ 1.56	153.7 $\pm$ 6.68	407.3 $\pm$ 17.03	844.2 $\pm$ 38.96	1290.7 $\pm$ 54.07 ^{ab}	1918.3 $\pm$ 47.82 ^b	2381 $\pm$ 50.25 ^b
V	47.94 $\pm$ 1.57	153 $\pm$ 6.45	427.5 $\pm$ 19.37	872.5 $\pm$ 37.53	1415.4 $\pm$ 66.39 ^b	1938.7 $\pm$ 64.36 ^b	2407.7 $\pm$ 76.13 ^b

^{a, b} - Values (Mean $\pm$ S. E.) bearing different superscripts within a same column differ significantly from each other ($P < 0.05$).

The results with respect to body weight were in accordance with the results of Dalkilic and Guler (2009) [9] who observed significantly ($p < 0.05$) higher body weight in clove extracts (@ 400 ppm) supplemented group as compared to control group in broiler chickens. Similarly, Bello *et al.* (2016) [10] also reported significantly ($p < 0.05$) increased in body weight of fowls supplemented with clove extracts (@ 400 and 600 mg/kg) in diet as compared to control group. Similarly, AL-Tabari *et al.* (2018) [11] also observed that body weight was significantly ($p < 0.05$) increased in broiler chickens supplemented with 1 and 5% clove extract in drinking water as compared to control group. Tahir *et al.* (2019) [6] also reported that addition of 1% eugenol of clove leaf essential oil in the diet of broilers significantly ($p < 0.05$) increased final body weight as compared to control group. Similar observation was also made by Moustafa *et al.* (2020) [8] observed significant ($p < 0.05$) increase in final body weight of broiler chickens supplemented with clove oil @ 100 mg/kg in diet as compared to control group.

The current study's findings demonstrated how the active ingredient in clove oil, eugenol, improved broiler productivity. Clove oil has a digestion stimulating element that acts as an antibiotic against organisms in the digestive canal, increasing feed utilization efficiency and improving growth performance [12]. According to numerous studies, clove is rich in trace minerals, which are essential for the metabolism of proteins and carbohydrates. Additionally, it decreased the production of cholesterol and fatty acids, which may enhance broiler performance [13]. Clove increased the pancreatic and intestinal mucosa's digestive enzyme activity

and bile salt output.

The results with respect to body weight were not in agreement with the results of Dalkilic and Guler (2009) [9] who observed non-significant difference in body weight of broilers supplemented with clove extract (@ 100, 200 and 400 ppm) in diet as compared to control group. Similarly, Mukhtar (2011) [14] also reported non-significant difference in body weight of broilers supplemented with 200, 400 and 600 mg/kg clove oil in diet as compared to control group in broiler chickens. Similarly, Mahrous *et al.* (2017) [15] also found non-significant difference in body weight of broilers supplemented with 0.5 and 1.0 g/kg clove bud powder in diet as compared to control group. Hussein *et al.* (2019) [7] also reported non-significant difference in body weight of Japanese quails supplemented with clove oil (1.5 ml/ kg) in diet as compared to control group.

Body Weight Gain (BWG)

Table 2 presents the mean body weight gain (g) values of broiler chickens in several experimental groups that were recorded at weekly intervals (BWG₀₋₁, BWG₁₋₂, BWG₂₋₃, BWG₃₋₄, BWG₄₋₅, and BWG₅₋₆) as well as the entire experimental period (BWG₀₋₆).

During 0-6 weeks of age, clove oil @ 400 and 800 mg/kg supplemented birds recorded significantly higher mean body weight gain (g) over birds of control group. Birds supplemented with avilamycin (group II) recorded significantly higher mean body weight gain as compared to birds of control group, which was closer to the performance of clove oil @ 400 and 800 mg/kg groups.

Table 2: Effect of dietary supplementation of clove oil for 42 days on body weight gain (g) of broiler birds (Mean $\pm$ S. E.; n=10)

Groups	Body Weight Gain (g)						
	BWG 0-1	BWG 1-2	BWG 2-3	BWG 3-4	BWG 4-5	BWG 5-6	BWG 0-6
I	124.96 $\pm$ 5.61	249 $\pm$ 8.31	422.9 $\pm$ 15.17	351.4 $\pm$ 60.81 ^a	564.5 $\pm$ 31.20	433.1 $\pm$ 32.46	2145.86 $\pm$ 27.89 ^a
II	123.47 $\pm$ 8.64	265.2 $\pm$ 12.09	408 $\pm$ 24.52	516.5 $\pm$ 71.38 ^b	593.4 $\pm$ 83.84	434.5 $\pm$ 32.51	2341.07 $\pm$ 52.43 ^b
III	105.87 $\pm$ 4.49	260.6 $\pm$ 11.15	431.1 $\pm$ 17.62	452.8 $\pm$ 14.63 ^{ab}	537.9 $\pm$ 35.30	495.2 $\pm$ 30.62	2283.47 $\pm$ 42.45 ^{ab}
IV	106.39 $\pm$ 6.02	253.6 $\pm$ 12.60	436.9 $\pm$ 24.27	446.5 $\pm$ 27.07 ^{ab}	627.6 $\pm$ 26.05	462.7 $\pm$ 37.83	2333.69 $\pm$ 48.98 ^b
V	105.06 $\pm$ 6.60	274.5 $\pm$ 14.05	445 $\pm$ 19.80	542.9 $\pm$ 32.21 ^b	523.3 $\pm$ 103.39	469 $\pm$ 53.57	2359.76 $\pm$ 75.62 ^b

^{a, b} - Values (Mean $\pm$ S. E.) bearing different superscripts within a same column differ significantly from each other ($P < 0.05$).

The results with respect to body weight gain were in accordance with the results of Ertas *et al.* (2005) [16] who reported that body weight gain was significantly ($p < 0.05$) increased in broiler chickens supplemented with essential oil mixture of oregano, clove and anise (@ 200 ppm) and avilamycin (10 mg/kg) in diet as compared to control group. Similar observation was also made by Mohammadi *et al.* (2014) [17] who reported that body weight gain was significantly ($p < 0.05$) increased in clove oil (@ 300 mg/kg)

and flavophospholipol (@ 600 mg/kg) supplemented groups as compared to control group in broiler chickens. Similarly, Mehr *et al.* (2014) [12] also reported that supplementation of 450 ppm clove essential oil in broiler diet significantly ($p < 0.05$) increased body weight gain as compared to control group. Similarly, Bello *et al.* (2016) [10] also observed significantly ($p < 0.01$) increased in body weight gain in clove extracts (@ 400 and 600 mg/kg) supplemented groups as compared to control group in fowls. Similarly, AL-Tabari *et*

al. (2018) ^[11] also observed that body weight gain was significantly ($p<0.05$) increased in broiler chickens supplemented with 1 and 5% clove extract in drinking water as compared to control group. Similar observation was also made by Moustafa *et al.* (2020) ^[8] who observed significant ($p<0.05$) increase in body weight gain of broiler chickens supplemented with clove oil @ 100 mg/kg in diet as compared to control group.

Because clove oil contains the active component eugenol, birds treated with it had a rise in body weight. Eugenol, the active component, has digestive-stimulating properties that improve broiler weight gain by regulating the gut microbial ecosystem and promoting the release of endogenous digestive enzymes ^[4].

The results with respect to body weight gain were not in agreement with the results of Dalkilic and Guler (2009) ^[9] who observed non-significant difference in body weight gain of broilers supplemented with clove extract (@ 100, 200 and 400 ppm) in diet as compared to control group. Similarly, Mukhtar (2011) ^[14] also reported non-significant difference in body weight gain of broiler birds supplemented with 200, 400

and 600 mg/kg clove oil in diet as compared to control group. Similar observation was also made by Mustafa and Mukhtar (2016) ^[18] reported non-significant difference in body weight gain of broilers supplemented with essential oil mixture of anise, clove and caraway in diet as compared to control group. Similarly, Mahrous *et al.* (2017) ^[15] also found non-significant difference in body weight gain of broilers supplemented with 0.5 and 1.0 g/kg clove bud powder in diet as compared to control group. Al-Mufarre *et al.* (2019) ^[19] also reported that increase level of clove powder beyond 2% in diet of broilers, led to a negative effect on body weight gain. Similarly, Tahir *et al.* (2019) ^[6] also observed non-significant difference in body weight gain of broilers supplemented with eugenol of clove leaf essential oil as compared to control group.

Feed Consumption (FC)

Table 3 shows the specifics of the mean feed consumption values (g/bird) of broiler chickens in several experimental groups that were measured at weekly intervals (FC₁, FC₂, FC₃, FC₄, FC₅, FC₆) and over the entire experimental period (FC₀₋₆).

Table 3: Effect of dietary supplementation of clove oil for 42 days on feed consumption (g/bird) of broiler birds (Mean $\pm$ S. E.; n=10)

Groups	Weekly and Total Feed Consumption (g/bird)						
	FC ₁	FC ₂	FC ₃	FC ₄	FC ₅	FC ₆	TFC ₀₋₆
I	198.5 $\pm$ 6.19	452.3 $\pm$ 14.47	695 $\pm$ 22.68	784 $\pm$ 28.75 ^{ab}	1149.2 $\pm$ 26.30 ^{bc}	1082 $\pm$ 13.64 ^b	4361 $\pm$ 57.48
II	196 $\pm$ 9.36	462.6 $\pm$ 20.18	634 $\pm$ 26.57	730 $\pm$ 30.03 ^a	1185.2 $\pm$ 26.04 ^c	1102.2 $\pm$ 24.10 ^b	4310 $\pm$ 84.02
III	197.4 $\pm$ 6.39	462.6 $\pm$ 16.47	676 $\pm$ 22.66	840 $\pm$ 23.50 ^{bc}	1123.9 $\pm$ 19.01 ^{bc}	983 $\pm$ 18.04 ^a	4282.9 $\pm$ 88.23
IV	195.3 $\pm$ 8.48	477.8 $\pm$ 19.98	673.6 $\pm$ 31.09	814.6 $\pm$ 34.13 ^{abc}	1082.4 $\pm$ 26.98 ^b	1100 $\pm$ 23.21 ^b	4343.7 $\pm$ 131.02
V	193.4 $\pm$ 8.15	443 $\pm$ 20.07	680.1 $\pm$ 29.26	900.6 $\pm$ 42.24 ^c	935 $\pm$ 31.04 ^a	1014.9 $\pm$ 32.09 ^a	4167 $\pm$ 88.16

^{a, b, c} - Values (Mean $\pm$ S. E.) bearing different superscripts within a same column differ significantly from each other ($P<0.05$).

Overall difference in feed consumption of birds was non-significant in all the experimental groups. The results with respect to feed consumption were in accordance with the results of Dalkilic and Guler (2009) ^[9] who observed non-significant difference in feed consumption of broiler birds supplemented with clove extract (@ 100, 200 and 400 ppm) and avilamycin (10 ppm) in diet as compared to control group. Similarly, Mukhtar (2011) ^[14] also reported non-significant difference in feed consumption of broilers supplemented with 200, 400 and 600 mg/kg clove oil in diet as compared to control group. Similar observation was also made by Mahrous *et al.* (2017) ^[15] reported non-significant difference in feed consumption broiler chickens supplemented with clove extracts (@ 0.5, 1.0 and 1.5 g/kg) in diet as compared to control group. Scherer *et al.* (2014) ^[20] also reported non-significant difference in feed consumption of broilers supplemented with microencapsulated eugenol (500 mg/kg) and avilamycin (10 mg/kg) in diet as compared to control group. Mehr *et al.* (2014) ^[12] also observed non-significant difference in feed consumption of broilers supplemented with 450 ppm clove essential oil in diet as compared to control group.

The results with respect to feed consumption were not in agreement with the results of Borazjanizadeh *et al.* (2011) ^[21] who reported that feed consumption was significantly ($p<0.05$) decreased in clove oil supplemented group as compared to control group. Similarly, Mohammadi *et al.* (2014) ^[17] also observed feed intake was significantly decreased in 500 mg/kg clove oil treated group as compared

to control group in broiler chickens. AL-Tabari *et al.* (2018) ^[11] also reported significantly ($p<0.05$) decreased in feed consumption of broiler chickens supplemented with 1 and 5% clove extract in drinking water as compared to control group. Similar results were obtained by Hussein *et al.* (2019) and Moustafa *et al.* (2020) ^[8] observed that feed consumption was significantly ($p<0.05$) increased in clove oil supplemented groups as compared to control group. Similarly, Tahir *et al.* (2019) ^[6] also observed that addition of 0.5 to 1.5% eugenol of clove leaf essential oil in diet of broilers significantly ($p<0.05$) decreased the feed consumption as compared to control group.

Feed Conversion Ratio (FCR)

A particularly useful benchmark for assessing a bird's feed conversion efficiency is the feed conversion ratio, which is calculated as feed consumption per body weight gain. Table 4 shows the details of the mean feed conversion ratio values of broiler chickens in several experimental groups that were recorded at each week (FCR₀₋₁, FCR₀₋₂, FCR₀₋₃, FCR₀₋₄, FCR₀₋₅, and FCR₀₋₆).

Overall feed conversion ratio during 0 to 6 weeks was significantly improved in birds supplemented with clove oil @ 200, 400 and 800 mg/kg (group III, IV and V) and avilamycin (group II) in diet as compared to birds of control group. In the present study, supplementation of clove oil @ 200, 400 and 800 mg/kg in the diet of broilers resulted into significant improvement in feed conversion ratio in dose dependent manner.

Table 4: Effect of dietary supplementation of clove oil for 42 days on feed conversion ratio of broiler birds (Mean $\pm$ S. E.; n=10)

Groups	Feed Conversion Ratio (FCR)					
	FCR ₀₋₁	FCR ₀₋₂	FCR ₀₋₃	FCR ₀₋₄	FCR ₀₋₅	FCR ₀₋₆
I	1.17 $\pm$ 0.04	1.57 $\pm$ 0.06	1.61 $\pm$ 0.06	1.81 $\pm$ 0.07 ^b	1.87 $\pm$ 0.04 ^c	1.99 $\pm$ 0.03 ^b
II	1.17 $\pm$ 0.06	1.53 $\pm$ 0.07	1.55 $\pm$ 0.07	1.51 $\pm$ 0.07 ^a	1.65 $\pm$ 0.03 ^a	1.81 $\pm$ 0.04 ^a
III	1.31 $\pm$ 0.04	1.62 $\pm$ 0.06	1.60 $\pm$ 0.05	1.69 $\pm$ 0.05 ^{ab}	1.80 $\pm$ 0.03 ^{bc}	1.84 $\pm$ 0.03 ^a
IV	1.29 $\pm$ 0.06	1.68 $\pm$ 0.07	1.63 $\pm$ 0.07	1.70 $\pm$ 0.08 ^{ab}	1.70 $\pm$ 0.04 ^{ab}	1.83 $\pm$ 0.04 ^a
V	1.29 $\pm$ 0.06	1.52 $\pm$ 0.07	1.54 $\pm$ 0.07	1.60 $\pm$ 0.08 ^{ab}	1.64 $\pm$ 0.06 ^a	1.75 $\pm$ 0.05 ^a

^{a, b, c} - Values (Mean $\pm$ S. E.) bearing different superscripts within a same column differ significantly from each other ($P < 0.05$).

The results with respect to feed conversion ratio were in accordance with the results of Ertas *et al.* (2005) [16] who reported that feed conversion ratio was significantly ($p < 0.05$) improved in broiler chickens supplemented with essential oil mixture of oregano, clove and anise (200 ppm) and avilamycin (10 mg/kg) in diet as compared to control group. Similarly, Dalkilic and Guler (2009) [9] also observed that feed conversion ratio was significantly ($p < 0.05$) improved in clove extract (@ 400 ppm) supplemented group as compared to control group in broiler chickens. Similarly, Borazjanizadeh *et al.* (2011) [21] reported that feed conversion ratio was improved in clove oil supplemented group as compared to control in broiler chickens. Similarly, Mohammadi *et al.* (2014) [17] reported that feed conversion ratio was significantly ($p < 0.05$) improved in broiler chickens supplemented with clove oil (300 mg/kg) and flavophospholipol (600 mg/kg) in diet as compared to control group. Similar observation was also made by Mehr *et al.* (2014) [12] who reported that supplementation of 450 ppm clove essential oil in broiler diet significantly ($p < 0.05$) improved feed conversion ratio as compared to control group. Similarly, Bello *et al.* (2016) also observed significantly ($p < 0.05$) improved feed conversion ratio in clove extracts (@ 400 and 600 mg/kg) supplemented group as compared to control group in fowls. Similar observation was also made by AL-Tabari *et al.* (2018) [11] reported that feed conversion ratio was significantly ($p < 0.05$) improved in broiler chickens supplemented with 1 and 5% clove extract in drinking water as compared to control group. Similar observation was also made by Moustafa *et al.* (2020) [8] observed significant ($p < 0.05$) improvement in feed conversion ratio in clove oil (100 mg/kg) supplemented group as compared to control group in broiler chickens.

Beneficial effects of clove oil on digestive system of broilers which is responsible for improved feed utilization. Additionally, essential oil improved the nutrient's digestion. For example, essential oils improve apparent whole tract and ileal nutritional digestibility [13], boost the actions of pancreatic lipase and amylase [23] and promote the digestion of protein, cellulose and fat [22]. According to reports, essential oils enhanced the feed conversion ratio in broilers and inhibited the effects of pathogens in the digestive system.

The results with respect to feed conversion ratio were not in agreement with the results of Mukhtar (2011) [14] reported non-significant difference in feed conversion ratio of broilers supplemented with 200, 400 and 600 mg/kg clove oil in diets as compared to control group. Similar observation was also made by Chalghoumi *et al.* (2013) [24] observed non-significant difference in feed conversion ratio of broilers supplemented with essential oil mixture of clove and cinnamon in diet as compared to control group. Similarly, Mahrous *et al.* (2017) [15] also found non-significant difference in feed conversion ratio of broilers supplemented with 0.5 and 1.0 g/kg clove bud powder as compared to control group. Al-Mufarrej *et al.* (2019) [19] also reported that increase level of clove powder beyond 2% of the diet, led to

increased feed conversion ratio as compared to control group.

Livability

All the standard managerial practices were carried out for rearing of birds during the whole experimental period. The livability (%) of birds in all the experimental groups was 100%. There was no bird death over the course of the experiment, indicating that adding clove essential oil to feed at the recommended dosages has no negative effects on birds' livability.

The present findings were in accordance with the results of Dalkilic and Guler (2009) [9] and Mahrous *et al.* (2017) [15] who reported no mortality in clove oil supplemented group of the birds during the whole experimental period. While, Mukhtar (2011) [14] who observed that chicks fed on diets contain clove oil recorded the lowest rate of mortality compared to control group.

The present findings were not in agreement with the results of AL-Tabari *et al.* (2018) [11] reported that chicks fed on diets contain clove oil showed no mortality during 0-28 days and recorded 1% mortality during 28 to 48 days of experimental period.

Conclusion

The current study's findings showed that birds supplemented with clove oil (400 and 800 mg/kg food) had significantly higher body weight and body weight gain, with results comparable to those of standard antibiotic (avilamycin) supplementation. Birds treated with clove oil demonstrated dose-dependent increases in body weight. The overall variations in feed consumption did not vary, indicating that there was no negative impact on feed consumption. Broilers fed with clove oil (200, 400, and 800 mg/kg diet) showed a significant improvement in FCR, suggesting that the oil possessed a positive impact on feed utilization. Birds treated with clove oil demonstrated a dose-dependent improvement in feed conversion ratio, which is comparable to the effects of conventional antibiotics. Conforming clove oil has the potential to replace conventional antibiotic growth promoters in broilers since it has growth-promoting effects at specific doses; no mortality was seen in any of the treatment groups.

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Conflict of Interest

Not available

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