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EFFECTS OF FERULA SUPPLEMENTATION ON PRODUCTIVE PERFORMANCE AND TOTAL ANTIOXIDANT STATUS OF BROILERS UNDER STOCKING DENSITY AND HEAT STRESS

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ABSTRACT

This study aimed to examine ferula dietary supplements on broilers productive performance and physiological parameters under stocking density and heat stress. A total of 480 one-day-old chicks were split up into nine treatments, each with four replicates. The experimental treatments included three control negative and positive treatments of both stocking densities: the control (base diet). Three levels of ferula powder (4, 8, and 12 g/kg of diet) were used for both stocking densities. The temperature was raised to 4°C over the typical range that birds require to survive. The temperature was set at 22°C and then increased to 26°C for 24 hours each day, and they were given constant light for 20 days of rearing without a break. In every phase, the treatment's LBW and BWG did not differ significantly from the negative control. Feed intake was significantly higher in the negative control group than in the positive control groups (8 g ferula/kg feed) and(12 g ferula/kg feed). FCR did not change compared to the control group. At 35 days of rearing, the low- density chicks' body weight, weight gain, feed intake, and feed conversion ratio are significantly higher due to stocking density than the high-density chicks. Significantly raises the positive control group's mortality rate when compared to the negative control group. There is a notable increase in the production index in the negative control group as compared to the positive control group and T2. There was a significant rise in antioxidant (GPX) in negative controls. Eventually, (MDA), there are notable improvements in positive control compared to treatments.

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INTRODUCTION

Ferula is a member of the Umbelliferae family, which has 130 species spread across Central Asia and the Mediterranean region (Chen *et al*., 2000; Shadmani *et al*.,2015). Ferula, which needs dry or moist soil, grows to a size of roughly 2 m by 1.5 m. For both medicinal and culinary purposes, the dried latex (oleo gum resin) that is obtained by deeply cutting the roots or rhizomes is typically favored (Latifi *et al*.,2019). Furthermore, according to recent research, this plant also has antispasmodic, antimicrobial, antiviral, antifungal, cancer chemopreventive, anti-diabetic, anti-hypertensive, anticarcinogenic, and antioxidant qualities. It also has

molluscicidal, intestinal parasite, neuroprotective, and relaxant qualities (Amalraj and Gopi., 2016; Mala *et al*., 2018; Tavassoli *et al*., 2018). One important point is that while antibiotics kill both harmful and beneficial bacteria in the digestive tract, they also increase the growth of gram-positive bacteria by removing gram-negative bacteria to compete. This is the case with herbal essences like probiotics (Mustafa *et al*., 2021). According to reports, the increase in feed intake and feed efficiency brought about by the herbal essential oil blend may be due to its beneficial effects on nutrient digestion (Tayeb *et al*,2019; Sulaiman and Tayeb, 2020). Phytochemicals' diverse biological actions have garnered more attention in recent years for animal health. The non-resistance and residue-free nature of phytochemicals is a benefit over the usage of antibiotics (Gupta and Birdi,2017). One of the active components of phenolic acid, ferulic acid (FA,4-hydroxy-3-methoxycinnamic acid), is isolated from the seeds and leaves of asafetida (Ferula foetida L.) and is known to be a low systemic toxicity antioxidant (Choi *et al*.,2018, and Liu *et al*.,2019). Based on recent reports, FA contains a variety of biological properties, including antimicrobial (Sánchez-Maldonado *et al*.,2011). antioxidant (Ren *et al*.,2017) and (Mir *et al*.,2018), inflammatory-reducing (Bumrungpert *et al*.,2018), antithrombotic (Hong *et al*.,2016), anticancer, and antidiabetic (Chowdhury *et al*.,2019) properties. One possible way that FA functions as an antioxidant is by preventing the production of reactive oxygen species (ROS) in addition to neutralizing free radicals (Ogiwara *et al*.,2002). Furthermore, it has been demonstrated that FA enhances superoxide dismutase's (SOD) antioxidant activity. It was found that FA (1 μM) could shield HEK293 cells exposed to H2 O2 by lowering ROS generation and CAT and SOD levels (Bian *et al*.,2015). FA may enhance the antioxidant capacity by dose-dependently promoting nuclear translocation of Nrf2 and HO-1 expression. Based on the findings of a prior study, FA increased the expression of heme oxygenase-1 (HO-1) to prevent lipid peroxidation and cellular death (Fetoni *et al*.,2010). By raising the Bcl-2/Bax ratio, FA can decrease apoptosis (Cheng *et al*.,2016). Additionally, according to a recent study, FA exhibits notable protective benefits during tissue or cellular damage (Xu *et al*., 2021). There is, however, no data on the therapeutic consequences of FA supplementation in chickens with liver damage brought on by LPS.

High SD may therefore cause pathological reactions that resemble those of HS. Similarly, we previously documented that broiler performance was negatively impacted by excessive SD and that this effect was linked to compromised intestinal barrier function (Goo et al.,2019).In intensive poultry production, stocking density (SD) can also be a major stressor because it is strongly linked to issues with the health, performance, and well-being of the birds (Estevez,2007). Reduced accessibility to feed and water, aberrant behavior, and poor air and floor quality are all potential causes of these issues (Estevez,2007; Bessei,2006). Furthermore, by raising the

temperature of the microenvironments around chickens and reducing heat dissipation from the body, excessive SD can result in a mild HS condition (Bessei,2006 ; Cengiz *et al*.,2015).

Reactive oxygen species (ROS) are increased by heat stress (HS) exposure, while oxidative stress is caused by decreased levels of antioxidants (such as vitamins C and E) and antioxidant precursors (like selenium) (Safdari-Rostamabad *et al*,2017). Numerous phytochemicals have been tested to reduce or even completely eradicate the negative effects of HS (Hosseini-Vashan *et al*., 2016). Furthermore, Shadmani *et al*. (2015) showed that the body weight, body weight gain, and feed intake, feed conversion ratio of broiler improved with supplemented Ferula powder in normal conditions. But while under stocking density and heat stress were not significantly different compared with the negative control. This study aims to evaluate the effects of supplementation with ferula in the diet on productive performance and some physiological parameters of birds under stocking density and heat stress.

MATERIALS AND METHODS

Ethical approve

This experiment followed the regulations and guidelines of the Animal Ethics Committee at the Animal Production Department, College of Agricultural Engineering Sciences, University of Duhok, under the approval No: AEC 27082024.

Experimental animals

The experiment was carried out at the University of Duhok's College of Agriculture, Engineering Science, and Animal Production Department. In a factorial randomized design, 36 experimental units of 480 day-old unsexed chickens (Ross 308) were utilized. The chicks were assigned to nine treatments with four replicates. Twelve chickens made up the same (20) experimental unit, and fifteen chickens made up the same (16) experimental unit, of comparable weight, were divided across 36 pens, each measuring 100 cm in width, 100 cm in length, and 60 cm in height. Three amounts of ferula powder (4, 8, and 12 g ferula /kg of food) and a control (base diet) were the experimental treatments. One male was randomly selected from each replication. Two tubes of blood were drawn from the jugular vein, and the two serum biochemical samples were used to measure antioxidants such as glutathione peroxidase (GPx), malondialdehyde (MDA), and total antioxidant capacity (TAC) according to the manufacturer (Kiazist Life Sciences, Hamedan, Iran. This Glutathione Peroxidase (GPx) kit can generally be used with chicken (avian) plasma or tissue samples, especially for research purposes. However, for full confirmation, it's important to: Check the kit manual inside the box and verify that it supports avian samples in the instructions or validation section. We use Statistical analysis was performed using the SPSS (2016) software package for Windows (SPSS Inc., Chicago, IL, USA). Two-way ANOVA (Factorial) was used to evaluate the effects

of essential oil combinations with the density of birds in the pens on performance. Duncan's multiple range test (Duncan,1955) was used as a post hoc test, and the level of significance (0.05) was used in all of the variables. Results are expressed as mean ± standard error of the mean. The tops of the ferula plant branches were gathered from Mountain Kurdistan, dried in the sun, and ground to create the ferula powder. And include Starter (1–16 days) and growth (17–35 days) meals, which were supplemented with ferula powder, which was added to the base food as follows:

T1- normal condition control (negative control).
T2 -heat stress (12 chickens), positive control.
T3- heat stress (15 chickens), positive control.
T4- heat stress (12 chickens) supplementation 4 gm of ferula \kg of feed.
T5- heat stress (12 chickens) supplementation 8 gm of ferula \kg of feed.
T6- heat stress (12 chickens) supplementation 12 gm of ferula \kg of feed.
T7- heat stress (15 chickens) supplementation 4 gm of ferula \kg of feed.
T8- heat stress (15 chickens) supplementation 8 gm of ferula \kg of feed.
T9- heat stress (15 chickens) supplementation 12 gm of ferula \kg of feed.

Formulation, Done Again (UFFDA) software was used to formulate the diets. The composition of experimental diets is shown in Table 1.

Table 1: Composition of experiment diets.

Ingredient %	Starter	Grower
Corn	38	38
Wheat	19	23
Soybean meal	37.5	33.5
Vegetable oil	1	1
Limestone	1.5	1.5
Dicalcium phosphate	0.5	0.5
DSM Rovimix	2.5%	2.5%
Nutrient ingredient %		
ME (Kcal/kg)	3087	3123
Crud protein	23.09	22.00
CF (Crud fiber)	2.59	2.59
Fat	2.95	3.00
Linoleic acid	1.43	1.44
Lysin	1.57	1.47
Methionine	0.62	0.60
Tryptophan	0.37	0.36
Methionine + cystine	1.05	0.98
Threonine	1.04	0.99
Arginine	1.62	1.52

Additives added :
- DSM Rovimix® per kg: 400.000,00 IU Vitamin A, 160.000,00 IU Vitamin D3, 1.200,00 mg Vitamin E, 100,00mg Vitamin K3, 120,00 mg Vitamin B1, 280,00 mg Vitamin B2, 160,00 mg Vitamin B6, 1.400,00 mcg Vitamin B12, 12.000,00 mg Choline Chloride, 10.411,20 mg Choline, 600,00 mg Calcium D-Pantotenate, 1.600,00 mg Niacin, 40,00 mg Folic acid, 4,00 mg Biotin.
Trace element: Calicum 1.4 %, Phosphor 0.48%, Sodium0.19%, Chloride 0.22%.
- DSM Remineral S® per kg: 3.200,00 mg Mn, 2.000,00 mg Fe, 2.400,00 mg Zn, 400,00 mg Cu, 40,00 mg I, 10,00 mg Se .
- Mycotoxin binder: 40,00 * 10^{12} CFC.
- Enzymes added per kg : 40.000,00 Fyt 6-Fytase EC 3.1.3.26 from Ronozyme Hiphos, 3.200,00 units Endo -1,4-Beta-gluconase activity, 2.800,00 units Endo-1,3(4)-Beta-gluconase activity, 10,800,00 units Endo-1,4-Beta-xylanase activity .
- Antioxidants added per kg: 1.340,00 mg B.H.T, 112,00 mg Propyl Gallate, 200,00 mg Citric Acid .

RESULTS AND DISCUSSION

Table 2 shows the effects of ferula supplementation on live body weight, varying the amount used in the diet, and the overall therapy on the periods of live body weight. The results indicate a significant increase in negative control compared to the other treatments in the three periods. In terms of overall density, there is a notable rise at 15 chicks per 10 days compared to 12 chicks. The density of 12 chicks is substantially higher than that of 15 chicks between days 24 and 35 of rearing. Regarding interaction, table 2 provides evidence of a significantly higher number of positive 12 chicks at 1 day of age compared to negative control, T3, T4, T7, and T8, and a significantly higher number of negative control chicks at 10 days compared to positive 12, T4, T5, T6, and T8, as well as a significantly higher number of negative control chicks at 24 and 35 days of rearing period compared to other treatments. The effect of ferula on live body weight was found to be 4 g/kg diet in comparison to other amounts. The results disagreed with the findings (Roy *et al*., 2014; Mohit *et al*.,2018; Tayeb,2022) reported that the supplementation of ferula in poultry diets leads to improved productive performance because it is a source of many minerals such as calcium, potassium, phosphorus, and ferrate. Other studies indicate that the supplementation of ferula leads to improved poultry performance because it reduces the role and activity of pathogen bacteria inside the digestive system of birds (Mahendra and Bisht, 2012; Shadmani *et al*., 2015). About the effect of density and stress, Mustafa and Tayeb (2022) and Qader and Tayeb (2024) reported that high density and heat stress lead to a reduction in productive performance.

Table .2: Effect of ferula supplementation on live body weight (gm/Bird) under stocking density and heat stress

Treatment	LBW1	LBW10	LBW24	LBW35
Effect of adding different proportions of ferula				
Negative	40.46±0.32	235.96±4.95a	854.21±15.59a	1905.97±38.06a
0	41.07±0.23	219.24±3.50b	730.14±11.02b	1724.45±26.91b
4	40.55±0.23	221.25±3.50b	725.13±11.02b	1778.19±26.91b
8	40.74±0.23	212.67±3.50b	722.69±11.02b	1736.97±26.91b
12	41.04±0.23	216.16±3.50b	701.26±11.02b	1746.63±26.91b
Density effect				
12	41.01±0.14	216.99±2.21b	743.53±6.97a	1771.31±17.02a
15	40.56±0.16	222.41±2.47a	723.76±7.79b	1755.48±19.03b
Interaction				
T1 N C	40.46±0.40b	235.96±1.47a	854.20±21.82a	1905.97±20.63a
T2 P C 12	41.80±0.30a	215.84±3.16bc	752.51±13.91b	1713.82±43.49b
T3 P C 15	40.35±0.32b	222.63±1.43abc	707.77±13.39bc	1735.09±45.65b
T4 4 12	40.54±0.27b	216.49±2.16bc	708.04±12.78bc	1762.40±45.46b
T5 8 12	41.08±0.46ab	207.25±3.96c	712.03±13.57bc	1710.25±56.28b
T6 12 12	41.17±0.43ab	209.42±9.29c	690.86±23.71c	1764.10±24.94b
T7 4 15	40.57±0.11b	226.00±8.11ab	742.23±9.97bc	1793.98±12.96b
T8 8 15	40.40±0.09b	218.09±5.42bc	733.36±12.20bc	1763.69±24.42b
T9 12 15	40.92±0.27ab	222.90±2.10abc	711.67±13.41bc	1729.15±44.88b

[ab] vertical mean significant differences between treatments ($P \leq 0.05$)

Ferula supplementation's impact on body weight gain, varying dosages in the diet, and overall therapy during the periods of body weight gain are shown in Table 3. The results indicate that the negative control significantly increased body weight gain compared to all treatments. About two densities, the weight gain of 12 chicks is significantly higher than that of 15 chicks. The weight gain of the negative control group is significantly higher than that of the other treatments during the entire duration. When compared to various rates of ferula supplementation, the optimal rate for weight gain in interaction treatment is 4g/kg in 15 chicks.

The results disagreed with the findings (Tayeb,2022), who reported that the supplementation of ferula in poultry diets led to improved productive performance, the active compounds of ferula, such as flavonoids, alkaloids, and phenols. About the effect of density and stress, Mustafa and Tayeb (2022) and Qader and Tayeb (2024) reported that high density and heat stress lead to a reduction in productive performance.

Table 3: Effect of Ferula supplementation on body weight gain (gm/Bird) under stocking density and heat stress

Treatment	BWG 1-10	BWG11-24	BWG25-35	WG 0-35
Effect of adding different proportions of ferula				
Negative	195.50±4.90a	618.25±14.10a	1051.77±35.49	1865.51±38.04a
0	178.17±3.47b	510.90±9.97b	994.32±25.10	1683.38±26.90b
4	180.69±3.47b	503.89±9.97b	1053.06±25.10	1737.64±26.90b
8	171.93±3.47b	510.03±9.97b	1014.28±25.10	1696.23±26.90b
12	175.12±3.47b	485.10±9.97b	1045.36±25.10	1705.59±26.90b
Density effect				
12	175.98±2.19b	526.54±6.31a	1027.78±15.87b	1730.30±17.01a
15	181.85±2.45a	501.35±7.05b	1031.73±17.75a	1714.92±19.02b
Interaction				
T1 N C	195.50±1.74a	618.25±21.46a	1051.77±22.28	1865.51±20.30a
T2 P C 12	174.05±3.45bc	536.67±14.80b	961.31±29.63	1672.03±43.42b
T3 P C 15	182.29±1.33abc	485.13±13.70c	1027.32±51.37	1694.74±45.84b
T4 4 12	175.95±2.16bc	491.55±11.21bc	1054.36±33.63	1721.86±45.40b
T5 8 12	166.17±3.52c	504.78±15.52bc	998.22±47.79	1669.17±56.23b
T6 12 12	168.25±9.13c	481.44±14.61c	1073.24±45.97	1722.93±25.22b
T7 4 15	185.43±8.08ab	516.23±9.49bc	1051.76±7.69	1753.42±12.89b
T8 8 15	177.69±5.43bc	515.27±8.22bc	1030.33±22.24	1723.29±24.37b
T9 12 15	181.98±2.08abc	488.77±13.56c	1017.48±35.23	1688.24±44.79b

[ab] vertical mean significant differences between treatments ($P \leq 0.05$)

The effect on feed consumption of varying amounts of ferula dietary supplementation. Table 4 presents the overall treatment during the periods and total feed consumption. According to the results, utilizing a variable rate of ferula resulted in a substantial increase in total feed intake and raising periods (12g ferula /Kg feed) as compared to the negative control in the 10- and 24-day rearing periods. There was a marked rise in negative control over 35 days as compared to therapy (4g ferula/kg feed, 8g ferula /kg feed, 12g ferula/kg feed). While there was a noticeable rise in density in 12 chicks at 10 and 24 and 0-35 days, there was a considerable increase in 15 chicks at 24-35 days compared to 12 chicks. At 10 days, there was a substantial increase in T4 compared to T1, T2, T3, T7, T8, and T9, but at 24 days, there was a significant increase in T4 compared to T1, T2, T3, T7, T8, and T9. However, compared to other treatments, there was a notable rise in negative control compared to the (T2, T3, T5, T6, and T7) during the 35-day rearing period. When ferula is added to the diet for feed intake in an interaction, the rate is 12 g/kg for 12 chicks. The results were also supported by (Alcicek *et al*.,2003; Garcia *et al*.,2007, and Tayeb,2022), who reported an important role of ferula to invigorate the digestive system secretion.

Table .4: Effect of Ferula supplementation on Feed Intake (gm feed/bird) under stocking density and heat stress.

Treatment	Feed intake 1-10	Feed intake 1-24	Feed intake 25-35	Feed intake 0-35
Effect of adding different proportions of ferula				
Negative	223.88±6.22b	872.27±24.24a	1791.65±55.32a	2887.79±48.74a
0	216.35±4.40b	810.59±17.14b	1668.68±39.11ab	2695.62±34.46b
4	248.88±4.40a	911.79±17.14a	1626.61±39.11b	2787.28±34.46ab
8	244.68±4.40a	857.44±17.14ab	1650.31±39.11b	2752.43±34.46b
12	249.20±4.40a	889.40±17.14a	1573.64±39.11b	2712.24±34.46b
Density effect				
12	238.14±2.78a	908.51±10.84a	1644.64±24.74b	2791.29±21.80a
15	237.85±3.11b	817.04±12.12b	1651.73±27.66a	2706.62±24.37b
Interaction				
T1 N C	223.88±4.64c	872.27±12.20bc	1791.65±20.64a	2887.79±20.48a
T2 P C 12	205.59±6.02d	828.35±30.87cd	1697.01±42.33a	2730.96±46.77bc
T3 P C 15	227.10±1.95bc	792.83±15.07d	1640.35±23.49ab	2660.29±28.57c
T4 4 12	256.92±3.51a	980.21±43.76a	1626.53±82.55ab	2863.65±42.40ab
T5 8 12	250.42±9.25a	908.91±12.51ab	1640.30±15.05ab	2799.62±23.46abc
T6 12 12	253.87±10.26a	952.79±16.35a	1467.74±112.84b	2674.41±110.77c
T7 4 15	240.83±4.12abc	843.37±7.44bcd	1626.70±15.07ab	2710.90±5.56bc
T8 8 15	238.93±6.90abc	805.97±38.52cd	1660.33±44.89a	2705.23±4.86bc
T9 12 15	244.53±4.36ab	826.00±9.03cd	1679.53±52.41a	2750.07±57.31abc

[ab] vertical mean significant differences between treatments ($P \leq 0.05$)

The effect of ferula on the feed conversion ratio of utilizing varying amounts of ferula as a dietary supplement. Table 5 presents the effect of treatment on the feed conversion ratio. According to the results, at 24 days, the negative control improved the FCR, and (4 and 12) g/Kg ferula reduced FCR compared to (0 and 8) g/Kg ferula, while at 35 days, the 12 g/Kg ferula significantly improved FCR compared to the negative control. The effect of high density is a better FCR than low density. In the first period, 10 days of age, the negative control improved FCR compared with other groups, while in 35 days of age, the negative control showed a reduction in FCR, and T6 12 g/Kg ferula with 12 birds improved FCR. These results contrast with the findings (Mohit *et al*.,2018, and Tayeb,2022) that reported that the supplementation of Ferula in poultry diets leads to improved feed conversion coefficient, which is because increase of production of the digestive enzymes. (Latifi *et al*.,2019) reported that the aqueous extract of the oleo gum resin shows promising anti-diabetic activity.

Table .5: Effect of ferula supplementation on feed conversion ratio (g)/birds under density and heat stress in broiler

Treatment	FCR 1-10 (g feed/g gain)	FCR 11-24 (g feed/g gain)	FC R 25-35 (g feed/g gain)	FCR 0-35 (g feed/g gain)
Effect of adding different proportions of ferula				
Negative	1.15±0.03	1.42±0.05c	1.71±0.07a	1.55±0.04
0	1.21±0.02	1.59±0.04b	1.69±0.05ab	1.60±0.03
4	1.38±0.02	1.81±0.04a	1.55±0.05ab	1.61±0.03
8	1.43±0.02	1.68±0.04b	1.63±0.05ab	1.63±0.03
12	1.43±0.02	1.84±0.04a	1.51±0.05b	1.59±0.03
Density effect				
12	1.36±0.01a	1.75±0.02a	1.61±0.3	1.62±0.02a
15	1.31±0.02b	1.63±0.03b	1.61±0.04	1.58±0.02b
Interaction				
T1 N C	1.15±0.03d	1.42±0.05d	1.71±0.06a	1.55±0.02
T2 P C 12	1.18±0.04cd	1.55±0.09cd	1.77±0.03a	1.64±0.04
T3 P C 15	1.25±0.02bc	1.64±0.04c	1.61±0.09a	1.57±0,04
T4 4 12	1.46±0.02a	1.99±0.05a	1.55±0.01ab	1.67±0.06
T5 8 12	1.51±0.03a	1.81±0.06b	1.65±0.08a	1.68±0.06
T6 12 12	1.51±0.05a	1.98±0.05a	1.38±0.01b	1.55±0.07
T7 4 15	1.30±0.04b	1.64±0.03c	1.55±0.02ab	1.55±0.01
T8 8 15	1.34±0.00b	1.56±0.06cd	1.61±0.04a	1.57±0.02
T9 12 15	1.34±0.04b	1.69±0.03bc	1.65±0.03a	1.63±0.01

[ab] vertical mean significant differences between treatments ($P \leq 0.05$)

The effect of treatment on the production index of varying amounts of ferula supplementation. The effects of varying dietary intake, overall treatment, overall density, and interaction treatment on the overall mortality, DP%, and productivity index are shown in Table 6. According to the results, the production index for all treatments showed a significant increase in negative control compared to positive control and T2 8g/kg, while the DP% of the treatment was significantly higher than that of both positive and negative controls, and the mortality rate was significantly higher for positive control compared to negative control. When comparing 15 chicks to 12 chicks and DP, there is a noticeable increase in the overall density production index. There is a noticeable increase in the number of 12 chicks compared to 15 chicks, and there is a noticeable increase in the number of 12 chicks compared to 15 chicks. When comparing negative control to T2, T4, and T5, the production index increased dramatically with interaction treatment. There is a numerical negative control about the DP interaction. Regarding mortality, there was a considerable rise in positive control 12 chicks when compared to negative control, T3, T5, T6, T7, T8, and T9. These results agreed with findings (Tayeb.,2022) that the use of ferula in

broiler diet led to improved performance of broiler because the ferula is an antioxidant that led to a decrease the mortality.

Table 6: Effect of ferula supplementation on production index (PI) and dressing percentage (DP) and mortality% under stocking density and heat stress in broilers.

Treatment	P I 1-35	D P %	MORTALITY
Effect of adding different proportions of ferula			
Negative	344.53±15.74a	70.59±0.90	0.00±1.83b
0	290.10±11.13b	70.09±0.63	5.00±1.29a
4	308.87±11.13ab	69.62±0.63	2.08±1.29ab
8	303.97±11.13b	70.42±0.63	1.88±1.29ab
12	311.98±11.13ab	70.24±0.63	0.83±1.29ab
Density effect			
12	303.74±7.74b	70.23±0.40a	3.25±0.82a
15	313.92±7.87a	70.06±0.45b	0.83±0.91b
Interaction			
T1 N C	344.53±8.50a	70.59±0.31	0.00±0.00b
T2 P C 12	269.55±20.55c	70.09±0.88	8.33±3.40a
T3 P C 15	310.65±13.24abc	70.09±1.56	1.67±1.67b
T4 4 12	291.68±22.04bc	69.98±0.74	4.17±2.41ab
T5 8 12	292.29±18.83bc	70.04±0.59	0.00±0.00b
T6 12 12	320.63±22.37abc	70.43±0.80	2.08±2.08b
T7 4 15	326.06±7.40ab	69.26±1.07	1.67±1.67b
T8 8 15	315.66±8.39abc	70.80±0.80	1.67±1.67b
T9 12 15	303.33±9.74abc	70.06±0.77	0.00±0.00b

[ab] vertical mean significant differences between treatment ($P \leq 0.05$)

The effect on antioxidants of varying amounts of ferula supplementation, dietary supplementation, and overall treatment, overall density, and interaction treatment on total antioxidants in (Table 7). Results showed that, when compared to other treatments, there was a significant increase in negative control for GPX, but not for TAC or MDA. When it came to density treatment, there was a significant increase in GPX and MDA for 12 chicks compared to 15 chicks, and a significant increase in TAC density for 15 chicks compared to 12 chicks. The revealed rate of ferula in diet for GPX is 8 g/kg, whereas there is no significant appearance in treatment interaction for TAC; the revealed rate of ferula in diet for TAC is 12 g/kg. In contrast, there is a significant increase in negative control compared to other treatments. The rate of ferula in the food for MDA is 8 g/kg, and there is a marked rise in positive control 12 chicks as compared to (T1, T3, T4, T5, T7, T8, and T9). The rise in antioxidants may be because of active compounds in ferula that reduce the effects of density and stress.

(Sulaiman and Tayeb.,2021; Qader and Tayeb.,2024). Those who explained that medical plants have the role of an antioxidant that improves immunity and livability of birds, that's led to improved productivity.

Table 7: Effect of Ferula supplementation on Antioxidant under Stoking Density and Heat Stress in Broiler

Treatment	GPX (1-10) (U/mL)	TAC (11-24) (µmol Trolox/L)	MDA (25-35) (nmol/mL).
Effect of adding different proportions of ferula			
Negative	69.74±3.12a	882.37±163.41	0.66±0.17
0	43.76±2.21b	844.03±115.55	1.07±0.12
4	28.09±2.21c	670.29±115.55	0.86±0.12
8	33.85±2.21c	567.96±115.55	0.76±0.12
12	32.75±2.21c	802.70±115.55	1.01±0.12
Density effect			
12	45.23±1.40a	692.32±73.08b	0.94±0.07a
15	30.12±1.56b	797.69±81.71a	0.84±0.08b
Interaction			
T1 N C	69.74±1.78a	882.37±38.30	0.66±0.09b
T2 P C 12	56.36±1.50b	653.91±20.81	1.43±0.47a
T3 P C 15	31.17±3.62c	1034.16±143.48	0.72±0.24b
T4 4 12	30.28±3.72c	643.98±53.60	0.80±0.14b
T5 8 12	35.83±1.71c	631.76±126.43	0.69±0.13b
T6 12 12	33.97±4.81c	649.58±108.62	1.12±0.19ab
T7 4 15	25.90±2.19c	696.61±135.33	0.91±0.17b
T8 8 15	31.88±2.24c	504.16±54.38	0.82±0.21b
T9 12 15	31.52±4.42c	955.83±407.33	0.90±0.18b

[ab] vertical mean significant differences between treatment ($P \leq 0.05$)

GPX= Glutathione peroxidase

TAC= Total antioxidant capacity

MDA= Malondialdehyde antioxidant

CONCLUSION

Ferula supplementation had varying effects on the broiler performance under stocking density and heat stress. Supplementing with 4g/Kg ration Ferula and using a lower stocking density (12 birds/m²) improved body weight gain (LBW), especially in the later stages (25–35 and 1–35 days). Overall, using 4g/Kg ration Ferula with lower density showed the best results for BWG. These findings confirm that medicinal plants like ferula can enhance immunity and productivity under heat stress, but their effects depend on dose and stocking density.

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CONFLICT OF INTEREST

The authors confirm that there are no conflicts of interest regarding this research work.

تأثير إضافة الفيرولا على الأداء الإنتاجي وحالة مضادات الاكسدة لفروج اللحم تحت كثافة الطيور(التربية) والإجهاد الحراري

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الخلاصة

أجريت هذه الدراســـة لمعرفة تأثير اضـــافة مســـحوق نبات الفيرولا على الاداء الانتاجي و بعض المعاير فيسيولوجية لفروج اللحم تحت الكثافة التربية والاجهاد الحراري. اذ وزع عشوائيا 480 فرخا بعمر يوم واحد فى تسعة معاملات وبواقع اربعة مكررات و فى كثافتين مختلفتين. تضمنت المعاملات التجريبية المتكونة من ثلاث معامل (سلبي وايجابي فى كل من الكثافتين المختلفتين (12دجاج\م^2 و15 دجاج\م^2) ومعامل الضبط. وتم استخدام ثلاثة مستويات من مسحوق الفيرولا (4 و8 و12 غم / كغم من العلف) لكل من الكثافتين التخزين ،و تم رفع درجة الحرارة (4^0)درجات مئوية فوق النطاق النموذجي. فى الوقت التي تحتاج الطيور الى درجة الحرارة 22 قمنا بزيادة هذه درجة المئوية إلى 26 درجة لمدة 24 ســـاعة خلال فترة التربية (35) يوم. وقد أعطيت ضـــوءًا ثابتًا لمدة 20 يوم الاول من التربية بدون اســـتراحة . لم يختلف وزن الجســـم الحي والزيادة الوزنية للمعاملات العلاج بشكل كبير عن المعامل السلبي . كان تناول العلف أعلى بشكل ملحوظ في المعاملات الضابطة السلبية منه في المجموعتين الضابطتين الإيجابية و(8غم فيرولا \كغم علف)و(12غم فيرولا \كغم علف).و لم يتغير معدل تحويل العلف مقارنة بالمجموعة الضـــابطة في فترة التربية (35) يوم. وفي النهاية اظهرت النتائج ان اضـــافة مســـحوق نبات الفيرولا الى العلف يكون وزن الجســـم الحي و وزيادة الوزن الطير وتناول العلف و نسبة تحويل العلف لدى الكتاكيت منخفضة الكثافة اعلى بكثير. وكان نسبة هلاكات عالية في معاملات التحكم الايجابية عند مقارنتها بالمعاملات الضابطة السلبية. هناك زيادة ملحوظة في موشر الانتاج في مجموعة التحكم الســـلبية مقارنة بالمجموعة الضـــابطة الإيجابية و(8غم فيرولا \كغم علف). فيما يتعلق بمضادات الاكسدة (GPX) تزداد معنويا في المجموعة الضابطة السلبية مقارنة بمعاملات نبات الفيرولا. في النهاية (MDA) تزداد معنويا في المجموعة الضابطة الإيجابية مقارنة بالعلاجات الأخرى.

الكلمات المفتاحية: الاجهاد الحراري , فروج اللحم, نبات الفيرولا

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