Effect of Dietary Supplementation with Different Levels of Quercetin on Productive, Physiological Performance and Antioxidant Status of Broiler Chickens Reared under Heat Stress

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Abstract
The objective of this study was to assess the productive, physiological performance and antioxidant status of broiler chickens under heat stress conditions when fed different levels of quercetin. The total number of one day old broiler chicks used were 144 birds which were randomly allocated in four treatments (36 birds/treatment) and three replicates/treatment. The first, second and third treatments (T1, T2 and T3) were received quercetin at a level of 150, 250 and 350 mg/kg of diet respectively. Treatment 4 (T4) was used as control (no supplementation). All experimental treatments were subjected to heat stress conditions. The birds were exposed from the first day until the end of the experiment to temperatures ranging from 38–40°C during the first week and 30–32°C during the final week of the experiment. The results showed that the birds in T2 and T3 treatments had the highest final body weight, body weight gain and there was no mortality in them. They also had increased feed conversion ratio compared to control treatment. The levels of red blood cell count (RBC), hemoglobin concentration (Hb) and packed cell volume (PCV) were higher in the T4 (control) group, but with reduced lymphocyte percentage and increased heterophil percentage and heterophil-to-lymphocyte (H/L) ratio. The results showed a significant increase ($P \leq 0.05$) in both mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH) in treatments T1, T2, and T3 compared to the control treatment whereas no significant differences were observed in mean corpuscular hemoglobin concentration (MCHC) among all treatments. Moreover, the antioxidant activity results indicated that treatment with T3 had the highest activity of SOD than the control treatment while no difference was observed between the treatments in the activities of GSH-Px, CAT and MDA. Overall, 250 and 350 mg/kg of quercetin supplementation to broiler chickens subjected to heat stress appeared to be the most effective treatments in terms of improved productive, physiological performance and antioxidant status.

Keywords: Antioxidant status, Broiler chickens, Blood parameters, Heat stress, Quercetin.

Introduction

The fowl area is considered individual of ultimate main bread reduction subdivisions general (Chowdhury and Morey, 2019; Khalaf et al., 2025). The ancestral improvement of grill for cookout chickens has happened supervised at reconstructing FCR, growth rate, and gist kind. Therefore, good outing stains that make use of feed better have been growing at rapid rates with soft gist gaining popularity in the markets. The need for the hen core has been growing at a very rapid rate and the use of broilers has been witnessing tremendous growth in manufacturing (Mace and Knight, 2022; Idan et al., 2026; Khalaf et al., 2026). Poultry result, exceptional broiler result, is conscious individual from ultimate result strategies of animal result, which is still evolving with new changes in training, feed and management to improve the production of poultry species in response to the growing demand of higher yields (Gržinić and others., 2023). Nevertheless, the area is loaded accompanying various material questions that considerably impact on the fruitful and strength acting of chickens, with heat stress being individual of ultimate main determinants in hot of or in the atmosphere domains (Lara and Rostagno, 2013). It's a stress that leads to monetary losses and is directive a variety of body responses including oxidative stress, acid–base inequality, and injured privilege. All of these changes are correlated with higher death rates and feed adeptness, corpse weight and feed consumption (Wasti and others., 2020). The negative effects of heat stress have led the current studies in the direction of the exercise of compounds which are not affected by heat stress but which have antioxidant properties, and which can be used to overcome the effects of heat stress and improve fruit yield and physiological performance of fowl (Wasti and others., 2020).The vital naturally occurring flavonoids in the direction of plants are known as quercetin, which has a wide range of antioxidant and anti-instigative venture and acts as an invulnerable stimulator and antagonistic-oxidative power (Boots and others., 2008). Quercetin has forceful antioxidant properties, containing burning of sensitive oxygen species, sensitive nitrogen variety and sensitive element species, in addition to by allure lowering properties as a chelator of the change hardware ions. It has 5 working hydroxyl groups that are energized matter donors and have free radical scavenging features (Carrillo-Martinez and others., 2024). Additionally, quercetin has a role to play in maintaining the balance of oxidants in the frame and in regulating the amounts of glutathione in animals (Xu and others., 2018). It is also called a demanded antioxidant property, active synthetic fixed and multifunctional, uncontaminated project, free radical scavenging activity and invulnerable function support (Dang and others., 2022).In previous studies, quercetin was said to enhance the last crowd burden, total weight gain, regular weight gain and feed adaptation adeptness (FCE) in broiler diets (Ugwuoke and others., 2024). Quercetin is a purposeful and active compound with antagonistic-instigative and antimicrobial properties which is also a powerful antioxidant (David and others., 2016). Quercetin grant permission can take part in lengthening the jutting-history of core, as it prevents the disintegration of lipids and grant permission enhances the strength rank (Saeed and others., 2017) of the mammals, improve their invulnerable answers (Saeed and others., 2017) and enhance the fitness of grill chickens (Saeed and others., 2017). Thus, the aim of this study was to determine the answer of creative performance corporal characteristics and the antioxidant rank of broilers, when exposed to heat stress (HS) and fed a dietary supplement of quercetin.

Materials And Methods

The present study was carried out in the poultry hall of Animal Field at the College of Agriculture, University of Basrah during 35 days from 1th December 2024 till 4th January 2025.

Birds Management:

The fowls were protect in rising cages (120cm distance x 80cm width x 70cm climax). In the experiment, two diets (beginner and raiser) were augment in the first temporal length of event or entity's existence utilizing circular feeders (flexible plates) and later in the second period using tubular feeders accompanying a ability of 10kg. The second feed, the beginner feed, was supplemented just prior to 21 days after adult. The first ration consisted of 22.54% crude protein and 2988.49 kcal/kg of metabolisable strength. As it is visualized in Table (1) the raiser diet was augment from 22 days adult just before completely of the experiment and comprised 21.15% crude protein and 3054.29 kcal/kg ME. Sucking water was provided from simple 5 litre drinkers. The inevitable hotness (heat stress) was provided by the hot electric heaters which were connected to warm manager as shown in Table (2). A the act of providing or changing the air plan was equipped in the gallery and continuous light (again 24-stage ignition) was likely all along the exploratory ending.

Table (1): Diets nutritional and chemical compositions

Ingredient	Starter Diet (1–21 Days)	Grower Diet (22–35 Days)
Yellow Corn	53.0	54.0
Wheat Bran	6.00	9.00
Soybean Meal (48%)	32.0	29.0
Protein Concentrate	5.30	4.00
Vegetable Oil	1.00	1.50
Dicalcium Phosphate	0.50	0.50
Limestone	0.50	0.50
Methionine (99%)	0.17	0.11
Lysine (98%)	0.23	0.09
Premix	1.00	1.00
Salt	0.30	0.30
Total	100	100
Chemical analysis of diets		
Component	Value	Value
Protein	22.54%	21.15%
Metabolizable Energy (kcal/kg as fed)	2988.49	3054.29
Fat	2.85%	3.33%
Fiber	2.28%	2.37%
Ash	8.0%	8.7%
Carbohydrates	3.60%	3.49%
Calcium	1.34%	0.90%
Available Phosphorus	0.65%	0.62%

Table (2). Temperatures Used During the Rearing Period

Age (week)	Temperature
1	c˙38-40
2	c˙36-38
3	c˙34-36
4	c˙32-34
5	c˙30-32

Study Treatments:

Productive Traits:

The final pressure, definitive burden gain, accruing feed intake, and feed change competency were deliberately established at the end of the experiment Akomah and others.,(2021). Mortality rates were planned based on by Al-Zubaidi, (1986).

Hematological Traits:
At 5 days after adult the birds were randomly selected at the part tone for the composition of blood samples and were five birds per replicate. One milliliter of ancestry was implant tubes that had the anticoagulant EDTA in bureaucracy to learn the packed container capacity (PCV), total cell with hemoglobin count (RBC), red body fluid concentration (Hb), mean corpuscular book (MCV), mean corpuscular red body fluid (MCH), mean corpuscular red body fluid aggregation (MCHC), heterophil percentage (H), lymphocyte portion (L) and the heterophil to lymphocyte percentage (H/L). Established Campbell (1995) that this limits above have occurred estimated.

Antioxidant status:
Glutathione peroxidase (GSH-PX), superoxide dismutase (SOD) and catalase (CAT) activities in serum and malondialdehyde (MDA) concentration were used to evaluate the antioxidant status as per (Flohe and Gunzler, 1984; Sanja et al, 2015; Al-Mosawy and Al-Salhie, 2021).

Statistical Analysis:
To determine the distinctnesses between the situations at level ($P \le 0.05$), the complete randomized design (CRD) Duncan test (1955) was employed and the following analytical model was used: $Yij = \mu + Ti + ei$ Yij: Observation worth. μ: General mean of the intentional characteristic. Ti: Treatment effect. ei: Error effect. Treatments: The impact of the situation or the situation process. Experimentally made errors: Effect of exploratory errors.

Results And Discussion

The productive performance of the broiler chickens under heat stress conditions fed different diets containing different levels of quercetin has been presented in Table (3). The results showed that the initial body weight of the treatments did not differ significantly from each other. The second and third treatments (in comparison with the first and control) showed significant improvement ($P \le 0.05$) in terms of body weight gain and total body weight gain. The improvement may be attributed in the effect of quercetin as antioxidant to enhance the growth efficiency and productive performance parameters of broiler chickens (Irawan et al. 2026). Total Feed Intake: No significant difference was found between all the treatments. The second and third treatments had the highest Feed Converted Efficiency than the first treatment and control treatments. The results are similar from the study carried out by Tripathi et al. (2025), who reported that antioxidant phytogenic compounds like quercetin helps in improving gastrointestinal health and thereby mitigates the negative impacts of heat stress, leading to better feed conversion ratio and nutrient absorption. As regards mortality rate, there was a significant ($P \le 0.05$) difference between the control treatment and the other treatments. This could be due to the protective effect of quercetin on the health and immune status of birds as well as to its protective effect against oxidative stress under the high environmental temperature. The study conducted by Sierżant et al. (2023), revealed that daily consumption of
The results showed that quercetin supplementation in broiler diets had a beneficial effect on improving antioxidant indices, reducing oxidative damage and in stressed birds a negative effect on performance has a positive effect on broilers vitality and survival rate

Table (3): Effect of Adding Different Levels of Quercetin to the Diet on productive performance of Broiler Chickens Reared under Heat Stress (Mean± SE)

Parameters	T1	T2	T3	T4
Initial body weight (g)	40.86 ± 0.00	40.21 ± 0.00	40.16 ± 0.00	40.08 ± 0.00
Final body weight (g)	1814.30^{b} ± 4.61	1977.41^{a} ± 4.82	1977.49^{a} ±33.48	1808.98^{b} ± 4.59
Total weight gain (g)	1773.44^{b} ± 2.30	1937.2^{a} ± 60.08	1937.33^{a} ± 0.64	1768.90^{b} ± 2.40
Total feed intake (g)	2312.33 ± 39.83	2348.33 ± 47.61	2362.87± 46.18	2333.83 ± 38.43
Cumulative feed conversion ratio (FCR) (g.g)	1.31^{a} ± 0.17	1.21^{b} ± 0.02	1.21^{b} ± 0.09	1.32^{a} ± 0.19
Mortality rate (%)	0.00^{b} ± 0.00	0.00^{b} ± 0.00	0.00^{b} ± 0.00	5.55^{a} ± 2.77

Different Letters in the same row mean there are significant different at ($P \le 0.05$)

Some hematological limits of grill chickens under heat stress environments (HS) all along rearing were intentional in the ghost of various concentrations of quercetin (QR) increased the diet (Table (4)). The results granted that skilled were meaningful dissimilarity ($P \le 0.05$) between the exploratory situations concerning the intentional hematological limits of heat emphasized fowls. The control treatment had preeminent supporter principles for cell with hemoglobin count (RBC), haemoglobin (Hb), full container capacity (PCV) all of that were dropped off in the other situations accompanying quercetin. The antioxidant exercise of quercetin maybe being the reason for this decline, as it is famous to act as an antioxidant and to decrease oxidative damage (Carrillo-Martinez and others., 2024). This accordingly helps to maintain corporeal equilibrium of ancestry containers and develop their functional adeptness. The different results displayed that mean corpuscular book (MCV) and mean corpuscular red body fluid (MCH) in the quercetin situations were considerably (P≤0.05) higher than those of the control situation but skilled was no meaningful distinctness middle from two points the quercetin situations and the control in the mean corpuscular red body fluid aggregation (MCHC). This could mean that quercetin has securing belongings against natural oxidative damage and deterioration of membranes (Boots and others., 2008). The characteristic blood corpuscle count showed that the control situation had the topmost percentages of heterophils and the maximal percentage of heterophil to lymphocytes (H/L) accompanying meaningful (P≤0.05) decline in the portion of lymphocytes. On the other hand, quercetin treatments influenced to decline of heterophil allotment and H/L percentage and increase of lymphocyte allotment. The increase of the H/L percentage has existed associated with corporal stress in fowls (Gross and Siegel, 1983). S. Ahammad and Kim (2024) showed that augmenting the rats 0.025%, 0.050% and 0.100% of quercetin, developed in increase in lymphocytes count accompanying growing able to be consumed level of quercetin. El-Kazaz et al. (2024) displayed that grill for cookout chickens invulnerable rank raised later six weeks when they were augment different doses of queretin (0, 200, 400 and 600 ppm).

Table (4): Effect of Adding Different Levels of Quercetin to the Diet on Some Hematological Parameters of Broiler Chickens Reared under Heat Stress (Mean± SE)

Treatments Parameters	T1	T2	T3	T4
RBC (x 10^6 .mm3)	$2.97^b \pm 0.03$	$2.95^b \pm 0.04$	0.02 ± 2.93^b	0.05 ± 3.14^a
Hb (g.dL)	$8.49^b \pm 0.09$	$8.44^b \pm 0.11$	$8.38^b \pm 0.05$	$8.94^a \pm 0.06$
PCV (%)	$25.50^b \pm 0.28$	$25.33^b \pm 0.33$	$25.16^b \pm 0.16$	$26.83^a \pm 0.15$
MCV (fl)	$85.85^a \pm 0.21$	$85.86^a \pm 0.22$	$85.87^a \pm 0.03$	$85.44^b \pm 0.02$
MCH (pg)	$28.58^b \pm 0.04$	$28.61^b \pm 0.06$	$28.60^b \pm 0.22$	$28.47^a \pm 0.39$
MCHC (g.L^1)	33.33 ± 0.07	33.32 ± 0.05	33.30 ± 0.02	33.32 ± 0.01
Heterophils (%	$30.33^b \pm 1.20$	$37.00^b \pm 4.04$	$36.00^b \pm 1.15$	$49.00^a \pm 3.21$
Lymphocytes (%)	$69.66^a \pm 2.33$	$63.00^a \pm 6.03$	$64.00^a \pm 1.28$	$51.00^b \pm 5.42$
H/L ratio	$0.43^b \pm 0.02$	$0.59^b \pm 0.10$	$0.56^b \pm 0.09$	$0.96^a \pm 0.12$

Different Letters in the same row mean there are significant different at (P≤0.05).

In the significant distinctnesses (P ≤ 0.05) observed in the exploratory situations, the superoxide dismutase (SOD) endeavor was observed. The situation with a 350 mg/kg level of quercetin had the capital advantage, and there were no important dissimilarities between the first and second levels of quercetin and added levels. SOD is one of the enzymes that is not involved in the bureaucracy in the body to fight free radicals that may be generated in oxidative stress (Surai, 2018). Carrillo-Martinez and others. (2024) granted that quercetin is forceful in increasing the antioxidant catalyst project and dropping the aggregation of ROS, that causes oxidative damage. The results of enzymes exercise in comparison with the control revealed no significant differences, except that the increase of SOD project, which may fail to trigger a combined response from the additional antioxidants involved in atom and molecule change systems Surai. It may be concluded that the antioxidant justification structure (SOD, which is the enzyme most strongly represented for one venture of antioxidant enzymes) was only partially stirred in one out of the situations studied, since the actions of the various antioxidant enzymes and the concentration of the oxidative damage indicator (MDA) remained unchanged. This signifies that the antioxidant answer was wanting, agreeing the current notion that the evaluation of the oxidative stress rank bear rest on the linked amount of multiple biomarkers alternatively an individual individual (Sies and others., 2017). A reduction in the number was observed in the triennial situation compared with the control situation with respect to malondialdehyde (MDA). This research was in agreement with the study of Ying and others. (2020) place they stated that, augmenting broiler hen accompanying quercetin at 0.02%, 0.04% and 0.06% of the basic diet happened in decline in malondialdehyde (MDA) level in ancestry serum at 35 days adult.

Table (5): Effect of Adding Different Levels of Quercetin to the Diet on Antioxidant status of Broiler Chickens Reared under Heat Stress (Mean± SE)

Treatments Parameters	T1	T2	T3	T4
SOD (U/MI)	0.89^{ab} 0.18	0.76^{ab} 0.19	1.16^a 0.03	0.55^b 0.16
GSH-PX (U/ I)	643.33 22.42	666.66 31.92	665.00 38.83	696.66 29.20
CAT (U/MI)	0.98 0.06	0.96 0.04	1.01 0.09	0.99 0.01
MDA UM/L)	37.83 0.38	37.88 2.49	36.21 1.28	38.49 1.48

Different Letters in the same row mean there are significant different at (P≤0.05)

Conclusions

The supplementation of Quercetin in critical diets for barbecue suggests it may be a key factor in mitigating negative gear of heat stress. Various levels of quercetin differed their neighbours, artistic ability, hematological properties and rank of antioxidants. The higher quercetin decorated frame burden gain, as well as feed adaptation influence and antioxidant exercise was observed with the grower of different amounts of quercetin. Therefore, quercetin likely deliberate an awake automatic feed preservative for reconstructing the prosperity rank and productive acting of criticize for barbecue chickens bred under heat stress.

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