Evaluating the Productive Performance of Japanese Quail When Naringenin Is Added To The Feed Under A Thermally Stressed Environment

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Abstract

This experiment was conducted at the Animal Production Field of the College of Agriculture, University of Sumer, from January 7, 2025, to February 19, 2025, for a period of six weeks, One hundred and eighty one-day-old Japanese quail were used, obtained from the Irfan Reserve in Suq al-Shuyukh District, Dhi Qar Governorate, and raised on the floor. At the end of the third week, the birds were randomly divided into four experimental treatments with three replicates per treatment. Each treatment consisted of 45 birds, and each replicate consisted of 15 birds. naringenin powder was used as a feed additive at a rate of 400 mg/kg of feed. T1 was the control, with no additives used. T2 involved the addition of 400 mg/kg of naringenin powder to the quail's diet. T3 involved the addition of naringenin powder at a rate of 400 mg/kg of feed with heat applied at a rate of 4°C resulted in a temperature of 29°C in the fourth week, exceeding the normal temperature in other treatments T4 was only a heat stress treatment and in this study we reached the following results:

1. T2 showed a significant improvement during the experimental weeks for all production performance indicators in quail: live body weight, weight gain, feed consumption, feed conversion ratio, and dressing percentage, which could be due to the addition of naringenin to the feed.

2. T3 had similar weight values to the control group, indicating no response or negative effects from heat stress caused by adding naringenin to the feed.

3. T4 recorded the lowest values for production performance indicators due to continuous exposure to heat stress.

Keywords : Naringenin, Production Performance, Heat stress, Japanese Quail

Introduction

Poultry is an important food source, providing animal protein and contributing to food security for the population. It is also a source of national income for many countries. one such bird is the Japanese quail. Recently, research on animal production related to the Japanese quail has increased due to its nutritional and economic importance [1] the quail is characterized by its small size, requiring minimal space for rearing and making it easy to handle. Its most important features are its rapid production and growth cycle and high feed conversion efficiency [2].however, the productivity of this bird faces a significant challenge due to environmental changes and adverse environmental conditions, most notably heat, which causes serious damage

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to the bird's internal balance, potentially leading to reduced growth rates, decreased feed conversion efficiency, and a decline in production [3],[4] . One of the disadvantages of heat stress is the weakening of the birds' immunity due to increased free radical production. As a result of these damages, most studies and research have focused on the use of supplements. Feed as a defensive measure to protect the bird from harm Stress, where feed additives play an important role in mitigating the damage caused by heat stress. These additives include vitamins, organic acids, probiotics, and antioxidants [5], Flavonoids, which are natural organic chemical compounds belonging to the polyphenol family, are plant byproducts. Their sources include vegetables, medicinal herbs, citrus fruits, berries, tea leaves, and extracts from oilseeds such as pomegranate peel. A key characteristic is their support of gut health through their antimicrobial activity [6].

Natural products are a rich source of phytochemicals, including polyphenols, which provide a reservoir of antioxidants to maintain poultry health. Polyphenols are classified based on the structure of their phenolic rings and the functional groups that link these rings. They are then divided into flavonoids, lignans, stilbenes, and phenolic acids. Flavonoids are essentially natural pigments found mainly in plants [7], and consist of a basic phenolic structure. Flavonoids have gained prominence in herbal medicine due to their biological benefits [8]. Among the flavonoids, naringenin has recently received considerable attention, with several studies revealing that many of its biological properties are medicinal in nature [9]. Naringenin, a trihydroxy flavonone, is found primarily in citrus fruits such as tomatoes, oranges, and grapefruits [10]. Therefore, this study was conducted to determine the effect of naringenin supplementation on the productive performance of Japanese quail under natural and heat stress conditions.

Materials and working methods

The study was conducted in the animal production field of the College of Agriculture / University of Sumer from (January 7, 2025 to February 19, 2025) until the end of the experiment at the age of 6 weeks. The rearing hall was prepared, cleaned, and sterilized and equipped with all the bird's needs, which are 5 cm thick wood shavings, feeders, waterers, vents, electronic thermometer, and gas and electric heating. The birds were raised on the floor. In the experiment, 180 one-day-old Japanese quail, with an average weight of 7.45 g, were used. They were obtained from the Irfan Reserve in Suq Al-Shuyukh District in Dhi Qar Governorate. At the end of the third week of rearing, the weights of all the birds were recorded, and their weights ranged between (145 - 160) and they were randomly divided into four experimental treatments with three replicates, each treatment with 45 birds and each replicate with 15 birds, numbering rings were placed on the birds' legs (banding).

Study **Treatments**

T1: a control transaction that was without any additions

T2 : naringenin powder was added at a rate of 400 mg/kg of feed at normal temperature .

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T3 : naringenin powder was added at a rate of 400 mg/kg of feed, with a temperature increase of 4°C above the average temperature the natural .

T4: treatment is a heat stress treatment only, with an increase of 4°C above the normal temperature without any additions. the first and second treatments were isolated from the third and fourth treatments, as the latter were exposed to high temperatures using an electric heater in addition to the gas incubator.

Table 1. The thermal program followed in the study

Treatments	Temperature		
	Week 4 (28 day)	Week 5 (35 day)	Week 6 (42 day)
T1 Control	25	21	19
T2 adding Naringenin	25	21	19
T3 Naringenin adding +Heat stress	29	25	23
T4 Heat stress	29	25	23

Naringenin

naringenin was used in a fine powder form prepared from local markets in Dhi Qar Governorate.

Nutrition

Japanese quail were fed a diet prepared by Barash Feed Factory located in Erbil Governorate, which contained (23% crude protein and energy equivalent to 2940 kcal/kg of feed) and was provided freely.

Studied Traits

Performance indicators were calculated, including live body weight, weight gain, feed consumption, feed conversion efficiency, and dressing percentage. Weights were recorded using a sensitive scale, and averages were calculated according to the equations [11].

1. Body weight (grams): The weights of the birds were recorded at one day old, then measured at the end of each week using a digital scale with two decimal places.

2.Weight gain (grams/week/bird): body weight at the end of the week − body weight at the beginning of the week

3. Feed conversion efficiency $= \frac{\text{total feed consumed}}{\text{total weight gain}} \times 100$

4. Feed consumed = the weight of the feed given at the beginning of the week _ the weight remaining at the end of the week

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5.Weight of the slaughtered animal (grams): The weight of the slaughtered animal was measured after removing the inedible parts using a digital scale with two decimal places.

6.Yield percentage % $= \frac{\text{Carcass weight}}{\text{Weight before slaughter}}$

Statistical Analysis

Statistical analysis of the study data was performed using the General Linear Model (GLM) procedure within the SAS (2012) [12] statistical software. The effects of the treatments on the studied traits were determined using a Completely Randomized Design (CRD), and Duncan's Multiple Range test Duncan, 1955 [13] was employed to assess the significance of differences between means at the ($P \leq 0.05$) and ($P \leq 0.01$) levels

$$Yij = \mu + ti + \varepsilon ij$$

the overall mean of the studied indicator the effect of adding naringenin under normal conditions and its addition under heat stress

Where :-

: the studied traits Yij

the overall mean of the studied indicator : μ

ti : the effect of adding naringenin under normal conditions and its addition under heat stress

ε ij the random error

Results and Discussion

From the results shown in Table (2), we notice a significant effect of the feed additive naringenin powder on bird weight throughout the weeks of the experiment—the fourth, fifth, and sixth weeks. The second experimental treatment T2 (addition of naringenin powder 400 mg/kg feed) showed a significant superiority ($p \leq 0.05$) compared to the control treatment T1 and all other experimental treatments T2, T3 during the experimental weeks. This agrees with [14]noted, as they concluded that adding naringenin and hesperidin improves digestion and absorption in the small intestine, which reflects in improved and increased body weight. Additionally, [15] and [16] revealed that feed additives in poultry diets in general improve production performance and help achieve higher body weights during the rearing period.

the third treatment recorded weights similar to the control treatment and appeared unaffected by the heat stress they were exposed to throughout the weeks of the experiment. This might be due to the addition of naringenin powder, which helps reduce the effects of heat stress by lowering corticosterone levels and increasing the relative weight of immune organs. This was confirmed by [17]and [18] in a study they conducted on Japanese quail, where they noted that nutrient absorption, production performance, and poultry health highly depend on the surrounding environmental conditions. Consequently, heat stress can destroy the physical barrier of the intestines, disrupting the microbial balance,It affects digestion and absorption in the intestines, which in turn leads to reduced productivity, specifically in body weight of quail.

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Meanwhile, the fourth treatment T4 (heat stress treatment) recorded the lowest bird weights compared to the control treatment. This could be due to exposure to high temperatures, as it is known that heat stress reduces a bird's appetite for feed, leading to lower feed intake to reduce the heat produced from eating and digestion. Feed intake is one of the indicators of production traits, as it is linked to the quail's body weight and feed conversion efficiency, which in turn leads to reduced production performance during heat stress. The results of this study were consistent with what has been found in other research [19], [20] they pointed out that exposure to heat stress activates the hypothalamic-pituitary axis and releases corticotropin-releasing hormone, which leads to the production of adrenocorticotropic hormone in the pituitary gland, which in turn stimulates the secretion of corticosterone from the adrenal cortex, in the adrenal medulla. Administering corticosterone at different concentrations gradually leads to a decrease in body weight. [21] and [22]revealed that the rate of body weight gain in heat-stressed birds drops by 40% and 43.3%, respectively, compareto the control group.

Table 2. Effect of different treatments on the weights of quail (g) at different ages (mean ± standard error(

Treatment	Temperature		
	Week 4 (21 day)	Week 5 (35 day)	Week 6 (42 day)
T1 Control	^{b}00 2.±199	2.65^{b} ± 250	297 ± 2.65^{b}
T2 Adding 400 mg/kg of naringenin to the feed	225 ± 2.00^{a}	281 ± 3.08^{a}	315 ± 3.00^{a}
T3 Adding 400 mg/kg of naringenin to the feed + heat stress	.00^{b}197 ± 2	2.65^{b}±250	289 ± 2.65^{c}
T4 Heat stress	2.00^{c}± 170	2.65^{c}±214	240 ± 2.65^{d}
Morale level	*	*	*

The different letters a, b, c, d indicate that there are significant differences between the treatments at the (P≤0.05) significance level, N.S significant different, * not significantly different

Table (3) Shows the effect of different treatments on the weight gain rate of quail. Significant differences were observed between the experimental treatments T1, T2, T3, and T4. Treatment T1 showed a significant advantage (P≤0.05) in weight gain during the fourth week, followed by the supplement and stress treatment T3, which was significantly superior in the fifth week of the experiment. Treatment T2 recorded the highest weight gain rate among all treatments compared to the control, while treatment T4 had the lowest values Throughout the weeks of the experiment. Regarding the cumulative weight gain rate, a highly significant increase was observed in

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favor of treatment T2 compared to the control and other treatments.

Table (4) Shows the effect of different treatments on the feed consumption rate of Japanese quail, with results showing a significant increase at ($P \leq 0.05$) for the experimental treatment T2 compared to the control treatment throughout all weeks of the experiment. T2 recorded the highest feed Consumption among all experimental treatments. The experimental treatment T3 had values close to the control T1 in feed consumption rates, while T4 recorded the lowest feed consumption rates throughout the experiment due to continuous exposure to heat stress.

Table (5) The effect of different treatments on the feed conversion ratio in quail, T2 recorded the best feed conversion rate, whereas experimental treatment T4 failed to achieve the desired level due to sensitivity issues.It was observed from the experiment results that treatment T2 outperformed in terms of body weight, gain feed intake, and feed conversion ratio. The improvements in live body weight, weight gain, and feed conversion ratio observed in birds receiving the naringenin powder-supplemented diet may be attributed to the active compounds present in the powder, such as phenols, flavonoids, and tannins. [23]. Flavonoids act as a growth promoter and improve metabolism, which leads to muscle tissue growth by stimulating the production of thyroxine hormone and increasing metabolic rates to build muscle mass in the body. This aligns with what [24] mentioned, that adding naringenin powder at different levels to quail feed for 21-42 days as the use of a dietary supplement improved feed intake, the feed conversion ratio, nitrogen excretion, and energy metabolism. Consequently, this improvement positively influenced the production performance of Japanese quail and increased antibody levels; similarly, it was shown in [25] That adding naringenin to broiler feed improved the weight gain rate, and improving the feed conversion ratio it Helps stimulate the secretion and activity of intestinal and pancreatic enzymes such as trypsin, amylase, and lipase thereby enhancing the bird's utilization of nutrients like proteins, carbohydrates, and fats. Results from the third experimental treatment (T3) showed values comparable to those of the control group, even under heat stress conditions. The maintenance of weights similar to the first treatment group may be attributed to the addition of naringenin. this compound acts as an antioxidant by activating enzymes that protect cells against harmful oxidative compounds, thereby safeguarding the birds' digestive systems from the adverse effects of high-temperature heat stress. This was further confirmed by [26] The results of his study showed that feed additives rich in antioxidants help reduce the harmful effects of heat stress. The experimental treatment T4 recorded the lowest weight values, which could be due to continuous exposure to heat stress.

[27]Found that increasing the body temperature of birds beyond the normal range triggers a series of irreversible thermoregulatory events that can lead to bird mortality. [28] indicated that birds try to reduce their heat production by eating less feed during high temperatures, and feed intake can drop by up to 1.5% for every one-degree Celsius increase above normal temperature levels. Consequently, reduced feed intake leads to a lack of essential nutrients, and when the temperature rises, birds spend the little energy they get from the feed on panting and wing lifting to try to

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relieve heat stress. The end result is that the birds show lower production performance.

Table 3. Effect of different treatments on the weekly weight gain rate (g/bird) of quail at different ages (mean ± standard error)

Treatments	Weeks		
	Week 4 (21 day)	Week 5 (35 day)	Week 6 (42 day)
T1 Control	47 ± 1.00[a]	51 ± 1.00[b]	54 ± 1.00[c]
T2 Adding 400 mg/kg of naringenin to the feed	43 ± 1.00[b]	47 ± 1.00[c]	69 ± 2.00[a]
T3 Adding 400 mg/kg of naringenin to the feed + heat stress	39 ± 1.00[c]	53 ± 1.00[a]	54 ± 1.00[c]
T4 Heat stress	26 ± 1.00[d]	44 ± 1.00[d]	58 ± 1.00[b]
Morale level	*	*	*

The different letters a, b, c, d indicate that there are significant differences between the treatments at the (P≤0.05) significance level, N.S significant different, * not significantly different

Table 4. Effect of different treatments on the weekly feed consumption rate (g/bird) for quail of different ages (mean ± standard error)

Treatments	Weeks		
	Week 4 (21 day)	Week 5 (35 day)	Week 6 (42 day)
T1 Control	349 ± 3.00[b]	290 ± 3.00[b]	211 ± 2.00[b]
T2 Adding 400 mg/kg of naringenin to the feed	364 ± 3.00[a]	311 ± 3.00[a]	236 ± 3.00[a]
T3 Adding 400 mg/kg of naringenin to the feed + heat stress	346 ± 3.00[c]	291 ± 3.00[b]	215.67 ± 4.16[b]
T4 Heat stress	264 ± 3.00[d]	230 ± 2.00[c]	184 ± 2.00[c]
Morale level	*	*	*

The different letters a, b, c, d indicate that there are significant differences between the treatments at the (P≤0.05) significance level, N.S significant different, * not significantly different

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Table 5. Effect of different treatments on the feed conversion ratio of quail at different ages (mean ± standard error)

Treatments	Weeks		
	Week 4 (21 day)	Week 5 (35 day)	Week 6 (42 day)
T1 Control	.09 ± 0.02a4	5.68 ± 0.02b	7.41 ± 0.02b
T2 Adding 400 mg/kg of naringenin to the feed	3.42 ± 0.02a	6.61± 0.02a	8.11± 0.60ab
T3 Adding 400 mg/kg of naringenin to the feed + heat stress	4.05 ± 0.02a	5.49 ± 0.02c	9.17 ± 0.89ab
T4 Heat stress	3.17 ± 0.02c	5.22 ± 0.02d	10.15 ± 0.02a
Morale level	*	*	*

The different letters a, b, c, d indicate that there are significant differences between the treatments at the (P≤0.05) significance level, N.S significant different, * not significantly different

The results of table (6) indicate that the experimental treatment T2 was significantly superior at the level (P≤0.05) in terms of dressing percentage, as it recorded the highest dressing percentage at the end of the sixth week after slaughter compared to all other experimental treatments and the control treatment. The study results agree with [29], who noted that feed additives, particularly those containing flavonoid compounds, improve metabolism, leading to an increase in dressing percentage. The experimental treatment T4 recorded the lowest dressing percentage compared to T1 and all other experimental treatments. The study results also align with [30],[31] who found that dressing percentage in birds is influenced by the breeding season, indicating a decrease in dressing percentage in birds raised in summer with high temperatures compared to those raised in moderate temperatures. This decrease may be due to the metabolism of muscle proteins triggered by the activation of adrenal hormones during heat stress, leading to lower slaughter weights in birds, which reflects on the dressing percentage.

Table 6. Effect of different treatments on the dressing percentage of quail at slaughter (mean ± standard error(

Treatments	% percentage
T1 Control	71 ± 0.30^{b}
T2 Adding 400 mg/kg of naringenin to the feed	73 ± 0.40^{a}
T3	70 ± 0.30^{b}

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Adding 400 mg/kg of naringenin to the feed + heat stress T4 Heat stress	64 ± 0.40^{c}
Morale level	*

The different letters a, b, c, d indicate that there are significant differences between the treatments at the (P≤0.05) significance level, N.S significant different, * not significantly different

Conclusion

1. A noticeable improvement in production performance and the clearance rate of Japanese quail when adding naringenin at a rate of 400 mg/kg of feed during the 42-day rearing period.

2. Adding naringenin may help reduce the harmful effects of heat stress that economically impact production traits.

3. Heat stress leads to a decrease in body weight and overall production performance.

Recommendation

1.The current study provided promising preliminary results. It is necessary to repeat its application and work on studying its impact on some productive performance indicators and reducing the effects of heat stress.

2. Conduct more studies on adding naringenin powder with other nutrients individually and on other types of poultry.

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