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Effect of *Piper betle* Leaf Powder Supplementation on Improving the Productive Performance of Broiler Chickens (Ross 308) Exposed to Oxidative Stress Induced by Hydrogen Peroxide

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ABSTRACT

The study was carried out at the broiler chicken farm of the Animal Production Unit, College of Medicinal and Industrial Plants, University of Kirkuk, Iraq, during the period from the 4th of September 2025 to the 8th of October 2025. The study was conducted to evaluate the effect of Piper betle leaf powder supplementation on the productive performance of broiler chickens (Ross 308) subjected to oxidative stress induced by hydrogen peroxide. The experiment was conducted using a total of 150 one-day-old broiler chicks of the Ross 308 strain. The chicks were weighed and randomly allocated to the treatments. The treatments were as follows: T1: control treatment; T2: control + 0.4 ml/L hydrogen peroxide in drinking water; T3: control + 0.4 ml/L hydrogen peroxide + 0.75 g/kg feed of Piper betle powder; T4: control + 0.4 ml/L hydrogen peroxide + 1 g/kg feed of Piper betle powder; T5: control + 0.4 ml/L hydrogen peroxide + 2 g/kg feed of Piper betle powder. The results revealed that the supplementation of Piper betle powder significantly improved the productive performance of the broiler chickens subjected to oxidative stress induced by hydrogen peroxide, as the treatments that contained the plant powder showed significant improvements in the productive performance parameters compared to the control and hydrogen peroxide treatments. Therefore, it can be concluded that the dietary supplementation of the broiler chickens with the plant powder may enhance their productive performance under oxidative stress conditions, which may be reflected in the improvements in the body weight gain and the reduction in the feed conversion ratio.

INTRODUCTION

In broiler production, the need for improved productivity and better feed conversion efficiency is continuously felt. The use of feed additives is one of the key strategies in broiler production for achieving better productivity and better feed conversion efficiency. Recently, medicinal plant-based feed additives were included in the broiler diet as natural growth promoters, in which the use of medicinal plants maintains the balance of microbes in the broiler intestine, improves the productive performance of broilers, and reduces gastrointestinal problems in broilers [1, 2]. Medicinal plants are considered natural antioxidants and are considered to be safe for broiler production, replacing synthetic antioxidants [3, 4].

Antioxidants are the molecules that inhibit oxidation reactions and play the key role in the

protection of cells from the damaging effects of free radicals [5, 6]. The deficiency of antioxidants and the accumulation of free radicals in the cells may lead to oxidative stress [7, 8]. Oxidative stress has been related to the development of many diseases, including stroke and cancer [9], myocardial infarction and diabetes [10].

Several researchers have focused on studying medicinal plants with antioxidant and growth-promoting activities, including various herbal plants, because of their pharmacological, antimicrobial, and nutritional properties. One of these plants of considerable importance is Piper betle, commonly known as betel vine, a perennial plant belonging to the Piperaceae family. This plant has been recognized as an important medicinal herb with various pharmacological activities, high medicinal value, and is commonly distributed in tropical Asia and East Africa. The leaves of this plant have shown numerous valuable biological activities, which are used traditionally in medicine [11]. Previous phytochemical studies on this plant revealed that the leaves of Piper betle contained high amounts of phenolic compounds, alkaloids, terpenes, and flavonoids. The most important bioactive compounds of this plant are essential oils, namely, eugenol and hydroxychavicol, which showed strong antimicrobial activities [12]. In addition, Piper betle has shown strong antioxidant, antimicrobial, and anthelmintic activities [12, 13, 14].

Hydrogen peroxide (H_2O_2) is a chemical compound composed of two atoms of hydrogen and two atoms of oxygen. This compound has been recognized as a natural generator of reactive oxygen species (ROS), which are strong oxidizing agents in living cells. Although this compound is naturally produced in the body as a byproduct of metabolism, high amounts of this compound cause oxidative stress, leading to damage of lipids, nucleic acids, and proteins [15].

The objective of this study was to evaluate the effect of Piper betle powder supplementation on improving the productive performance of broiler chickens (Ross 308) exposed to oxidative stress caused by hydrogen peroxide.

MATERIALS AND METHODS

This experiment was carried out in the broiler chicken farm of the Animal Production Unit, College of Medicinal and Industrial Plants, University of Kirkuk, Iraq, during the period from 4 September 2025 to 8 October 2025. The study aimed to evaluate the effect of Piper betle powder supplementation on the growth performance of broiler chickens (Ross 308) under oxidative stress induced by hydrogen peroxide.

A total of 150 one-day-old broiler chicks of the Ross 308 breed were used in this experiment. The chicks were weighed and randomly assigned to five experimental treatments with three replications for each treatment.

Description of the experimental treatments:

T1: This treatment was the control without the addition of any supplements.

T2: This treatment was the control + 0.4 ml/L hydrogen peroxide in the water of the broiler chickens.

T3: This treatment was the control + 0.4 ml/L hydrogen peroxide in the water of the broiler chickens + 0.75 g/kg feed of Piper betle powder.

T4: This treatment was the control + 0.4 ml/L hydrogen peroxide in the water of the broiler chickens + 1 g/kg feed of Piper betle powder.

T5: This treatment was the control + 0.4 ml/L hydrogen peroxide in the water of the broiler chickens + 2 g/kg feed of Piper betle powder.

The starter diet was fed from 1 to 10 days of age, grower diet from 11 to 24 days of age, and finisher diet from 25 to 35 days of age. The starter diet had 23.59% crude protein and 3000 kcal/kg metabolizable energy, grower diet had 21.7% crude protein and 3081 kcal/kg metabolizable energy, and finisher diet had

19.7% crude protein and 3210.8 kcal/kg metabolizable energy.

The source of the ingredients used for the feed was Noor Poultry Feed Factory, Kirkuk, Iraq. The chicks were procured early in the morning from a hatchery, weighed, and then placed in the cages. Water was supplied through inverted waterers, each holding 4 L, and feed was supplied through plastic trays for the first week, then through cylindrical feeders placed at the height of the back of the bird.

Feed and water were offered ad libitum throughout the experimental period. The temperature under the brooders was kept at 33°C for the first week, and then it was reduced gradually to 23°C by the third week of the birds' age. The lighting program included 23 hours of light and 1 hour of darkness for the first week to get the birds accustomed to darkness, whereas from the second week to the end of the experiment, the lighting program included 20 hours of light and 4 hours of darkness. The relative humidity was kept at the recommended levels according to the broiler management guide. The ventilation fans were kept running at low speeds for the first days, and then they were run according to the age of the birds.

The productive performance parameters were recorded weekly, and they included body weight, feed intake, weekly weight gain, and feed conversion ratio.

The analysis of the data included using the [17] following the Completely Randomized Design (CRD) to evaluate the effect of the applied treatments on the studied parameters. Duncan's Multiple Range Test (DMRT) was applied to determine the differences between the means of the studied parameters at a significance level of $P \leq 0.05$.

Table 1. Ingredient composition (%) and calculated chemical composition of experimental diets

Feed ingredient	Starter (1–10 d)	Grower (11–24 d)	Finisher (25–35 d)
Wheat	39.29	43.68	22.28
Yellow corn	17.31	20.12	41.81
Soybean meal (48.42%)	34.75	29.15	27.00
Sodium chloride (salt)	0.30	0.22	0.22
Sunflower oil	4.00	4.00	5.00
Limestone	1.00	0.60	0.69
Dicalcium phosphate	2.66	1.32	2.19
Vitamin and mineral premix (a)	0.10	0.10	0.10
Methionine	0.27	0.25	0.21
Lysine	0.32	0.32	0.25
Choline chloride (60%)	–	0.24	0.25
Total	100	100	100
Calculated chemical composition			
Nutrient	Starter	Grower	Finisher
Metabolizable energy (kcal/kg)	3000.53	3097.79	3210
Crude protein (%)	23.67	21.75	19.84
Calcium (%)	1.01	0.54	0.78
Available phosphorus (%)	0.47	0.23	0.39
Methionine (%)	0.59	0.55	0.49
Lysine (%)	1.44	1.31	1.16

(a) One kilogram of vitamin–mineral premix provides: Vitamin A (12,000 IU), Vitamin D3 (2,500 IU), Vitamin E (200 mg), Vitamin K3 (20 mg), Vitamin B1 (20 mg), Vitamin B2 (50 mg), Vitamin B6 (30 mg), Vitamin B12 (150 µg), Folic acid (10 mg), Niacin (300 mg), Calcium (8%), Manganese (400 mg), Zinc (150 mg), Iron (53 mg), Copper (43 mg), and Choline (40 mg). (b) Calculated according to the chemical composition of feed ingredients based on [16].

RESULTS AND DISCUSSION

The results obtained from the experiment are shown in Table 2. The table shows the effect of Piper betle powder supplementation on the body weight of broiler chickens (Ross 308) at different ages during the five-week experimental period. At the end of the first week, no significant differences were observed in all the experimental treatments. However, in the second week, the body weight of broiler chickens in the T3 and T4 treatments was significantly ($P \leq 0.05$) higher compared to the T1 and T2 treatments, while no significant differences were observed in the body weight of broiler chickens in the T3, T4, and T5 treatments. In the third week, the body weight of broiler chickens in the T4 and T5 treatments was significantly ($P \leq 0.05$) higher compared to the T1, T2, and T3 treatments, while the T3 treatment was significantly higher compared to the T1 and T2 treatments. At the end of the fourth week, the T5 treatment had the highest body weight with significant ($P \leq 0.05$) differences compared to the other treatments (T1, T2, T3, and T4), while the T3 and T4 treatments were significantly higher compared to the T1 and T2 treatments. Similarly, in the fifth week, the T5 treatment had the highest body weight with significant ($P \leq 0.05$) differences compared to the other treatments (T1, T2, T3, and T4), while the T3 and T4 treatments were significantly higher compared to the T1 and T2 treatments. The improvement in the body weight of broiler chickens in the T3, T4, and T5 treatments could be attributed to the presence of biologically active compounds such as phenolic compounds, flavonoids, and essential oils in the Piper betle powder, which improves the digestive efficiency of broiler chickens under oxidative stress induced by hydrogen peroxide.

The findings of the present study revealed that the addition of Piper betle powder to the dietary regimen of broiler chickens subjected to oxidative stress induced by hydrogen peroxide resulted in significant improvements in the body weight of the broiler chickens, especially at the dietary levels of 1 and 2 g/kg of feed. The body weight increased gradually with the advancement of age compared to the control treatments. This improvement in the body weight of broiler chickens could be attributed to the fact that the Piper betle plant is rich in phenolic compounds, flavonoids, and essential oils, which have potent antioxidant properties. The antioxidant properties of the bioactive compounds of the plant reduce the production of free radicals resulting from hydrogen peroxide, leading to the enhancement of the metabolic processes of the body and the improvement of the body weight of the broiler chickens [12].

The improvement in the body weight of the broiler chickens could also be attributed to the efficacy of the bioactive compounds of the Piper betle plant, which results in the enhancement of the health of the digestive system and the absorption efficiency of the nutrients from the food ingested by the broiler chickens. The medicinal properties of the plant have been reported to enhance the productive performance of the broiler chickens and reduce the adverse effects of oxidative stress [1, 2].

Table 2. Effect of *Piper betle* powder supplementation on body weight (g) of broiler chickens (Ross 308) exposed to hydrogen peroxide-induced oxidative stress (Mean $\pm$ SE)

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5
T1	161.16 $\pm$ 1.85 a	532.33 $\pm$ 0.88 c	1029.00 $\pm$ 1.52 c	1544.67 $\pm$ 1.01 d	2464.67 $\pm$ 2.60 e
T2	159.83 $\pm$ 2.16 a	539.16 $\pm$ 0.60 b	1032.67 $\pm$ 1.33 c	1547.83 $\pm$ 1.09 d	2474.83 $\pm$ 2.45 d
T3	157.16 $\pm$ 0.44 a	543.66 $\pm$ 1.76 a	1045.33 $\pm$ 2.02 b	1560.50 $\pm$ 0.57 c	2496.83 $\pm$ 0.72 c
T4	157.83 $\pm$ 0.60 a	544.16 $\pm$ 1.64 a	1057.67 $\pm$ 0.83 a	1575.67 $\pm$ 1.76 b	2517.50 $\pm$ 1.04 b
T5	161.50 $\pm$ 1.44 a	542.33 $\pm$ 1.20 ab	1054.83 $\pm$ 2.04 a	1582.83 $\pm$ 0.72 a	0.72 a

T1: Control (no supplementation), T2: Control + 0.4 ml/L hydrogen peroxide in drinking water, T3: Control + 0.4 ml/L hydrogen peroxide + 0.75 g/kg *Piper betle* powder, T4: Control + 0.4 ml/L hydrogen peroxide + 1 g/kg *Piper betle* powder, T5: Control + 0.4 ml/L hydrogen peroxide + 2 g/kg *Piper betle* powder. Different letters within the same column indicate significant differences ($P \leq 0.05$) among treatments.

The results obtained from the experiment, as shown in Table 3, indicate the effect of Piper betle powder supplementation on the weekly weight gain of broiler chickens (Ross 308) during the experiment, which was conducted for 35 days. In the first week, the statistical test did not reveal any significant difference in weight gain among all the experimental treatments. However, in the second week, the weight gain of broiler chickens in the T3 and T4 treatments was significantly higher ($P \leq 0.05$) compared with the weight gain in the T1 and T2 treatments, while no significant difference was observed in the weight gain of broiler chickens in the T3, T4, and T5 treatments.

In the third week, the weight gain of broiler chickens in the T4 and T5 treatments was significantly higher ($P \leq 0.05$) compared with the weight gain of broiler chickens in the T1, T2, and T3 treatments, while the weight gain of broiler chickens in the T3 treatment was significantly higher ($P \leq 0.05$) compared with the weight gain of broiler chickens in the T1 and T2 treatments. In the fourth week, the weight gain of broiler chickens in the T5 treatment was significantly higher ($P \leq 0.05$) compared with the weight gain of broiler chickens in the T1, T2, T3, and T4 treatments, while no significant difference was observed in the weight gain of broiler chickens in the

Likewise, in the fifth week, treatment T5 showed the highest weight gain with significant differences ($P \leq 0.05$) when compared to treatments T1, T2, T3, and T4. In addition, treatments T3 and T4 showed significant differences in weight gain when compared to treatments T1 and T2. Regarding the cumulative weight gain, treatment T5 showed significant superiority over the other treatments (T1, T2, T3, and T4) with $P \leq 0.05$, while treatments T3 and T4 showed significant differences over treatments T1 and T2.

The findings of this study revealed that the supplementation of Piper betle powder in broilers exposed to oxidative stress induced by hydrogen peroxide showed significant improvement in weekly and cumulative weight gain when compared to the control treatments. This improvement in weekly and cumulative weight gain may be attributed to the bioactive compounds present in Piper betle that stimulate the activities of digestive enzymes, thus enhancing the rate of protein and energy metabolism, resulting in the efficient conversion of ingested nutrients into muscle mass [12].

In addition, the improvement in weekly and cumulative weight gain in broilers exposed to oxidative stress induced by hydrogen peroxide may also be attributed to the fact that the antioxidants present in Piper betle help to reduce the oxidative stress in the body, thus protecting the body from the degradation of proteins and lipids in the body [13]. Many researchers have shown that plant-derived antioxidants help to maintain the oxidative level in the body, thus protecting the body from cellular damage, resulting in an increase in body weight [5, 6].

Table 3. Effect of *Piper betle* powder supplementation on weekly and cumulative weight gain (g) of broiler chickens (Ross 308) exposed to hydrogen peroxide-induced oxidative stress (Mean $\pm$ SE)

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Cumulative weight gain
T1	113.00 $\pm$ 1.60 a	371.16 $\pm$ 2.02 c	496.66 $\pm$ 0.88 bc	515.66 $\pm$ 0.72 b	1496.50 $\pm$ 0.76 e	2464.67 $\pm$ 2.60 e
T2	112.83 $\pm$ 1.74 a	379.33 $\pm$ 1.76 b	493.50 $\pm$ 0.76 c	515.16 $\pm$ 1.09 b	1500.82 $\pm$ 0.88 d	2474.83 $\pm$ 2.45 d
T3	109.33 $\pm$ 1.01 a	386.50 $\pm$ 2.02 a	501.66 $\pm$ 2.33 b	515.16 $\pm$ 2.40 b	1512.67 $\pm$ 0.16 c	2496.83 $\pm$ 0.72 c
T4	110.16 $\pm$ 0.33 a	386.33 $\pm$ 2.18 a	513.50 $\pm$ 2.30 a	518.00 $\pm$ 1.80 b	1528.00 $\pm$ 1.76 b	2517.50 $\pm$ 1.04 b
T5	113.33 $\pm$ 1.74 a	380.83 $\pm$ 2.45 ab	512.50 $\pm$ 2.29 a	528.00 $\pm$ 2.32 a	1534.67 $\pm$ 1.36 a	2528.83 $\pm$ 0.72 a

The feed intake is considered to be one of the most important characteristics and is considered to be a major economic factor in calculating the cost of production of broiler rearing systems, especially since it covers over two-thirds of the total cost of production. The results obtained, as shown in Table 4, describe the effect of the experimental treatments on the weekly feed intake of broiler chickens, expressed in grams, over the five-week rearing period.

The statistical analysis showed that, during the first week, there were significant differences between

treatments, where T4 showed a significant improvement in feed intake compared to T1 and T2. In the second week, there were significant differences between treatments, where T3 and T4 showed significantly higher feed intake compared to T1 and T2.

In the third week, there were significant differences between treatments, where T4 and T5 showed significantly higher feed intake compared to T3, whereas T1 and T2 showed higher feed intake compared to T3. In the fourth week, T5 showed a significant increase in feed intake compared to T1 and T2, whereas T3 and T4 showed significantly higher feed intake compared to T1 and T2.

Likewise, in the fifth week, the feed intake in treatment T5 was significantly higher than that in treatment T2, while treatments T3 and T4 showed significantly higher feed intake than treatment T1. In the case of the cumulative feed intake (1-35 days), the statistical analysis revealed that the feed intake in treatment T4 was significantly higher than that in the other treatments, while the cumulative feed intake in treatment T5 was significantly higher than that in treatments T1, T2, and T3.

The findings of the present study revealed that the supplementation of Piper betle powder in the broiler diet exposed to oxidative stress induced by hydrogen peroxide significantly increased the feed intake in the birds compared to the control treatments. This improvement in feed intake may be attributed to the effect of Piper betle in improving the palatability of the feed and stimulating the appetite in the birds, in addition to its improvement in the microbial balance in the birds' intestines, leading to the reduction of the growth of harmful bacteria in the birds' intestines, thus improving the birds' ability to feed [1, 2; 12, 14].

Table 4. Effect of *Piper betle* powder supplementation on feed intake (g) of broiler chickens (Ross 308) exposed to hydrogen peroxide-induced oxidative stress (Mean $\pm$ SE)

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Cumulative feed intake
T1	156.00 $\pm$ 4.07 a	490.83 $\pm$ 1.36 a	639.50 $\pm$ 2.92 b	1001.83 $\pm$ 0.66 b	1910.17 $\pm$ 1.87 a	4198.33 $\pm$ 3.37 b
T2	155.50 $\pm$ 2.78 a	483.50 $\pm$ 2.46 ab	628.50 $\pm$ 1.25 c	1038.17 $\pm$ 4.79 a	1913.50 $\pm$ 1.52 a	4219.17 $\pm$ 2.45 a
T3	148.83 $\pm$ 3.34 ab	425.83 $\pm$ 2.45 c	648.33 $\pm$ 1.09 a	952.33 $\pm$ 3.46 c	1895.33 $\pm$ 2.58 b	4070.67 $\pm$ 3.01 c
T4	143.50 $\pm$ 2.08 b	430.50 $\pm$ 2.00 c	608.50 $\pm$ 1.04 d	946.66 $\pm$ 1.76 c	1821.83 $\pm$ 2.18 c	3951.00 $\pm$ 0.76 e
T5	149.83 $\pm$ 1.58 ab	480.66 $\pm$ 4.20 b	611.46 $\pm$ 0.29 d	923.86 $\pm$ 3.25 d	1812.83 $\pm$ 1.09 d	3978.67 $\pm$ 3.64 d

The feed conversion ratio is influenced by feed intake and weight gain, and it is one of the most critical economic measures of the efficiency of birds in converting feed into body mass. Results obtained in the statistical analysis of the effect of different treatments on feed conversion ratio (FCR, g feed/g weight gain) of broiler chickens during the period of 1–5 weeks of age are presented in Table 5. Results obtained in the statistical analysis of the effect of different treatments on feed conversion ratio of broiler chickens during the first week of the experiment revealed that there were no significant differences among the treatments with regard to feed conversion ratio, whereas in the second week, there were significant differences among the treatments, and the feed conversion ratio was significantly improved in the T3 and T4 treatments compared with the T1 and T2 treatments.

Results obtained in the statistical analysis of the effect of different treatments on feed conversion ratio of broiler chickens during the third week of the experiment revealed that there were significant differences among the treatments, and the feed conversion ratio was significantly improved in the T4 and T5 treatments compared with the T3 treatment, whereas the feed conversion ratio was also significantly improved in the T1 and T2 treatments compared with the T3 treatment, whereas in the fourth week of the experiment, the feed conversion ratio was significantly improved in the T5 treatment compared with the T1 and T2 treatments, whereas the feed conversion ratio was also significantly improved in the T3 and T4 treatments compared with the T1 and T2 treatments.

Likewise, in the fifth week, the results revealed that treatment T5 showed significant improvement

in FCR compared to treatment T2, while treatments T3 and T4 showed improvement in FCR compared to treatment T1. In relation to the cumulative feed conversion ratio (1-35 days), the results revealed that the statistical analysis showed that treatments T4 and T5 showed significant improvement in feed conversion ratio compared to other treatments, while treatment T3 showed significant improvement in feed conversion ratio compared to treatments T1 and T2.

The results of the study revealed that the supplementation of *Piper betle* powder in the diet of the broiler chickens exposed to oxidative stress induced by hydrogen peroxide showed significant improvement in the weekly feed conversion ratio, particularly in treatments T4 and T5. The improvement in the feed conversion ratio may have been due to the synergistic effect of the antioxidants in the improvement of the absorption of nutrients, the cellular damage caused by oxidative stress, and the enhancement of the efficiency of protein and energy metabolism in the broiler chickens [1, 2].

Table 5. Effect of *Piper betle* powder supplementation on feed conversion ratio (FCR) of broiler chickens (Ross 308) exposed to hydrogen peroxide-induced oxidative stress (Mean $\pm$ SE)

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Cumulative FCR
T1	1.38 $\pm$ 0.04 a	1.32 $\pm$ 0.00 a	1.28 $\pm$ 0.00 ab	1.94 $\pm$ 0.00 b	1.27 $\pm$ 0.00 a	1.44 $\pm$ 0.00 a
T2	1.37 $\pm$ 0.01 a	1.27 $\pm$ 0.01 b	1.27 $\pm$ 0.00 b	1.99 $\pm$ 0.00 a	1.27 $\pm$ 0.00 a	1.44 $\pm$ 0.00 a
T3	1.36 $\pm$ 0.04 a	1.10 $\pm$ 0.00 c	1.29 $\pm$ 0.00 a	1.84 $\pm$ 0.00 c	1.25 $\pm$ 0.00 b	1.37 $\pm$ 0.00 b
T4	1.30 $\pm$ 0.01 a	1.11 $\pm$ 0.00 c	1.18 $\pm$ 0.00 c	1.82 $\pm$ 0.00 c	1.19 $\pm$ 0.00 c	1.32 $\pm$ 0.00 c
T5	1.32 $\pm$ 0.02 a	1.26 $\pm$ 0.01 b	1.19 $\pm$ 0.00 c	1.74 $\pm$ 0.01 d	1.18 $\pm$ 0.00 d	1.34 $\pm$ 0.00 c

CONCLUSION

Dietary supplementation with *Piper betle* powder improved growth performance and feed efficiency of broiler chickens exposed to hydrogen peroxide-induced oxidative stress. The inclusion levels of 1 and 2 g/kg feed showed the most pronounced improvements in body weight, weight gain, and feed conversion ratio. These findings suggest that *Piper betle* may serve as a promising natural phytochemical feed additive to enhance broiler productivity under oxidative stress conditions.

REFERENCES

- [1] Ahmed, B., & Aziz, A. (2023). Effect of encapsulated organic acid (GALLINAT+) supplementation with diet on physiological parameters and performance of broilers at different ages. *Kirkuk University Journal for Agricultural Sciences*, 14(1), 160–176.
- [2] Hassan, H. M. A., Mohamed, M. A., Youssef, A. W., & Hassan, E. R. (2010). Effect of using organic acids to substitute antibiotic growth promoters on performance and intestinal microflora of broilers. *Asian-Australasian Journal of Animal Sciences*, 23(10), 1348–1353.
- [3] Abdulrahman, A. S., & Mustafa, N. A. (2025). Effect of adding *Moringa oleifera* seed powder (MOSP) to diet on the productive performance, carcass characteristics, and meat quality of broiler chickens. *Kirkuk University Journal for Agricultural Sciences*.
- [4] Zafar, F., Asif, H. M., Shaheen, G., Ghauri, A. O., Rajpoot, S. R., Tasleem, M. W., & Nazar, H. (2023). A comprehensive review on medicinal plants possessing antioxidant potential. *Clinical and Experimental Pharmacology and Physiology*, 50(3), 205–217.
- [5] Firuzi, O., Miri, R., Tavakkoli, M., & Saso, L. (2011). Antioxidant therapy: Current status and future prospects. *Current Medicinal Chemistry*, 18, 3871–3888.
- [6] Hamid, A., Aiyelaagbe, O., Usman, L., Ameen, O., & Lawal, A. (2010). Antioxidants: Its medicinal and pharmacological applications. *African Journal of Pure and Applied Chemistry*, 4, 142–151.
- [7] Espinosa-Diez, C., Miguel, V., Mennerich, D., Kietzmann, T., Sánchez-Pérez, P., Cadenas, S., & Lamas, S. (2015). Antioxidant responses and cellular adjustments to oxidative stress. *Redox Biology*, 6, 183–197.

- [8] Pizzino, G., Irrera, N., Cucinotta, M., Pallio, G., Mannino, F., Arcoraci, V., Squadrito, F., Altavilla, D., & Bitto, A. (2017). Oxidative stress: Harms and benefits for human health. *Oxidative Medicine and Cellular Longevity*, 2017, 8416763.
- [9] Sharifi-Rad, M., Kumar, N. V. A., Zucca, P., Varoni, E. M., Dini, L., Panzarini, E., Rajkovic, J., Tsouh Fokou, P. V., Azzini, E., & Peluso, I. (2020). Lifestyle, oxidative stress, and antioxidants: Back and forth in the pathophysiology of chronic diseases. *Frontiers in Physiology*, 11, 694.
- [10] Padureanu, R., Albu, C. V., Mititelu, R. R., Bacanoiu, M. V., Docea, A. O., Calina, D., Padureanu, V., Olaru, G., Sandu, R. E., & Malin, R. D. (2019). Oxidative stress and inflammation interdependence in multiple sclerosis. *Journal of Clinical Medicine*, 8, 1815.
- [11] Patra, B., Das, M. T., Dey, S. K., & Das, T. (2016). A review on *Piper betle* L. *Journal of Medicinal Plants Studies*.
- [12] Syahidah, A., Saad, C. R., Hassan, M. D., Rukayadi, Y., Norazian, M. H., & Kamarudin, M. S. (2017). Phytochemical analysis, identification and quantification of antibacterial active compounds in betel leaves (*Piper betle*) methanolic extract. *Pakistan Journal of Biological Sciences*, 20, 70–81.
- [13] Jaiswal, S. G., Patel, M., Saxena, D. K., & Naik, S. N. (2014). Antioxidant properties of *Piper betle* (L.) leaf extracts from six different geographical domains of India. *Journal of Bioresource Engineering and Technology*, 2, 12–20.
- [14] Shah, S. K., Garg, G., Jhade, D., & Patel, N. (2016). *Piper betle*: A review. *International Journal of Pharmaceutical Sciences Review and Research*, 38, 181–189.
- [15] Sies, H. (2017). Hydrogen peroxide as a central redox signaling molecule in physiological oxidative stress: An update. *Free Radical Biology and Medicine*, 100, 1–10.
- [16] NRC. National Research Council.(1994). Nutrient Requirements of Poultry. 9th Revised Edition. Washington, .DC: National Academy Press
- [17] SAS Institute.(2004). SAS/STAT User's Guide: Statistics, Version 9.1. SAS Institute Inc., Cary, NC, USA