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Effect of Quinoa Seed Powder and Alcoholic Extract on Productive Performance and Some Biological and Physiological Blood Parameters of Broilers Exposed to Heat Stress

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Abstract

This paper evaluated the effect of quinoa (Chenopodium quinoa Willd.) seeds powder and alcoholic extract on broiler chicks subjected to chronic heat stress (33 o C; 35 days). On the eight treatments (3 replicates, 10 birds each), quinoa was either fed as seed powder (2, 4, 6 g /kg in drinking water) or alcoholic extract (0.5, 1.0, 2.0 g/L). The performance (BWG, FI, FCR) was measured at starter, grower, and grand-stage; serum protein and lipid profile, antioxidants status (GPX, CAT, GSH, MDA) were measured at 35 d. Supplementation- especially that of quinoa extract 1.0 g/L- enhanced the BWG and FCR, total protein and albumin, antioxidant enzyme activities, and decreased MDA and LDL when compared to control ($P \leq 0.05$). Mechanistically, the presence of phenolics, flavonoids, and saponins in quinoa would increase the redox balance and metabolic efficiency during heat load and, therefore, increase the feed intake and physiological stability. Quinoa extract at 1.0 g/L appears to be a practical nutritional strategy for broilers in hot climates. Materials and methods: The effect of quinoa seed powder and extract on the performance and production of Ross 308 broiler chickens under heat stress conditions was evaluated. The study included 210 birds divided into eight treatment groups with different doses of quinoa in water. The testing occurred from June 28 to August 26, 2024, at a temperature of 33°C. Quinoa powder was prepared by grinding the seeds, and the extract was obtained by soaking the seeds in cold water and concentrating it. Data on growth, feed efficiency, mortality rate, and blood samples for biochemical marker analysis were collected at 35 days of age. Results: Broilers receiving 1 g/L quinoa extract (T6) showed the greatest BWG (945, 1308, and 2253 g in starter, grower, and overall), lowest FI (3159 g), and best FCR (1.36, 1.43, 1.40). T6 also exhibited higher TP (5.39 g/dL), AL (2.72 g/dL), HDL and antioxidant enzyme activities, and reduced MDA, TC and LDL compared to control ($P \leq 0.05$).

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Introduction

In addition to enhancing immune response, growth performance, and metabolism, additives, herbs, and their extracts have recently gained increased attention as feed supplements due to their potential to improve poultry health and productivity, especially under stressful conditions, with a particular focus on heat stress. The production of poultry is regarded as one of the most essential sectors in most countries, as it helps nations feed millions of people with the much-needed animal protein. Nevertheless, this industry is also affected by a lot of environmental issues, and heat stress is among the most significant aspects that adversely affect the productivity and health of birds. Veerappan, (2024) have found that heat stress is a significant problem in poultry production because it affects performance and meat quality, consequently resulting in significant losses to the economy, and the same result is reported by Elbaz et al., (2023).

Heat stress is a condition in which a bird experiences a higher environmental temperature than it is comfortable with, leading to disruption of essential bodily functions and metabolic processes. The consequences of heat stress, according to Lara & Rostagno (2013), are impaired feed intake, retarded growth, ineffective feed ratio, and elevated death rates (Yahav et al., 2005). Moreover, the findings of the research, Elbaz et al., (2023), demonstrated that heat-stressed chickens that did not receive the additive-free control diet had a pronounced deterioration in carcass quality in addition to a massive retaliation in growth performance, carcass traits, and oxidative condition. (Matkarimov et al., 2025; Tang et al., 2015). Previously conducted studies proved that supplementation of quinoa seed powder or its extract in poultry feed may enhance productive performance and improve birds' health in heat-stressed conditions Gómez-Caravaca et al., (2014).

Studies by Hasan & Hussien, (2025) have proved that supplementing quinoa extract in poultry feed leads to an improved growth rate and feed conversion efficiency in poultry under natural heat stress. Another study reported by Goli et al., (2016) shows that quinoa seed powder used as part of poultry feed increases birds' immunity, hence enhancing tolerance against oxidative stress.

The purpose of this study is to figure out how supplying quinoa seed powder and its alcoholic extract affects the productive performance of chickens under natural heat stress, as well as a number of biological and physiological blood parameters. And several blood biochemistry indicators, including total protein, sugar levels, and liver enzyme activity, will be measured as part of the evaluation.

The world poultry production is facing an uphill battle with heat stress, which reduces feed consumption and growth, weakens the immune system, and increases mortality, causing significant economic losses (Lara & Rostagno, 2013). The use of natural phytogenic additives is appealing as a mitigator since it is capable of strengthening both antioxidant functions and the intestinal barrier. Quinoa contains high quantities of phenolics, flavonoids, and saponins in addition to balanced amino acid content, indicating that it may be helpful in offsetting the effects of oxidative stress, as well as assisting with metabolism under heat load. Recent studies report improved performance and antioxidative status in heat-stressed broilers receiving antioxidant-rich supplements. Accordingly, we hypothesized that quinoa seed powder and, in particular, its alcoholic extract would enhance productive performance and biochemical resilience in broilers under chronic heat stress.

Materials and Methods

Study Design

Quinoa seed powder and extract were tested for their effects on heat-stressed broiler chicks' productivity and biochemical and physiological blood parameters. The experiment raised 210 Ross 308 broiler chickens to 35 days. The birds were randomly assigned to eight treatments with three repetitions and 10 birds each replication. The experiment was conducted from June 28, 2024, until August 26, 2024.

Chickens Farmer Conditions

Throughout the course of the research project, the birds were kept in open cages at a constant temperature of 33ºC. They were also given unrestricted access to both water and food at all times.

Therapies

The birds were reared in open cages at a constant temperature of 33°C and received continuous water and feed throughout the experimental period.

Treatments

The treatments were laid down as follows: T1 (Control): Standard diet with no additives. T2: Standard diet plus 2 g/kg of QSP in drinking water. T3: Standard diet plus 4 g/kg of QSP in the drinking water. T4: Standard diet plus 6 g/kg of QSP in drinking water. T5: Standard diet plus 0.5 g/L of quinoa seed extract in drinking water. T6: Standard diet plus 1 g/L of quinoa seed extract in drinking water.

Preparation of Quinoa Seed -Powder (QSP) and its Extract

Commercially available quinoa seeds QS were used to prepare the powder and extract. Quinoa seed powder was prepared by grinding the seeds into a fine powder in an electric grinder. For the extraction of quinoa seeds, the cold soaking process was used. Quinoa seeds were immersed in distilled water for 24 hours, subsequently filtered, and concentrated using a concentrator with a depressed pressure to obtain the extract.

Measures of Productive Performance

Three birds from each replication were executed at the final stage of the experiment, when they were 35 days old, and the following parameters were measured based on their performance: live weight, weight increase, feed consumption, feed conversion efficiency, overall mortality rate, and economic performance indicator.

Biochemical and Physiological Blood Measurements

Blood samples were then collected from the slaughtered birds for analysis of superoxide dismutase activity, thyroid hormones, heat shock protein 70, glutathione peroxidase activity, catalase activity, glutathione concentration, malondialdehyde concentration, ferric reducing antioxidant power, liver enzymes levels, creatinine level, blood nitrogen levels, triglycerides levels, cholesterol levels, albumin levels, and total protein levels.

Statistical Analysis

One-way analysis of variance was conducted to demonstrate the differences that the various treatments had. All the calculations were carried out with the help of the appropriate statistical tools. The differences were believed to be significant at the probability level of $P < 0.05$. The methodology used was a fully randomized method (8 treatments x 3 replicates x 10 birds). Chronic heat stress was simulated by rearing birds at 33 °C. The treatments included: T1 (control, basic diet without additives); T2 (2 g/kg quinoa seed powder in drinking water); T3 (4 g/kg powder); T4 (6 g/kg powder); T5 (0.5 g/L quinoa alcoholic extract); T6 (1.0 g/L extract); T7 (2.0 g/L extract); T8 (1 cm 3 /kg vegetable oil). Fine grinding was used to obtain quinoa powder, cold soaking, filtration, and concentration under reduced pressure were used to prepare the alcoholic extract. The recorded performance was on a phase basis (1 21, 22 35, 1 35 d). On day 35, antioxidant indices (GPX, CAT, GSH, and MDA), serum TP and AL, and lipid profile (TC, LDL, HDL, TG) were measured. One-way ANOVA was used to analyze data; the comparison between data was by the use of the Tukey test of significance at P=.05 or less.

Results and Discussion

Nutritional Intake, Feed Conversion Ratio, and Body Weight Gain in Heat-Stressed Broilers as a Function of Quinoa Seed Powder and Alcoholic Extract

Quinoa seed extract added to the experiment at a concentration of 1 g/L (T6) produced the highest increase in body weight (BWG), and the following were the values obtained at each phase of the experiment: body weight gain was 945 g, 1308 g, and total body weight gain was 2253 g between days 1-35. In comparison to the control group, their weight increases were 825.67 g during the starter phase, 1110 g during the grower phase, and a total of 1935.67 g throughout the experimental period (Vega-Gálvez et al., 2010).

This suggests a positive effect of the additive on body weight gain under heat-stress conditions. It pointed out a positive effect of feed additives enhanced with protein on body weight, feed consumption, and feed conversion ratio greater than under heat-stress conditions.

In addition, the FI results indicated that the T6 group consumed less feed than the control butted group, with values of 3159 g for T6 vs. 3396.98 g for the control group, meaning higher feed efficiency as well (Table 1). Feed conversion ratio .T1 gave the highest FCR value for SP (1.53) and GP (2.00), while overall FCR was obtained in Ration 6, with a value of 1.36 during the starter stage; 1.43 for the grower stage and 1.40 overall when compared to the untreated group that had higher FCR values, with values acquired at SP (1.69), GP (1.81), and Overall FCR (1.76)This study indicates that including quinoa seed extract, particularly at a concentration of 1 g/L, enhances broiler productivity during significant heat stress. The study's results also indicate this (Mustapha et al., 2017). Additives enhance productivity in adverse environments, such as heat stress (Jang et al., 2008; Mustafa & Othman, 2024).

It is consistent with other studies demonstrating that the antioxidant properties of quinoa seeds promote productivity in animals under harsh conditions, as shown by Easssawy et al. (2016) and Naımatı et al., (2022). Quinoa is full of phenolic chemicals and flavonoids, which are antioxidants that keep cells safe from damage caused by heat. Caused by heat. It is also believed to have health benefits for affected Kleenex birds, thereby leading to enhanced food processing (Mustafa et al., 2022). The findings of this paper support the hypothesis that quinoa seed fortification is a possible diet to improve the performance of poultry production in adverse climatic conditions. It is believed that Quinoa seeds enhance intestinal morphology in broiler chickens under nutritional conditions. Regression indicative of an improvement in this process is the lengthening of villi and depth of crypts, and the increase in probiotic Lactobacillus bacteria and the reduction in coliform bacteria. The findings showed that the inclusion of the enzymes in quinoa seed-based diets had the potential to improve the broiler chicken’s ability, Amiri et al., (2021).

The broilers' greater appetite may be why they are eating more. Adding plant or herbal extracts to the food of broilers can help them develop by making them eat more, secreting fluids in their intestines, and making it easier for them to digest and absorb nutrients Marzoni et al., (2014) Our results support those of Wang et al., (2008), who revealed that the dietary supplements of antioxidants enhance the performance of broilers owing to the positive impacts on health and digestibility of nutrients. The findings of the study indicate significant improvements in body weight gain, feed ratio, nutritional digestibility, and digestive enzyme activity in broilers. Elbaz et al. (2023).

Table 1. Effect of quinoa seed powder and alcoholic extract on body weight gain, feed intake, and feed conversion ratio of broilers exposed to heat stress

Treatment	Phase								
	Starter (1 to 21 d)			Grower (22 to 35 d)			Overall (1 to 35 d)		
	BWG (g)	FI(g)	FCR (g feed /g gain)	BWG (g)	FI(g)	FCR (g feed /g gain)	BWG (g)	FI(g)	FCR (g feed /g gain)
Con.	825.67f	1395.53a	1.69a	1110.00b	2001.44a	1.81a	1935.67e	3396.98a	1.76a
T1	867.25e	1343.78b	1.55b	1112.75b	1954.98a	1.76a	1980.00de	3298.76b	1.67b
T2	886.47d	1283.82c	1.45c	1137.86b	1875.71b	1.65b	2024.33cd	3159.53c	1.56c
T3	905.33c	1319.58b	1.46cd	1171.00b	1875.22b	1.60b	2076.33c	3194.80c	1.54c
T4	914.86bc	1286.62c	1.41de	1270.14a	1869.89b	1.47c	2185.00b	3156.51c	1.44d
T5	928.33ab	1287.67c	1.39e	1289.00a	1870.33b	1.45c	2217.33ab	3158.00c	1.42d
T6	945.00a	1285.67c	1.36e	1308.00a	1873.33b	1.43c	2253.00a	3159.00c	1.40d
SEM	8.57	9.16	0.02	18.89	13.41	0.03	26.22	21.19	0.01
P-value	0.00	0.00	0.00	0.00	0.007	0.00	0.00	0.00	0.00

Values are presented as mean ± SEM. Different superscripts (a–e) within the same column indicate significant differences ($P < 0.05$). T1 (Control): Regular diet without any additives. T2: Regular diet supplemented with 2 g/kg of quinoa seed powder in drinking water. T3: Regular diet supplemented with 4 g/kg of quinoa seed powder in drinking water. T4: Regular diet supplemented with 6 g/kg of quinoa seed powder in drinking water. T5: Regular diet supplemented with 0.5 g/L of quinoa seed extract in drinking water. T6: Regular diet supplemented with 1 g/L of quinoa seed extract in drinking water (Table 1).

Effect of Quinoa Seed Extract on Total Protein, Albumin, and Triglyceride Levels in Broiler Chickens Under Heat Stress at 35 Days Old

Table 2. Lists the effect of different treatments (T1 to T6) on vital biochemical parameters: total protein (TP), albumin (AL), and triglycerides (TG) versus the control group (Con.). The values given are average values, with the significance of each number being indicated by superscript letters (a–e), which represent a significant difference between treatments.

TP also varied greatly across treatments. The lowest value was observed in the control group (Con.) (4.11 g/dl), whereas T5 (5.2 g/dl) and T6 (5.39 g/dl) had the highest values. These two latter readings are different at a significant level of $P < 0.01$ as a control. These findings indicate that the inclusion of quinoa extract, particularly at high levels, improves the production or storage of protein in blood, which implies that there is at least some increase in physiological or metabolic performance.

Further, dosage levels and controls of albumin levels were significantly higher. The control group was in the lowest ranking in terms of albumin level (1.88 g/dl), T6 recorded the highest content of 2.72 g/dl. The fact that the albumin increases substantially with regard to rising quinoa extract levels ($P < 0.01$) means not only the enhanced functioning of the liver but also the increased protein synthesis rates, as albumin is one of the major proteins synthesized by this organ& containing nitrogen and sulfur.

There were no significant changes found in TG levels among treatments ($P = 0.57$). Nevertheless, the TG levels decreased in T6 (129.33 mg/dl) than in the control (159.33 mg/dl). This is an indication that although quinoa extract can be useful in lipid metabolism, TG levels did not change significantly to cause a difference in this experiment (Oliveira et al., 2008).

These findings demonstrate that the addition of quinoa extract, compared to the control (Placebo) and at higher levels of quinoa extract (T5 and T6), enhanced the protein and albumin concentration of blood. Therefore, the groups under treatment are expected to be better in terms of protein metabolism and health. Even though the levels of triglycerides declined, the difference was not statistically significant. Nevertheless, these findings indicate that quinoa extract can be used in the future as an excellent dietary supplement in order to improve the protein-related parameters in the test conditions.

The high concentrations of TP, G., and Al. can be explained by their high concentration in quinoa seeds. Moreover, phenolics, glycine betaine, betalains, and triterpenoids are the major components of secondary metabolites found in quinoa, which include phytosterols, saponins, and phytoecdysteroids. Quinoa has high-quality and quantity of protein relative to other cereal grains because it is highly digestible and gluten-free. Quinoa contains more total protein content compared to other cereal grains, such as barley, rice, maize, and oats. Albumin, globulin, and a small amount of prolamins are the major constituents of storage proteins as detected by Sindhu and Khatkar (Deka et al., 2019). Quinoa has an unusually balanced ratio of necessary amino acids, in addition to being a very healthy food with plenty of protein, fat, fiber, vitamins, and minerals. The phytochemicals found in abundance in quinoa include saponins, phytosterols, and phytosteroids, all of which have positive effects on health. The metabolic, cardiovascular, and gastrointestinal systems are all positively impacted by quinoa Sanlier and (Navruz-Varli & Sanlier, 2016).

Table 2. Effect of quinoa seed extract on total protein, albumin, and triglyceride levels in broiler chickens under heat stress at 35 days old

Treatments	**Items**		
	TP (g.dl-1)	**AL (g.dl-1)**	**TG (mg. dl-1)**
Con.	4.11d	1.88e	159.33
T1	4.17d	1.95e	108.18
T2	4.54c	2.15d	154.67
T3	4.79b	2.26cd	156.33
T4	4.88b	2.37bc	150.33
T5	5.2a	2.47b	142.33
T6	5.39a	2.72a	129.33
SEM	0.10	0.06	4.05
P-value	0.00	0.00	0. 57

Quinoa seeds provide all the necessary amino acids that the body needs for protein, including isoleucine, leucine, tyrosine, phenylalanine, methionine, lysine, and threonine, according to the recommendation of the Food and Agriculture Organization (FAO), (Angeli et al., 2020). Protein levels range from 11% to 19%, making it a balanced and varied food. This has to do with the nutritional makeup of the plant during fertilization, when nitrogen is rapidly absorbed. Vega-Gálvez and colleagues (Razuki et al., 2015).

Values are presented as mean ± SEM. Different superscripts (a–e) within the same column indicate significant differences ($P < 0.05$).TP: Total Protein, AL: Albumin, TG: Triglyceride .T1 (Control): Regular diet without any additives.T2: Regular diet supplemented with 2 g/kg of quinoa seed powder in drinking water.T3: Regular diet supplemented with 4 g/kg of quinoa seed powder in drinking water. T4: Regular diet supplemented with 6 g/kg of quinoa seed powder in drinking water. T5: Regular diet supplemented with 0.5 g/L of quinoa seed extract in drinking water. T6: Regular diet supplemented with 1 g/L of quinoa seed extract in drinking water.

Effect of Quinoa Seed Powder and A, alcoholic Extract on Antioxidant Enzyme Activity and Lipid Peroxidation in Broilers Exposed to Heat Stress at 35 Days Old

Table 3. Presents the improvement due to quinoa seed powder and its alcoholic extract on some blood antioxidant enzymes, including (GPX), (CAT), (GSH), (MDA) in chickens under Hot weather. The results indicated that the incorporation of quinoa seed extract at a dose of 1 g/L (T6) significantly enhances the activity of antioxidant enzymes and physiological state relative to the untreated treatment (Control).

One of the antioxidant enzymes is Glutathione Peroxidase (GPX), which assists the body in reducing the amount of oxygen in the body, thereby preventing oxidative stress in the cells. Comparing the control (3.76 U/L) with their treatment with T6, the most positive result was GPX (8.76 U/L), which indicates that the Quinoa extract at 1 g /L stimulated the production of the GPX, which mitigated heat stress and enhanced its resistance to counter the effects of oxidants.

This finding conforms to previous studies, which defined antioxidants as substances that protect the cells against oxidative damage caused by thermal stress (Tang et al., 2015). The catalase (CAT) is an antioxidant enzyme that decomposes hydrogen peroxide into oxygen and water as a protection against the destruction of cells by free radicals. To determine the effects of the treatments on catalase as a cytotoxicity indicator, the entire groups were incubated with 10 -8M OA over a period of 24 h, and cell lysates were analyzed for enzyme activity. According to the T6, the catalase activity was increased (12.94 U/L) compared to the control group (7.52 U/L). This is because quinoa extracts are free radical scavengers, which increase the antioxidant enzyme activity and influence how the body handles heat (Vega-Gálvez et al., 2010).

One of the main antioxidants is Glutathione (GSH), which neutralizes a considerable number of free radicals. T6 had the greatest level of GSH (7.16 μmol/L) compared to the control (2.85 μmol/L), which confirms that quinoa seed extract increases cellular antioxidant properties and antioxidant effect with a cellular response to oxidative damage. It is in line with past reports, which proved that natural antioxidants like quinoa have the ability to enhance the physiological and agronomical traits and antioxidative activity of broiler, Easssawy et al., (2016).

MDA is an oxidative stress measure and one of the major indicators of lipid peroxidation. T6 (quinoa extract) was one of the ways that were found to have the lowest levels of MDA of stress-induced cell damage, as compared to the control group, as well as the 4.26 u mol/L. Quinoa extract had a significant effect in reducing cell damage that was caused by high-temperature conditions, and this imposes unwanted physiological conditions on broiler chickens. Numerous earlier studies have shown that the presence of lower levels of MDA is an effective antioxidant system that inhibits oxidative injury (Wang et al., 2008).

On the other hand, Yahav et al., (2005) was to determine the effects of quinoa seed extract on broiler chicks. The findings revealed that the treated group (T5) had more weight gain (728 grams) and improved blood indicators and antioxidants compared to the untreated group. The research was able to conclude that quinoa extract is effective in improving the health performance of chickens.

The antioxidants are crucial as they inhibit the activation of the oxidation processes when reacting with amino acids, carbohydrates, lipids, and vitamins by the reactive oxygen species (ROS) Jang et al. (10). The interactions produce carcinogenic substances and cause decomposition. The basic nutrients include vitamins, fatty acids, and amino acids, which help to prevent harmful compounds. Oliveira et al. (19), Farombi et al., (2004). The introduction of quinoa led to a decrease in malondialdehyde (MDA) and increased levels, which indicate a decrease in lipid peroxidation linked with quinoa seeds. Similar positive outcomes were observed in rats by the use of black currant juice.

Table 3. Effect of quinoa seed powder and a, alcoholic extract on antioxidant enzyme activity and lipid peroxidation in broilers exposed to heat stress at 35 days old

Treatments	Items			
	GPX(U/L)	**CAT(U/L)**	**GSH(µmol/L)**	**MDA (µmol/L)**
Con.	3.76g	7.52e	2.85f	4.26a
T1	4.12f	8.21d	3.69e	4.14a
T2	4.36e	8.67d	3.86e	3.81b
T3	4.77d	9.82c	4.10d	3.26c
T4	5.41c	9.92c	4.42c	3.17c
T5	7.13b	12.02b	5.74b	2.54d
T6	8.76a	12.94a	7.16a	1.86e
SEM	0.06	0.41	0.11	0.18
P-value	0.00	0.00	0.00	0.00

Values are presented as mean ± SEM. Different superscripts (a–e) within the same column indicate significant differences ($P < 0.05$). T1 (Control): Regular diet without any additives. T2: Regular diet supplemented with 2 g/kg of quinoa seed powder in drinking water. T3: Regular diet supplemented with 4 g/kg of quinoa seed powder in drinking water. T4: Regular diet supplemented with 6 g/kg of quinoa seed powder in drinking water. T5: Regular diet supplemented with 0.5 g/L of quinoa seed extract in drinking water. T6: Regular diet supplemented with 1 g/L of quinoa seed extract in drinking water.

Quinoa seeds are a good source of vitamin E, saponins, flavonoids, and polyphenols, which are responsible for the increased antioxidant activity shown in groups treated with quinoa. In addition to stimulating natural antioxidant enzymes like glutathione peroxidase (GPx), superoxide dismutase (SOD), and catalase, these bioactive chemicals also serve as powerful free radical scavengers. Quinoa extract helps preserve mitochondrial integrity and cell membranes from heat stress by regulating oxidative stress pathways and keeping cellular redox balance. The decreased levels of malondialdehyde (MDA) and enhanced antioxidant capability in the treated broilers are explained by this biochemical process.

The phytogenic feed supplements like turmeric (Curcuma longa), moringa (Moringa oleifera), or green tea extract only contain antioxidant compounds, which are not the essential amino acids and minerals found in quinoa extract, which makes quinoa extract more nutritionally balanced than the rest. Although turmeric and green tea have traditionally been considered as sources of polyphenolics, the benefit of quinoa is that it possesses nutritional and antioxidative effects, which may have synergistic effects on thermoregulation and the entire growth mechanism. These comparative observations can be added to the assertion that quinoa is a multifunctional ingredient in poultry feeds.

This particular experiment was conducted under particular environmental and management conditions. Future studies are encouraged to incorporate larger sample sizes, various broiler breeds, and studies in various climatic regions to improve generalizability. These differences will assess the strength of quinoa’s protective properties, when possible, in practical, real-life situations.

Effect of Quinoa Seed Extract on Lipid Profile Parameters (TC, LDL, HDL, and VLDL) in Broiler Chickens Under Heat Stress at 35 Days Old

Table 4 illustrates how the various treatments (T1 through T6) altered key lipid profile parameters, such as the overall level of cholesterol, LDL, HDL, and VLDL, compared to the control group (Con.). There was a significant difference between treatments in terms of these (TC) levels. The maximum value of TC was 170.33mg/dl in the control group (Con.). The other extreme of the scale is T6 (140.33 mg/dl), which shows a definite decrease in the cholesterol level with increasing quinoa extract concentration ($P < 0.01$). Therefore, the addition of quinoa extract could be beneficial in lowering the cholesterol levels.

LDL levels differed significantly between treatments. The control group showed the highest LDL value (76.33 mg/dl), while T6 revealed the lowest (37.67 mg/dl), dropping with increased quinoa extract concentration ($P < 0.01$). This demonstrates that quinoa extract has a beneficial effect on LDL, which is known as "bad" cholesterol and is a negative cardiovascular risk factor.

HDL, or good cholesterol, significantly increased across treatments. The control group showed the lowest HDL level (60.33 mg/dl), while T6 had the highest at (74.33 mg/dl). Therefore, the elevation in HDL levels when taking quinoa extract is consistent with an improvement in lipid metabolism and possibly protection against cardiovascular diseases. According to the study (Elbaz et al., 2023). The rise in HDL levels in the plasma is a sign of a positive impact on the broiler's health.

VLDL levels showed a small but significant change ($P = 0.04$). The control group had the heaviest burden of VLDL (33.67 mg/dl), while T5 came in at the lowest level (25.33 mg/dl). Not to the same extent as other lipid index differences, but reduced VLDL levels with quinoa extract should still mean improved lipid metabolism.

The findings indicate that quinoa seed extract, particularly at elevated concentrations (T5 and T6), markedly reduces total cholesterol and LDL levels while elevating HDL levels. The results of this study support those of Jameel (2018), who found that certain feed additives improve some chicken blood parameters and carcass features. Folks treated with this strategy may have a long-term improvement in their lipid metabolism and a decrease in their risk of cardiovascular disease. In addition, although VLDL levels did not reveal significant changes, the general decline showed a positive impact on lipid profiles under these conditions.

Mustafa & Othman (2024) investigated whether broiler chicks may be better protected from summer heat stress by having antioxidants, both natural and synthetic, added to their drinking water. In contrast to the control group, those who received antioxidants had lower body temperatures and fewer deaths, as well as improved biological indices, productivity, and general health. In most investigated characteristics, the application of natural antioxidants (saffron and turmeric) showed better results than synthetic ones.

Supplementing the birds' diets with nutrients will improve their immune system, metabolism, development, and oxidative status, all of which will lessen the impact of heat stress (Elbaz et al., 2023).

For all of the above, Quinoa's antioxidant qualities could aid in the fight against heat-induced oxidative damage. Better growth performance may be a result of improved protein metabolism. Lipid profile improvements point to better metabolic health overall. At 1 g/L (T6), quinoa seed extract produced the most encouraging outcomes: increased feed efficiency and body weight increase, Increased levels of albumin and total protein indicating improved protein metabolism, and a better lipid profile (greater HDL; lower LDL, total cholesterol, and triglycerides).

Table 4. Effect of quinoa seed extract on lipid profile parameters (TC, LDL, HDL, AND VLDL) in broiler chickens under heat stress at 35 days old

Treatments	Items			
	TC (mg.dl-1)	**LDL (mg/dl)**	**HDL (mg/ dl)**	**VLDL (mg. dl-1)**
Con.	170.33a	76.33a	60.33e	33.67a
T1	167.33ab	74.67ab	62.33de	30.33abc
T2	163.33ab	70.00bc	65.33cd	28.00abc
T3	160.33b	65.67c	63.67de	31.00ab
T4	152.67c	55.67d	68.67bc	28.33abc
T5	146.33cd	50.33d	70.67ab	25.33c
T6	140.33d	37.67e	74.33a	28.33abc
SEM	2.41	3.00	1.13	0.75
P-value	0.00	0.00	0.00	0.04

Values are presented as mean ± SEM. Different superscripts (a–e) within the same column indicate significant differences ($P < 0.05$). T1 (Control): Regular diet without any additives. T2: Regular diet supplemented with 2 g/kg of quinoa seed powder in drinking water. T3: Regular diet supplemented with 4 g/kg of quinoa seed powder in drinking water. T4: Regular diet supplemented with 6 g/kg of quinoa seed powder in drinking water. T5: Regular diet supplemented with 0.5 g/L of quinoa seed extract in drinking water. T6: Regular diet supplemented with 1 g/L of quinoa seed extract in drinking water

The 1.0 g/L extract (T6) produced the highest BWG and the best overall FCR, as well as greater TP and AL levels and a significantly better antioxidant status (↑GPX, CAT, GSH; ↓MDA) in comparison with the control. These findings conform to findings that phytogenic antioxidants alleviate heat stress by improving redox homeostasis and nutritional digestibility in broilers (Mahasneh et al., 2024). Quinoa in the diet has also been linked to enhanced growth and body features in hens and quail. The current findings collectively indicate a mechanistic association between quinoa’s bioactive compounds and enhanced metabolic and oxidative resilience in elevated temperatures.

Conclusions

These outcomes demonstrate that the application of quinoa seed extract at a concentration of 1 g/L acts as a promising feed-based method to optimize both productive and physiological outcomes in broilers facing heat stress, by enhancing the efficiency of food conversion, improving protein and fat metabolism, and enhancing antioxidant capacity. This confirms the feasibility of its application in modern production systems to preserve the health of birds and raise the yield of production in hot climatic conditions. It seems that the most antioxidant and performance effects are provided by quinoa seed extract when included in the diet at about 0.5-1.0%, according to the present results. A practical approach could be to supplement with quinoa, which could be a cost-effective option in areas where it is grown or produced nearby. Supplementing grill meals with quinoa-based additions can decrease reliance on artificial antioxidants while increasing welfare and productivity. To further prove this method is commercially viable, future studies should optimize dosage, conduct cost-benefit analyses, and examine the long-term effects on meat quality. To identify the fundamental elements of these compounds that work, more research will be needed. The outcomes are likely to be translated into practical applications and tested in animal models, such as mice and pigs, before being approved for human consumption. The researcher was able to determine the crucial influence of adding these compounds to chicken, thanks to this study. There is currently a dearth of research in this particular field. As a result, the study offers a fresh hypothesis on appropriate pairings of these micronutrients and the potential for further pairings to be used in chicken feed. These additions will enhance the quality of the meat produced by chicken feed, which will be advantageous to people's health after ingesting it. Although these results are encouraging, Additional studies are required to evaluate the viability of utilizing quinoa extract as a feed addition.

Ethics committee conclusion

The experimental protocol was reviewed and approved by the Animal Care and Use Committee of the Department of Animal Production, College of Agriculture, University of Basrah (Approval No. 5849/AGRO), in full compliance with the “Guide to the Care and Use of Experimental Animals” of the Canadian Council on Animal Care (Olfert et al., 1993) and the Iraqi Agricultural Research Ethics Committee guidelines.

Abbreviations

Main abbreviations used throughout the manuscript, with their full elaborations:

QSP: quinoa seed powder

BW: Body Weight

BWG: Body Weight Gain

FI: Feed Intake

FCR: Feed Conversion Ratio (g feed/g gain)

TP: Total Protein

AL: Albumin

TG: Triglyceride

GPX: Glutathione Peroxidase (activity, U/L)

CAT: Catalase (activity, U/L)

GSH: Reduced Glutathione (concentration, μmol/L)

MDA: Malondialdehyde (index of lipid peroxidation, μmol/L)

TC: Total Cholesterol (mg/dl)

LDL: Low-Density Lipoprotein (mg/dl)

HDL: High-Density Lipoprotein (mg/dl)

VLDL: Very Low-Density Lipoprotein (mg/dl)

SEM: Standard Error of the Mean

SOD: Superoxide Dismutase

HSP70: Heat Shock Protein 70

FRAP: Ferric Reducing Antioxidant Power.

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Author Contributions

All Authors contributed equally.

Conflict of Interest Information

The authors declare no conflict of interest.

Informed Consent

Informed consent means that participants are fully informed about the purpose, procedures, risks, and benefits of the study, and voluntarily agree to participate with full understanding. It ensures respect for participants' autonomy and protects their rights.

Sponsorship Information

There is no sponsor or funding organization for this research or project, and there are no conflicts of interest

Practical Implications

Simple and low-cost intervention of performance and heat-related losses in hot climates may be applied through supplementation of broiler drinking water with quinoa alcoholic extract at 1.0 1/L. Manufacturers are supposed to maintain regular dosage and controlled preparation of extracts of quality. These results can be used to make future commercial test under hot climatic conditions.

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