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Effect of adding the cold-water extract of Arugula leaves to drinking water on the growth performance of broilers

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Abstract The current study investigated the effects of cold-water extract of Arugula (*Eruca sativa*) leaves on the performance of broiler chickens. A total of 144 Ross 308 broiler chicks was randomly allocated to the experimental treatments, regardless of sex (93 male:51 female), and assigned to four treatment groups from day one. Each treatment group consisted of 36 chicks, divided into 12 chicks per replicate. The first treatment (T1) served as the control (without any additives), while the second treatment (T2) included 50 mg/mL of cold-water extract of Arugula leaves added to each liter of drinking water. The third treatment (T3) involved 100 mg/mL of the extract, and the fourth treatment contained 150 mg/mL of the extract in the drinking water. The study demonstrated that the chicks receiving 100 mg/mL cold-water extract of Arugula leaves (T3) recorded higher body weight and weight gain, along with an improved feed conversion ratio (FCR) and reduced feed intake compared to the other treatments ($P<0.05$). Consequently, the T3 treatment resulted in markedly enhanced performance. Antioxidant enzyme activities, including glutathione peroxidase (GSH-PX), catalase (CAT), and superoxide dismutase (SOD), significantly increased in this group, accompanied by reduced levels of malondialdehyde (MDA) ($P<0.05$). Additionally, the T3 treatment led to a significant increase in hemoglobin concentration (Hb), packed cell volume (PCV), and total red blood cell (RBC) counts compared to the other treatments ($P<0.05$). The T3 group exhibited lower percentages of heterophils and higher percentages of lymphocytes, resulting in a more favorable heterophil-to-lymphocyte ratio. These findings indicated that the cold-water extract of Arugula leaves effectively mitigated the oxidative stress and enhanced both the growth performance and hematological parameters in broilers.

Keywords: antioxidant, Arugula leaves, blood, broilers, growth performance

Introduction

Concerns regarding animal production and food safety have garnered widespread attention, largely due to the overuse of antibiotics and the presence of drug residues. To address these issues, numerous countries have introduced strict regulations that limit or prohibit the inclusion of antibiotics in poultry feed. In the USA, the FDA enforced revised guidelines in early 2017 to regulate antibiotic administration in poultry (Brüssow, 2017). As of July 1, 2020, China officially ceased the production of commercial poultry feeds supplemented with growth-promoting drugs, while allowing the continued use of traditional herbal supplements (Zhang et al., 2022). Recent research increasingly highlights the efficacy of plant-derived

compounds as alternatives to antibiotics. These compounds serve as effective substitutes by activating innate defenses, reducing oxidative damage, maintaining gut mucosal health, fostering beneficial gut flora, and supporting healthy bacterial populations. Consequently, these substances reduce the impact of intestinal infections and promote growth efficiency in poultry and ruminants (Lillehoj et al., 2018). Medicinal plants have established a significant role in the global animal production industry due to their natural chemical compounds, which profoundly influence the physiological performance of both humans and animals. Arugula leaves are widely recognized as a prominent medicinal plant for their therapeutic and beneficial properties. They contain biologically active compounds such as beta-carotene, vitamins E and C, and other essential nutrients (Khoobchandani et al., 2011; Lourenço et al., 2019). Arugula leaves are rich in various minerals, including calcium, zinc, iron, potassium, manganese, sodium, and copper, as well as bioactive compounds such as flavonoids and glucosinolates, which play a crucial role in influencing production characteristics (Duru et al., 2022). Research has demonstrated that dietary supplementation with Arugula leaves reduces glucose and cholesterol concentrations while significantly elevating serum calcium and total protein levels in roosters. This suggests a potential role for Eruca sativa in modulating metabolic health and performance (Siddiqa et al., 2024). A recent study investigated the effect of Arugula on the performance and blood analyses of broiler chickens, revealing that Arugula oil enhances their performance. The study also recommended incorporating Arugula as a nutritional supplement in their diet to achieve optimal results (Kathi et al., 2024). Despite the numerous benefits and various applications of cold-water extracts from Arugula leaves for both humans and animals (Duru et al., 2022; Kathi et al., 2024), the impact of Arugula leaf powder on poultry performance has not been well investigated. Consequently, this study aimed to evaluate the impact of cold-water extract of Arugula leaves, added to drinking water, on the productive and physiological performance of broiler chickens.

Materials and methods

The Ethics Committee of the College of Agriculture, Department of Animal Production at Al-Qasim Green University (Agri. No. 3314, September 29, 2024) approved the broiler chicken management guidelines. The current study was conducted for 35 days, from September 9, 2024, to October 13, 2024, in the poultry hall at North Babylon Field.

Preparation of the cold-water extract of Arugula leaves

Cold-water extract of Arugula leaves was prepared following the method outlined by Pouyanfar et al. (2022) by mixing 20 grams of the powder with 200 milliliters of cold distilled water using a magnetic stirrer for 15 minutes. The solution was then allowed to sit for 24 hours, tightly covered to prevent the entry of impurities for better extraction. The solution was filtered multiple times using filter paper and then centrifuged at 3,000 rpm for ten minutes to obtain dry residues. These were stored in small glass bottles, which were tightly sealed and kept in the refrigerator until needed.

Bird management

A total of 144 broiler chicks, each with an initial weight of 44 g, was reared over 35 days in a controlled environment within a room that maintained consistent conditions. They were kept in metal cages, each measuring 100 cm (length) 80 cm (width) 70 cm (height), with each cage accommodating twelve chicks. The initial temperature was set at 33.5°C during the first week and was subsequently reduced by 2°C each week until the end of the fifth week. From the eighth to the 35th day, the lighting schedule provided 1 hour of darkness and 23 hours of light. At 7 days of age, the birds were vaccinated against Newcastle disease via drinking water. Throughout the experiment, there were no recorded instances of mortality. The broilers were fed growth diets containing 20.21% crude protein and 3170.5 kcal/kg of metabolizable energy. Table 1 presents the composition and chemical analysis of the diets (NRC, 1994).

Table 1. Nutritional and chemical compositions of diets

Ingredient (%)	(1-21 days) Starter diet	(22-35 days) Grower diet
Corn grain	50	55
Wheat	12	12
Soybean (48%)	29	25.5
Protein concentrate (40%)	5	3
Plant oil	2	3
Limestone	1	0.5
NaCl	0.2	0.2
Premix (29%)[1]	0.5	0.5
L – Lysine.HCl	0.2	0.2
Methionine	0.1	0.1
Total	100	100
Calculated chemical composition		
Metabolizable energy (kcal per kg)	3074	3170.5
Protein (%)	22.34	20.21
Calorie: Protein ratio	137.60	156.87
Ether extract (%)	5.02	5.94
Fiber (%)	3.45	3.26
Calcium (%)	0.71	0.42
Available phosphorus (%)	0.30	0.24
Lysine (%)	1.25	1.11
Methionine + cysteine (%)	0.83	0.75

Each kilogram of the premix providing 12,000 IU of vitamin A, 10 mg of vitamin E, 2,200 IU of vitamin D_3, 2 mg of vitamin K_3, 1.8 mg of vitamin B_1, 6.6 mg of vitamin B_2, 3.0 mg of vitamin B_6, and 0.015 mg of vitamin B_{12}. It also included 30 mg of niacin, 10 mg of pantothenic acid, 1 mg of folic acid, 0.05 mg of biotin,50 mg iron, 60 mg manganese, 60 mg zinc, 5 mg copper, 1 mg iodine, 0.2 mg selenium, and 100 mg of antioxidant compounds.

Study design and data collection

The birds were divided into four treatment groups, each consisting of 36 chicks. Each treatment group was further subdivided into three replicates, with 12 chicks

per replicate. The treatments included the following: The first treatment (T1) served as the control group, with no additions made to the drinking water. Treatment T2, T3, and T4 involved administering 50, 100, and 150 mg of cold-water extract of Arugula leaves per milliliter of drinking water.

Performance indicators

These measurements, recorded weekly, included the body weight, weight gain, feed consumption, and feed conversion ratio (FCR), which were calculated according to the source (Al-Jebory et al., 2023).

Hematological parameters

At 35 days of age, blood samples (3 mL) were randomly collected from one bird per replicate via the brachial vein. One milliliter of blood was placed in a tube containing the anticoagulant EDTA to measure hemoglobin concentration (Hb), packed cell volume (PCV), total red blood cell count (RBC), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), lymphocyte percentage (L), heterophil percentage (H), and the heterophil-to-lymphocyte ratio (H/L). These parameters were estimated manually according to Jones (2015). The remaining 2 mL of blood was collected in test tubes without EDTA for serum analysis. The serum separated from each blood sample was decanted after centrifugation at 3,000 rpm for 10 minutes. All samples were then refrigerated and stored at -20°C until biochemical analysis was performed.

Serum antioxidants

This study evaluated antioxidant status by measuring the activities of glutathione peroxidase (GSH-PX) following the methodologies established by Flohé and Günzler (1984), catalase (CAT) and superoxide dismutase (SOD), which were calculated according to the source (Carmo de Carvalho e Martins et al., 2022), as well as the concentration of malondialdehyde (MDA) in serum following the methodologies established by Yagi (1998).

Statistical analysis

Data analysis was conducted using the statistical program SPSS (2011) and employed a completely randomized design (CRD), based on the following mathematical model: Yij = μ + Ti + ei, where Yij was the observation value, μ was the overall mean of the studied trait, Ti denoted the treatment effect, and ei signified the experimental error effect. The Duncan's multiple range test (1955) was used to test for significant differences between treatment means.

Results

Performance data

The results regarding body weight, weight gain, feed intake, and feed conversion ratio are presented in Tables 2, 3, 4, and 5. Broiler chickens that received 100 mg/mL of cold-water extract of Arugula leaves (T3) demonstrated a substantial increase in body weight and weight gain, along with a marked decrease in feed intake and FCR when compared to the other treatments. According to the results in Table 2, no significant differences in body weight were observed during the first and second weeks. However, broiler chicks that received 50, 100, and 150 mg/mL of cold-water Arugula leaf extract exhibited a significant increase in body weight compared to the control treatment in the third week. Additionally, the Arugula leaf extract (T3) administered at 100 mg/mL in cold water demonstrated a significant increase in body weight compared to the other treatments during the fourth week. In the fifth week of the experiment, the T3 treatment continued to show a significant increase in body weight.

Table 2. Effect of Aragula leaf water extract on live body weight (g) in broilers

Treatments\ weeks	T1	T2	T3	T4	Significant
1st day	44.00 ± 2.01	44.00 ± 3.00	44.00 ± 2.70	44.00 ± 3.13	N.S.
1st week	136.34±2.20	136.40±1.11	135.90±2.31	136.18±2.18	N.S.
2nd week	349.80±3.52	352.00±5.72	355.30a±5.72	349.80±3.74	N.S.
3rd week	695.20^{b}±3.52	723.80^{a}±4.29	732.60^{a}±5.50	707.74^{a}±3.74	*
4th week	1252.90^{c}±16.61	1302.40^{b}±25.31	1338.70^{a}±21.13	1276.00^{b}±20.80	*
5th week	1852.40^{c}±16.64	1966.30^{b}±21.49	2081.23^{a}±21.03	1929.55^{a}±16.64	*

T1, control treatment (no extract), T2, T3, and T4 contained 50, 100, and 150 mg/mL cold-water extract of Arugula leaves in drinking water, respectively. *: P<0.05. NS: Non-significant. ^{a,b} Within row, means with common superscript(s) are not different (P>0.05; Duncan's multiple range test).

No statistically significant differences in weight gain were observed during the first and second weeks (Table 3). However, broiler chicks that received 100 mg/mL of cold-water extract of Arugula leaves (treatment T3) exhibited a significant increase in weight gain compared to T1, T2, and T4 during the 3rd, 4th, and 5th weeks.

No statistically significant differences in feed intake were observed during the first, second, and third weeks (Table 4). In contrast, broiler chickens that received 100 mg/mL of cold-water Arugula leaf extract in their feed (T3) exhibited a significant decrease in feed intake compared to the other treatments during the fourth and fifth weeks (P<0.05). This observation also pertained to the cumulative feed intake from the first week through the fifth week.

Feed conversion ratios were not influenced by the treatments during the first and second weeks (Table 5). However, a significant improvement in the feed

conversion ratio was recorded for treatments T2 and T3 during the third and fourth weeks. Additionally, we noted an enhancement in the feed conversion ratios at 50, 100, and 150 mg/mL of the extract in the fifth week, as well as in the cumulative feed conversion rate from the first week through the fifth week.

Table 3. Effect of Aragula leaf water extract on weight gain (g) in broilers

Treatments\ weeks	T1	T2	T3	T4	Significant
0-1 week	92.34±4.89	92.40±3.11	91.60±2.15	92.18±4.16	N.S.
1-2 week	213.46±4.69	215.60±5.33	219.40±4.18	213.62±5.01	N.S.
2-3 week	345.40^{b}±4.96	371.80^{b}±5.73	377.30^{a}±4.38	357.94^{b}±5.41	*
3-4 week	557.70^{c}±14.30	578.60^{b}±15.54	606.10^{a}±15.39	568.26^{b}±14.34	*
4-5 week	599.60^{c}±15.44	663.90^{b}±19.00	742.53^{a}±17.93	653.55^{b}±14.30	*
0-5 week	1808.40^{c}±15.91	1922.30^{b}±17.09	2037.23^{a}±15.82	1885.55^{b}±16.14	*

T1, control treatment (no extract), T2, T3, and T4 contained 50, 100, and 150 mg/mL cold-water extract of Arugula leaves in drinking water, respectively. *: P<0.05. NS: Non-significant. ^{a,b} Within row, means with common superscript(s) are not different (P>0.05; Duncan's multiple range test).

Table 4. Effect of Aragula leaf water extract on feed intake (g) in broilers

Treatments\ weeks	T1	T2	T3	T4	Significant
1st week	1.18±0.04	1.24±0.01	1.26±0.02	1.19±0.01	N.S.
2nd week	1.60±0.01	1.58±0.03	1.56±0.01	1.59±0.05	N.S.
3rd week	1.49^{a}±0.05	1.39^{b}±0.01	1.37^{b}±0.09	1.44^{a}±0.01	*
4th week	1.43^{a}±0.01	1.39^{b}±0.03	1.34^{c}±0.04	1.42^{a}±0.02	*
5th week	1.88^{a}±0.01	1.73^{b}±0.12	1.57^{c}±0.13	1.76^{b}±0.02	*
0-5 week	1.60^{a}±0.06	1.52^{b}±0.02	1.45^{c}±0.05	1.55^{b}±0.07	*

T1, control treatment (no extract), T2, T3, and T4 contained 50, 100, and 150 mg/mL cold-water extract of Arugula leaves in drinking water, respectively. *: P<0.05. NS: Non-significant. ^{a,b} Within row, means with common superscript(s) are not different (P>0.05; Duncan's multiple range test).

Table 5. Effect of Aragula leaf water extract on feed conversion ratio (g:g) in broilers

Treatments\ weeks	T1	T2	T3	T4	Significant
1st week	1.18±0.04	1.24±0.01	1.26±0.02	1.19±0.01	N.S.
2nd week	1.60±0.01	1.58±0.03	1.56±0.01	1.59±0.05	N.S.
3rd week	1.49^{a}±0.05	1.39^{b}±0.01	1.37^{b}±0.09	1.44^{a}±0.01	*
4th week	1.43^{a}±0.01	1.39^{b}±0.03	1.34^{c}±0.04	1.42^{a}±0.02	*
5th week	1.88^{a}±0.01	1.73^{b}±0.12	1.57^{c}±0.13	1.76^{b}±0.02	*
0-5 week	1.60^{a}±0.06	1.52^{b}±0.02	1.45^{c}±0.03	1.55^{b}±0.07	*

T1, control treatment (no extract), T2, T3, and T4 contained 50, 100, and 150 mg/mL cold-water extract of Arugula leaves in drinking water, respectively. *: P<0.05. NS: Non-significant. ^{a,b} Within row, means with common superscript(s) are not different (P>0.05; Duncan's multiple range test).

Serum antioxidant indices were significantly improved by the treatments (Table 6). Specifically, T3 treatment (100 mg/mL of the cold-water extract) resulted in a significant increase in superoxide dismutase levels compared to the other treatments. All levels of the extract exhibited a significant increase in glutathione peroxidase and catalase activities compared to the control treatment. Furthermore, there was a significant decrease in malondialdehyde concentration in the serum of the birds receiving 50 and 100 mg/mL extract compared to the other treatments.

Table 6. Effect of Aragula leaf water extract on serum antioxidant indices in broilers

Treatments	T1	T2	T3	T4	Significant
SOD (U/MI)	275.66^{c}±7.36	297.35^{b}±8.88	330.25^{a}±9.66	297.92^{b}±10.38	*
GSH-PX (U I)	141.07^{b}±16.61	162.41^{a}±12.20	167.12^{a}±13.52	163.52^{a}±13.52	*
CAT (U/MI)	2.55^{c}±0.09	5.10^{a}±0.01	5.10^{a}±0.005	5.81^{b}±0.03	*
MDA (UM/L)	1.81^{c}±0.02	1.13^{a}±0.05	1.17^{a}±0.06	1.40^{b}±0.09	*

T1, control treatment (no extract), T2, T3, and T4 contained 50, 100, and 150 mg/mL cold-water extract of Arugula leaves in drinking water, respectively. *: P<0.05. NS: Non-significant. ^{a,b} Within row, means with common superscript(s) are not different (P>0.05; Duncan's multiple range test). SOD: superoxide dismutase; GSH-PX: glutathione peroxidase; CAT: catalase; MDA: malondialdehyde.

Table 7 illustrates the effects of experimental treatments on the hematological parameters of broilers. The T3 treatment, containing 100 mg/mL of the cold-water extract, performed significantly better than the other treatments in terms of packed cell volume, hemoglobin, and red blood cell counts. There were no significant differences in mean corpuscular volume, mean corpuscular hemoglobin concentration, and mean corpuscular hemoglobin levels among the treatments. Lymphocyte levels were significantly elevated in the T2 and T3 treatments compared to the other treatments. Furthermore, there was a notable decrease in heterophils and the heterophil-to-lymphocyte (H/L) ratio in the treatments containing 50, 100, and 150 mg/mL of the cold-water extract compared to the control treatments.

Table 7. Effect of Aragula leaf water extract on hematological parameters in broilers

Treatments	T1	T2	T3	T4	Significant
RBC (x 10^6 .mm3)	2.90^{b}±0.07	3.11^{ab}±0.03	3.36^{a}±0.11	3.04^{ab}±0.19	*
Hb (g/dL)	7.60^{b}±0.18	8.07^{ab}±0.08	8.65^{a}±0.27	7.91^{ab}±0.47	*
PCV (%)	26.40^{b}±0.62	28.05^{ab}±0.30	30.06^{a}±0.96	27.50^{ab}±1.67	*
MCV (fL)	99.99±2.31	99.01±5.19	98.24±4.31	99.27±6.78	N.S.
MCH (pg)	33.33±2.29	33.03±3.09	32.74±4.00	33.07±3.19	N.S.
MCHC (g/dL)	36.66±6.61	36.66±2.20	36.66±3.52	36.65±3.52	N.S.
Heterophils (%)	38.50^{a}±1.26	24.56^{c}±1.59	19.06^{d}±3.96	28.60^{b}±2.90	*
Lymphocytes (%)	61.60^{c}±3.26	70.02^{a}±3.59	85.42^{a}±2.96	68.20^{b}±4.90	*
H/L ratio	0.62^{a}±0.03	0.35^{c}±0.02	0.22^{d}±0.01	0.41^{b}±0.04	*

T1, control treatment (no extract), T2, T3, and T4 contained 50, 100, and 150 mg/mL cold-water extract of Arugula leaves in drinking water, respectively. *: P<0.05. NS: Non-significant. ^{a,b} Within row, means with common superscript(s) are not different (P>0.05; Duncan's multiple range test). RBC: red blood cell; Hb: hemoglobin; PCV: packed cell volume; MCV: mean corpuscular volume; fL : femtoliters; MCH: mean corpuscular hemoglobin; pg : picograms; MCHC: mean corpuscular hemoglobin concentration; g/dL : grams per deciliter; H/L:heterophil-to-lymphocyte ratio.

Discussion

Broiler chickens that received 100 mg/mL of cold-water extract of Arugula leaves (T3) demonstrated a substantial increase in body weight and weight gain, along with improved feed conversion rates and performance. This can likely be attributed to the higher levels of several beneficial compounds in Arugula leaves, and limited amount of glucosinolates, which possess antioxidant and antimicrobial properties. These compounds positively influence the vitality and health of birds while also enhancing digestion, nutrient absorption, and conversion processes. This indicates that Arugula may play a significant role in improving feed intake and growth performance parameters through its essential oils (Qaddoumi and El-Banna, 2021). Furthermore, essential oils of Arugula enhance the activity and secretion of pancreatic enzymes such as lipase, amylase, trypsin, and chymotrypsin, and improve the digestion of proteins, fats, and cellulose, which may enhance the productive performance of broilers (Ibrhim et al., 2021). This study is consistent with others that have demonstrated that the alcoholic extract of Arugula leaves improved production in broiler chickens, as this extract enhances the secretion of digestive enzymes and subsequently increases the digestion rate (Jang et al., 2004). Additionally, the feed conversion ratio improved compared to the control treatment which aligns with findings of Ertas et al. (2005), which found that essential oils of Arugula can enhance food conversion ratio by increasing the secretion of digestive enzymes, stimulating appetite, boosting immunity, enhancing vitality, exhibiting antiviral activity, providing antioxidant properties, and regulating intestinal bacteria, in addition to demonstrating antimicrobial effects. The enhancement in the FCR upon incorporating Arugula into poultry diets is linked to its antimicrobial and immunosuppressive properties. These components contribute positively to the birds' overall health, leading to a more efficient digestive process and improved growth performance (Alispahic et al., 2024). Arugula can also enhance energy metabolism, stimulate appetite, aid digestion, and increase bile secretion (Barillari et al., 2005; Shani et al., 2019). Chaturvedi et al. (1993) reported a clear improvement in the feed conversion ratio of broiler chickens after consuming Arugula. Similar results are reported by Al-Fityin and AlSaig (2009), where substituting soybean protein with Arugula in the diet of Awassi lambs resulted in significant increases in weight, feed conversion ratio, body weight, and feed intake. Furthermore, the reduction in feed intake can positively impact cost efficiency in agricultural operations (Zeinab, 2003). However, Alcicek et al. (2003) observed that adding Arugula to the drinking water of broiler chickens did not significantly change the feed intake.

The findings of this study also demonstrated that the cold-water extract of Arugula leaves increased the levels of superoxide dismutase, glutathione peroxidase, and catalase, while reducing malondialdehyde levels. These results suggested that the leaves of Arugula possess strong antioxidant properties. These effects are attributed to bioactive compounds such as flavonoids and polyphenols found in *Eruca sativa* (Alam et al., 2007). The results highlight the beneficial effects of cold water on Arugula leaves, particularly in enhancing antioxidant concentration and preserving blood cell integrity. This may be attributed to the influence of Arugula leaves in increasing antioxidant enzyme activity and hematological parameters, and reducing levels of malondialdehyde (MDA) (Al-Shammari and Batkowska, 2021; Hana and Al-Salhie, 2024). The elevated levels of hemoglobin (Hb), packed cell volume (PCV), and red blood cells (RBC) observed in the T3 treatment are likely attributable to the bioactive compounds found in Arugula extract, particularly phenols and flavonoids. These compounds serve as antioxidants, protecting body cells from damage caused by free radicals (Kaurinovic and Vastag, 2019; Salman et al., 2024). The data also indicated that there were no significant differences in mean corpuscular volume (MCV), mean corpuscular hemoglobin concentration (MCHC), and mean corpuscular hemoglobin (MCH) levels among the treatments. These findings are consistent with those of Hana and Al-Salhie (2024), who reported no significant differences in MCHC, MCH, and MCV among the treatments of Arugula leaves. The study results also revealed a significant decrease in heterophils and the heterophil-to-lymphocyte (H/L) ratio in the treatments

that contained 50, 100, and 150 mg/mL of the cold-water extract compared to the control treatments. The Heterophil/Lymphocyte (H/L) ratio serves as an indicator of poultry robustness and immune system health. Physiological stress in birds can be assessed using the H/L ratio. Notably, the H/L ratio appears to correlate positively with the strength of the innate immune response (Minias, 2019). Chickens exhibiting low H/L ratios demonstrate better survival rates, immune responses, and resistance to infections compared to those with high H/L ratios. Additionally, birds with low H/L ratios are associated with enhanced resistance to heat stress (Thiam et al., 2022). This consistency suggests that watercress leaf supplements do not negatively affect red blood cell formation or stability. Arugula is rich in bioactive compounds, such as glucosinolates, flavonoids, and phenolic acids, which have antioxidant and anti-inflammatory properties; These compounds may mitigate oxidative stress without significantly altering red blood cell markers, which supports cellular balance under normal physiological conditions (Al-Sulivany et al., 2024).

Conclusion

This study demonstrated that the nutritional supplementation of a cold-water extract of Arugula leaves (100 mg/mL) significantly improved growth performance, serum antioxidant levels, and hematological parameters in broiler chickens compared to the control group and other treatments. Further research is needed to explore the long-term effects of Arugula leaf supplementation on the health and productivity of broiler chickens.

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Conflict of interests

There is no conflict of interest associated with this publication.

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