Analysis of the phytochemicals of *Coriandrum sativum* and *Cichorium intybus* aqueous extracts and their biological effects on broiler chickens

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Spices and herbs can be used as feed additives and viable alternatives to antibiotics in chicken production. This study analyzed the phytochemicals, minerals, and antioxidant activity of aqueous extracts from *Coriandrum sativum* seeds and *Cichorium intybus* roots. The effects of different concentrations of *C. sativum* and *C. intybus* extracts on blood parameters, growth and carcass traits, biochemical parameters, and antioxidant activity of broiler chicks were also examined. The results showed that *C. sativum* aqueous extract has relatively higher contents of total flavonoids and total phenolic acids than *C. intybus* aqueous extract. Both extracts contain elevated mineral elements, especially iron, potassium, and sodium. Therefore, dietary supplementation of *C. sativum* seed and *C. intybus* root extracts could enhance broiler chicken growth performance, carcass characteristics, liver function, lipid profile, and antioxidant status. These extracts could be utilized as natural feed additives and growth promoters for broiler chickens.

Dietary antibiotic growth promoters significantly contributed to animal and poultry production. However, most of these antibiotics have been banned in many countries, particularly the European Union, because of public health concerns regarding their residues in animal products and the development of antibiotic resistance in bacteria1. Presently, Scientists are increasing interested in discovering non-synthetic alternatives to antibiotics. Phytochemicals such as herbs and spices are commonly incorporated into the diets of agricultural livestock, particularly swine and poultry, to improve flavor and palatability and thus to enhance productive performance2. Herbs and spices have been shown to exert potent antimicrobial properties in vitro against various pathogens and as alternative feeding strategies to replace antibiotic growth promoters3. Nevertheless, our knowledge regarding their modes of action and aspects of their application is still limited.

Chicory (*Cichorium intybus* L.) is regarded as a significant medicinal perennial herbaceous plant belonging to the family of Asteraceae4. It contains significant amounts of inulin, fructooligosaccharides, flavonoids, coumarins, as well as a wide range of vitamins5. Chicory has been utilized as an anti-inflammatory, antiulcerogenic, anti-hepatotoxic, depurative, digestive, alexiteric, diuretic, as well as a tonic agent6. Inulin, in particular, is a beneficial constituent of chicory, which has the potential to standardize appetite, as well as the metabolism of lipids to glucose7. Chicory has been found to enhance the development of beneficial microorganisms8, in addition to inhibiting the growth of pathogenic bacteria in the gut9. Consequently, chicory can be added to the poultry diet to control the microbiota composition of the gut and improve its integrity9, optimizing the performance of broiler besides health status via modifying lipid metabolism along with hypolipidemic impacts10.

Coriander (*Coriandrum sativum* L.) is primarily utilized due to its seeds. They are a flavoring ingredient in food industries or spice in fish, curry, bread, meat, as well as meat confections. The seeds of coriander include up to 1% essential oil. Linalool is the main component that is characteristic by antioxidant11, antibacterial12, hypolipidemic13, and anti-diabetic properties14. Additionally, it is featured by appetizing as well as stimulative impacts throughout the digesting process15.

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Antioxidants act as reductants and oxidant activators. Reducing power may be a significant indicator of possible antioxidant activity. In the present study, the antioxidant capacity of C. sativum and C. intybus extracts was determined by their ability to decrease the TPTZ–Fe (III) complex to the TPTZ–Fe (II) complex (Table 2). The ORAC test is the only one among the analysis methods based on the hydrogen atom transfer mechanism, uses a biologically relevant radical and quantifies the inhibition time and degree of an antioxidant. The ORAC test was performed to assess free radical scavenging, and the results were denoted by IC50, which is the proportion of antioxidants required to reduce the initial DPPH concentration by 50%. A low IC50 indicates high antioxidant efficacy, whereas trolox was used as the reference component. As depicted in Table 2, the antioxidant activity of C. sativum was 81.9 ± 1.02 µg mL−1 in aqueous extract, 105.5 ± 1.03 µg mL−1 in aqueous extract, and 1067.18 ± 69.10 µM TE/mg of extract. Therefore, C. sativum has an antioxidant profile that includes chelation activity, phospholipid peroxide inhibition, radical free radical scavenging activity, hydroxyl radical, and peroxided peroxidation scavenging.

C. sativum and C. intybus aqueous extracts were confirmed to be rapid and efficient scavengers of ABTS radicals (Table 2). The ABTST+ scavenging activity results differed substantially (P < 0.05) between C. sativum and C. intybus extracts. The effects of supplementing broiler chickens with varying amounts of these extracts and their combinations on productive performance, carcass features, and physiological responses were also investigated.

The aim of the current study was to evaluate the phytochemicals, in vitro antioxidant activity, and metal analysis of C. sativum and C. intybus aqueous extracts. The chemical compounds in plants are responsible for their natural antioxidant activity, and the majority of these active compounds are natural phenols or polyphenols. Leaves, fruits, seeds, and flowers have the highest natural flavonoid and phenol contents. Increased dietary consumption of antioxidants or vegetables or fruits with antioxidant activities can improve quality of life.

### Results and discussions

#### Phytochemical quantification.

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Table 1 demonstrates that C. sativum and C. intybus extracts have different phytochemical compounds. The aqueous extract of C. sativum seeds had a significantly higher content of total flavonoids (p < 0.05, Table 1) and total phenolics (36.5 ± 1.7 mg of gallic acid/g of extract) than in the aqueous extract of C. intybus leaves (28.16 ± 1.60 mg of gallic acid/g of extract). These results agree with Nhut et al.17, who reported that C. sativum extract has significant phenolic contents.

#### Antioxidant activities of C. sativum and C. intybus aqueous extracts.

The antioxidant activities of C. sativum and C. intybus aqueous extracts were examined using DPPH, ABTS, FRAP, metal chelation, and ORAC assays. Moreover, the DPPH test was performed to assess free radical scavenging, and the results were denoted by IC50, which is the proportion of antioxidants required to reduce the initial DPPH concentration by 50%. A low IC50 indicates high antioxidant efficacy, whereas trolox was used as the reference component. As depicted in Table 2, the antioxidant activity of C. sativum was 81.9 ± 1.02 µg mL−1 in aqueous extract, 105.5 ± 1.03 µg mL−1 in aqueous extract, and 1067.18 ± 69.10 µM TE/mg of extract. Therefore, C. sativum has an antioxidant profile that includes chelation activity, phospholipid peroxide inhibition, radical free radical scavenging activity, hydroxyl radical, and peroxided peroxidation scavenging.

C. sativum and C. intybus aqueous extracts were confirmed to be rapid and efficient scavengers of ABTS radicals (Table 2). The ABTST+ scavenging activity results differed substantially (P < 0.05) between C. sativum and C. intybus at 706.07 ± 16.02 and 636.27 ± 12.87 µM Trolox/mg of extract, respectively. ABTS radical cation scavenging activity is a reflection of its hydrogen-donating capacity. According to Pandey et al.18, high molecular weight phenolics (tannins) have a high capacity to quench free radicals (ABTST+). When combined with a nutrient, these extracts can function as potential nutraceuticals.

Antioxidants act as reductants and oxidant activators. Reducing power may be a significant indicator of possible antioxidant activity. In the present study, the antioxidant capacity of C. sativum and C. intybus extracts was determined by their ability to decrease the TPTZ–Fe (III) complex to the TPTZ–Fe (II) complex (Table 2). The capacity to reduce ferric ions also indicated their significant FRAP activity. The aqueous extract of C. sativum had a more pronounced activity (102.91 ± 3.07 µM TE/mg of extract) than that of C. intybus (94.25 ± 7.46 µM TE/mg of extract).

Although iron is required for proper physiology, its excessive amount can induce cellular damage. If the reduced metals go through the Fenton reaction, they may generate reactive hydroxyl radicals that contribute to oxidative stress. The capacity to chelate/deactivate transition metals, catalyze hydroperoxide breakdown,
Table 3. Mineral content (mg/kg) of *C. sativum* and *C. intybus* extracts. N. D.: Not detected.

|        | Ca       | Na       | K        | Mg        | Al        | P        | B         |
|--------|----------|----------|----------|-----------|-----------|----------|-----------|
| *C. sativum* | 68.69 ± 101.3 | 360.54 ± 12.7 | 11,200 ± 200.5 | 5234.11 ± 113.1 | 19.4 ± 1.3 | 702.53 ± 11.29 | 30.14 ± 4.1 |
| *C. intybus* | 61.63 ± 112.1 | 500.76 ± 13.1 | 12,500 ± 111.1 | 6211.21 ± 81.0 | 217.5 ± 1.7 | 675.32 ± 14.1 | 185.2 ± 2.41 |
| Ba     | 4.28 ± 0.65 | 0.20 ± 0.01 | 0.18 ± 0.01 | 12.45 ± 0.65 | 4.16 ± 1.2 | 15,630 ± 181.1 | 56.7 ± 7.1 |
| Cd     | 11.2 ± 0.42 | 0.22 ± 0.02 | 0.21 ± 0.02 | 53.01 ± 0.61 | 6.81 ± 0.89 | 1317 ± 71.3 | 42.44 ± 3.8 |
| Cr     | 1.699 ± 0.1 | < 0.002 | 1.06 ± 0.1 | 58.88 ± 1.8 | 0.43 ± 0.1 | 0.24 ± 0.02 | 36.21 ± 2.1 |
| Cu     | 1.093 ± 0.6 | 1.57 ± 0.02 | 2.49 ± 0.02 | 540.76 ± 0.11 | 47.91 ± 3.4 | < 0.01 | 46.7 ± 0.89 |
| Mn     | 4.28 ± 0.65 | 0.20 ± 0.01 | 0.18 ± 0.01 | 12.45 ± 0.65 | 4.16 ± 1.2 | 15,630 ± 181.1 | 56.7 ± 7.1 |
| Mo     | 11.2 ± 0.42 | 0.22 ± 0.02 | 0.21 ± 0.02 | 53.01 ± 0.61 | 6.81 ± 0.89 | 1317 ± 71.3 | 42.44 ± 3.8 |
| Ni     | 1.699 ± 0.1 | < 0.002 | 1.06 ± 0.1 | 58.88 ± 1.8 | 0.43 ± 0.1 | 0.24 ± 0.02 | 36.21 ± 2.1 |
| Pb     | 1.093 ± 0.6 | 1.57 ± 0.02 | 2.49 ± 0.02 | 540.76 ± 0.11 | 47.91 ± 3.4 | < 0.01 | 46.7 ± 0.89 |
| Si     | 4.28 ± 0.65 | 0.20 ± 0.01 | 0.18 ± 0.01 | 12.45 ± 0.65 | 4.16 ± 1.2 | 15,630 ± 181.1 | 56.7 ± 7.1 |
| Sr     | 11.2 ± 0.42 | 0.22 ± 0.02 | 0.21 ± 0.02 | 53.01 ± 0.61 | 6.81 ± 0.89 | 1317 ± 71.3 | 42.44 ± 3.8 |
| V      | 1.699 ± 0.1 | < 0.002 | 1.06 ± 0.1 | 58.88 ± 1.8 | 0.43 ± 0.1 | 0.24 ± 0.02 | 36.21 ± 2.1 |
| Zn     | 1.093 ± 0.6 | 1.57 ± 0.02 | 2.49 ± 0.02 | 540.76 ± 0.11 | 47.91 ± 3.4 | < 0.01 | 46.7 ± 0.89 |

and facilitate Fenton-type reaction is a critical mechanism of antioxidant activity. Therefore, the extracts’ iron (II) chelating activity was evaluated. Both exhibited a high capacity to chelate metal ions (Table 2). The aqueous extract of *C. sativum* (64.23 ± 2.6 µMEDTA eq/mg of extract) showed more high chelating ability than that of *C. intybus* (47.15 ± 1.9 µMEDTA eq/mg of extract). These findings indicate that the extracts may serve as an antioxidant by sequestering Fe (II) ions, initiating Fenton-type reactions, or engaging in metal-catalyzed hydroperoxide breakdown activities. The scavenging and chelating abilities of antioxidants are determined by the number of hydroxyl groups and their unique phenolic structure.²²

**Elemental analysis.** The presence of inorganic components is essential for the survival of bioactive chemical entities. In addition to the four-building elements, carbon, hydrogen, nitrogen, and oxygen (forming the main organic molecules), living organisms require many inorganic components to function properly. Numerous elements are fundamentally necessary for normal physiological function.²³

Twenty-two inorganic elements with an essential role in biological activities were detected in *C. sativum* and *C. intybus* extracts (Table 3). Inductively coupled plasma–optical emission spectrometry was used to analyze these elements, which is one of the most effective techniques for performing multi-element analysis quickly and with high sensitivity.

The most abundant element in the samples was calcium, followed by iron, potassium, and sodium. This element is critical for various physiological processes and, along with phosphorus, serves as a structural bone component. Calcium supplementation contributes to the prevention of bone fractures and calcium-deficient element is critical for various physiological processes and, along with phosphorus, serves as a structural bone...
be attributed to the presence of antioxidants and phenolic substances in diets significantly improved body increase weight during starter, finisher, and entire periods. This finding could finisher, and entire experimental periods. The inclusion of and C. sativum intybus enhanced growth performance. Jang30 adding coriander oil to broiler diets contributed significantly to increas-
stimulating, and antimicrobial effects of the two extracts36. According to the present findings, the fed diet of conversion during all three periods. This improvement could be attributed to the appetite-enhancing, digestive-
food products.

Growth performance. Table 4 lists the average body weight gain, feed consumption, feed conversion ratio, and mortality rate of broiler chicks fed with diets supplemented with 1000 mg of C. sativum, 500 mg of C. intybus, or a mixture of 500 mg of C. sativum plus 250 mg of C. intybus extracts/kg of diet during starter, finisher, and entire experimental periods. The inclusion of C. sativum and C. intybus extracts in broiler chick diets significantly improved body increase weight during starter, finisher, and entire periods. This finding could be attributed to the presence of antioxidants and phenolic substances in C. sativum and C. intybus extracts that enhanced growth performance. Jang30 adding coriander oil to broiler diets contributed significantly to increasing weight. Comparable findings were revealed by Faramarzzadeh et al.31, who added 4.5% of chicory powder to the broiler diet.

Consumption of feed during starter and finisher periods was not significantly affected by the supplementation of C. sativum and C. intybus extracts in the broiler chick diet. Meanwhile, the addition of 500 mg of C. intybus extract/kg of diet significantly increased feed consumption during the entire experimental period (0–6 weeks). This increase could be attributed to the phytogenic feed additives that improved the flavor and palatability of feeds32,33. The improvement in feed consumption induced by the powder of coriander seeds can be due to essent-
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Cadmium and lead have permissible limits of 0.3 and 10 mg/kg, respectively29. Table 3 lists the additional elements detected in trace amounts.

Based on these results, C. sativum and C. intybus can be recommended as raw or processed supplements for food products.

Table 4. Effect of the addition of C. sativum and C. intybus extracts on the growth performance of broiler chicks. a,b Within the same rows, means have similar letter(s) are not significant different at ≤ 0.05.

| Treatments                  | Control | 1000 mg of C. sativum | 500 mg of C. intybus | 500 mg of C. sativum + 250 mg of C. intybus | SEM  | P values |
|-----------------------------|---------|-----------------------|----------------------|---------------------------------------------|------|----------|
| Body weight gain            |         |                       |                      |                                             |      |          |
| 0–3 weeks                   | 737.0a  | 824.0a                | 822.0a               | 779.0a                                      | 8.97 | 0.002    |
| 4–6 weeks                   | 1398.1c | 1633.4c               | 1626.7c              | 1526.6c                                     | 14.56| 0.001    |
| 0–6 weeks                   | 2121.2c | 2442.3c               | 2433.4c              | 2331.0c                                     | 18.54| 0.001    |
| Feed consumption            |         |                       |                      |                                             |      |          |
| 0–3 weeks                   | 1090.9  | 1097.5                | 1108.8               | 1113.9                                      | 10.48| 0.290    |
| 4–6 weeks                   | 3435.8  | 3389.8                | 3443.3               | 3520.0                                      | 24.60| 0.336    |
| 0–6 weeks                   | 4551.3b | 4509.3b               | 4655.6b              | 4590.2a                                     | 24.76| 0.009    |
| Feed conversion             |         |                       |                      |                                             |      |          |
| 0–3 weeks                   | 1.48a   | 1.33c                 | 1.33c                | 1.43c                                       | 0.022| 0.005    |
| 4–6 weeks                   | 2.46c   | 2.07c                 | 2.16c                | 2.20c                                       | 0.025| 0.001    |
| 0–6 weeks                   | 2.12c   | 1.82c                 | 1.89c                | 1.95c                                       | 0.018| 0.001    |
| Mortality rate %            | 6.67a   | 3.34a                 | 3.34a                | 3.34a                                       | 0.288| 0.050    |

Table 4. Effect of the addition of C. sativum and C. intybus extracts on the growth performance of broiler chicks. a,b Within the same rows, means have similar letter(s) are not significant different at ≤ 0.05.

plants. This element is essential for protein synthesis and DNA and collaborates with copper as a cofactor in several crucial enzyme systems28.

In addition to these basic elements, bromine, lead, cadmium, and barium were found in the extracts of C. sativum and C. intybus. These inorganic elements are hazardous, though their concentrations were within the acceptable range.

Cadmium and lead have permissible limits of 0.3 and 10 mg/kg, respectively29. Table 3 lists the additional elements detected in trace amounts.

Based on these results, C. sativum and C. intybus can be recommended as raw or processed supplements for food products.
and contributes to the production of enzymes as well as digestive juices in the stomach, stimulating peristaltic motion and digestion, and consequently enhancing FCR.

Dietary supplementation of these extracts significantly decreased the mortality rate of broiler chicks during the experimental period. This finding could be attributed to the positive results of the two extracts for tannins, alkaloids, terpenoids, flavonoids, and saponins and the negative for glycosides. Adisa et al. \textsuperscript{36} indicated that tannins possess antiviral and antibacterial activities. Taraz et al. \textsuperscript{43} concluded that coriander seeds inhibit pathogenic microorganisms in the digestive system, decreasing birds’ mortality or disease infection. The improved growth performance of broilers fed with both extracts could be attributed to coriander. Chicory extracts have some components with antimicrobial properties, such as flavonoids and phenolics (Table \textsuperscript{1}). Deans and Waterman \textsuperscript{44} concluded that the addition of plant extracts to poultry diets could enhance the growth performance by stimulating endogenous enzymes and regulating intestinal microflora balance.

**Carcass characteristics.** Table \textsuperscript{5} depicts the carcass traits of broiler chicks fed with diets supplemented with 1000 mg of \textit{C. sativum}, 500 mg of \textit{C. intybus}, or 500 mg of \textit{C. sativum} + 250 mg of \textit{C. intybus} extracts/kg of diet. These results indicated that dietary supplementation with \textit{C. sativum} and \textit{C. intybus} extracts significantly increased liver and carcass weight and decreased abdominal fat percentage. In contrast, the other carcass organs were not significantly affected. These findings are in agreement with prior studies \textsuperscript{45}. The increased dressing percentage may be linked to the stimulatory effects of coriander on pancreatic secretions, which in turn boost digestive enzyme secretion and produce additional nutrients, such as amino acids that are digested and absorbed from the digestive system \textsuperscript{46}. Generally, the accumulation of body fats can be the net result of the balance between fat catabolism, fat synthesis (lipogenesis), as well as dietary absorbed fat via β-oxidation (lipolysis).

Consequently, when the quantity of ingested fat remains constant, reduced deposition of body fats can be due to diminished synthesis of fatty acids, elevated fat catabolism, or both mechanisms. Hence, carcass characteristics are enhanced. Antioxidants and phenolic substances in herbous extracts enhanced the broiler chicken’s carcass reaching 1.2% \textsuperscript{47}.

Panda et al. \textsuperscript{48} and Faramarzzadeh et al. \textsuperscript{31} demonstrated marked improvement in the proportion of dressing by supplementation of chicory powder (3.0%) to broiler diet. The current findings also agree with Yusrizal and Chen \textsuperscript{49}, who illustrated that the fed diets of broiler chickens supplied with chicory fructans (1%) were heavier than controls. In addition, they detected a positive correlation between the addition of chicory supplementation as well as carcass characteristics in poultry species \textsuperscript{50}.

| Items            | Control 1000 mg of \textit{C. sativum} | 500 mg of \textit{C. intybus} | 500 mg of \textit{C. sativum} + 250 mg of \textit{C. intybus} | SEM | P-values |
|------------------|--------------------------------------|-----------------------------|-------------------------------------------------------------|-----|---------|
| Live body weight | 2190.2 \textsuperscript{a}          | 2375.4 \textsuperscript{a}  | 2400.0 \textsuperscript{b}                                   | 16.24 | 0.001   |
| Carcass weight   | 1609.0 \textsuperscript{a}          | 1749.7 \textsuperscript{b}  | 1768.6 \textsuperscript{b}                                   | 12.89 | 0.001   |
| Dressing %       | 73.47                                 | 73.66                       | 73.69                                                       | 0.14 | 0.492   |
| Liver %          | 2.97                                 | 2.65                        | 2.52                                                        | 0.09 | 0.434   |
| Gizzard %        | 1.61                                 | 1.68                        | 1.66                                                        | 0.07 | 0.890   |
| Heart %          | 0.51                                 | 0.56                        | 0.60                                                        | 0.01 | 0.253   |
| Abdominal fat %  | 1.00 \textsuperscript{a}            | 0.87 \textsuperscript{b}    | 0.77 \textsuperscript{b}                                    | 0.01 | 0.011   |

| Items            | Extracts (mg/kg of diet)          | SEM | P-values |
|------------------|-----------------------------------|-----|---------|
| WBCs (10\textsuperscript{3}/µL) | 54.79 \textsuperscript{a}         | 52.35 \textsuperscript{a}  | 50.66 \textsuperscript{b}                                   | 2.48 | 0.042   |
| LYM (L)%         | 72.16                              | 72.88                       | 74.96                                                       | 5.88 | 0.275   |
| Heterophil (H)%  | 18.98 \textsuperscript{a}         | 16.65 \textsuperscript{b}   | 16.68 \textsuperscript{b}                                   | 0.97 | 0.045   |
| Monocyte %       | 8.86                               | 9.47                        | 8.36                                                        | 0.09 | 0.638   |
| H/L ratio        | 0.26 \textsuperscript{a}          | 0.23 \textsuperscript{b}    | 0.22 \textsuperscript{b}                                    | 0.03 | 0.051   |
| RBCs (10\textsuperscript{6}/µL) | 2.98 \textsuperscript{a}         | 3.00 \textsuperscript{b}    | 2.93 \textsuperscript{a}                                   | 0.08 | 0.018   |
| Hb (g/dL)        | 12.11 \textsuperscript{a}         | 16.11 \textsuperscript{b}   | 17.61 \textsuperscript{b}                                   | 0.71 | 0.001   |
| HCT%             | 23.46                              | 27.54 \textsuperscript{a}   | 25.07 \textsuperscript{a}                                   | 0.29 | 0.032   |

Table 5. Effect of \textit{C. sativum} and \textit{C. intybus} extracts supplementation to diet on carcass characteristics of broiler chicks. \textsuperscript{ab}Within the same rows, means have similar letter (s) are not significant different at ≤ 0.05.

Table 6. Effect of the dietary supplementation of \textit{C. sativum} and \textit{C. intybus} extracts on the plasma hematological parameters of broiler chicks. \textsuperscript{ab}Within the same rows, means have similar letter (s) are not significant different at ≤ 0.05.
Hematological parameters. Table 6 presents the effects of supplementing the broiler chick diet with 1000 mg of C. sativum, 500 mg of C. intybus, or 500 mg of C. sativum + 250 mg of C. intybus extracts/kg of diet on hematological plasma parameters. These results revealed that this supplementation significantly increased RBCs, hemoglobin concentration, and hematocrit percentage. In contrast, WBC: heterophil and heterophil:LYM ratios were significantly reduced at six weeks of age, while LYM and MON percentages were not significantly affected. Khubeiz and Shirif51 reported that adding coriander seed powder to broiler chick diets significantly reduced heterophil percentage and heterophil:LYM ratio, whereas the LYM percentage significantly increased. The increase in the H/L ratio indicated that the birds were under acute stress. In the present work, the addition of C. sativum and C. intybus extracts to the broiler chick diet improved the hematological parameters at 6 weeks of age.

Liver and kidney function. The effects of supplementing the broiler chick diet with 1000 mg of C. sativum, 500 mg of C. intybus, or 500 mg of C. sativum + 250 mg of C. intybus extracts/kg of diet on liver and kidney function are depicted in Table 7. These results indicate that this supplementation did not significantly affect total plasma protein, albumin, globulin, and A/G ratio. Plasma AST and ALT were significantly affected by the dietary addition of the two extracts (Table 7). Similar results were obtained by Al-Jaff39, who reported that supplementing broiler diets with coriander seeds significantly decreased AST and ALT. This reduction in plasma AST and ALT indicated that plant extracts do not negatively affect liver function and have no adverse influence on the growth and health of broiler chicks. Table 7 shows that plasma urea and uric acid concentrations in broiler chicks were significantly decreased when fed with a diet supplemented with C. sativum and C. intybus extracts. Therefore, adding C. sativum and C. intybus extracts to the broiler chick diet did not adversely affect kidney function, and the extracts do not have any toxic substances. These findings support the hepatoprotective impact of C. intybus and C. sativum extracts, suggesting enhanced kidney and liver functions, which is consistent with Khubeiz and Shirif et al.31 and Hosseinzadeh et al.32. Aromatic plant supplements in the chicken are characterized by stimulatory impacts on the digesting process by increasing digestive enzymes production and enhancing the use of digestive products through an improved liver function32.

Lipid profile and glucose. Table 8 shows the average levels of plasma TC, TG, LDL, HDL, and Glucose of the broiler chicks supplemented with 1000 mg of C. sativum, 500 mg of C. intybus, or 500 mg of C. sativum and C. intybus extracts/kg of diet.

**Table 7.** Effect of the dietary supplementation of C. sativum and C. intybus extracts on the plasma liver and kidney function of broiler chicks. a,b Within the same rows, means have similar letter(s) are not significant different at ≤ 0.05.

| Items                  | Control | 1000 mg of C. sativum | 500 mg of C. intybus | 500 mg of C. sativum + 250 mg of C. intybus | SEM | P-values |
|------------------------|---------|-----------------------|----------------------|---------------------------------------------|-----|---------|
| Total protein (mg/dl)  | 4.53    | 4.60                  | 4.42                 | 4.31                                        | 0.10| 0.381   |
| Albumin (mg/dl)        | 2.40    | 2.53                  | 2.29                 | 2.31                                        | 0.08| 0.504   |
| Globulin (mg/dl)       | 2.13    | 2.07                  | 2.13                 | 2.00                                        | 0.07| 0.412   |
| A/G                    | 1.13    | 1.22                  | 1.08                 | 1.16                                        | 0.05| 0.325   |
| AST (U/ml)             | 41.48b  | 43.39a                | 45.35a               | 41.39b                                      |     | 4.12    |
| ALT (U/ml)             | 24.40b  | 27.53a                | 29.17a               | 24.30b                                      |     | 2.98    |
| Uric acid (mg/dl)      | 0.46a   | 0.26b                 | 0.19b                | 0.14b                                       | 0.01| 0.048   |
| Urea (mg/dl)           | 4.42a   | 3.94b                 | 4.15b                | 4.10b                                       | 0.24| 0.051   |

**Table 8.** Effect of C. sativum and C. intybus extracts supplementation to diet on plasma lipid profile and glucose of broiler chicks. a,b Within the same rows, means have similar letter(s) are not significant different at ≤ 0.05.

| Items                  | Control | 1000 mg of C. sativum | 500 mg of C. intybus | 500 mg of C. sativum + 250 mg of C. intybus | SE  | P value |
|------------------------|---------|-----------------------|----------------------|---------------------------------------------|-----|---------|
| Cholesterol (mg/dl)    | 151.4a  | 143.1b                | 140.8b               | 138.2b                                      | 9.12| 0.041   |
| Triglycerides (mg/dl)  | 82.7a   | 64.11b                | 52.4b                | 57.1b                                       | 8.27| 0.021   |
| HDL (mg/dl)            | 75.4a   | 79.88b                | 87.1b                | 88.4b                                       | 5.33| 0.032   |
| LDL (mg/dl)            | 64.8a   | 60.4b                 | 30.6b                | 43.5b                                       | 9.17| 0.025   |
| Glucose (mg/dl)        | 199.4a  | 179.2b                | 162.8b               | 149.9b                                      | 6.20| 0.020   |
The antioxidant state of poultry may be determined by testing four main antioxidant enzymes: GSH-Px, T-AOC, MDA, and T-SOD. Total superoxide dismutase and GSH-Px are natural scavengers to free radicals and enzymatic systems, can be indicated by T-AOC, with elevated T-AOC in broiler chicks supplied with extracts. The mixture was heated for 30 min in a water bath at 65 °C after 24 h of maceration at room temperature.

| Items       | Control  | 1000 mg of C. sativum | 500 mg of C. intybus | 500 mg of C. sativum + 250 mg of C. intybus | SE | P value |
|-------------|----------|-----------------------|----------------------|--------------------------------------------|----|---------|
| SOD (U/ml)  | 41.81a   | 48.4b                 | 53.54ab              | 58.08a                                     | 1.45 | 0.052   |
| MAD (mmo/ml)| 5100     | 52.38                 | 54.58                | 53.65                                      | 2.08 | 0.568   |
| TAC (U/ml)  | 0.75c    | 0.80a                 | 0.77b                | 1.21a                                      | 0.05 | 0.051   |
| GSH (µg/ml) | 72.42    | 77.65                 | 74.92                | 75.66                                      | 2.18 | 0.468   |
| CAT (µg/ml) | 314.2    | 309.6                 | 2.899                | 2.847                                      | 21.8 | 0.652   |

Table 9. Effect of C. sativum and C. intybus extracts supplementation to diet on antioxidant status of broiler chicks. a-b Within the same rows, means have similar letter (s) are not significant different at ≤0.05.

Conclusion
This study demonstrated that C. intybus and C. sativum extract enhanced broiler chicks' performance indices, hematobiochemical profiles, as well as carcass characteristics. In addition, they improve animal health and well-being through their contribution to the antioxidant defense mechanism against free radical generation. Consequently, it is evident that these two herbs (Cichorium intybus and Coriandrum sativum) can improve performance without inducing any adverse effects on studied features.

Materials and methods
Extraction preparation. C. sativum seeds and C. intybus roots were purchased from a local market, dried, separately ground to a fine powder, and added 500 mL of distilled water to prepare C. sativum and C. intybus extracts. The mixture was heated for 30 min in a water bath at 65 °C after 24 h of maceration at room temperature. Following filtration, the extracts were concentrated using a rotary evaporator and stored at 4 °C for later use. The collection of herbs complies with relevant institutional, national, and international guidelines.
Estimation of total flavonoid content and total phenolic content. Total phenolic content was measured using Folin–Ciocalteu colorimetric technique and expressed using gallic acid equivalents (mg gallic acid/g of extract). Colorimetry with aluminum chloride determined total flavonoid content and expressed using quercetin equivalents (mg of quercetin/g of extract).

In vitro antioxidant activity of extracts. Antioxidant capacity was evaluated using the assays of scavenging free radicals (ABTS and DPPH), ferric-reducing antioxidant power (FRAP), oxygen radical antioxidant capacity (ORAC), and metal chelation, which was performed following the methods of Brand-Williams et al. for DPPH, Benzie et al. for FRAP, Arnao et al. for ABTS, Chew et al. for metal chelation, and Liang et al. for ORAC.

Elemental analysis by ICP-MS. Inductively coupled argon plasma (ICAP 6500 Duo, Thermo Scientific, England) was used to identify the components in the extracts and digests. The stock solution for instrument standardization was a 1000 mg/L multi-element certified standard solution from Merck, Germany. Leggett and Westermann’s technique was followed for sample digestion.

Animal welfare. The committee of the Poultry Production Department at Faculty of Agriculture, Minia University, approved the current research procedures. These procedures recommend animal rights and welfare by assuring minimal stress to animals. All methods were carried out in accordance with relevant guidelines and regulations. The study was carried out in compliance with the ARRIVE guidelines.

Growth performance trial. A total of 240-day-old unsexed broiler chicks (Ross 308) were randomly divided into 60 birds per treatment group. Each group was randomly allocated into five replicates (12 chicks each), kept in a wire cage (100 × 50 × 50 cm), and provided with a feeder and drinker. For the first 3 days, the brooding temperature was set at 34 °C and then decreased gradually to 24 °C at the end of the experimental period. The chicks were reared under a continuous program with 24 h of light during the 1st week and 23 h of light and 1 h of darkness for the remaining experimental period. The first group was fed on a basal diet (control), and the remaining groups were fed on a basal diet supplemented with 1000 mg of C. sativum (2nd group), 500 mg of C. intybus (3rd group), and 500 mg of C. sativum + 250 mg C. intybus extracts/kg of diet (4th group). All broiler chicks were fed with starter (0–3 weeks) and finisher (4–6 weeks) diets formulated according to the National Research Council (NRC, 1994). Table 10 presents starter and finisher diets’ ingredients and chemical composition. Feed and water were supplied ad libitum during the experimental period. The birds were vaccinated against Newcastle disease at 1 and 18 days of age and Gumboro disease at 14 and 24 days of age. Body-weight gain feed consumption and feed conversion ratio were measured during starter (0–3 weeks), finisher (4–6 weeks), and whole experimental periods (0–6 weeks).

Carcass traits and blood samplings. Ten birds were selected from each experimental group at six weeks of age and hand slaughtered. Carcass, liver, gizzard heart, and abdominal fat were removed and individually weighed, and values were expressed as percentages of pre-slaughter live weight. Blood was collected at slaughter time in heparinized tubes to determine the following hematological parameters: red blood cells (RBCs), hemoglobin concentration (Hb), hematocrit (HC), white blood cells (WBCs), lymphocytes (LYMs), monocytes.

| Ingredients       | Starter diet | Finisher diet |
|-------------------|--------------|---------------|
| Yellow corn       | 54.35        | 61.85         |
| Soy bean meal (44% CP%) | 30.00        | 22.70         |
| Concentrate mixture | 10.00        | 10.00         |
| Vegetable oil     | 2.20         | 2.20          |
| Dicalcium phosphate | 2.00         | 1.80          |
| Calcium carbonate | 0.80         | 0.80          |
| Premix            | 0.25         | 0.25          |
| Methionine        | 0.25         | 0.25          |
| Lysine            | 0.10         | 0.10          |
| Total             | 100          | 100           |

| Calculated chemical analysis | | |
|-----------------------------|--|---|
| Digestible protein (%)      | 22.69 | 20.13 |
| Metabolizable energy (Kcal/kg) | 3030 | 3150 |
| Calcium (%)                  | 1.00  | 0.98  |
| Available phosphorus (%)     | 0.54  | 0.49  |
| Lysine (%)                   | 1.24  | 1.18  |
| Methionine (%)               | 0.60  | 0.58  |

Table 10. Ingredients and chemical composition of the starter and finisher diets of broiler chicks.
**Statistical analysis.** Data were assessed by one-way ANOVA in the SAS Institute. Differences between means at p < 0.05 were compared using Duncan’s multiple range test.

**Data availability**

The datasets utilized and analyzed during this investigation are available upon reasonable request from the corresponding author.

Received: 10 January 2022; Accepted: 5 April 2022

Published online: 16 April 2022

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Author contributions
H.S.S.G. and E.M.A.T. contributed to the idea, design, and execution of the study. E.M.A.T. assisted in all broiler chickens procedures for the experiment. H.S.S.G. and M.E.M. performed chemical analyses of plant samples. All authors contributed equally to the write-up of the manuscript.

Funding
Open access funding provided by The Science, Technology & Innovation Funding Authority (STDF) in cooperation with The Egyptian Knowledge Bank (EKB).

Competing interests
The authors declare no competing interests.

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