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USING STINGING NETTLE (*Urtica dioica*) in POULTRY NUTRITION

Ahmet Onder USTUNDAG

Aydin Adnan Menderes University, Faculty of Agriculture, Animal Science Department, South Campus, Cakmar, Aydin, Turkey

Corresponding author email: austundag@adu.edu.tr

Abstract

Stinging nettle (Urtica dioica) which belong to the family Urticaceae in the major group Angiosperms (flowering plants) is a wild, herbaceous, perennial flowering plant. Stinging nettle is considered a weed by intensive agriculture. However, nettle leaves are good sources of protein, fat, carbohydrates, vitamins, minerals and trace elements. Besides, stinging nettle leaves contain a significant number of biologically-active compounds such as terpenoids, carotenoids and fatty acids, as well as various essential amino acids, chlorophyll, vitamins, tannins, sterols, polysaccharides, isolectins and minerals. Stinging nettle has antiproliferative, anti-inflammatory, antioxidant, analgesic, anti-infectious, hypotensive and antiulcer properties, as well as the ability to prevent cardiovascular diseases thanks to the biologically-active compounds it contains. Due to its biological properties, availability and simple processing technology, stinging nettle can be thought of as an excellent nutritional supplement for poultry. The aim of this review is to evaluate the potential of stinging nettle utilization in poultry nutrition in light of the studies conducted.

Key words*: nutrition, pharmacological activities, poultry, stinging nettle, usage possibilities.*

INTRODUCTION

With the rapid growth of global population and living standards, demand for poultry and livestock production has increased rapidly, leading to intensive poultry production with rapidly developing breeds and high stocking density. However, these conditions have made poultry highly susceptible to infectious diseases as a result of a weakened immune system. Weakened immunity can be caused by various factors such as stress, nutrition, and infectious agents. This has become a recurring economic problem in commercial poultry flocks (Sharma et al., 2018; Zhang et al., 2020; Skomorucha & Sosnówka-Czajka, 2021). Antibiotics have been used in poultry rations for years to eliminate these unfavorable conditions, improve growth and feed utilization, and reduce mortality. However, the continuous use of antibiotics in diets has led to cross-resistance in humans and the development of antibiotic-resistant bacteria, resulting in the ban of antibiotics in poultry rations and directing poultry producers to reduce the use of antibiotics and find potential alternatives in poultry rations (Moula et al., 2019). Recently, medical and aromatic plants and their extracts have gained great interest due to their potential for use as growth promoters and for managing and treating various diseases and conditions. Phytopharmaceuticals are not only cheap and affordable but also accepted as safe, non-antibiotic alternatives to antibiotics by consumers, as they cause either no or minimum side effects (Mansoub, 2011a; Sharma et al., 2018; Abdul-Majeed et al., 2021). One of the medicinal plants that has gained attention as a phytogenic feed additive in poultry rations is stinging nettle (*Urtica dioica*), which has a long history of traditional medical use in many countries. Despite its potential, nettle is considered a wild plant in intensive agriculture. However, its biological characteristics, sufficient availability, and simple processing technology make it a good feed supplement in poultry farms (Krawęcka et al., 2021; Milosevic et al., 2021).

Stinging nettle leaves were reported to be excellent nutritional and functional values. The leaves contain are rich in proteins, fats, carbohydrates, vitamins, minerals, and trace elements and also contain many biologically active compounds. This makes the leaves suitable for feeding monogastric animals such as chickens (Bekele et al., 2015; Moula et al., 2019; Zhang et al., 2020; Abdul-Majeed et al., 2021; Devkota et al., 2022).

This review intends to evaluate the suitability of stinging nettle (*Urtica diocia*) as a potential feed ingredient for poultry by examining its nutritional and pharmacological properties, based on previous research conducted on its utilization.

DESCRIPTION OF STINGING NETTLE

Stinging nettle is a weedy perennial plant that belongs to the family Urticaceae and *Urtica* genus. The *Urtica* genus contains around 46 species of flowering plants. The two most well-known species are the stinging nettle (*Urtica dioica*) and the small nettle (*Urtica urens*). The genus name *Urtica* comes from the Latin verb "urere," which means "to burn," referencing the stinging hairs containing a fluid of formic acid and histamine found on the leaves and stems of the plant. The species name "dioica" of the stinging nettle (*Urtica dioica*) means "two houses" referencing the plant usually has separate male and female flowers on separate plants. It can grow up to a height of around 2 to 4 meters. It has characteristic pointed leaves and small greenish-white flowers. Stinging nettle is distributed almost worldwide, but is particularly common in Europe, North America, North Africa and parts of Asia (Ahmed & Parsuraman, 2014; Kregiel et al., 2018; Moula et al., 2019; Petruzzello, 2022). Taxonomy of stinging nettle has been shown in Table 1.

Table 1. Taxonomy of stinging nettle

Kingdom	Plantae – Plants
Subkingdom	Tracheobionta - Vascular plants
Superdivision	Spermatophyta - Seed plants
Division	Magnoliophyta - Flowering plants
Class	Magnoliopsida - Dicotyledons
Subclass	Hamamelididae
Order	Urticales
Family	Urticaceae - Nettle family
Genus	*Urtica* L.
Species	*Urtica dioica* L. - stinging nettle

NUTRITIONAL COMPOSITION OF STINGING NETTLE

Stinging nettle is a good source of nutritional components, such as protein with a well-balanced amino acid profile, fat, carbohydrates, vitamins, minerals, and trace elements. However, various factors, such as variety and genotype, climate, soil, vegetative stage, harvest time, storage, processing, and treatment can influence the chemical composition of nettle plants. Rutto et al. (2013) reported that harvested upgrowths in Fall contained 89% moisture, 3.7% protein, 0.6% fat, 2.1% ash, 6.4% dietary fiber, 7.1% carbohydrates and 45.7 kcal/100 g energy, 4935 IU/100g Vitamin A, 1.1 mg/100 g Vitamin C, 278 mg/100 g calcium, 1.2 mg/100 g iron, while harvested upgrowths in Spring contained 75% moisture, 6.3% protein, 1.4% fat, 3.4% ash, 9.7% fiber, 16.5% carbohydrates and 99.7 kcal/100 g energy, 11403 IU/100 g Vitamin A, 0.5 mg/ 100 g Vitamin C, 788 mg/100 g calcium, 3.4 mg/100 g iron. On the other hand, it was reported that nettle leaf powders contain on average 8% moisture, 30% protein, 4% fat, 15% ash, 10% fiber, 40% carbohydrates and 310 kcal/100 g energy, 170 mg/100 g calcium, 230 mg/100 g iron (Rutto et al., 2013; Adhikari et al., 2016; Kregiel et al., 2018). Composition of stinging nettle leaves is summarized in Table 2.

Table 2. Chemical composition of stinging nettle leaf powder (Adhikari et al., 2016)

Moisture, %	7.04
Crude protein, %	33.77
Crude fat, %	3.55
Crude fiber, %	9.08
Total ash, %	16.21
Carbohydrates, %	37.39
Calcium, mg/100 g	168.77
Iron, mg/100 g	227.89
Tannin content, %	0.93
Polyphenols, mg GAE/g, db	128.75
Carotenoids, µg/g, db	3496.67
Energy, kcal/100 g	307.24

GAE: gaelic acid equivalent; db: dry basis

PHYTOCHEMICAL COMPOSITION OF STINGING NETTLE

Various studies on the nettle have revealed the presence of more than fifty different chemical components. Stinging nettle (*Urtica dioica*) contains a wide range of phytochemicals, many of which have potential health benefits, including flavonoids, phenolic acids, amino acids, carotenoids, organic acids, fatty acids, tannins, terpenes, chlorophyll, sterols, isolectins (Joshi et al., 2014; Said et al., 2015; Grauso et al., 2020; Milosevic et al., 2021; Taheri et al., 2022). Some bioactive constituents of stinging nettle were given Table 3.

Table 3. Bioactive constituents of stinging nettle (Devkota et al., 2022)

Chemical Group	Compounds
Flavonoids	Amentoflavone, apiin, apigenin, apigenin 7-O-β-D-glucoside, baicalin, baicalein, catechin, epicatechin, epigallocatechin gallate, chrysoeriol, genestein, isorhamnetin, kaempferol, keampferol 3-O-β-D-glucoside, luteolin, luteolin 7-O-β-D-glucoside, myrecetin, naringenin, quercetin, quercetin 3-O-β-D-glucoside, quercetin 3-O-β-D-galactoside, rutin, vitexin.
Phenolic acids	**Hydroxybenzoic acid derivatives** Gallic acid, vanillic acid, syringic acid, protocatechuic acid, gentisic acid **Cinnamic acid derivatives** Cinnamic acid, caffeic acid, p-coumaric acid, ferulic acid, chlorogenic acid, sinapic acid
Amino acids	Alanine, γ-aminobutyric acid, glutamic acid, isoleucine, leucine, phenylalanine, proline, tyrosine, valine
Carotenoids	β-Carotene, lutein isomers, neoxanthin, violaxanthin
Organic acids	Acetic acid, citric acid, formic acid, malic acid, succinic acid
Fatty acids	Arachidic acid, arachidonic acid, behenic acid, dodecendioic acid, euric acid, palmitic acid, palmitolic acid, stearic acid, tricosanoic acid, lauric acid, etc.

PHARMACOLOGICAL PROPERTIES OF STINGING NETTLE

Stinging nettle has been reported to have various pharmacological activities such as antimicrobial, antioxidant, antidiabetic, anticancer, antiulcer, anti-inflammatory hypocholesterolemic, hepatoprotective activity and immune-modulatory activity (Majedi et al., 2022)

ANTIMICROBIAL ACTIVITY

Stinging nettle (*Urtica dioica*) has the potential to exhibit antibacterial effects due to its significant amounts of hydroxycinnamic acids (such as chlorogenic acid, caffeic acid, and rosmarinic acid) and flavonoid quercetin.

Both ethanol and aqueous extracts of *U. dioica* have demonstrated antibacterial activity against a wide range of bacteria, including both Gram-positive and Gram-negative strains including *Escherichia coli, Salmonella typhi, Bacillus cereus, Bacillus subtilis, Enterococcus faecalis, Shigella flexneri, Enterobacter aerogenes, Pseudomonas aeruginosa, Staphylococcus epidermis, methicillin-resistant (MRSA)* and *methicillin-sensitive (MSSA) Staphylococcus aureus* strains and multi drug resistant bacteria - *Mycobacterium semegmatis.*

Also, extract of nettle showed antifungal activity against *Rhizoctonia solani, Fusarium oxysporium, Fusarium solani, Alternaria alternate* and antiviral activity against HIV-1, HIV-2, CMV, RSV, and flu (Joshi et al., 2014; Kregiel et al., 2018; Rajput et al., 2018; Devkota et al., 2022; Teheri et al., 2022).

ANTIOXIDANT ACTIVITY

Free radicals and ROS are unstable molecules that can cause cellular damage and are associated with the development of various diseases. The harmful effects of free radicals and reactive oxygen species (ROS) on cells can be mitigated with the use of antioxidants, which are known to have prophylactic and therapeutic properties. Antioxidants work by neutralizing these harmful molecules, thereby protecting cells from damage.

Nettle is considered a natural source of antioxidants due to the presence of flavonoids and phenolic compounds. Several in vitro and in vivo studies have been conducted to evaluate its antioxidant activity, and the results confirm its potential in scavenging free radicals and reactive oxygen species. The antioxidant properties of nettle make it a promising natural agent for preventing oxidative stress-related cellular damage, which can contribute to the development of various diseases (Joshi et al., 2014; Kregiel et al., 2018; Rajput et al., 2018; Milosevic et al., 2021; Devkota et al., 2022; Jaiswal & Lee, 2022; Teheri et al., 2022).

HEPATOPROTECTIVE ACTIVITY

Due to the liver's importance in metabolism, it is crucial to maintain its health and functionality. Unfortunately, the liver can be damaged by various factors, including exposure to toxic substances like chemicals, alcohol, and viruses, which can produce harmful metabolites like free radicals that cause oxidative stress and liver injury. As a result, liver diseases are common and diverse, and the organ is frequently targeted by toxicants. However, medicinal plants are being studied for their potential as safe and effective treatments for liver diseases. These plants contain bioactive compounds such as natural polyphenols, which possess powerful antioxidant properties that can protect the liver from damage. The maximum hepatoprotective activity of the stinging nettle leaf extract was observed at a dosage of 400 mg/kg, as indicated by a decrease in the levels of serum alanine transaminase (ALT), aspartate amino-transferase (AST), alkaline phosphatase (ALP), total bilirubin, and malonyldehyde (MDA), and an increase in the level of superoxide dismutase (SOD). These results demonstrate the efficacy of the leaf extract in preventing liver damage and promoting healthy liver enzyme levels (Kar et al., 2007; Joshi et al., 2015; Deniz, 2018; Rajput et al., 2018; Teheri et al., 2022).

ANTIDIABETIC ACTIVITY

Urtica dioica leaves have the potential as an antidiabetic agent by reducing blood sugar levels, HbA1C percentage, and insulin resistance through their anti-inflammatory properties, which lead to a decrease in C-reactive protein and TNF-α levels in serum, and their antioxidant properties, which decrease MDA levels and increase GSH levels, SOD, and catalase activities in pancreatic tissues. The antidiabetic effect of nettle is attributed to the presence of various compounds, such as polyphenols, triterpenes, sterols, flavonoids, and lectin. Studies on diabetic rat models have shown that Urtica dioica leaves decrease fasting blood glucose, total cholesterol, and total triglyceride levels while increasing HDL and insulin levels. Furthermore, the hydroalcoholic extract of Urtica dioica leaves may help regenerate β-cells and reduce the severity of diabetes when administered before the induction of hyperglycemia. Urtica dioica leaves also demonstrate effectiveness in reducing blood sugar and glycated hemoglobin levels in STZ-induced diabetes and can mitigate the complications of dexamethasone-induced diabetes (Rajput et al., 2018; Zangeneh et al., 2020; Ziaei et al., 2020; Bhusal et al., 2022; Samakar et al., 2022).

ANTI-INFLAMMATORY ACTIVITY

Scientific research has revealed that *Urtica dioica*, commonly known as stinging nettle, has the ability to reduce the inflammatory response through various mechanisms, resulting in decreased synthesis of lipid mediators and proinflammatory cytokines. One of the key mechanisms is the inhibition of the arachidonic acid cascade enzymes, specifically the cyclo oxygenases COX-1 and COX-2, which block the biosynthesis of prostaglandins and thromboxanes. Additionally, *Urtica dioica* has been found to inhibit the NF-kappa B (Nuclear factor kappa-light-chain-enhancer of activated B cells) system, which plays a role in immune, inflammatory, and antiapoptotic responses, as well as the PAF (Platelet activating factor) system. Several studies have also demonstrated that *Urtica dioica* leaf extracts reduce the release of proinflammatory cytokines, including interleukins IL-2 and IL-1β, interferon γ, and TNF-α (Tumour necrosis factor). Overall, the multiple mechanisms through which *Urtica dioica* can reduce inflammation make it a promising natural remedy for inflammatory conditions (Joshi et al., 2014; Said et al., 2015; Carvalho et al., 2017; Rajput et al., 2018; Dhouibi et al., 2020; Grauso et al., 2020; Majedi et al., 2021; Bhusal et al., 2022; Devkota et al., 2022).

ANTI-HYPERLIPIDEMIC ACTIVITY

Atherogenic dyslipidemia is a medical condition characterized by increased levels of low-density lipoprotein particles (LDL), elevated levels of triglycerides (TG), and decreased levels of high-density lipoprotein particles (HDL), in the bloodstream. This condition increases the risk of developing atherosclerosis. As high levels of serum LDL can lead to cholesterol build up in the arteries, while HDL can remove cholesterol from tissues and transport it to the liver for breakdown (reverse cholesterol transport), thereby exhibiting anti-atherogenic effects. Numerous animal and human studies have shown that nettle extract has potential anti-hyperlipidemic effects by lowering lipid and lipoprotein concentrations in the blood, specifically by reducing LDL and increasing HDL levels. In one study, rats were given a daily supplement of 150mg/kg of aqueous nettle extract for 30 days while consuming either a normal or high-fat diet, resulting in an improved blood lipid profile with decreased total cholesterol levels and reduced LDL/HDL ratios by lowering LDL content and plasma total apolipoprotein B levels. In another study, hypercholesterolemic rats were given the ethanoic extract of nettle at doses of 100 and 300mg/kg, resulting in a significant reduction in total cholesterol and LDL levels (Joshi et al., 2014; Rajput et al., 2018; Samakar et al., 2022).

IMMUNOMODULATORY ACTIVITY

Several studies have demonstrated that *Urtica dioica* agglutinin (UDA), a protein isolated from the roots of the stinging nettle plant, has immunomodulatory effects. These effects have been observed in T cells, macrophages, thymocytes, and the release of TNF-α, a cytokine involved in inflammation and immune system regulation. These studies have provided insights into how UDA can stimulate T cell proliferation, enhance macrophage activity, promote thymocyte differentiation, and inhibit TNF-α release, potentially leading to therapeutic applications in immune-related disorders (Akbay et al., 2003; Joshi et al., 2014; Said et al., 2015; Francišković et al., 2017; Sharma et al., 2018).

ANTIULSER and ANTICANCER ACTIVITY

Stinging nettle (*Urtica dioica*) has been investigated for its potential anti-ulcer and anti-cancer activities. In an animal study, a water extract of stinging nettle was found to reduce mucosal injury by up to 77.8% at a dose of 200 mg/kg, and also decreased stomach acidity in a model of peptic ulcer caused by pylorus ligation. Stinging nettle extracts have also been evaluated for their cytotoxic effects on various cancer cell lines. For instance, the aqueous extract of the plant roots demonstrated a dose-dependent inhibition of cell proliferation in HeLa cells, and reduced viability of MCF-7 breast cancer cells with an IC50 value of 34 µg/ml at 48 hours. In addition, the aqueous extract of stinging nettle leaves was found to have significant anti-cancer activity against LNCaP prostate carcinoma cells, leading to reduced cell viability in a dose-dependent manner. Furthermore, a dichloromethane extract of stinging nettle has demonstrated anti-cancer activity in a mouse model of breast cancer, with reductions in tumor size and weight at doses of 10 and 20 mg/kg b.w/day (i.p.). These effects were attributed to increased cell apoptosis and suppression of cell proliferation through downregulation of BCL2 and increased caspase-3 activity (Gülçin et al., 2004; Burkova et al., 2011; Joshi et al., 2014; Said et al., 2015; Mansoori et al., 2017; Mohammedi et al., 2017; Rajput et al., 2018; Grauso et al., 2020; Ahmed et al., 2022; Taheri et al., 2022).

EFFECTS OF STINGING NETTLE ON POULTRY

Stinging nettle has been regarded as a promising alternative to antibiotic growth promoters due to its various pharmacological effects and natural growth-promoting properties, leading to its investigation by researchers as a potential candidate for use in the poultry industry. Numerous studies have been conducted to examine the impact of stinging nettle, in various forms, on poultry nutrition. In a study investigating the effects of nettle on performance, Mansoub (2011a) reported that the addition of 1.5% nettle to broiler diets increased feed conversion ratio and body weight gain of animals. Similarly, in another study conducted with broilers, it was reported that the addition of nettle in the form of dried leaves at 1-2% level had positive effects on performance, carcass and blood biochemical parameters (Safamehr et al., 2012). Ahmadipour & Khajali (2019), at the end of a trial with broiler chickens using nettle powder, observed that when nettle was added to the diets at 1% and 1.5%, body weight gain and feed conversion ratio improved significantly, breast meat yield increased, and liver, heart, bursa fabricius and abdominal fat ratios were significantly reduced. It was also reported that the addition of nettle can positively affect the fatty acid profile of breast meat by increasing linoleic acid, linolenic acid, and PUFA, while decreasing MUFA, and may improve the quality of breast meat (Stojčić et al., 2016). However, Keshavarz et al. (2014) reported that the addition of 5 and 10g/kg nettle powder to broiler diets had no effect on performance, carcass and blood biochemical parameters. Another study reported that the addition of nettle leaf extract (NLE) powder at 0.15, 0.20, and 0.25% levels to broiler diets improved performance (Hashemi et al., 2018). In the studies conducted with nettle root extract, the addition of 0.05% nettle root extract to the rations increased the live weight and feed conversion ratio of the animals (Tabari et al. 2016; Meimandipour et al., 2017). Apart from the effects of nettle on the performance of poultry, its effects on antimicrobial, antioxidant, antihyperlipidemic, and immunomodulatory activities have also been investigated in various studies. Safamehr et al. (2012) reported that serum triglyceride and cholesterol concentrations in female broiler chicks were significantly decreased under the effect of 1% nettle addition to the diet, but HDL cholesterol was not significant between groups ($P < 0.05$). In another study conducted with male broilers, similar results were obtained with 1.5% nettle supplementation (Mansoub, 2011a). Abdul-Majeed et al. (2021) reported that the addition of 0.5% crushed nettle leaves to broiler diets may improve lipoprotein synthesis and metabolism by increasing HDL levels and decreasing LDL and risk index levels.

In a study conducted by Al-Salihi et al. (2018), the immunomodulatory effect of nettle in broilers was investigated using a water extract of nettle leaves administered through drinking water at three different concentrations (10, 15, 20 ml/l). The results of the study revealed a significant improvement in various immunological traits, including Delayed-Type Hypersensitivity test (DTH), Enzyme-Linked Immunosorbent Assay, relative weight of fabricia bursi and fabricia index, as well as blood constituents such as red blood cells, white blood cells, Packed Cell Volume (PCV), hemoglobin concentration, and heterophil to lymphocyte ratio. These results demonstrate the immunostimulatory potential of nettle leaf extract. Similar to the results of the previous study, Abdul-Majeed et al. (2021) reported that 0.50% chopped leaves increased hemoglobin, PCV, immunoglobulin and white blood cell count in the blood. Hashemi et al. (2018) also reported an increase in haemoglobin and haematocrit blood content in broiler chickens treated with nettle, indicating a potential impact on immune system function. In another study, Şandru et al. (2017) reported that repeated alcoholic nettle extract treatments in broiler chickens improve not only the weight gain but also the non-specific cell-mediated immunity.

The flavonoids and polyphenolic compounds found in nettle exhibit antioxidant properties that help inhibit harmful free radical reactions, affecting positively immunity and general health both directly and indirectly. In a study investigating the antioxidant properties of nettle in broilers, Ahmadipour & Khajali (2019) reported that higher nitric oxide concentration and lower malondialdehyde (MDA), heterophil/lymphocyte ratio (H:L ratio), and hematocrit concentrations were observed with the addition of 1 and 1.5% nettle to broiler diets compared to the control group. Behboodi et al. (2021) reported that the addition of 0.25 ml/l nettle extract to the drinking water of broilers increased total antioxidant capacity (TAC), total superoxide dismutase (SOD), glutathione peroxidase (GPX) and decreased MDA in accordance with the results of previous studies. Mehboob et al. (2022) also reported that the birds in the treatment group given nettle at a 2% concentration had a significantly lower value of Thiobarbituric Acid Reactive Substances (TBARS) compared to the control group. Studies have consistently shown that stress can lead to oxidative damage in the body, which can cause an increase in MDA level. Therefore, the decrease in MDA level as observed in broiler chickens receiving nettle extract indicates the strong antioxidant capacity of nettle. Furthermore, since antioxidant enzymes, including TAC, GPX, and SOD, are responsible for inhibiting free radicals in the body, the increase in their level indicates strong antioxidant capacity. In addition, the HL ratio is a commonly used stress index in chickens and a higher ratio indicates a greater degree of stress. The reduction in the HL ratio observed in nettle-consuming broilers suggests that nettle has a curative effect on oxidative stress in these birds (Xu et al., 2018; Behboodi et al., 2021; Milosevic et al., 2021).

Recently, a study conducted by Skomorucha & Sosnówka-Czajka (2021) investigated the antioxidant capacity of nettle in an induced thermal stress environment. The results of the study revealed that the addition of 2 ml/l nettle extract was effective in reducing the thyroid hormone (triiodothyronine) and rectal temperature in chickens during the initial period of thermal stress.

Moreover, broilers that received nettle extract had lower radiated temperature of the unfeathered body, a lower HL ratio in the blood during the increase in ambient temperature, and the lowest mortality percentage among all the experimental groups. Farahani & Hosseinian (2022) reported that administering 4% stinging nettle powder in the diet of broilers minimized the effects of chronic heat stress by normalizing serum cortisol, total cholesterol (TC), and uric acid (UA) levels. Additionally, this treatment reduced serum activities of alanine aminotransferase (ALT), aspartate aminotransferase (AST), and creatine kinase (CK) enzymes, which are indices of tissue damage in broilers exposed to chronic heat stress.

In studies investigating the antimicrobial effect of nettle, it was reported that extracts from the root and leaves of nettle decreased the number of small intestinal coliform and total bacteria, while increasing the number of lactobacillus (Tabari et al., 2016; Al Salhi, 2020). Moreover, several studies have shown that nettle exhibits a protective hepatorenal effect in broilers affected by aflatoxin, while also decreasing certain chemical factors associated with kidney complications, such as nephritis, nephrosis, and urolithiasis (Uyar et al., 2016; Khalesi et al., 2022).

The potential of stinging nettle leaf meal as a viable substitute for soybean meal in broiler diets was also explored. In an experiment where soybean meal was replaced with 3%, 6%, 9%, and 12% nettle leaf meal, no significant difference was observed among the treatment groups. Based on this finding, the authors concluded that incorporating stinging nettle leaf meal in broiler diets up to 9% could be a feasible alternative feeding strategy to soybean meal (Bekele et al., 2015).

There are various studies investigating the effects of stinging nettle not only on broilers, but also on laying hens and quails. Mansoob (2011b) reported an increase in eggshell thickness and yolk index, as well as a decrease in serum total cholesterol, triglyceride, and LDL concentrations with the addition of 2% nettle meal to laying hen diets. A study investigating the effects of 15% nettle supplementation on laying hen feeds found that it increased egg production, eggshell thickness, yolk n-3 polyunsaturated fatty acid levels, and yolk color. Additionally, nettle supplementation decreased both yolk and serum cholesterol content, which is consistent with the findings of a previous study (Zhang et al., 2020). Grigorova et al. (2022) reported that supplementing the laying hen diet with 0.3% and 0.5% nettle had a positive effect on yolk color pigmentation. In addition, 0.3% nettle supplementation resulted in a significant decrease in yolk cholesterol content. Nettle supplementation was also found to significantly reduce blood serum glucose and total serum cholesterol levels. However, the performance of laying hens was not affected by nettle supplementation. However, unlike the findings of previously conducted studies investigating the effects of nettle on laying hens, Kavan et al. (2023) reported that supplementing the diet of laying hens with 100 and 200 mg/kg nettle essential oil did not affect egg quality characteristics or serum parameters. In a study conducted with quails, similar results were obtained to those seen in studies with laying hens. It was reported that supplementing the quail diet with 6% nettle led to a decrease in egg yolk cholesterol, serum total cholesterol, and serum triglyceride concentrations. Additionally, quail performance was not adversely affected by the nettle supplementation (Moula et al., 2019)

CONCLUSIONS

Stinging nettle, typically considered a weed in agriculture, could be a valuable and underexplored resource in poultry production. Recent studies suggest that incorporating nettle into broiler and layer diets can effectively tackle various industry challenges by providing nutrients and bioactive compounds that enhance growth, feed utilization, metabolic regulation, and immune support in poultry. However, more research is needed to fully comprehend the plant's phytochemical composition, mode of action, and nutritional value. In conclusion, stinging nettle has the potential to enhance poultry nutrition and address industry issues, making it a promising and overlooked tool in modern agriculture.

REFERENCES

Abdul-Majeed, A.F., Rahawi, G.A., & Al-Chalabi, A.M. (2019). Effect of adding nettle plant on some physiological and biochemical parameters of broiler chickens. *Iraqi Journal of Veterinary Sciences*, 35(Supl. 3), 115-119.

Adhikari, B.M., Bajracharya, A., & Shrestha, A.K. (2016). Comparison of nutritional properties of stinging nettle (*Urtica dioica*) flour with wheat and barley flours. *Food Science & Nutrition*, 4(1), 119-124.

Ahmed, KK.M., & Parsuraman, S. (2014). *Urtica dioica* L. (Urticaceae): A stinging nettle. *Systematic Reviews in Pharmacy*, 5(1), 6-8.

Ahmed, O., Nedi, T., & Yimer, E.M. (2022). Evaluation of anti-gastric ulcer activity of aqueous and 80% methanol leaf extracts of *Urtica simensis* in rats. *Metabolism Open,* 14, 100172. https://doi.org/10.1016/j.metop.2022.100172.

Ahmedipour, B., & Khajali, F. (2019) Expression of antioxidant genes in broiler chickens fed nettle (*Urtica dioica*) and its link with pulmonary hypertension. *Animal Nutrition*, 5, 265-269.

Akbay, P., Basaran, A.A., Undeger, U., & Basaran N. (2003). *In vitro* immunomodulatory activity of flavonoid glycosides from. *Urtica dioica* L. *Phytotherapy Research*, 17, 34-37.

Al-Salihi, A.AK., Hassan, M.A., & Al-Gharawi, J.K.M. (2018). Effect of using water extract of nettle leaves (*Urtica dioica*) on some immunological and blood traits of broiler. *Journal of Research in Ecology*, 6(2), 1794-1799.

Behboodi, H., Alemi, H., & Baradaran, A. (2021). *Urtica dioica* extract – suitable dietary supplement influencing the growth body characteristics, antioxidant status, and serum biochemical parameters of broiler chickens. *Comparative Clinical Pathology*, 30, 913-920.

Bekele, B., Melesse, A., Beyan, M., Berihun, K. (2015). The effect of feeding stinging nettle (*Urtica simensis* S.) leaf meal on feed intake, growth performance and carcass characteristics of Hubbard broiler chickens. *Global Journal of Science Frontier Research: D Agriculture and Veterinary*, 15(3), 1-20.

Bhusal, K.K., Magar, S.K., Thapa, R., Lamsal, A., Bhandari, S., Maharjan, R., Shrestha, S., & Shrestha, J. (2022). Nutritional and pharmacological importance of stinging nettle (*Urtica dioica* L.): A review. *Heliyon*, 8, e09717. https://doi.org/10.1016/j.heliyon.2022.e09717.

Carvalho, A.R., Costa, G., Figuerinha, A., Liberal, J., Prior, J.A.V., Lopes, M.C., Cruz, M.T., & Batista, M.T. (2017). *Urtica* spp.: Phenolic composition, safety, antioxidant and anti-inflammatory activites. *Food Research International*, 99, 485-494.

Deniz, G.Y. (2018). Protective mechanism of Urtica dioica on carbon tetrachloride-induced hepatic encephalopathy in rats. *Van Veterinary Journal*, 29(2), 77-81.

Devkota, H.P., Paudel, K.R., Khanal, S., Baral, A., Panth, N., Adhikari-Devkota, A., Jha, N.K., Das, N., Singh, S.K., Chellappan, D.K., et al. (2022). Stinging Nettle (*Urtica dioica* L.): Nutritional composition, bioactive compounds, and food functional properties. *Molecules*, 27, 5219. https://doi.org/10.3390/molecules27165219.

Douibi, R., Affes, H., Salem, M.B., Hammami, S., Sahnoun, Z., Zeghal, K.M., & Ksouda, K. (2020). Screening of pharmacological uses of *Urtica dioica* and other benefits. *Progress in Biophysics and Molecular Biology*, 150, 67-77.

Farahani, M.M., & Hosseinian, S.A. (2022). Effects of dietary stinging nettle (*Urtica dioica*) on hormone stress and selected serum biochemical parameters of broilers subjected to chronic heat stress. *Veterinary Medicine and Science*, 8, 660-667.

Francišković, M., Gonzalez-Pérez, R., Orčić, D., Medina, F.S., Martínez-Augustin, O., Svirćev, E., Simin, N., & Mimika-Dukić, N. (2017). Chemical composition and immuno-modulatory effects of Ur*tica dioica* L. (stinging nettle) extracts. *Phytotherapy Research*, 31, 1183-1191. https://doi.org/10.1002/ptr.5836.

Grauso, L., Falco, B., Lanzotti, V., & Motti, R. (2020). Stinging nettle, *Urtica dioica* L.: botanical, phytochemical and pharmacological overview. *Phytochemistry Reviews*, 19, 1341-1377.

Grigorova, S., Gjorgovska, N., Petkov, E., & Levkov, V. (2022). Evaluation of the effects of *Urtica dioica* L. supplementation on egg quality and blood parameters in laying hens. *Veterinarija ir Zootechnika*, 80(1), 35-40.

Gülçin, İ., Küfrevioğlu, Ö.İ., Oktay, M., & Büyükokuroğlu, M.E. (2004). Antioxidant, antimicrobial, antiulcer and analgesic activities of nettle (*Urtica dioica* L.). *Journal of Ethnopharmacology*, 90, 205-215.

Hashemi, S.M., Soleimanifar, A., Sharifi, S.D., & Vakili, N. (2018). Growth promoting effects of dried nettle extracts and its impact on hematology and antibody titter in broiler chickens. *International Journal of Animal Science*, 2(2), 1016.

Jaiswal, V., & Lee, H.J. (2022). Antioxidant activity of Urtica dioica: An important property contributing to multiple biological activities. *Antioxidants*, 11, 2494. https://doi.org/10.3390/antiox11122494.

Joshi, B.C, Mukhija, M., & Kalia, A.N. (2014). Pharmocological review of *Urtica dioica* L. *International Journal of Green Pharmacy*, 201-209.

Joshi, B.C., Prakash, A., & Kalia, A.N. (2015). Hepatoprotective potential of antioxidant potent fraction from *Urtica dioica* Linn. (whole plant) in CCL_4 challenged rats. *Toxicology Reports*, 2, 101-1110.

Kar, P.K., Nath, L., Dash, S., Sutharson, L., & Nanda, B. (2007). Hepatoprotective effect of the ethanolic extract of *Urtica parviflora* Roxb. in CCL_4 treated rats. *International Journal of Pharmacology*, 3(4), 362-366.

Kavan, B.P., Khosravinia, H., Karimirad, R., & Tavakolinasab, F. (2023). Effects of dietary supplementation of milk thistle and nettle essential oils on performance, egg quality, and haematological parameters in layer hens. *Poultry Science Journal*, 11(1), 125-131.

Keshavarz, M., Rezaeipour, V., & Asadzadeh, S. (2014). Growth performance, blood metabolites, antioxidant stability and carcass characteristics of broiler chicken fed diets containing nettle (*Urtica dioica L.*) powder or essential oil. *International Journal of Advanced Biological and Biomedical Research*, 2(9), 2553-2561.

Khalesi, B., Fatemi, S.A.R., Goodarzi, M.T., Ghorashi, S.A., Motamed, N., & Andalib, F. (2022). Effects of *Urtica dioica* hydroalcoholic extract on the urinary tract of broilers. *Egyptian Journal of Veterinary Science*, 53(2), 147-156.

Krawęcka, A., Sobota, A., Pankiewicz, U., Zielińska, E., & Zarzycki, P. (2021). Stinging nettle (*Urtica dioica* L.) as functional component in durum wheat pasta production: Impact on chemical composition, in vitro glycemic index, and quality properties. *Molecules*, 26, 6909. doi:10.3390/molecules26226909.

Kregiel, D., Pawlikowska, E., & Antolak, H. (2018). Urtica spp.: Ordinary plants with extraordinary properties. *Molecules*, 23, 1664. doi: 10.3390/molecules23071664.

Majedi, S., Faraj, T.A., Ahmed, H.J., & Hussain, F.H.S. (2022). A review of biochemical structures of Urtica dioica metabolites and their pharmaceutical effects. *Chemical Reviews and Letters*, 4, 206-212.

Mansoori, B., Mohammadi, A., Hashemzadeh, S., Shirjang, S., Baradaran, A., Asadi, M., Doustvandi, M.A., & Baradaran, B. (2017). Urtica dioica extract suppress m*iR*-21 and metastasis-related genes in breast cancer. *Biomedicine & Pharmacotherapy*, 93, 95-102.

Mansoub, N.H. (2011a). Comparison of effects of using nettle (*Urtica dioica*) and probiotic on performance and serum composition of broiler chickens. *Global Veterineria*, 6(3), 247-250.

Mansoub, N.H. (2011b). Effect of nettle (*Urtica dioica*) on performance, quality of eggs and blood parameters of laying hens. *Advances in Environmental Biology*, 5(9), 2718-2721.

Mehboob, S., Ganai, A.M., Sheikh, G.G., Khan, A.A., Ahmad, S.B., Muhee, A., & Haq, Z. (2022). Effect of herb *Urtica dioica* as feed additive on carcass traits and oxidative stability of meat in broilers. *The Pharma Innovation Journal*, SP-11(1), 787-791.

Meimandipour, A., Emamzadeh, A.N., & Soleimani, A. (2017). Effects of nanoencapsulated aloe vera, dill and nettle root extract as feed antibiotic substitutes in broiler chickens. *Archives Animal Breeding*, 60, 1-7.

Milosevic, B. Omerovic, I., Savic, Z., Andjusic, L., Milanovic, V., & Ciric, S. (2021). Stinging nettle (*Urtica dioica*) in broiler nutrition. *World's Poultry Science Journal*, 77(4), 901-912.

Mohammadi, A., Mansoori, B., Baradaran, P.C., Khaze, V., Aghapour, M., Farhadi, M., & Baradaran, B. (2017). Urtica dioica extract inhibits proliferation and induces apoptosis and related gene expression of breast cancer cells in vitro and in vivo. *Clinical Breast Cancer*, 17(6), 463-470.

Moula, N., Sadoudi, A., Touazi, L., Leroy, P., & Geda, F. (2019). Effects of stinging nettle (*Urtica dioica*) powder on laying performance, egg quality, and serum biochemical parameters of Japanese quails. *Animal Nutrition*, 5, 410-415.

Petruzzello, M. (2022). Stinging nettle plant. https://www.britannica.com/plant/stinging-nettle.

Rajput, P., Chaudhary, M., & Sharma, R.A. (2018). Phytochemical and pharmacological importance of genus urtica - a review. *International Journal of Pharmaceutical Sciences and Research*, 9(4), 1387-1396.

Rutto, L.K., Xu, Y., Ramirez, E., & Brandt, M. (2013). Mineral properties and dietary value of raw and processed stinging nettle (*Urtica dioica* L.). *International Journal of Food Science*, Volume 2013, Article ID 857120, 9 pages. https://dx.doi.org/10.1155/2013/857120.

Safamehr, A., Mirahmadi, M., & Nobakht, A. (2012). Effect of nettle (*Urtica dioica*) medicanal plant on growth performance, immune responses, and serum biochemical parameters of broiler chickens. *International Research Journal of Applied and Basic Sciences*, 3(4), 721-728.

Said, A.A.H., Otmani, I.S.E., Derfoufi, S., & Benmoussa, A. (2015). Highlights on nutritional and therapeutic value of stinging nettle (*Urtica dioica*). *International Journal of Pharmacy and Pharmaceutical Sciences*, 7(10), 8-14.

Samakar, B., Mehri, S., & Hosseinzadeh, H. (2022). A review of the effects of *Urtica dioica* (nettle) in metabolic syndrome. *Iranian Journal of Basic Medical Sciences*, 25, 543-553.

Șandru, C.D., Niculae, M., Pall, E., Vasiu, A., Brudașcă, F., & Spînu, M. (2017). Potential use of the stinging nettle as an enhancer of weight gain and innate immune response in broiler chickens. *Ştiinţa Agricolă,* 1, 119-122.

Sharma, S., Singh, D.K., Gurung, Y.B., Shrestha, S.P., & Pantha, C. (2018). Immunomodulatory effect of Stinging nettle (*Urtica dioica*) and Aloe vera (*Aloe barbadensis*) in broiler chickens. *Veterinary and Animal Science*, 6, 56-63.

Skomorucha, I., & Sosnówka-Czajka, E. (2021). The effect of adding herbal extracts to drinking water on body temperature, level of thyroid hormones and H:L ratio in the blood of broiler chickens exposed to elevated ambient temperature. *Annals of Animal Science*, 21(4), 1511-1522.

Tabari, M.A., Ghazvinian, K.H., Irani, M., & Molaei, R. (2016). Effects of dietary supplementation of nettle root extract and pumpkin seed oil on production traits and intestinal microflora in broiler chickens. *Bulgarian Journal of Veterinary Medicine*, 19(2), 108-116.

Taheri, Y., Quispe, C., Herrera-Bravo J., Sharifi-Rad, J., Ezzat, S.M., Merghany, R.M., Shaheen, S., Azmi L. et al. (2022). *Urtica dioica*-derived phytochemicals for pharmacological and therapeutic applications. *Evidance-Based Complementary and Alternative Medicine*, Volume 2022, Article ID 4024331, 30 pages. https://doi.org/10.1155/22/4024331.

Uyar, A., Yener, Z., & Dogan, A. (2016). Protective effects of *Urtica dioica* seed extract in aflatoxicosis: histopathological and biochemical findings. *British Poultry Science*, 57(2), 235-345.

Xu, Y., Lai, X., Li, Z., Zhang, X., & Luo, Q. (2018). Effect of chronic heat stress on some physiological and immunological parameters in different breed of broilers. *Poultry Science*, 97, 4073-4082.

Zangeneh, M.M., Mohammadi, G., Salmani, S., Tehrani, R.P., Rashidi, K., & Zangeneh, A. (2020). A comporative evaluation of nephroprotective property of *Urtica dioica* L. aqueous extract and glibenclamide in diabetic mice. *Research Journal of Pharmococnosy*, 7(1), 31-40.

Zhang, J., Na, T., Jin, Y., Zhang, X., Qu, H., & Zhang, Q. (2020). Thicker shell eggs with enriched n-3 polyunsaturated fatty acids and lower yolk cholesterol contents, as affected by dietary nettle (*Urtica cannabina*) supplementation in laying hens. *Animals*, 10, 1994. doi: 10.3390/ani10111994.

Ziaei, R., Foshati, S., Hadi, A., Kermani, M.A.H., Ghavami, A., Clark, C.C.T., & Tarrahi, M.J. (2020). The effect of nettle (*Urtica dioica*) supplementation on the glycemic control of patients with type 2 diabetes mellitus: A systematic review and meta-analysis. *Phytotherapy Research*, 34, 282-294.