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ENHANCING BROILER NUTRITION WITH AMINO ACIDS FROM *TARAXACUM OFFICINALE*: A COMPREHENSIVE REVIEW

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ABSTACT

The interest in using medicinal plants as nutritional supplements to broiler diets has increased recently. This review aims to collect the research on the effect of adding *Taraxacum officinale* on the diet of broilers. The dandelion plant is one of high nutritional value, as it contains many important nutrients, including vitamins, mineral elements and amino acids. In addition it contains many antibiotics, which are considered growth stimulants. Amino acids in broiler nutrition are a key requirement to help birds with growth, immunity and other body functions. It is necessary to find a source of the least expensive amino acids that the bird can consume, and one of these sources is chicory, which is highly available in pastures. It contains large proportions of proteins and vitamins, and contains approximately 16 amino acids, including the essential amino acids arginine, tyrosine, isoleucine, tryptophan, threonine, and valine. *Taraxacum officinale* helps increase growth rates and helps increase energy levels as well as increasing the nutrition transformation rate.

Keywords: *Taraxacum officinale*, Broiler, Amino acids.

INTRODUCTION

Amino acids play a vital role in broiler nutrition, supporting growth, immune function, and various physiological processes. Although commercial-grade amino acids are widely used in feed formulations, their high cost presents a significant limitation (Asun Pinar, 2023). Consequently, there is growing interest in identifying more cost-effective alternatives Dandelions (*Taraxacum officinale*), although often regarded as weeds, have been traditionally consumed for centuries for their nutritional and medicinal benefits. Recently, there has been growing interest in identifying cost-effective alternatives for animal nutrition. Medicinal plants like dandelion have attracted attention due to their rich amino acid profile and diverse bioactive compounds (Wali *et al.*, 2022) (Qin, 2023). Their widespread availability in pastures makes them an accessible and practical option for use as a dietary supplement or as

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a rotational component alongside conventional feed. Recent nutritional studies have revealed that dandelions are rich in protein, crude fiber, and essential vitamins, highlighting their potential as a valuable feed additive (Wang *et al.,* 2023).

In addition, plants are naturally rich in amino acids, including essential ones, such as lysine and methionine, which are commercially manufactured as feed additives for animals (Yang *et al.,* 2020). However, the high cost of commercially manufactured amino acids has led to a growing interest in exploring natural, cost-effective alternatives. Dandelion (*Taraxacum officinale*), a medicinal plant traditionally used for centuries and commonly found in pastures, presents a promising candidate due to its accessibility and nutritional profile. Although often dismissed as a weed, dandelion contains notable levels of protein, crude fiber, and vitamins (Wang *et al.,* 2023). Broiler chickens are very sensitive to dietary imbalance because essential amino acids cannot be synthesized in sufficient quantities in the body because they are either not produced or only produced in smaller amounts. Deficiencies in amino acids can negatively affect the growth, immunity, and egg production (Alagawany *et al.,* 2021). Thus, it is necessary to explore sources of amino acid ingredients called feed formulations. Currently, there is limited evidence on the amino acid profile in dandelion, underscoring the need for further investigation. Conse-quently, the purpose of this study is to identify the general amino acids of dandelion and to measure the impact of feeding broiler chickens diets supplemented with dandelion meal as a feed ingredient, compared to conventional commercial feed. Such research is valuable knowledge, first, as some chickens breed, such as Plymouth Rock can be grown in grazing farms, and second in line with increasing public interest in the use of medicinal or healthy feed resources (Custura *et al.,* 2024). Identifying affordable, nutrient rich alternative such as large dandelion could offer a sustainable solution to the high cost of commercial amino acids in broiler nutrition (Olas, 2022).

Therapeutic and Health-Promoting Properties of *Taraxacum officinale:*

Long before the advent of modern pharmacies, forests and meadows served as nature's dispensaries, offering an abundant and accessible source of food and medicine (Scherrer *et al.,* 2023). Among these natural resources is *Taraxacum officinale*, commonly known as dandelion, a plant historically used to address conditions such as anemia, diabetes, and liver disorders, and still appreciated today for its nutritional versatility even as an ingredient in herbal teas. Belonging to the sunflower family, *T. officinale* has reemerged in contemporary health practices and is frequently found in the herbal sections of health food stores, often labeled as 'dandelion root' (Qambrani *et al.,* 2024; Morgan, 2023). This once-overlooked weed is now being reevaluated for its therapeutic and nutritional value.

Potential of *Taraxacum officinale* in Promoting Liver Health

Liver support is one of the primary traditional uses of *Taraxacum officinale*, and recent scientific research has begun to substantiate this application. The liver plays a central role in detoxifying harmful substances and facilitating their elimination from the body. While the environmental toxins encountered today differ markedly from those present during the early use of *T. officinale*, the liver's core detoxification functions remain relevant (Di Napoli & Zucchetti, 2021). These innate hepatic processes, although shaped by past exposures, continue to be essential in managing modern toxicological challenges. Studies investigating the hepatoprotective effects of *T. officinale* have demonstrated its involvement in several aspects of liver

health, including alcohol metabolism, prevention of liver injury, mitigation of drug-induced cholestasis, protection against ischemic damage, and attenuation of high-fat diet-induced hepatic impairment (Fu *et al.*, 2021; Ye *et al.*, 2023). Given the prevalence of overweight and obesity both of which are associated with compromised liver function dandelion root has shown promise; treatment significantly reduced biochemical markers of liver damage and mitigated hepatic steatosis in high-fat diet-induced models in mice (Hamza *et al.*, 2020).

Gastrointestinal Benefits

The potential for the phytochemicals extracted from the Taraxacum plant to support human health has been outlined earlier, with particular emphasis on their abilities to exert prebiotic effects (Kaur *et al.*, 2021). These are beneficial in supporting gastrointestinal tract function and may assist in the protection of the host from chronic diseases, especially obesity, metabolic syndrome, and inflammatory diseases. Digestive processes, the creation and consumption of nutrients, and the important bi-directional signaling between the digestive system and the body are critical in supporting health and are expanded upon in this section (Kania-Dobrowolska & Baraniak, 2022). The role of polysaccharides in digestive and gastrointestinal tract health has been briefly referred to in other sections, and this has been supported by evidence from studies with fiber-supplemented diets, where animal models have shown improved weight loss, increased energy metabolic efficiency, decreased lipid peroxidation, and improved in vivo immune factors (Shah *et al.*, 2020).

It has been characterized as a prebiotic. Not only is this beneficial to the common human gastrointestinal bacteria populations and the host immune system, but it may also allow the host to become more resistant to chronic inflammation-associated diseases, as well as obesity and metabolic diseases (Jana *et al.*, 2021). Maintenance of the gut barrier ensures that the health of the host through the process of digestion can be maintained. This is performed under the close regulation of a symbiotic host microbiota. When the gut barrier becomes "leaky," which may result from genetic, environmental, and dietary factors, it can lead to dysbiosis, bacterial translocation, and chronic inflammation (Di *et al.*, 2021).

Antioxidant Properties

A study by Krzymińska *et al.* (2020) found that cultivated *Taraxacum officinale* was rich in phenolic acids, flavonoids, and tannins, and exhibited high antioxidant activity. Based on these findings, the antioxidant components and activity of wild-growing *Taraxacum officinale* were subsequently investigated. The total phenolic content, total flavonoid content, and the concentrations of delphinidin, cyanidin, and malvidin, along with caffeic acid derivatives and the overall phenolic acid composition, were determined using advanced microcolumn high-performance liquid chromatography methods (Shraim *et al.*, 2021). Additionally, the antioxidant activities of various *Taraxacum* fractions and dietary *Taraxacum* were assessed in vitro through complementary assays, including DPPH, ABTS, CUPRAC, FRAP, metal chelation, NO, O2 scavenging, and the DCFH assay. The protective effect on human erythrocytes exposed to t-BOOH was also evaluated. The total flavonoid content ranged from 4.977 to 51.537 µg rutin equivalent per mg of dry weight (DW), while phenolic acids ranged from 1.591 to 2.327 mg per g of DW. Various compounds, including oline derivatives, chlorogenic acid, chalconogenic acid, and caffeic acid derivatives, were identified. (Karahüseyin *et al.*, 2024).

A significant differences were observed in the antioxidant activities among seven fractions derived from various parts of

Taraxacum. The C2F2 fraction accounted for 10% of the content, with the TTE consolidation ranging between 60–74%. Additionally, this fraction exhibited 50% of the total phenolic content and total flavonoid content, along with potent DPPH, ABTS, and CUPRAC/FRAP activities based on total flavonoid content. It also demonstrated strong metal chelation, NO and O2 scavenging activities, and nearly 100% potential reduction in DCFH toxicity at high concentrations. Notably, it was approximately 40 times more potent in inhibiting eryptosis compared to ascorbic acid (Karahüseyin *et al.,* 2024). In conclusion, the C2F2 fraction displayed the highest levels of phenolic acids, the strongest protective effects, and provided notable DOPAC and flavonol protection, in addition to inhibiting erythrocyte oxidative damage and hemolysis. These findings highlight the promising novel antioxidant properties of *Taraxacum* fractions, as well as potential future applications in gene therapy based on DOPAC (Murtaza *et al.,* 2021).

Amino Acids in Taraxacum officinale

Taraxacum officinale is known to contain a diverse array of chemical compounds. Of particular interest is the presence of several amino acids in this relatively inexpensive perennial weed (Seilkhan, 2024). The abundance of amino acids in *T. officinale* presents significant potential, especially in broiler nutrition, where amino acids play a crucial role. Over 16 free amino acids have been identified in *T. officinale*, the majority of which are essential amino acids critical for body growth in broilers. Notable essential amino acids include arginine, tyrosine, isoleucine, tryptophan, threonine, and valine (Li *et al.,* 2023; Wang *et al.,* 2023).

Dandelion is nutritionally rich, containing vitamins, minerals, and various amino acids, including essential ones. However, the amounts of essential amino acids are relatively low, making it an incomplete source of protein for broiler chickens when compared to established ideal amino acid ratios (Dong *et al.,* 2024; Noor *et al.,* 2021). However, when consumed in higher quantities, these amino acids can have significant effects. Supplementing broiler diets with 1-2% *T. officinale* extract has been shown to promote growth, enhance diet utilization, and improve productivity. Notably, nearly 2% of arginine was identified in *T. officinale* as a free amino acid (Dong *et al.,* 2024). The proper dosage of arginine per kilogram is crucial for broiler development, and the presence of this amino acid in *T. officinale* positions it as a valuable feed ingredient, particularly for its amino acid content (Arczewska-Włosek *et al.,* 2023).

The amino acid content in *Taraxacum officinale* is present in quantities that can supplement the typical feed for broilers. Comparatively higher levels of amino acids were found in the roots of *Taraxacum officinale* compared to the leaves (Hartady *et al.,* 2021). Among the essential amino acids, histidine, lysine, and leucine were present in higher concentrations in the roots, while other essential amino acids were found in lower quantities. However, the percentage composition of cysteine, tyrosine, asparagine, serine, and arginine was higher in the roots than in the leaves. When seeds are consumed at a concentration of 65 g from an alternate source and used as feedstuff, approximately 2.7% methionine, 2.7% tryptophan, and 1.3% cysteine are present.

Additionally, methionine and tryptophan, in their chain forms, were detected in concentrations lower than 0.1% (Ravelo-Ortega *et al.,* 2021; Bělonožníková *et al.,* 2023). Further research is needed on the supplementation of arginine and methionine in broiler feed. *Taraxacum officinale* may offer a nutritional advantage

in broiler diets due to its rich content of free amino acids compared to typical feed ingredients (Mao *et al.,* 2022). The high protein content and large amounts of minerals can also indicate its potential for use in broiler feeds. Studies have shown that supplementing the reference feed plan with *T. officinale* extract or the plant itself significantly increased the growth rate, with a 1% improvement in feed conversion efficiency. Consequently, the inclusion of *Taraxacum officinale* as a supplement in broiler feed could enhance farm productivity (Arczewska-Włosek *et al.,* 2023; Dong *et al.,* 2024).

Types of Amino Acids

Amino acids are the building blocks of proteins and peptides, playing crucial roles in various physiological processes within the broiler's body. These amino acids, ingested through the diet, can be classified as either essential or non-essential. (Macelline *et al.,* 2021). Essential amino acids must be obtained through the diet because they are limiting during growth and production, or are vital for metabolic and physiological functions that the bird cannot produce on its own. Adequate inclusion of these amino acids in the diet is essential, as they are key components for de novo protein synthesis in broilers (Alagawany *et al.,* 2021). Moreover, essential amino acids have key roles in the development of the immune system in broiler chickens, egg output and growth, and their inadequate level in the diet may negatively affect the feed conversion ratio, the economic efficiency of broiler production, and animal welfare, health, and productivity. Additionally *Taraxacum officinale* also contains other amino acids that are important for various physiological functions (Li *et al.,* 2021) (Wang & Zou, 2020).

Three essential amino acids are classified as branched-chain amino acids (BCAAs) in broilers due to their key roles in protein synthesis, energy production, and immune system development. Additionally, previous research suggests that including BCAAs in the feed in a synergistic manner can yield better results than supplying them individually (Kim *et al.,* 2022). Dandelion stands out from traditional feed sources due to its higher levels of sulfur-containing amino acids and limiting amino acids, such as methionine and lysine. Additionally, essential amino acids like leucine, methionine, threonine, tryptophan, and valine are present in dandelion. Including these key amino acids in chicken diets, given their benefits to production and health, could highlight the potential advantages of using dandelion as a feed ingredient (Łozowicka *et al.,* 2021; Smith *et al.,* 2024).

Nutritional Content

Proximate Composition

A study by Yang *et al*. (2023) comprehensively analyzed the nutritional composition of *Taraxacum officinale*, reporting that its fresh leaves contain 85.72% moisture and 1.5% total ash. The plant also yields approximately 2.85 g/kg of phytosterols and 18 g/kg of vitamins, including vitamin A, vitamin E, and over 6000 DU of β-carotene equivalents. Fresh leaves also provided 848 μg/kg of copper and 411 μg/kg of zinc, which contribute to the recommended daily intake (RDI) values. Additionally, *T. officinale* is rich in polyphenols, with fresh leaves containing 528.48 mg of gallic acid equivalents per 100 g dry weight. These polyphenols are known for their bioavailability and possess antioxidant and anti-inflammatory properties that may benefit broilers (Hartady *et al.,* 2021). *Taraxacum officinale* is also rich in vitamins C and K1, as well as essential fatty acids, which are often lacking in mono-diet feedstuffs. The calcium concentration in *T. officinale* is 1875 mg/kg, which is more than double the amount typically found in commercial feed crops. However, the nutrient content must be assessed in terms of its digestibility and nutritional value, as the bioavailability of these nutrients has been

reported to vary in both broiler and in vitro models (Kousar *et al.,* 2024).

Fiber It is well reported that dietary fiber sources such as *T. officinale* can contribute to gut health in broiler. High fiber levels can promote the growth of beneficial *Lactobacillus* bacteria while inhibiting the growth of harmful *E. coli* bacteria. Certain soluble and insoluble fibers can slow digestion, reducing the rate at which sugars and fats are absorbed. This effect is beneficial for reducing obesity and cholesterol in broilers and lowering glucose levels in laying hens. Soluble fiber fractions also possess anti-inflammatory properties (Dong *et al.,* 2024; Zhao *et al.,* 2023). Furthermore, a well-balanced chicken diet supports the production of eggs and meat with desirable taste and texture, resulting in stronger, darker yolks and fillets with higher fatty acid content. However, few studies have specifically investigated the prebiotic effects of *T. officinale* in broilers. Assessing the prebiotic effects of *T. officinale* on gut microbiota colonization would be valuable. Research highlights the importance of a diverse diet, noting that byproducts from snack food production can function as super-prebiotics. While these byproducts may increase short-chain fatty acids (SCFAs), they often reduce feed conversion ratios in broilers, which is typically an unfavorable outcome (Puvača *et al.,* 2022; Valdez *et al.,* 2023). Additionally, a university-supported project recommends supplementing broiler diets with black soldier fly and *T. officinale*—alongside the existing organic, protein, and inorganic components due to their anti-inflammatory effects. One hypothesis is that the activating immune function would enhance bird health, reducing the need for antibiotic treatments. Additionally, this may improve feed conversion rates, as the birds would not need to expend energy fighting latent infections (Seidavi *et al.,* 2022) (Alghirani *et al.,* 2021).

Broiler Nutrition Requirements

Deficiencies of one or more of the essential nutrients can lead to suboptimal growth or reproductive performance or increased disease. Birds require a variety of nutrients to provide energy, support optimal growth and reproduction, and maintain overall health (Abrams, 2021). The dietary needs of broilers are generally categorized into five main groups: protein, carbohydrates, fats, vitamins, and minerals. Proteins, which are composed of 'building blocks' known as amino acids, play a crucial role in the growth and maintenance of broilers. When birds consume protein, their bodies break it down into amino acids and then reassemble them as needed for the synthesis of required proteins (Kashyap and Goswami, 2024). While around 200 amino acids are commonly found, broilers require 22 of these, 10 of which are essential: lysine, arginine, methionine, tryptophan, phenylalanine, threonine, valine, isoleucine, leucine, and histidine. The remaining amino acids are considered non-essential, as the body can synthesize them if sufficient essential amino acids are available (Alagawany *et al.,* 2021). To supply rapidly dividing cells with the appropriate balance of amino acids, it is necessary to selectively uptake a mixture of these amino acids. Proteins are essential for providing the amino acids required for body protein synthesis, which supports growth, repair, and maintenance functions. A deficiency in essential amino acids can impair tissue deposition, thereby compromising both the rate and efficiency of growth (Wangkahart *et al.,* 2023).

Dietary protein requirements are influenced by several factors, including the species of bird and its production stage. For instance, pullets and layers require more dietary protein than broilers and turkeys, with broilers generally needing less than 21% of the dietary protein requirement. In addition to protein, lipids (fats) play an important role in poultry nutrition. While much of the research on

fats focuses on their function as an energy source, fatty acids also provide structural and functional lipids that are essential for normal physiological functioning (Gous *et al.*, 2023). A diet that supplies fats with an optimal fatty acid composition positively impacts reproductive performance and egg quality. The polyunsaturated fatty acids found in plant and fish oils ensure effective embryogenesis due to their specific role in the formation of the retina, central nervous system, and cellular membranes. An insufficient daily intake of unsaturated fatty acids can negatively impact the bird's metabolism, which may, in turn, affect its overall production. Fats also play a critical "carrier" role for the fat-soluble vitamins A, D, E, and K (Muro *et al.*, 2023). An adequate fat intake enables chickens to use "free" carbohydrates for energy metabolism, helping to reduce the risk of acidosis and supporting the optimal development of the gastrointestinal tract. Furthermore, dietary fat helps regulate insulin releas (Noce *et al.*, 2021).

Essential Amino Acids

Essential amino acids are necessary for optimal growth and productivity of broiler and must be provided through the diet as the birds themselves cannot synthesize them. In this context, methionine, lysine, threonine, tryptophan, arginine, valine, histidine, isoleucine, phenylalanine, and leucine are directly considered essential amino acids. These ten amino acids are essential for enhancing the growth performance of broilers, particularly in layer and broiler chickens. For example, lysine is the first limiting amino acid in broilers, and its primary role is in protein synthesis (Alagawany *et al.*, 2021; Alkuhla & Ibraheem, 2021). Additionally, threonine plays a key role in maintaining energy balance and nitrogen equilibrium. In broilers, it supports intestinal development during stressful conditions. Conversely, a decrease in leucine and valine levels can reduce feed consumption in birds (Kim *et al.*, 2024).

Also, cysteine is an essential amino acid for broiler and is very important for the synthesis of the primary antioxidant, glutathione, preventing oxidative damage in the body (Kachungwa Lugata *et al.*, 2022). If the required levels of essential amino acids are not maintained, egg production in layers declines. A proper balance of these amino acids is crucial for both feed costs and animal health (Alagawany *et al.*, 2021). Reducing any of these vital amino acids in the diet can lead to several issues, such as suboptimal growth rates, failure to reach maximum weight, and increased susceptibility to illness. In summary, the protein should contain an ideal combination of these essential amino acids, particularly lysine, as the synergistic effect of alanine promotes the growth of chickens (Maynard *et al.*, 2022).

Current Challenges in Optimizing Broiler Feed

Shifting broiler productivity patterns in response to changing consumer demands over quality attributes and health benefits, alongside mandatory legal restrictions on antibiotic use, have been the motive behind an ongoing quest for the cultivation of transgenic plants whose seed lines exhibit constitutively enhanced levels of desirable proteinaceous amino acids compared to seed protein as a whole. Whether these efforts result in economically feasible breakthroughs catering to various broiler production standards remains speculative. However, to date, no such domesticated crops are already available or in the pipeline for commercial utilization (Gasparini *et al.*, 2021) (Kumar *et al.*, 2021). These apparent shortcomings in crop availability necessitate a more balanced approach regarding the exploration of indigenous flora that includes naturalized potentially convertible weeds with grass-like properties and extensive herbicidal resistance traits. The goal of improving broiler feed formulations by increasing amino acid

availability and absorption from a wide range of cultivated crops remains a challenging and unrealistic ambition (Wolaver, 2021). The current landscape of broiler feed remains largely unchanged, with most demands focused on just a few categories of dietary ingredients for livestock. While there is a growing shift towards reducing the use of animal-derived proteins, both humans and animals continue to rely heavily on a limited variety of cereals, legume seeds, and vegetable oils, which serve as the primary components in both adult and embryonic diets. However, the poor essential amino acid composition of these crops limits their effectiveness, reducing their nutritional value for everyday meals, even though they offer other general nutrients commonly found in cereals and forages (Brouwer *et al*., 2020).

Potential Benefits of Amino Acids from *Taraxacum officinale*

Dandelions have been utilized for thousands of years in traditional Chinese medicine and are recognized for containing compounds that support broiler health, egg production, and growth (Kuralkar & Kuralkar, 2021). Several studies have highlighted the nutritional benefits of dandelions, noting their rich content of vitamins and minerals, which can enhance nutrient intake, promote growth, improve egg production, and boost the overall health of various broiler species. This paper examines the bioactive amino acids present in dandelion flowers, their benefits for animals of all ages, and the dosages that have been tested. Among the most frequently mentioned bioactive amino acids in the research are L-ornithine, 6,7-dimethyl-3-β-D-ribofuranosyl-iso-alloxazine, and L-pyroglutamic acid (Farag *et al*., 2022).

Low-protein feeds have become widely used in animal farming to reduce environmental pollution. However, this practice can restrict the intake of essential amino acids, leading to growth delays, weakened immune function, and thinning eggshells. Amino acids are crucial components in broiler diets, serving various purposes such as promoting overall health, growth, egg production, egg quality, and disease resistance (Li & Wu, 2020). Dandelion, once again gaining attention, is recognized for its health-boosting properties for both humans and animals. Its flowers are known to help regulate amino acids such as histidine, tryptophan, lysine, and others in the body (Farag *et al*., 2022).

Improved Productive Qualities

Based on the study's findings, which include a detailed analysis of the amino acid and vitamin composition of dandelion leaves and roots, we recommend incorporating dandelion into specialized broiler feed. When layers were fed dandelion leaves containing 10–12% protein at a dosage of 3.5 g or 7 ml per bird for egg production, the fat content in the yolk significantly decreased from 29.3% to 22.1% compared to hens receiving the basal diet (Farag *et al*., 2022). Reducing the dandelion intake to 50% of the recommended dose still resulted in a similar yolk fat content of 22.3%. Additionally, when layers were fed the basal diet containing 16.1% protein, along with 3.5 grams of dandelion roots containing 43.7% protein, the fat content in both the egg yolk and white decreased significantly, reaching a statistically reliable level compared to the yolk fat levels in hens fed the basal diet (Kim *et al.,* 2024).

A previous study showed that egg yolk cholesterol levels followed a similar pattern when comparing the control group with layers fed dandelion roots at an intake of 3.5 g per bird. The cholesterol content in these layers was lower, measuring 5.7 mmol/L, while the LDR50 group had an even lower cholesterol level of 4.3 mmol/L (Ürüşan, 2023). This cholesterol-reducing

effect was less pronounced in the hens receiving smaller amounts of dandelion roots. When given 3.5 grams, dandelion roots caused a reduction of only 10 micromolar/L in plasma cholesterol, and when given in smaller amounts, the difference was not statistically significant. These beneficial effects are likely due to the presence of biologically active compounds in dandelion roots, which have strong antioxidative and hypolipidemic properties (Kania-Dobrowolska & Baraniak, 2022). Additionally, deficiencies in essential dietary components may result in lower concentrations of critical nutrients, including those in egg yolk. The use of dandelion root in the LDR50 and LDR25 groups significantly reduced the levels of linoleic, stearic, and arachidonic acids compared to the control group (Ürüşan, 2023).

Improved Nutritional Content

The addition of *T. officinale* to broiler diets possibly results in the enhanced nutritional value of several meat quality parameters. More substantial changes in the moisture content primarily decrease the water-to-protein ratio. In the dietary plan, adding *T. officinale* to broiler diets does not significantly affect breast meat parameters, such as pH (Pliego *et al*., 2022). However, it may enhance water-holding capacity, improve the color of the meat and skin, increase juiciness, and boost antioxidant levels, as well as improve the stability of fatty acids against oxidation. Furthermore, *T. officinale* is a safe herb that positively influences the studied muscles in both dietary treatments. It alters the physiological parameters of broiler breast meat, including free essential fatty acids, protein concentrations, total dry matter, fat, ash, vitamins (thiamine, C, and E), amino acids, and collagen. Additionally, it contributes to improved oxidative stability, sensory quality, and reduced shrinkage. (Puvača *et al.*, 2022). Furthermore, Antioxidant activity is significantly higher in treatments incorporating *T. officinale* extract combined with inulin, which may partially enhance oxidative stability in broiler meat (Jachimowicz *et al.*, 2022; Al-Sanjary *et al*., 2023). Inulin, an inert carbohydrate, contributes to the palatability and shelf-life extension of fresh chicken nuggets. Although treatment with *T. officinale* extract slightly reduces animal body weight initially, by day 42, the weight increases. These changes in meat properties can be attributed to the pH level, with a lower pH observed in the *T. officinale* extract group. Overall, the evidence suggests that incorporating *T. officinale* extract into broiler diets may result in improved meat quality (Puvača *et al.*, 2022).

Methods for Incorporating Amino Acids into Broiler Diets

There are many ways of incorporating amino acids from *T. officinale* plants into the broiler diet, from using whole dandelion plants to isolates obtained from dandelion substrates (Ibrahim & Abdul-Rahman, 2024). When considering the formulation methods for the nutrient base or the mixture of conventional formulas to which the necessary amino acids from *T. officinale* parts will be added, the final physical or chemical form can have repercussions for the designed formulations. There are other strategies to consider when incorporating bio-compounds from various parts of *T. officinale* plants into the diets of broiler, swine, small ruminants, and others, including the use of other nutrients and the combination of process-based techniques as well as the level of intended use according to plant anatomy and proper composition (Djunaidi *et al.*, 2023). Furthermore, it has been clearly demonstrated that, for optimal results, all diets based on *T. officinale* must be adjusted to total diet content, specifically, the combination of conventional and *T. officinale*-based diets supplied to different-purposed types of broiler, e.g., laying hens, broilers, roosters, ducks, etc. Consulting

with a nutritionist for expert guidance is crucial. Scientific assessments of growth performance and other broiler management indicators—such as meat quality and egg production—when fed diets enriched with T. officinale, compared to conventional diets, will offer valuable insights into the need for nutritional adjustments in formulated diets. These assessments should accurately reflect the proportion of T. officinale in the feed mixtures, such as 1%, 2%, 3%, or 4% (Zagórska *et al.*, 2023) (She *et al.*, 2024).

Feeding Trials

In a study by Yamamoto *et al*. (2022) and Alhayaly *et al*. (2024), a few hundred animals of the same health status were selected for feeding trials and provided with carefully measured amounts of experimental diets, formulated according to standardized recommendations. The animals were grouped by weight and evenly distributed across replicates to ensure uniformity in the average weight of each replicate. The "cleanskin" principle was adhered to, meaning that no therapeutic agents were used that could potentially influence the results and obscure the effects of the specific treatments being tested. Consequently, the control diet was designed to meet the dietary protein recommendations and provide the minimal necessary amino acid concentrations (EFSA *et al*., 2021). Throughout the trial, animal performance was carefully monitored, with key growth parameters such as body weight, feed intake, mortality, and carcass yield. Health indicators were also assessed, including foot pad quality, egg production, egg quality, and overall behavior. The animals were scored using an agreed-upon system, which also accounted for the presence of production diseases like "woody breast" or "fatty liver." The trials could potentially reveal a DIVA effect (Monteiro *et al*., 2021; Al-Klw *et al*., 2023), in which certain birds, while remaining healthy, might produce less or more expensive meat. It is suggested that management practices could exacerbate these differences, as the mild levels of plant extracts used in the trials are unlikely to suppress overall performance (Rahman *et al.,* 2020).

Effects on Productive Qualities

Supplementing broiler diets with amino acids from dandelion led to improved growth rates, shorter slaughter times, and enhanced egg productivity and hatchability. Amino acids, as essential components of protein, help regulate vital hormones and gamma-interferon, which boost tissue energy supply and strengthen immunity (Wang *et al*., 2023; Wu *et al*., 2024). These findings are reliable and can help optimize production practices in broiler farming. Studies conducted in both laboratory and industrial settings in the Steppe showed that adding 1% dandelion amino acids improved weight gain in broilers, while bald-headed broilers required 1.5% dandelion cake for similar results (Wang *et al*., 2023). The studies also determined the optimal level of carrot meal for breeding hens. These long-term nutritional improvements not only enhance production but also reduce costs, increase profitability, and minimize the environmental impact of broiler farming (Weyh *et al.,* 2022).

Growth Rates

Previous research by (Ramakrishnan *et al.,* 2023; Alhayaly *et al.,* 2024) demonstrated positive growth gains in all batch trials where TAC amino acids were included in the feed. This supplementation resulted in increased average body weights at each observed growth stage and higher individual body weights at the end of the experiment. Several mechanisms may explain the improved growth observed with the inclusion of smoke-dried TAC amino acids in broiler diets. One possibility is that the protein quality improves compared to diets that rely solely on soybean meal as the primary protein

source. TAC amino acids supplement the amino acid profile, providing the essential components needed for optimal growth (Frances *et al*., 2023; Al-Sanjary *et al.,* 2023). Additionally, TAC amino acid supplementation increased energy levels in broiler diets. Nutritional data suggested that the metabolizable energy content from TAC as a protein source surpassed that of kernels. This aligns with the nutritional profile of TAC, indicating it also serves as an energy source. These factors likely contribute to faster growth in broilers fed with TAC (Attia *et al.,* 2024).

Feed Conversion Ratio

The feed conversion ratio (FCR) indicates the effective conversion of ingested feed into the final product. It describes the kilograms of feed required to increase the animal's body weight by 1 kg. Lower FCR values represent a more efficient feed utilization and are, therefore, more desirable in terms of feed costs and sustainability (Prakash *et al.,* 2020). A possible influencing factor for the improvement of FCR values is the amino acid supplementation of the feed by *Taraxacum officinale*. In conventional farming, attempts are made to reduce the number of animals by improving the efficiency of feed conversion in order to increase gains without having to increase input (Li *et al.,* 2023; Ibrahim *et al.,* 2024). A positive shift in the FCR in feeding trials comparing a non-supplemented treatment with a *Taraxacum officinale* supplemented treatment is presented, which leads to the conclusion that the utilization of amino acids by feeding with *Taraxacum officinale* leads to a saving of feed inputs on one hand and to an increase in performance in the form of an increased weight gain of the animals. By reducing the cost of feed inputs and simultaneously maximizing weight gain, meat production becomes more sustainable, and, consequently, the economic viability of the farmer is strengthened (Arczewska-Włosek *et al.,* 2023). FCR is also critical in cattle farming, as it helps ensure efficient feed-to-meat conversion. Amino acids—especially methionine and cysteine—are key to this process, as they support energy metabolism and enhance the overall utilization of feed energy, making them essential for animal growth and productivity (Macelline *et al.,* 2021). A supplement with gastrointestinal active amino acids such as methionine and cysteine can also support digestive processes and the intestinal metabolism of slaughtered animals due to the bacteriostatic properties of sulfur-containing amino acids, resulting in positively influenced FCR values in the supernatants in the field of methodically reviewed feeding trials. In the final product, a further shift in the FCR to the advantage of *Taraxacum officinale* supplementation can be achieved. Feeding an experimental group with a methionine and cysteine supplement has not yet been carried out; that might be a further target for testing in subsequent feeding trials (Liu *et al.,* 2023) (Wang *et al.,* 2021).

Effects on Nutritional Value

The most widely recognized effects of dietary addition of amino acids from *Taraxacum officinale* on the nutritional value of the products of broiler farming are in the area of meat supplementation and egg yolk. The protein content of broiler meat and parts cannot be controlled directly at the molecular level (Cao *et al.,* 2023) (Vlaicu *et al.,* 2024). Improving the conservative properties of meat can be indirectly influenced by the quality balance of individual amino acids, which is also achieved by supplementing amino acids. The gross sexual constitution of broiler meat proteins is later related to the intensity of crustacean synthesis and, thus the possible immobilization of injected cells (Macelline *et al.,* 2021; Ibrahim & Abdul-Rahman, 2024). Although the digestibility and nutritional value of broiler meat were not investigated in relation to the diet with amino acids from *Taraxacum*

officinale, it was possible to manipulate the metabolism of broiler meat. The body composition of broiler changes slightly in line with a diet supplemented with synthetic amino acids, giving a pleasant taste to the consumer, high succulence, texture, and good flavor (Abou-Elkhair *et al.*, 2020).

In commercial broiler production, meat quality is generally inversely correlated with fat content, as higher intramuscular fat is often associated with reduced consumer preference and lower market value. The fatty acid profile is a key determinant of meat quality and functionality, influencing both its nutritional application and trophic energy yield. Although broiler meat is frequently categorized as lower quality due to its lipid composition, it remains a valuable source of structural and barrier proteins for human consumption. Nutritional enhancement strategies, including the targeted supplementation of amino acids, have the potential to improve the protein profile and overall meat quality. These interventions may be further optimized by considering broiler genotype and sex-specific responses (Alagawany *et al.*, 2021). The quantity of protein varies with age and oxidative processes, and the process of growing proteins continuously continues to achieve its apparent potential for up to twelve years after cleansing and histochemistry (Kehm *et al.*, 2021). The protein structure of skeletal muscles consists of about 200 components in terms of texture, succulence, and taste perception, which directly affects the consumer. Additionally, by consuming relatively low-fat products that meet high protein and amino acid requirements, additional antioxidants are present. When used exclusively as an ingredient in feed, dietary supplements improve flavor and taste in some broiler products (Ren *et al.*, 2024). Therefore, the inclusion of Taraxacum officinale in broiler nutrition holds promise, particularly in the development of functional foods with potential health benefits. The decomposition of polyphenols, specifically phenolic acids, may influence the sensory properties of T. officinale, such as its odor (Alfaifi *et al.*, 2023). Although docosahexaenoic acid (DHA) has been detected in the juices of this plant, further research suggests that broilers raised under optimized management practices may produce meat enriched with DHA, contributing to animal welfare-friendly food systems (Pérez *et al.*, 2021). Regarding omega fatty acids, which play a role in the aging of meat proteins and lipids, alterations in their metabolic profiles were observed. Oxidative degradation slowed under conditions of hyperemia in broilers fed diets enriched with T. officinale. These findings indicate the potential of this supplement to enhance meat quality. Future studies should explore the role of *T. officinale* in breeding programs, particularly those focused on flavor-related traits and nutritional quality from a farm-to-fork perspective (Liang *et al.*, 2021).

Protein Content in Meat

Previous studies have aimed to quantify the extent of protein content enhancement in broilers supplemented with *Taraxacum officinale*. While the effects were not statistically compelling in all cases, the use of bioformulations containing *T. officinale* significantly increased the percentage of protein in the breast muscle of broiler chickens (Mounir *et al.*, 2022). These findings are attributed to the presence of amino acids in *T. officinale*, which play a crucial role in muscle protein synthesis due to their high fractional synthesis rate. Amino acids are fundamental building blocks in broiler muscle development, serving as essential nutritional substrates required for the construction of muscle tissue (Wang *et al.*, 2023).

The amino acid profile of broiler feed directly affects the quality characteristics

of the meat, with higher quality meat produced as the ratio of passive and active amino acids improves. The content of protein in the breast muscle of broiler chickens is considered a direct indication of its quality since the protein percentage is the most sought-after indication by the customer. Protein supplies 4 calories per gram and accounts for 20% of Arabian foods (Tang *et al.,* 2021). Eggs contain identical amounts of protein and provide 20 vitamins and minerals for 70 calories. Hence, the source of amino acids from *Taraxacum officinale* can impact the production of breast muscle that is a popular dish. This could be a technique for reducing fat content in food and, consequently the risk of chronic diseases in customers (Wang *et al.,* 2023). Given the increasing health awareness of individuals and the subsequent growth in the demand for protein food, producing profitable and protein-containing food, such as broiler meat, is crucial. There are other factors influencing meat quality, such as consumer perceptions about meat quality. From a consumer's viewpoint, meat is judged to be of high quality if it is high in protein (Abilov *et al.*, 2021). Moreover, not only is the protein volume required, but the quality of protein in the diet, particularly in micro and essential amino acids. Feeding organic animals is an important approach to increasing the nutritional content of meat (Gasco *et al.,* 2020).

Taraxacum officinale offers several key characteristics that make it highly beneficial for increasing the protein content in meat. Notably, it thrives in drought conditions, requires minimal water, and provides both pharmaceutical and feed value. The roots and leaves of this plant are rich in protein and dietary fiber (Murtaza *et al.,* 2022; Cacak-Pietrzak *et al.,* 2021). Amino acids in the diet play a crucial role in determining various meat characteristics, including texture, amino acid composition, and the distinct odor and flavor of the final product. Taraxacum officinale is particularly valuable due to its high concentration of essential amino acids in both its roots and leaves (Li *et al.,* 2023).

A study by Arczewska-Włosek *et al*. (2023) revealed that Taraxacum officinale generally promotes body weight development in chickens compared to the control group. However, the Taraxacum officinale treatment did not result in significant differences in overall body weight. Notably, chickens fed a diet supplemented with Taraxacum officinale showed significantly higher relative breast muscle weights. The increased protein content in the breast muscles further supports this finding. The results suggest that incorporating Taraxacum officinale into the diet enhances the protein percentage in the meat compared to the control group. However, regulatory testing remains essential to validate these outcomes. In contrast, the high biological value of these proteins, combined with their low fiber content, ensures a safe and efficient intake of protein in the muscles, making it suitable for commercial use (Sajad *et al.,* 2020). Taraxacum officinale-based feed supplements have shown potential in increasing protein concentration in broiler meat. However, as indicated by the studies mentioned, further research is needed to fully establish the benefits of using Taraxacum officinale as a dietary protein supplement. (Dong *et al.,* 2024).

Future Research Directions

Limited research exists on the use of *Taraxacum officinale* to enhance broiler health by providing amino acids, including for broilers, layers, and turkey poults. This presents several promising avenues for future investigation.

One key concern is the lack of long-term studies on the effects of amino acids from *Taraxacum officinale* in broiler diets. Future research should assess the impact of

these amino acids at different growth stages or during peak egg production, focusing on improvements in carcass and egg quality, as well as other beneficial changes (Dong *et al*., 2024; Arczewska-Włosek *et al*., 2023). Another priority is to explore the duration effect of these amino acids, including determining their optimal dosages and ratios. It is also essential to investigate the additional effects of other bioactive compounds in *Taraxacum officinale*, as these could interact synergistically or antagonistically with amino acids (Kania-Dobrowolska & Baraniak, 2022; Pierzak-Sominka, 2020). Combining these compounds could enhance the overall impact.

To validate these findings for the broiler industry, area-based farming studies are needed. Additionally, as *Taraxacum officinale* contains several beneficial compounds, further research targeting the expansion of the broiler sector is recommended (Kleyn & Ciacciariello, 2021; Ibraheem & Al-Kuhla, 2022). It is also important to evaluate the ecological and sustainability aspects of using these supplements (Chen *et al*., 2023).

Ultimately, future studies will deepen our understanding of *Taraxacum officinale* and may reveal potent nutrient sources for the industry. The primary goal is to find innovative solutions to challenges such as improving broiler health and providing supplements to protect against infections (Dong *et al*., 2024).

CONCLUSION

This study explores the use of amino acids from *Taraxacum officinale* in broiler feeds, including the potential of an invasive plant rich in amino acids to enhance animal diets and broiler production. Future studies should focus on integrating *Taraxacum officinale* into conventional diets to further optimize broiler nutrition and production.

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تعزيز تغذية الدجاج اللاحم بالأحماض الأمينية من *Taraxacum officinale*: مراجعة شاملة

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ازداد الاهتمام في الآونة الأخيرة باستخدام النباتات الطبية كمكملات غذائية لأعلاف دجاج التسمين. تهدف هذه المراجعة إلى جمع الأبحاث حول تأثير إضافة نبات الهندباء المخزنية (*Taraxacum officinale*) على النظام الغذائي للفراريج. يعتبر نبات الهندباء من النباتات ذات القيمة الغذائية العالية، حيث يحتوي على العديد من العناصر الغذائية الهامة، بما في ذلك الفيتامينات والعناصر المعدنية والأحماض الأمينية. بالإضافة إلى احتوائه على العديد من المضادات الحيوية، والتي تعتبر من محفزات النمو. وتُعد الأحماض الأمينية في تغذية اللاحم من المتطلبات الرئيسية لمساعدة الطيور في النمو والمناعة ووظائف الجسم الأخرى. ومن الضروري العثور على مصدر للأحماض الأمينية الأقل تكلفة التي يمكن أن يستهلكها الطائر، وأحد هذه المصادر هو الهندباء التي تتوافر بكثرة في المراعي. فهي تحتوي على نسب كبيرة من البروتينات والفيتامينات، وتحتوي على ما يقرب من ١٦ حمضاً أمينياً، بما في ذلك الأحماض الأمينية الأساسية الأرجينين والتيروزين والإيزولوسين والتريبتوفان والثريونين والفالين. يساعد *Taraxacum officinale* على زيادة معدلات النمو ويساعد على زيادة مستويات الطاقة بالإضافة إلى زيادة معدل التحول الغذائي.

الكلمات المفتاحية: الهندباء البري، فروج اللحم، الاحماض الامينية.