EVIDENCE-BASED LITERATURE ON THE BENEFITS OF USING MEDICINAL PLANTS IN BROILER POULTRY PRODUCTION

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Abstract. This review article provides a comprehensive backup literature on the benefits of using medicinal plants in broiler poultry production. The use of medicinal plants as feed supplements for poultry has gained increasing attention in recent years in an effort to halt the use of antibiotics and synthetic growth promoters. Medicinal plants contain bioactive compounds that have been shown to possess antimicrobial, antioxidant, anti-inflammatory, and immunomodulatory properties, which can promote growth performance, enhance feed efficiency, and improve the overall health status of broiler chickens. Numerous studies demonstrated that including medicinal plants in broiler diets can significantly improve growth performance parameters such as body weight gain, feed intake, feed conversion ratio, and carcass characteristics. Moreover, medicinal plants have also been shown to enhance the immune response of broiler chickens and reduce the incidence of various diseases, including bacterial infections, coccidiosis, and oxidative stress-related disorders. In conclusion, the evidence gathered in this review strongly supports the use of medicinal plants in feeds for broiler poultry production.
Keywords: *antimicrobial, bioactive, immunomodulatory, meat quality, performance, poultry*

Introduction

Poultry production contributes to employment creation and poverty eradication (Kabir et al., 2015; Ngongolo et al., 2019; Hafez and Attia, 2020; Abd El-Hack et al., 2022). Ravindran (2013) and FAO (2017) reported the dominance of the poultry sector globally with an approximated annual output of 90 billion metric tons. A report by DAFF (2017) indicated that broiler production was the largest agricultural sector in South Africa with a contribution of about 33% to the total market share. The rapid growth in poultry meat consumption worldwide demands that the sector produces meat of high quality with a prolonged shelf-life through various practices that include incorporation of medicinal plants in formulated feeds (Sofowora et al., 2013; Tan et al., 2018; USDA, 2021). Omolere and Alglo (2020) cited high feed costs as one of the key challenges limiting productivity in the poultry industry. In the world of poultry farming, disease outbreaks can devastate flocks and stunt growth, highlighting a major challenge in health management (Hafez and Attia, 2020). Nutrition is a crucial factor, impacting growth rates and production costs (Lo et al., 2009). Environmental sustainability and infrastructure are vital for optimal performance (Fay et al., 2010). Market dynamics, regulations, skilled labor availability, climate variations, and economic fluctuations all play crucial roles, shaping the complex narrative of poultry production (Castro et al., 2023).

According to Nemauluma et al. (2022), in an effort to cut feed costs without compromising poultry growth performance, producers often resort to including antibiotics in poultry diets as growth promoters. Gobvu et al. (2022) reported that the

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use of synthetic antibiotics is associated with exorbitant costs. Masud et al. (2020) reported the indiscriminate use of antibiotics as growth promoters as a major contributor to antibiotic resistance. A ban on the use of antibiotics as growth promoters in poultry production in some countries has promoted research on the feasibility of alternatives such as probiotics, prebiotics, organic acids and plant extracts (Seal et al., 2013). Traditional medicine practitioners have utilized medicinal plants for centuries due to their potential therapeutic properties (Souza et al., 2018; Ullah et al., 2020).

Medicinal plants contain numerous bioactive compounds, including phytochemicals, essential oils, and antioxidants, which have positive effects on animal health (Diniz do Nascimento et al., 2020; Bansal and Priyadarsini, 2022). The antimicrobial, immunomodulatory, anti-inflammatory, and growth-promoting properties of these natural compounds make them promising candidates for enhancing broiler production (Lillehoj et al., 2018; Abd El-Hack et al., 2022; Onyenibe et al., 2023). Incorporating medicinal plants into broiler poultry production is associated with several benefits (El-Sabrout et al., 2023). Singled among the key benefits include an improvement of growth performance, enhanced immune function, and decreased oxidative stress (Selaledi et al., 2020).

Jamil et al. (2022) stated that bioactive compounds contained by these medicinal plants positively impact the health and well-being of broiler chickens. Cherkupally et al. (2017), Oluwafemi et al. (2020), Al-Khalaifah et al. (2022) reported popularity in the use of plant extracts also known as phytogenic feed additives due to their preferred attributes such as antimicrobial, anti-inflammatory, anti-oxidative and anti-parasitic properties. Research on phytogenic feed additives over the past two decades has shown the potential for improved growth performance in poultry (Abdelli et al., 2021). Shahrajabian et al. (2021) indicated that medicinal plants or herbal extracts meet the nutrient requirements of animals and contain unique organic phytochemicals that are believed to promote optimal health in birds.

Athanasiadou et al. (2007) reported that medicinal plants improve the absorption of nutrients and promote the removal of pathogens from the gut. Alloui et al. (2014) reported dietary lipids protection during the process of oxidation. Cheng et al. (2014) alluded to the high margin of safety associated with herbal medicines which has led to their growing popularity in some Asian, South American and African countries. Herbal plant components are affected by various factors such as plant structure, environmental conditions, and seasonal changes, which can have a significant impact on the amount and composition of active substances and chemical compounds present in them (Windisch et al., 2008; Plant et al., 2021). In addition, the incorporation of medicinal plants into broiler production systems can meet consumer demands for products with reduced chemical residues and a natural production process (Mahfuz and Piao, 2019).

The use of medicinal plants can accommodate this growing demand for poultry products derived from animals reared with minimal synthetic inputs (Jamil et al., 2022; Ajide et al., 2023). Despite their potential benefits, the use of medicinal plants in broiler production is a relatively new and developing field. Identifying and validating specific plant species, their optimal inclusion levels, and their potential interactions with dietary components requires additional research (Henkhaus et al., 2020). In addition, practical considerations such as plant availability, cost-effectiveness, and integration with existing production systems must be addressed (OECD, 2001). This review highlights the utilization of plant-based substances in the poultry industry and their effects on poultry health and growth performance. Negative perceptions around the use of

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antibiotics in poultry production paves way for research on alternative substances that can promote growth performance and enhance poultry health.

Properties, groupings, and growth requirements of medicinal plants

Medicinal plants have been used for centuries to treat and prevent diseases due to their various therapeutic properties (Ekor, 2014; Eshete and Molla, 2021). They are not only used for medicinal purposes but also as a source of food for human consumption and as an ingredient in animal diets (El-Hack et al., 2020). The inclusion of medicinal plants in animal diets has been shown to improve the growth rates and health of poultry in a cost-effective manner (Jamil et al., 2022). Additionally, the use of these plants for disease treatment is considered safe for both humans and animals, as well as the environment (Eshethe and Molla, 2021). Medicinal plants are classified based on their growth habits into trees, shrubs, herbs, annuals, biennials, tubers, rhizomes or climbers (Daswani et al., 2017). However, the classification of medicinal and aromatic plants can be difficult due to the overlap between the two groups. Medicinal plants are widely available and adaptable to various environmental conditions, but their growth and quality can be influenced by factors such as soil conditions, climatic conditions, harvest time, biological community and field management measures (Ekor, 2014). Soil conditions, in particular, are considered a key factor in the agricultural production of medicinal plants.

Nutrient and chemical composition of medicinal plants

Medicinal plants have been used for centuries to treat various health conditions, and their efficacy can be attributed to their nutrient and chemical composition (Sofowora et al., 2013). Chemically, medicinal plants contain various phytochemicals, such as alkaloids, flavonoids, terpenes, tannins, and phenolic acids (Agidew, 2022). These phytochemicals, along with the diverse range of nutrients present in medicinal plants, contribute to their healing properties (Radha et al., 2021). The compounds found in medicinal plants are responsible for their medicinal properties and can have a range of effects on the body (Tungmunnithum et al., 2018). For instance, alkaloids, including morphine and codeine, possess analgesic properties, offering pain relief. On the other hand, flavonoids like quercetin and apigenin exhibit anti-inflammatory and antioxidant properties, which can help reduce inflammation and protect against oxidative damage (Paumgartten et al., 2022). It is worth noting that the chemical makeup of medicinal plants can be influenced by various factors such as the environment in which they grow, harvesting methods, and storage conditions (Chen et al., 2016). These factors can impact the concentration and composition of bioactive compounds, and thus, it is important to use standardized methods for harvesting and processing medicinal plants to ensure consistency in terms of their efficacy (Makunga et al., 2008). Proper attention to these factors can help maintain the quality and potency of medicinal plants, allowing for reliable and effective therapeutic outcomes (Wagner and Ulrich-Merzenich, 2009).

Mode of action and mechanisms as feed additives

Broiler poultry production faces the challenge of meeting the increasing demand for poultry products while adhering to sustainable and health-conscious practices

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(Hafez and Attia, 2020). One approach gaining attention is the use of medicinal plants as feed additives (Mbokane and Moyo, 2022). This review aims to provide an in-depth analysis of the effects of medicinal plants when incorporated into broiler diets. A variety of medicinal plants are utilized as feed additives in broiler diets (Abaza, 2001). These plants encompass a wide range of active compounds, such as polyphenols, essential oils, and phytochemicals, which have shown promise in improving broiler health and performance (Loetscher et al., 2013; Morovat et al., 2016). Commonly used medicinal plants include oregano, garlic, thyme, and turmeric (Parham et al., 2020).

Medicinal plants, when employed as feed additives, exhibit diverse modes of action (Mbokane and Moyo, 2022. These include their antimicrobial properties, anti-inflammatory effects, and immunomodulatory functions (Makkar et al., 2007).

Benefits of medicinal plants as feed additives

Medicinal plants used as feed additives for broiler poultry production have been shown to have a positive impact (Jachimowicz et al., 2022). They can improve growth rates, enhance feed efficiency, and positively affect the quality of broiler meat (Choi et al., 2023). This makes them a promising natural alternative to conventional additives. When used as feed additives, medicinal plants contribute to enhanced disease resistance in broilers (Jamil et al., 2022). Their immune-boosting properties and potential to reduce the incidence of common poultry diseases, such as coccidiosis and necrotic enteritis, make them valuable additions to broiler diets (Ayalew et al., 2022).

Medicinal plants as anti-parasitic and antimicrobial remedies in broiler poultry production

Incorporating medicinal plants into the diets of animals has been reported to boost growth performance, due to the inherent antiparasitic and antimicrobial properties (Lillehoj et al., 2018). Internal and external parasites are a common challenge in avians (Jamil et al., 2022). Extracts of some plant species exhibit antimicrobial properties that can combat bacterial and fungal pathogens inclusive of *E. coli* and *Salmonella* spp which are common in poultry production (Windisch et al., 2008). The use of traditional herbs to treat avian diseases such as infectious bursal disease, Newcastle disease, and infectious laryngotracheitis has been reported in previous studies (Hartady et al., 2021). *Table 1* summarizes the findings of several studies that investigated the bioactive properties of medicinal plants that are commonly used in broiler production.

Effects of medicinal plants on growth performance of broiler chickens

Several medicinal plants have been found to potentially enhance the growth performance of broiler chickens and can be used as natural substitutes for antibiotics and other growth-promoting agents in poultry production (Abd El-Hack et al., 2022). The effectiveness of these plants in improving broiler growth performance can vary depending on the specific plant and its active compounds (Hashemi et al., 2013). Many medicinal plants contain bioactive compounds that can enhance gut health by promoting the growth of beneficial gut bacteria, suppressing harmful bacteria, and improving gut

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barrier function (Chen et al., 2022). This can result in improved nutrient absorption, improved feed conversion efficiency, and overall enhanced growth performance (Oanh et al., 2021).

Additionally, some medicinal plants have bioactive compounds that may strengthen the immune system of broiler chickens, which can help in resisting infections, thus reducing the dependence on antibiotics and other drugs that could negatively impact broiler health and performance (Windisch et al., 2008; Ayalew et al., 2022). Furthermore, some medicinal plants contain anti-inflammatory compounds that can suppress inflammatory reactions in the gut and other parts of the body, thereby relieving stress and improving health and growth performance of birds (Kikusato, 2021). Although medicinal plants can improve broiler growth and performance, it is crucial to ensure their safe, effective, and sustainable use, and to determine the optimal dosage and duration of supplementation based on the specific plant and production system.

Effects of including medicinal plants in diets on broiler meat quality and sensory attributes

According to Attia (2017), the inclusion of plant extracts in poultry feeds can improve meat sensory attributes, leading to improved feed intake and palatability, which in turn can enhance growth performance and reduce mortality rates. Poultry meat has a shorter shelf life compared to meat of other animal species making it more susceptible to spoilage through auto-oxidation (Addis, 2015). Therefore, it is important to safeguard the quality of meat that is supplied to consumers (Bischoff and Liebenberg, 2017) Chemical preservatives are often used to prevent spoilage of poultry meat (Teshome et al., 2022). However, recent studies have demonstrated that plant extracts can be a natural alternative to chemical preservatives and may enhance meat quality and maintain its original state. Medicinal plants have been found to positively impact meat quality and consumer preferences (Ri et al., 2017). Babiker et al. (2019) reported that Vachellia species plant extracts improved the cooking loss of meat, thereby prolonging its shelf life for up to 15 days of refrigerated storage.

Alhijazeen et al. (2021) reported a positive effect on meat odour when oregano and tannic mixture were added to a broiler diet. Kolobe et al. (2022) investigated the inclusion levels of *Vachellia karroo* leaf meal in broiler diets and reported no effects on breast meat pH, shear force, or cooking loss at day zero after slaughter. Similar results were reported by Al-Hijazeen et al. (2016), Przywitowski et al. (2016), and Ncube et al. (2017). The lack of effect on meat quality may be attributed to the low inclusion levels of tanniniferous feed ingredients in broiler diets. The conflicting results among studies may be due to differences in inclusion levels of plant extracts in diets and the duration of experimental trials. Several studies reported the effect of including medicinal plants in diets on meat quality and sensory attributes of broiler meat (*Table 2*). Conflicting findings were reported possibly due to variations in inclusion levels of plant extracts in diets and duration of experimental trials.

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Table 1. *Bioactive properties and effects on growth performance of some medicinal plants that are used in broiler production*

Scientific name	Common name	Properties	Part utilized	Inclusion level	Method of administration	Observations	References
Thymus vulgaris	Thyme	Antioxidant, antimicrobial	Leaves	100-300 mg/kg	Feed	Improved immune response, growth performance, and antioxidant status	Noruzi et al. (2022)
Curcuma longa	Turmeric	Anti-inflammatory, antioxidant	Rhizomes	200 mg/kg	Feed	Reduced oxidative stress and improved performance	Hafez et al. (2022)
Origanum vulgare	Oregano	Antimicrobial, antioxidant	Leaves and flowers	200-300 mg/kg	Feed	Improved growth performance and antioxidant status	Jin et al. (2022)
Artemisia annu	Sweet wormwood	Antimicrobial	Leaves	0.1 g kg^{-1}	Feed	Reduced pathogenic bacterial load and improved growth performance	Panaite et al. (2019)
Allium sativum	Garlic	Antimicrobial, antioxidant	Bulbs	2%	Feed	Improved growth performance, gut health, and immune response	Shojai et al. (2016)
Azadirachta indica	Neem	Antimicrobial, antiparasitic	Leaves	1-2%	Feed	Reduced pathogenic bacterial load and improved growth performance	Anwarul et al. (2018)
Cinnamomum zeylanicum	Cinnamon	Antimicrobial, antioxidant, anti-inflammatory	Bark	2 g/kg	Mixed with feed	Increased growth performance and optimized feed utilization	Qaid et al. (2022)
Nigella sativa	Black cumin	Antimicrobial, anti-inflammatory, Immunomodulatory	Seeds	0.75%	Mixed with feed	Increased body weight gain and improved feed conversion rate	Majeed et al. (2010)
Thymus vulgaris	Thyme	Antimicrobial, antioxidant, anti-inflammatory	Leaves	0.5%	Mixed with feed	Non-significantly improved final body weight, body weight gain, feed conversion ratio, and protein efficiency ratio of broiler chicks	AbdelGhaney et al. (2017)
Ocimum basilicum	Basil	Antimicrobial, antioxidant, anti-inflammatory	Leaves	1 g/kg	Mixed with feed	Improved weight gain and feed conversion ratio	Alagawany et al. (2017)
Allium sativum	Garlic	Antimicrobial, anti-inflammatory, immunomodulatory	Bulbs	10,15,20 g/kg	Mixed with feed	No significant effect on body weight gain, carcass characteristics and feed conversion ratio	Ibrahim et al. (2022)
Zingiber officinale	Ginger	Antioxidant, anti-inflammatory	Rhizomes	6 g/kg	Mixed with feed	Significant differences in feed intake, body weight gain and feed conversion ratio	Otokini (2013)
Curcuma longa	Turmeric	Antimicrobial, antioxidant, anti-inflammatory	Rhizomes	2%, 4%	Mixed with feed	Differences in body weight gain and FCR were not significant	Anyanwu et al. (2022)
Origanum vulgare	Oregano	Antimicrobial, antioxidant, anti-inflammatory	Leaves	200 mg/kg	Mixed with feed	Optimised bird growth performance, behavioural patterns, and immunity	Hafez et al. (2022)

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Aloe barbadensis Miller	Aloe vera	Anti-inflammatory	Aloe vera gel	05%, 0.75%	Drinking water	Body weight of broilers supplemented with different levels of AV increased compared with control group. Feed-to-gain ratio (F:G) were improved	Shokraneh et al. (2016)
Scutellaria baicalensis	Baikal skullcap	Antimicrobial, antioxidant	Roots	5, 10, 15 g/kg	Mixed with feed	Promoted higher body weight and better feed conversion in broilers	Króliczewska et al. (2008)
Trigonella foenum-graecum	Fenugreek	Antimicrobial, anti-inflammatory	Seeds	4%, 5%	Mixed with feed	The weight gain of the birds that were fed with 4 and 5% fenugreek was significantly lower (p 0.05) altered by dietary fenugreek	Weerasingha and Atapattu (2015)

Table 2. *Effects of including medicinal plants in diets on quality and sensory attributes of broiler meat*

Scientific name	Common name	Inclusion level	Method of administration	Bird species	Findings on meat quality and sensory attributes	References
Thymus vulgaris, Origanum vulgare, Cinnamomum verum	Thyme, oregano, cinnamon essential oils	Not specified	Added to feed	Broiler chickens	The addition of thyme enhanced the flavor, juiciness, and overall acceptability of meat	Mehdi et al. (2018)
Origanum vulgare	Oregano and Tannic acid	0.1%	Added to feed	Broiler chickens	Incorporating oregano and tannic acid improved meat odor	Al-Hijazeen et al. (2017)
Vachellia karoo	Acacia extracts	1.0%	Added to feed	Broiler chickens	Improved cooking loss of meat, leading to prolonged shelf-life	Babiker et al. (2019)
Origanum vulgare	Oregano powder	0.1%, 0.2%, 0.3%	Added to feed	Broiler chickens	No significant improvements in meat quality and sensory attributes were reported	Ri et al. (2017)
Vachellia karoo	Acacia leaf meal	0.5%, 1.0%	Added to feed	Broiler chickens	No significant effects were reported on breast meat pH, shear force, and cooking loss at day zero after slaughter	Kolobe et al. (2022)
Vachellia karoo	Tannic acid	1.0%	Added to drinking water	Broiler chickens	No significant effects were reported on meat quality and sensory attributes	Al-Hijazeen et al. (2016)
Vitis vinifera pomace	Grape pomace extract	1%	Added to feed	Turkey	No significant effects were reported on meat quality and sensory attributes	Przywitowski et al. (2016)
Acacia nilotica	Babul tree	5%, 10%	Added to feed	Free-range chickens	No significant effects were reported on sensory attributes and cooking properties of meat	Ncube et al. (2017)

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An economic evaluation on the use of medicinal plants as growth promoters in poultry production.

Poultry production costs are largely driven by feed expenses, which account for 60-80% of total costs (Elahi et al., 2022). Thus, it is crucial for producers to set clear targets for optimizing feed efficiency and reducing costs, and work diligently towards achieving those targets. The recent surge in feed ingredient prices, especially soybean meal, has prompted producers to focus on cost-effective feeding strategies and more efficient conversion of feed protein into meat (Rakita et al., 2021). Although prices for ingredients have reduced in recent years, long-term projections suggest that prices will remain high and will continue to rise (FAO, 2022). Consequently, it is essential to put extra efforts to optimize feed utilization and ensure long-term sustainability.

Providing farmers with affordable and readily available alternatives has been shown to reduce production costs and enhance economic benefits (Kolobe et al., 2022). While some medicinal plants may be widely available and inexpensive, others may be more difficult to obtain or may require specialized cultivation methods. Additionally, the cost of preparing and administering the plants as feed additives may also impact their economic feasibility (Bosselmann et al., 2013). Another factor to consider is the potential for variability in the efficacy of different plant extracts, which can make it difficult to ensure consistent results and may require additional testing and experimentation (Wachtel-Galor and Benzie, 2011). Overall, while the use of medicinal plants as growth promoters in poultry may have potential economic benefits, additional research is needed to fully understand the costs and benefits of this practice, including factors such as plant availability, preparation costs, and potential variability in efficacy.

Conclusion

Based on the available evidence, there appears to be potential benefits of using medicinal plants as feed additives in poultry production. These benefits include improved growth performance and feed consumption, enhanced function of the immune system and improved bird health. Using therapeutic plants may also reduce the need of synthetic chemicals and antibiotics, which has economic and environmental benefits. It is vital to note that different plant species and preparation methods have variable efficacy. More research on medicinal plant use in poultry production is imperative to explore further advantages and disadvantages of this approach.

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