

MEDICINAL PLANTS AS AN ALTERNATIVE TO ANTIBIOTIC GROWTH PROMOTERS IN BROILER CHICKEN REARING

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Abstract

The use of antibiotics as growth promoters and chemotherapeutic agents was, until recently, a common practice in poultry production. However, their overuse has led to the widespread problem of bacterial antibiotic resistance, i.e. resistance to the bactericidal or bacteriostatic effects of antibiotics. Consequently, on 1 January 2006, a complete EU-wide ban on the use of antibiotic growth promoters (AGPs) in feed for all farm animals came into force. This decision had unintended consequences, including increased infection rates and mortality in animals. In turn, this led to a sharp rise in the use of prescription antimicrobial drugs. To break the "vicious circle" of antibiotic use in animal production, modern feeding strategies began to be sought that would promote animal growth, including poultry, without causing adverse side effects. Numerous scientific studies have shown that medicinal plants and products derived from them may constitute a safe and effective alternative to AGPs. Active compounds present in medicinal plants may exert antibacterial, antioxidant and immunomodulatory effects, thereby positively influencing bird health and performance. The aim of this paper is to review the available literature on the possibilities and effects of using selected medicinal plants (oregano, thyme, ginger and garlic) as alternatives to AGPs in broiler chicken nutrition.

Keywords: antibiotic growth promoters (AGPs), medicinal plants, broiler chickens, production performance

Introduction

With the rapid growth of the global human population, which is estimated to reach nearly 10 billion by 2050, the demand for food is also increasing (Gil et al., 2024). Animal-derived products, especially meat, play an important role in the human diet. Meat has a high nutritional

value, primarily because of its high content of high-quality protein, which is difficult to replace with protein from other food products (Marangoni et al., 2015). Poultry meat is one of the most popular sources of protein in the everyday human diet (El-Sabroun et al., 2023). Poultry accounts for 40% of the global meat production sector (Kober et al., 2025), contributing substantially to alleviating nutritional deficiencies in many countries. Poultry meat has a diverse nutrient profile, while its production costs are considerably lower than those of other types of meat (Abd El-Hack et al., 2022). The growing demand for poultry, and poultry meat in particular, requires an increase in production scale. Performance in meat poultry production can be improved by adding various ingredients to feed or drinking water (Seidavi et al., 2021). Until recently, the addition of antibiotics to feed in the form of antibiotic growth promoters (AGPs) was a common practice in animal production. However, antibiotic use, including in poultry rearing, is associated with the development of resistant pathogenic bacteria, with consequences for both animal and human health (Azizi et al., 2024). At the same time, consumer awareness of animal welfare, food safety and personal health is increasing, and consumer preferences are increasingly shifting toward products from animals raised without antibiotics (Barrett et al., 2021). There is therefore a need to identify effective alternatives to veterinary growth promoters. According to many available literature sources, a range of herbal spices has a positive effect on bird performance and health status (Karangiya et al., 2016; Ri et al., 2017; Al-Khalaifah et al., 2022; Shams-ul-Hayat et al., 2022; Kairalla et al., 2022).

The aim of this review is to examine the available literature on the possibilities and effects of using selected medicinal plants as fully effective and safe alternatives to AGPs in broiler chicken production.

History of AGPs

Alexander Fleming's discovery of penicillin in 1928 was one of the most important events in the history of medicine (Ikusika and Haruzivi, 2022). Although the discovery itself was groundbreaking, the full practical use of penicillin became possible only in the 1940s, when methods for its mass production were developed. This marked the beginning of the antibiotic era, in which antibiotics played a key role in the treatment of bacterial infections in humans. Following their success in human medicine, they also began to be used in veterinary medicine and animal production. Initially, antibiotics were used in animals exclusively to improve health and prevent infections. At the turn of the 1940s and 1950s, it was accidentally observed that adding streptomycin to chicken feed increased body-weight gain. A similar effect was observed in 1949 in chickens given a fermentation by-product containing small amounts of chlortetracycline produced by *Streptomyces aureofaciens* (Stokstad and Jukes, 1950). The growth-promoting effect of antibiotics was subsequently confirmed in studies on pigs and cattle (Patyra and Kwiatek, 2022). This led to the theory that continuous administration of such drugs as feed supplements at subtherapeutic doses not only improves animal health status but also increases feed-use efficiency and accelerates growth (Lillehoj et al., 2018). This resulted in the widespread use of antibiotics as growth promoters in farm-animal nutrition (Patyra and Kwiatek, 2022). It was later established that the growth-promoting action of antibiotics is correlated with reduced activity of bile salt hydrolase, an enzyme produced by intestinal bacteria that adversely affects digestion and utilization of fat by the host (Cheng et al., 2014). In addition, antibiotics prevent the proliferation of pathogenic bacteria, which is directly associated with reduced production of metabolites that impair organismal development and with decreased inflammation of the intestinal wall.

The increase in global demand for animal protein (meat, milk and eggs) led to greater use of AGPs in large-scale animal production. In 1951, the United States Food and Drug Administration allowed farmers to use antibiotics as feed additives without a veterinary prescription. Subsequently, between 1950 and 1970, individual European countries adopted their own regulations permitting the use of antibiotics in feed for farm animals (Castanon, 2007). However, imprudent use of antibiotics by overzealous producers became the cause of numerous problems. One of the most serious was the increasing development of bacterial resistance to the pharmaceuticals used, thereby posing a potential threat to human and animal health (Ikusika and Haruzivi, 2022). Gram-negative bacteria, including *Salmonella spp.* and *Escherichia coli*, proved particularly prone to developing resistance (Butaye et al., 2003). Over the past 40 years, further bacterial strains have been identified as causes of infections in humans and animals that may show resistance only to selected antibiotics. Among newly identified strains, so-called pan-resistant bacteria have also been distinguished, i.e. bacteria resistant to all currently available antibiotics (Stanton, 2013). The first restrictions on the use of some antibiotics in feed were introduced in Sweden as early as 1986. On 1 January 2006, European Union Member States introduced a complete ban on antibiotic growth promoters (AGPs) under Regulation (EC) No. 1831/2003 of the European Parliament and of the Council (Cheng et al., 2014). However, the complete ban on AGPs also has consequences in the form of adverse effects on animal health, including increased infections, and on production performance, especially in animals kept at high stocking densities (Casewell et al., 2003). This creates challenges for the entire animal-production sector, particularly the feed industry. Effective alternatives to antibiotics are therefore continually needed to help maintain high levels of animal production while safeguarding both animal and human health (Millet and Maertens, 2011).

What are medicinal plants?

Medicinal plants comprise a broad group of plants, most commonly terrestrial species, from which herbal raw materials are obtained. They are characterized by a rich composition of biologically active substances and have beneficial effects on the body. These substances include flavonoids, anthocyanins, glycosides, tannins, mucilages, bitter compounds, essential oils, alkaloids, terpenes, triterpenes, saponins, iridoids, naphthoquinones, anthraquinones, phenols, phenolic acids and mineral salts (Budny et al., 2012; Urban et al., 2024). Although their share in the overall plant composition is small and usually amounts to about 1%, their effects are highly valuable (Michalska and Mituniewicz, 2023). The accumulation and concentration of these compounds depend on the plant part and its growth stage. Moreover, the chemical composition and properties of herbs depend on factors such as the environment, soil type, geographical origin, harvest time and method, as well as processing, preservation and storage methods (Radkowska, 2013). The abundance and diversity of bioactive substances present in herbs give them broad, multidirectional activity (Dankowiakowska, 2023). They may exhibit antibacterial, antiviral, antiparasitic, coccidiostatic, anti-inflammatory, antioxidant and immunostimulatory effects (Abd El-Hack et al., 2022). For treatment and prevention, whole plants or individual plant parts may be used fresh or dried, as well as in the form of infusions, decoctions, extracts, macerates and essential oils (Radkowska, 2013). In broiler chicken production, phytogetic additives are most commonly used as dried plant material, dry extracts and essential oils. Dried plant material, i.e. dried fruit or plants intended for food, medicinal or feed purposes, should be used at 0.5-5%. Dry extracts are concentrated herbal preparations obtained by extracting plant material with a solvent, for example water or ethanol or their mixtures, followed by appropriate concentration. They have the consistency of a loose powder, with a permissible water content of no more than 5%. The recommended inclusion rate is 0.5 kg/t of feed. Essential oils are mixtures of volatile organic compounds, including esters, ketones and aldehydes, characterized

by an intense aroma and occurring in different plant parts such as roots, fruit and bark; the recommended inclusion rate is 0.05%/t of feed. Supplementing poultry feed or water with medicinal plants in appropriate proportions supports, among other things, normal gastrointestinal function, strengthens circulatory-system structures and helps regulate the oxidative status of the body (Urban et al., 2023; Urban et al., 2024). Based on the research results available in the literature, medicinal plants and their products are regarded as promising growth promoters in animal diets (Hashemi and Davoodi, 2011).

Medicinal plants as growth promoters in poultry nutrition

Over the past several years, considerable research has focused on the potential use of medicinal-plant additives in poultry production. The mechanisms by which phytogetic feed additives act on birds have also been investigated, with particular emphasis on production efficiency. Studies have shown that adding products derived from medicinal plants to bird diets may support growth (Mohammadi Gheisar and Kim, 2017), although the mechanisms underlying this effect have not yet been fully elucidated. According to Valenzuela-Grijalva et al. (2017), herbs and herbal preparations may support the growth of farm animals, including poultry, in several ways: by improving feed quality and intake through enhanced palatability and aroma; by beneficially stimulating digestion and nutrient absorption through stimulation of bile and digestive-enzyme secretion; and by modifying intestinal morphology and gut health. The effectiveness of plant-derived compounds is particularly apparent in young animals whose digestive and immune systems have not yet reached full functional maturity, as well as in animals kept at high stocking densities, where intensive contact between individuals increases the risk of stress and infection.

Effects of selected medicinal plants

Oregano (*Origanum vulgare* L.)

Oregano is a perennial plant belonging to the *Lamiaceae* family and has long been widely used in traditional folk medicine to treat a variety of ailments and diseases. The composition of biologically active substances in oregano is highly diverse and includes primarily terpenes, phenols and phenolic acids, with carvacrol and thymol as the main components. Owing to these biologically active substances, oregano exhibits antibacterial, antiviral, antioxidant and anti-inflammatory activity (Elbaz et al., 2025). According to recent studies, oregano and the essential oils produced from it act in a manner similar to antibiotics, inhibiting the growth of or killing many zoonotic bacteria and plant pathogens. In addition, they may enhance disease resistance and beneficially stimulate animal growth (Zhao et al., 2021). The use of powdered oregano at 150 mg/kg of feed in broiler diets may positively affect growth and systemic antioxidant defenses in broiler chickens and may therefore act as a growth promoter comparable with an antibiotic growth promoter (Ri et al., 2017). Zhao et al. (2021) studied the effects of oregano essential oil (OEO) and aureomycin (an antibiotic) on broiler production performance over 28 days, including average daily body-weight gain, average daily feed intake and feed conversion ratio (FCR). Mortality was also monitored throughout the experiment. Birds in the supplemented groups, receiving either oregano essential oil or aureomycin, showed more favorable daily body-weight gains and feed intake and had lower mortality than birds in the unsupplemented group ($p < 0.05$). No differences were found between the experimental groups ($p > 0.05$). Moreover, no significant differences in FCR were observed among the three groups. These results again demonstrate that biologically active substances present in oregano can show activity comparable with that of antibiotics.

Thyme (*Thymus vulgaris* L.)

Thyme is an aromatic, perennial medicinal herb belonging to the *Lamiaceae* family. In farm-animal nutrition, thyme is used as one of the alternative herbs that can improve appetite and feed intake. Thymol and carvacrol are the most important bioactive compounds found in thyme. Their proportions in thyme essential oil are 28.53% and 25.06%, respectively (Fawaz et al., 2021). In addition to thymol and carvacrol, thyme is also a rich source of linalool, terpineol, borneol, cineole and bornyl acetate. These substances reduce the numbers of harmful intestinal microorganisms and exert antiseptic and antioxidant effects. They also reduce the risk of diarrhea and can improve body weight and feed conversion (Urban et al., 2024). Bioactive compounds present in thyme also increase the secretion of endogenous digestive enzymes (protease, amylase and lipase) and stimulate the immune status of poultry because of their phenolic compounds (Hassan et al., 2024). These compounds also possess strong anticoccidial properties (Maustafa et al., 2020). Studies have shown that thymol, carvacrol and cinnamaldehyde contained in essential oils obtained from thyme and marjoram have antibacterial activity against *Escherichia coli* and *Salmonella typhimurium* (Hernandez et al.; Tavangar et al., 2021). Supplementation with a thermostable mixture containing 4.5 g cinnamaldehyde and 13.5 g thymol in feed replaced zinc bacitracin (a polypeptide antibiotic), improving growth, production-performance indicators and immune-system function in broiler chickens (Attia et al., 2019; Saartje Mandey and Nery Sompie, 2021). Supplementing broiler diets with a phytogenic product containing equal proportions of thymol and carvacrol at four inclusion levels (0, 60, 100 and 200 mg/kg feed) increased body-weight gain and feed utilization while reducing feed consumption. The additives also increased antioxidant and digestive-enzyme activity and improved the immune response, which may beneficially affect broiler health and performance (Hashemipour et al., 2013; Saartje Mandey and Nery Sompie, 2021). Deeb et al. (2024) showed that dietary supplementation with powdered thyme leaves at 1-3 g/kg improved body weight, daily weight gain and FCR in broilers, particularly at 2 g/kg. Powdered thyme in broiler diets was also studied by Hassan et al. (2024). The first experimental group received feed supplemented with 1% powdered thyme, while the second received 0.05% antibiotic growth promoter. Birds receiving the thyme-supplemented diet showed significant ($p<0.05$) increases in total body weight and daily weight gain and improved FCR compared with the control group throughout the 0-35-day experimental period. No differences ($p>0.05$) in performance parameters were found between the herbal additive and the antibiotic treatment. According to Noruzi et al. (2022), supplementation of broiler feed with thyme essential oil at 250 mg/kg had beneficial effects on feed intake, body-weight gain and final body weight. The results indicate that thyme can also be successfully used as an effective alternative to AGPs.

Ginger (*Zingiber officinale* Rosc.)

Ginger is a rhizomatous plant belonging to the *Zingiberaceae* family. For centuries it has been used by people as a popular culinary and medicinal raw material (Al-Khalaifah et al., 2022). The principal bioactive compounds in ginger are gingerol, gingerdiol and gingerdione. They exhibit anti-inflammatory, antioxidant, antibacterial and immunomodulatory activity (Apalowo et al., 2024). According to Saleh et al. (2014) and Al-Khalaifah et al. (2022), adding ginger to feed at 100 mg/kg effectively stimulated innate immunity by increasing the phagocytic capacity of heterophils and humoral immunity by increasing antibody production, thereby improving the immune profile of broiler chickens. Recent studies also indicate that powdered ginger has lipid-lowering effects and may be used as a safe substitute for antibiotic growth promoters in poultry production. Ginger supplementation in broiler diets produces effects comparable with antibiotic use, including reduction of pathogenic intestinal microbiota, improved feed intake and enhanced digestion and nutrient absorption (Al-Khalaifah et al., 2022). As a result, it can beneficially affect live body weight, daily gains and carcass yield (Irivboje et al., 2020).

In a 35-day study, Hassan et al. (2024) evaluated powdered ginger (1%) as an alternative to bacitracin (0.05% AGP) in terms of broiler production performance. Ginger supplementation significantly improved body weight, daily gains and FCR compared with the control group ($p < 0.05$), while no significant differences were observed relative to the antibiotic-supplemented group. These findings indicate that ginger may be an effective substitute for AGPs in poultry nutrition. Al-Khalaifah et al. (2022) also investigated the effect of powdered ginger on broiler production performance, including total body weight, weekly body-weight gain, feed intake and feed efficiency. Powdered ginger was included in the diet at 0, 5, 10 or 15 g/kg. The results showed that adding powdered ginger to feed, regardless of inclusion level, improved total body weight of broiler chickens at five weeks of age ($p < 0.001$) while reducing feed intake ($p < 0.031$), which is favorable from an economic perspective. Powdered ginger had no significant effect on feed utilization. In addition, analysis showed that total body-weight gain in birds receiving ginger was significantly higher than in control birds ($p < 0.048$).

Garlic (*Allium sativum* L.)

Garlic is a perennial bulbous plant of the genus *Allium* in the Liliaceae family (Abd El-Ghany, 2024). It has attracted considerable interest worldwide since ancient times. Because of its biologically active substances, it has been used for both medicinal and therapeutic purposes (Toghyani et al., 2011). Today, garlic is one of the most popular components of herbal preparations (Elbaz et al., 2022). Its principal active compounds are organosulfur compounds such as S-allyl cysteine sulfoxide (alliin), diallyl thiosulfinate (allicin) and diallyl sulfides (Ampode, 2019). These constituents exhibit antibacterial, antifungal, antiparasitic, antiviral, antioxidant, immunostimulatory, anticancer and antithrombotic activity, including vasodilation (Toghyani et al., 2011). The presence of these bioactive compounds also means that garlic can be successfully used as a plant-derived feed additive to improve growth efficiency in broiler chickens (Ahmad et al., 2011; Ismail et al., 2021). Numerous studies indicate that garlic is one of the most effective medicinal plants used in poultry nutrition, showing growth-promoting effects, improving blood biochemical parameters and gut health, and reducing mortality (Varmaghany et al., 2015; Karangiya et al., 2016; Elbaz et al., 2022; Shams-ul-Hayat et al., 2022).

Allicin, one of the active substances present in garlic (*Allium sativum* L.), with alliin as its precursor, has antimicrobial properties (Kim et al., 2013; Olukosi and Dono, 2014) and modifies the intestinal microbial population by reducing pathogenic gut microbiota (Olukosi and Dono, 2014). Garlic may be administered in feed or water in the form of powder, aqueous extract, essential oil and other commercial products available on the market (Abd El-Ghany, 2024). Shams-ul-Hayat et al. (2022) investigated the effect of garlic powder on feed intake, body-weight gain and feed conversion ratio. The study included four groups with different levels of garlic-powder supplementation: 0 (control), 0.3%, 0.6% and 0.9%. In the fourth week of life, significant differences were observed among groups ($p < 0.05$). The greatest body-weight gain was recorded in birds receiving 0.9% garlic, followed by 0.6%, the control group and 0.3%. The control group had the highest feed intake, whereas the 0.9% group had the lowest. Feed-use efficiency was best in the 0.9% group, followed by 0.6%, 0.3% and the control group. A similar study was conducted by Kairalla et al. (2022), in which broiler feed was supplemented for 42 days with garlic powder at 0.0%, 0.1%, 0.2% and 0.3%. Birds receiving 0.3% garlic in the feed achieved the best production results, with the highest body weight and the lowest FCR ($p < 0.05$), while feed intake did not differ significantly among groups. The beneficial effect of 0.3% garlic supplementation was also confirmed by Senthilkumar et al. (2015). However, those authors did not observe positive effects on body-weight gain, feed intake or FCR at the higher garlic dose of 0.6%. Supplementation with garlic powder at 0.125%, 0.5% and 1% throughout the 42-day experiment reduced the feed conversion ratio compared with the control group without garlic powder and the group receiving 2% garlic powder in the feed (Javandel et al., 2008).

Based on the findings of Javandel et al. (2008), it can therefore be concluded that the inclusion level of medicinal-plant additives in broiler nutrition has an upper limit.

The effectiveness of medicinal plants in broiler chicken rearing is variable. Many studies demonstrate beneficial effects on bird production performance, but other studies suggest that medicinal-plant additives have no effect and may occasionally even have adverse effects. Such variability may result from a range of factors, including supplementation level, route of administration, chemical composition, source and type of raw material, interactions with other dietary components, bird health status and even housing conditions.

Conclusion

The results of recent studies on the use of the medicinal plants discussed here as agents supporting growth and meat-poultry production are promising, despite a small number of studies that do not unequivocally confirm their effectiveness in improving bird performance. Owing to their properties, these plants reduce the need for antibiotics and may thereby contribute to improved public-health safety. The main effects of alternative medicinal-plant additives as growth modulators include supporting the immune system, improving digestion and thus increasing nutrient availability, exerting antibacterial and antioxidant effects, improving intestinal integrity and health, and shaping the host gut microbiota. However, further in-depth research will be required to understand their precise mechanisms of action and to establish appropriate standards for their use.

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MEDICINAL PLANTS AS AN ALTERNATIVE TO ANTIBIOTIC GROWTH PROMOTERS IN CHICKEN BROILER REARING

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SUMMARY

The use of antibiotics as a form of growth promoters and chemotherapeutics was, until recently, a common practice in poultry production. However, their overuse has led to the emergence and prevalence of the problem of bacterial antibiotic resistance, i.e., resistance to the bactericidal or bacteriostatic effects of antibiotics. As a result, a total EU-wide ban on the use of antibiotic growth promoters (AGPs) in feed for all livestock was introduced, effective 1 January 2006. However, this decision has had the unintended consequence of increasing animal infections and mortality. This turn of events, in turn, led to a sharp increase in the use of prescription antimicrobial drugs. To break the 'vicious circle' of antibiotic use in animal production, the search began for modern feeding strategies that would benefit the growth of animals (including poultry) without causing negative side effects. Numerous scientific studies have shown that one safe and effective alternative to AGP can be medicinal plants and products derived from them. The active ingredients contained in medicinal plants can exhibit antibacterial, antioxidant and immunomodulatory effects, resulting in positive effects on bird health and performance. This study aims to review the available literature on the possibilities and effects of using selected medicinal plants (oregano, thyme, ginger, garlic) as an alternative to AGP in the feeding of broiler chickens.

Keywords: antibiotic growth promoters (AGPs), medicinal plants, broiler chickens, production performance