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IMPACTS OF CINNAMON (*CINNAMOMUM ZEYLANICUM*) OIL AS FEED ADDITIVE ON PERFORMANCE, CARCASS CHARACTERISTICS AND INTESTINAL MICROBIOTA OF POULTRY

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ABSTRACT

The banning of antibiotics as feed additive growth promoters (AGPs) in poultry nutrition across various countries has driven researchers to explore alternative, safe, and effective solutions. Natural feed additives, such as eubiotics, phytogenic compounds, and immune boosters, along with essential oils (EOs), have gained considerable attention in the poultry industry. Among these, cinnamon is one of the earliest medical plants commonly employed for its numerous health benefits. It can be incorporated into poultry diets in either powdered form or as an essential oil. Cinnamon and its bioactive compounds, such as cinnamaldehyde and eugenol, have been studied extensively for their positive effects on poultry health. These components exhibit strong antibacterial properties, inhibiting harmful pathogens, while promoting beneficial intestinal bacteria like lactic acid producing bacteria and bifidobacteria. Essential oils derived from aromatic plants, including cinnamon oil, have demonstrated numerous bioactivities, including antimicrobial, antifungal, antioxidant, and hypocholesterolemic effects. Moreover, they can stimulate digestive enzyme activity, thereby enhancing nutrient absorption and overall poultry performance. Cinnamon essential oil, rich in volatile compounds such as cinnamaldehyde, eugenol, and carvacrol, has shown promise in improving poultry health by reducing disease risks and preventing spoilage in agricultural products. Its antimicrobial and insecticidal properties further contribute to its potential as a natural feed additive. Given these benefits, researchers have increasingly interested in evaluating the impact of cinnamon oil on poultry growth performance, carcass quality, and gut microbiota composition. This review aims to explore the functional roles of cinnamon essential oil in poultry production, highlighting its potential as a viable alternative to AGPs for improving productivity and overall bird health.

Keywords: Cinnamon, essential oil, poultry.

INTRODUCTION

The poultry production industry is a major sector of global agriculture, playing a crucial role in food production (Alagawany *et al.,* 2019a). The inclusion of natural feed additives with bioactive compounds in poultry diets have demonstrated promising results in enhancing growth performance and health (Alagawany *et al.,* 2018; Hussein *et al.,* 2019; Alagawany *et al.,* 2019b,c; Gado *et al.,* 2019; Reda *et al.,* 2020; Zhang *et al.,* 2024). Among these alternatives, EOs obtained from aromatic plants have gained attention as eco-friendly and cost-effective substitutes for antibiotics in poultry nutrition. Essential oils have long been

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utilized in various industries, including skincare (Gutiérrez *et al.,* 2008), aromatherapy, cosmetics (Price, 2003), herbal medicine (Lau *et al.,* 1998), and perfumery (Nielsen & Rios, 2000). They are recognized for their antimicrobial and insecticidal properties, which make them valuable in agricultural applications (Abd El-Hack *et al.,* 2020; Singh *et al.,* 2005). Additionally, some plant extracts have been found to enhance digestion and improve nutrient absorption (Ertas *et al.,* 2005). Also, EOs can enhance digestion and alleviate heat stress, along with acting against pathogens (Mahmoud *et al.,* 2025). Due to their natural origin, easy availability, and lack of toxic residues, herbs and their essential oils are increasingly considered as alternatives to AGPs Antibiotic Growth Promoters (AGPS) in poultry production (Al-Abdullatif *et al.,* 2023; Khan & Ahmad, 2023).

Cinnamomum zeylanicum, a member of the Lauraceae family, is one of the oldest medicinal herbs. Its essential oil (CEO) contains bioactive compounds like cinnamaldehyde and eugenol, making it a valuable plant-based additive with significant potential (Ali *et al.,* 2025). These compounds exhibit strong antibacterial activity against pathogens such as *Vibrio parahaemolyticus*, *Staphylococcus aureus*, *Salmonella* spp., and *Escherichia coli* (Chang *et al.,* 2001). Additionally, cinnamon oil possesses hypocholesterolemic, anti-oxidant, analgesic, antiulcer, and antifungal properties (Mastura *et al.,* 1999; Lin *et al.,* 2003; Entana and Alejandro, 2024). According to Wenk (2000), plant-based feed additives can inhibit the growth of harmful bacteria while supporting beneficial gut microbiota, ultimately improving poultry health and productivity.

2. Chemical composition

Frequent investigations had been performed to identify and quantify the biochemical constituents of EOs in various species of wild and true cinnamon, particularly in their bark and leaves (Schmidt *et al.,* 2006; Vazirian *et al.,* 2015; Kamaliroosta, 2012; Ainane *et al.,* 2019). Abdelwahab *et al.* (2017) reported that the primary components of cinnamon bark oil include linalool (36.0%), terpinen-4-ol (6.4%), limonene (8.3%), methyl eugenol (12.7%), alpha-terpineol (7.9 %) and total phenols (5.04%). The antioxidant capability was 345.20 μM Fe^{2+}/g with an IC50 of 38.50 μg/ml. Liyanage *et al.* (2017) found that leaves' oil of *Cinnamomum verum* contained the greatest percentage of volatile compounds (3.23%), whereas the greatest bark oil yield (3.52%) was detected in *Cinnamomum sinharajense*. Conversely, *Cinnamomum rivulorum* had the lowest oil content, with just 0.51% in the stem bark and 0.41% in the leaves. Across different cinnamon species, essential oils contain at least 15 significant volatile components. Notably, *Cinnamomum verum* had the highest cinnamaldehyde concentration (67.57%), while *Cinnamomum sinharajense* leaves contained the most eugenol (87.54%). Paranagama *et al.* (2001) determined the analysis of essential oil from different cinnamon plant parts and detected the mainly contained γ-cadinene (36.00%), T-cadinol (7.70%), and β-caryophyllene (5.60%), with sesquiterpenes making up 84.00% of CFO but less than 9.00% in other parts. In addition, phenylpropanoids were the predominant constituents in cinnamon oils of leaves and barks, while monoterpenes accounted for 95.00% of oil extracted from cinnamon root. Kasim *et al.* (2014) demonstrated that extraction methods significantly impact the yield and chemical composition of cinnamon oil. By using Soxhlet, the maximum oil harvest was obtained with dichloromethane (5.20%), followed by hexane (3.80%), and then by petroleum ether (3.70%). In contrast, hydrodistillation resulted in the minimal oil harvest (1.80%). CEO extracted via hydrodistillation contained nine major volatile compounds, including alcohols, ethers, esters, aldehydes, and ketones. Atiphasaworn *et al.* (2017) analyzed the volatile components of *Cinnamomum bejolghota* bark oil, identifying 36 constituents. This study was among the first to examine the antimicrobial properties of such oil. The minimum inhibitory concentration (MIC) against bacteria varied between 31.26 to 62.51 mg/L, while fungal pathogens exhibited moderate inhibition at MIC values of 125-500 µg/mL. Additional research by Adinew (2014) discovered six key compounds in cinnamon bark oil sourced from Tepi, Ethiopia. Şimşek *et al.* (2013) used hydrodistillation followed by GC and GC-MS analysis to examine *Cinnamomum zeylanicum* bark oil, identifying 12 major constituents, making up 99.2% of the total oil. The dominant components included 88% cinnamaldehyde, 1% eugenol, and 8% benzyl alcohol. Similarly, El-Baroty *et al.* (2010) found that *Cinnamomum zeylanicum* bark oil is a rich natural source of aromatic monoterpenes, with 45.6% trans-cinnamaldehyde as the primary compound. The most abundant component, 3-phenyl-2-propenal (87.01%), contributes significantly to the therapeutic properties and characteristic aroma of cinnamon bark oil.

Impacts on poultry growth

Numerous works have been conducted to evaluate the effects of supplementing poultry feeds with cinnamon in both powdered and oil forms, as well as its bioactive components, on growth performance. Al-Kassie (2009) reported that broilers consumed feed enriched with CEO gained more live weight than the control. Similarly, Sarica *et al.* (2009) demonstrated that incorporating CEO into quail diets had comparable effects to antibiotics, probiotics, enzymes, and mannanoligosaccharides in promoting live weight through the growing stage. Toghyani *et al.* (2011) observed that adding cinnamon powder at a concentration of 2 g/kg to broiler feed significantly improved final body weight. Likewise, Mehdipour *et al.* (2013) noted a significant increase (P=0.003) in BWG of quails aged 21–35 days when supplemented with 200 mg/kg of cinnamon oil, outperforming groups receiving cinnamon powder, antibiotics (virginiamycin), and symbiotics. Shirzadegan (2014) further confirmed that broiler chickens fed diets containing various concentrations of cinnamon powder, particularly at a 0.5% inclusion level, exhibited notable improvements in final body weight. Devi *et al.* (2018) also reported a significant (P<0.01) increase in broiler body weight at 42 days when diets were supplemented with CEO. Conversely, some studies have indicated no significant impact of CEO on poultry growth. Lee *et al.* (2003) found no changes in broiler weight gain as affected by cinnamaldehyde administration, though it significantly reduced water intake. Muhl & Liebert (2007) recorded insignificant changes in performance of broiler that fed diets containing cinnamaldehyde and other bioactive phytogenic compounds. Similarly, Koochaksaraie *et al.* (2011) found that cinnamon treatment (0.50–2.00 g/kg diet) exerted an insignificant effect on broiler growth. Further research by Tonbak & Çiftçi (2012) revealed that adding CEO (*Cinnamomum zeylanicum L.*) at doses of 250 or 500 ppm to quail diets, whether under heat stress or normal conditions, did not significantly impact live weight or weight gain. Symeon *et al.* (2014) also found no substantial differences in broiler body weight at market age, when CEO was included at 0.5 or 1.0 ml per kg of feed. Despite these mixed findings, alternative strategies have focused on improving poultry health by modulating intestinal microflora and preventing pathogenic bacterial spread. Essential oils, including cinnamon oil, enhance feed efficiency and growth performance by boosting immune function, regulating gut microbiota, stimulating the secretion of digestive enzymes, and exerting antioxidant and antimicrobial effects (Kishawy *et al.,* 2019; Saeed *et al.,* 2018; Mahgoub *et al.,* 2019; Abo Ghanima *et al.,* 2020).

3.2 Feed utilization

Research on the impacts of cinnamon oil on feed consumption (FC) and feed efficiency (FE) has yielded mixed results. While several studies (Mehdipour & Afsharmanesh, 2018; Pathak *et al.,* 2017; Şimşek *et al.,* 2015; Torki *et al.,* 2015;

Mehdipour *et al.,* 2013; Al-Kassie, 2009; Ciftci *et al.,* 2009) have demonstrated positive effects of cinnamon oil on FC and FE, others have found no significant impact. Al-Kassie (2009) reported that broiler fed diets containing 200 ppm of a thyme and cinnamon essential oil blend exhibited significant improvements in both feed utilization and feed consumption. Also, Ciftci *et al.* (2009) observed that broiler chicks consuming diets with 0.5 g/kg of CEO had the best FE compared to those fed diets without supplementation or with avilamycin (an antibiotic). Mehdipour *et al.* (2013) further noted that supplementing quail diets with 200 mg/kg of cinnamon oil significantly improved FE over a 35-day period, although FC remained unchanged. Şimşek *et al.* (2015) also found that adding CEO to poultry feeds significantly increased FE. Torki *et al.* (2015) highlighted that FE was substantially increased in cold-stressed laying hens by feeding them on diets supplemented with zinc and cinnamon EO, either individually or in combination. Pathak *et al.* (2017) demonstrated that feeding *E. coli*-challenged broiler chicks on a diet containing 125 ppm enramycin or on a diet containing 500 ppm of calcium formate + cinnamaldehyde exhibited significantly better FE compared to the control group, supporting the idea that essential oils and organic acids could serve as antibiotic alternatives. Likewise, Mehdipour & Afsharmanesh (2018) reported that supplementing quail diets with either cinnamon oil or virginiamycin (200 mg/kg) resulted in similar improvements in FE at day 35, though FC remained unaffected. Contradictory outcomes were detected by Pathak *et al.* (2017), Symeon *et al.* (2014), Tonbak & Çiftçi (2012), Sarica *et al.* (2009), Hernandez *et al.* (2004), and Lee *et al.* (2003), all of whom found no significant impact of cinnamon oil or powder on FC or FE. Lee *et al.* (2003) noted that while adding cinnamaldehyde in broiler diets did not influence FC or FE, it significantly reduced water intake. Hernandez *et al.* (2004) observed insignificant changes in FC or FE in broilers fed a diet supplemented with 200 ppm of essential oils from cinnamon, oregano, and pepper. Similarly, Tonbak & Çiftçi (2012) found that dietary addition of CEO (250 or 500 ppm) had no notable effects on the FE of either heat-stressed or non-stressed quail.

4. Carcass traits

Numerous studies have studied the influence of cinnamon essential oil on carcass traits, yielding either beneficial outcomes or no significant impact. Dalkilic *et al.* (2009) examined how CEO influences abdominal fat and liver fatty acid composition in broilers. They found that birds fed diets containing 500 or 1000 ppm of cinnamon oil had lower levels of saturated fatty acids (SFA) in liver lipids, while showing increased polyunsaturated fatty acids (PUFA), omega-3, and total fatty acids compared to those on a basal diet or receiving the antibiotic avilamycin. Conversely, Hernandez *et al.* (2004) reported no notable variations in the weight of the gizzard, proventriculus, pancreas, liver, and intestines in broilers fed diets with 200 mg/kg EO at 14 and 21 days of age. Similarly, Tonbak & Çiftçi (2012) found that supplementing quail diets with CEO at 250 or 500 mg/kg did not significantly alter carcass traits in either heat-stressed or non-stressed birds. Symeon *et al.* (2014) assessed the impact of cinnamon oil supplementation at 0.5 and 1.0 ml per kg in broiler diets, concluding that while CEO did not significantly influence carcass composition or internal organ weights, the highest cold carcass weight was observed by adding 0.5 ml CEO per kg diet. Likewise, Devi *et al.* (2018) found insignificant effects on carcass characteristics when essential oils from cinnamon and ajwain were included in broiler diets at 3 or 4 g per kg diet. Further, Gomathi *et al.* (2018) demonstrated that supplementing broiler diets with 250 or 500 mg/kg of cinnamon oil exerted inconsiderable effects on carcass yield %, abdominal fat %, or the relative weights of the liver, gizzard, heart, and giblets. Despite these findings, cinnamon's distinctive aroma is highly desirable in poultry diets.

Additionally, its inclusion has been linked to an increase in unsaturated fatty acid content in the carcass, while simultaneously reducing SFA levels, which may contribute to the overall improvement of meat quality.

5. Blood parameters

Numerous reports have highlighted the favorable impacts of CEO on blood biochemistry and hematology, particularly its influence on lipid profiles, antioxidant activity, and immune function. Research conducted by Al-Kassie (2009), Ciftci *et al.* (2010), and Faix *et al.* (2009) demonstrated that broilers fed diets enriched with CEO exhibited significant increases in serum catalase and glutathione peroxidase activity, accompanied by an increase in phagocytic activity. Conversely, CEO supplementation led to notable reductions in serum lipid peroxidation, cholesterol levels, and liver enzyme activity. Similarly, Yang *et al.* (2019) found that broilers consuming diets supplemented with varying concentrations of CEO (ranging from 50 to 800 mg/kg) either alone or in combination with bamboo leaf flavonoids (BLF) experienced significant ($P<0.05$) improvements in liver content of malondialdehyde (MDA) and increased serum immunoglobulin M. Likewise, Torki *et al.* (2015) noted cold-stressed layers that receiving CEO combined with zinc showed a marked decrease in serum triglyceride and glucose levels while exhibiting higher plasma zinc concentrations than those on a control diet. Furthermore, Sarica *et al.* (2009) proposed that quails receiving feed enriched with a combination of oregano essential oil (OEO), CEO, or mannan-oligosaccharides experienced a significant reduction in blood levels of triglycerides and total cholesterol, compared to birds on a basal diet. Supporting this, Abudabos *et al.* (2018) observed that broilers challenged with pathogenic bacteria *(Clostridium perfringens*) and fed on diets containing essential oils exhibited increased levels of plasma MDA, total protein, and globulin. However, conflicting findings were reported by Lee *et al.* (2003), who found no significant alterations in blood lipid profile due to dietary cinnamaldehyde treatment. The cholesterol-lowering effects observed in EO-fed groups may be attributed to the inhibition of a key enzyme in cholesterol biosynthesis (3-hydroxy-3-methylglutaryl coenzyme A) (Elson *et al.,* 1989; Goldstein & Brown, 1990). Additionally, active compounds found in spices have been documented to reduce lipid oxidation (Naidu, 1995). Through this mechanism, essential oils help protect cell membranes from oxidative damage, ultimately reducing malondialdehyde formation.

Gastrointestinal microbiome

The antimicrobial properties of CEO have been extensively examined by researchers, including Yang *et al.* (2019), Mehdipour & Afsharmanesh (2018), Pathak *et al.* (2017), El-Baroty *et al.* (2010), Gupta *et al.* (2008), and Gende *et al.* (2008). The majority of these studies confirm that CEO exhibits strong antimicrobial effects and holds great potential as a natural food preservative. Yang *et al.* (2019) found that supplementing broilers' feed with 100 ppm CEO reduced ($P<0.05$) *Escherichia coli* populations in the cecum, while increasing the relative abundance of *Lactobacillus* and *Bifidobacterium*. This suggests that CEO may serve as an effective alternative to antibiotics (such as aureomycin) in modulating the broiler gut microbiota. Similarly, Mehdipour & Afsharmanesh (2018) reported that quails fed CEO (200 ppm/kg diet) exhibited a reduction in ileal coliform counts and an increase in *Lactobacillus* populations. Gupta *et al.* (2008) conducted *in vitro* research demonstrating the strong inhibitory effects of CEO against pathogenic microorganisms. Their study also concluded that CEO exhibited higher antimicrobial potency compared to cinnamon extract. Conversely, Pathak *et al.* (2017) found no significant impact on total bacterial counts, *Lactobacillus*, or *E. coli* populations in the intestine of broiler receiving diets with 500 ppm of calcium formate + cinnamaldehyde. However, they observed a significant reduction in *Salmonella* counts. The antimicrobial properties of CEO are primarily attributed to its volatile compounds, with cinnamaldehyde being the predominant component, along with eugenol and carvacrol compounds. These bioactive components possess notable antimicrobial properties (Basilico & Basilico, 1999). Carvacrol, in particular, is known to alter the pH balance of inorganic ions by disrupting membrane integrity (Lambert *et al.,* 2001). Additionally, cinnamaldehyde, eugenol, and carvacrol have been shown to exert antibacterial effects by inhibiting pathogenic microorganisms (Hernandez *et al.,* 2004). Beyond its antimicrobial effects, CEO and other plant-derived extracts play a crucial role in suppressing harmful bacterial growth while promoting beneficial gut microbiota in poultry (Wenk, 2000). Overall, CEO supplementation in poultry diets has demonstrated positive effects on growth performance, lipid metabolism, antioxidant activity, immune function, and microbial balance.

CONCLUSION

This study highlights the significant benefits of incorporating CEO extracts as feed additives in poultry diets. CEO supplementation has been shown to enhance growth performance, reduce cholesterol levels, boost antioxidant activity, strengthen immunity, and improve microbial balance. The findings suggest that cinnamon serves as a promising natural alternative to antibiotics, offering a safer and more environmentally friendly option for poultry production, while also being economically viable. However, due to the limited number of studies and variations in experimental conditions, further high-quality research is needed to establish more precise and comprehensive recommendations for its optimal use.

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تأثير زيت القرفة كإضافة علفية على الأداء وخصائص الذبيحة والمحتوى الميكروبي للأمعاء في الدواجن

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أدى حظر استخدام المضادات الحيوية كإضافة علفية محفزة للنمو في تغذية الدواجن في العديد من الدول إلى دفع الباحثين لاستكشاف بدائل آمنة وفعالة، وقد حظيت الإضافات العلفية الطبيعية، مثل الايوبيوتكس والمركبات النباتية والمحفزات المناعية والزيوت العطرية باهتمام كبير في صناعة الدواجن، ومن بين هذه البدائل تُعد القرفة واحدة من أقدم النباتات الطبية التي استخدمت على نطاق واسع لفوائدها الصحية العديدة، ويمكن إدخال القرفة في علائق الدواجن إما على شكل مسحوق أو زيت أساسي، وقد تمت دراسة تأثير القرفة ومركباتها النشطة بيولوجيًا مثل سينمالدهيد والأوجينول على نطاق واسع بسبب تأثيراتها الإيجابية على صحة الدواجن، حيث أظهرت هذه المركبات خصائص قوية مضادة للبكتيريا، مما يساعد على تثبيط مسببات الأمراض الضارة وتعزيز نمو البكتيريا النافعة في الأمعاء، مثل بكتيريا حمض اللاكتيك والبيفيدوباكتيريا، لقد أثبتت الزيوت العطرية المستخلصة من النباتات، بما في ذلك زيت القرفة، قدرتها على تحقيق العديد من الفوائد البيولوجية، مثل الخصائص المضادة للميكروبات والفطريات، والتأثيرات المضادة للأكسدة، وخفض مستويات الكوليسترول، علاوة على ذلك، فإنها تحفز نشاط الإنزيمات الهاضمة، مما يعزز امتصاص العناصر الغذائية ويحسن الأداء العام للدواجن، ويُعد زيت القرفة العطري غنيًا بالمركبات المتطايرة مثل سينمالدهيد، وأوجينول، وكارفاكرول، والذي أظهر نتائج واعدة في تحسين صحة الدواجن من خلال تقليل مخاطر الإصابة بالأمراض ومنع تلف المنتجات الزراعية، كما أن خصائصه المضادة للميكروبات والحشرات تعزز من إمكاناته كمضاف علفي طبيعي، ونظرًا لهذه الفوائد، زاد اهتمام الباحثين بدراسة تأثير زيت القرفة على النمو وجودة الذبيحة والمحتوى الميكروبي للأمعاء في الدواجن. تهدف هذه المقالة المرجعية إلى استكشاف الأدوار الوظيفية لزيت القرفة العطري في إنتاج الدواجن، مع تسليط الضوء على إمكانية استخدامه كبديل فعال للمضادات الحيوية كمحفزات النمو، مما يسهم في تحسين إنتاجية الدواجن وصحتها العامة.