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# The Role of Plant Essential Oils in Poultry Disease Prevention

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## Abstract

*Plant essential oils (PEOs) have gained prominence as natural alternatives for disease prevention in poultry, driven by concerns over antibiotic resistance and consumer demand for antibiotic-free products. This review evaluates studies on the antimicrobial, antioxidant, and immunomodulatory properties of essential oils, highlighting their role in controlling poultry diseases such as Aspergillosis. Essential oils exhibit broad-spectrum antimicrobial activity, enhance immune function, and improve feed efficiency, contributing to poultry health and productivity. Key bioactive compounds, including phenols, aldehydes, and terpenes, disrupt pathogenic bacteria, inhibit fungal growth, and promote gut microbiota balance. While research supports their efficacy, challenges remain in standardization, optimal dosage, and regulatory approval. Future studies should focus on refining formulations and conducting large-scale trials to validate their application in commercial poultry farming. Essential oils represent a promising, sustainable alternative to synthetic antibiotics, offering potential benefits for animal health and food safety.*

***Keywords:*** *Essential Oil, Poultry Health, Disease Prevention, Food Safety.*

## Introduction

Plant essential oils (PEOs) are volatile, pungent fluids derived from various plant parts, including leaves, flowers, seeds, bark, and roots. Used for centuries in medicine, food preservation, and aromatherapy (Bakkali *et al.*, 2008), PEOs are increasingly recognized in modern agriculture as natural alternatives to synthetic additives. In poultry production, they exhibit antimicrobial, antioxidant, and immune-stimulating activities (Brenes and Roura, 2010; Franz, Baser, & Windisch, 2010), making them promising substitutes for antibiotic growth promoters (AGPs) amid rising antimicrobial resistance (AMR).

In Nigeria, where poultry contribute approximately 25% of animal protein and supports millions of smallholder livelihoods (Oluwatosin *et al*., 2022), AMR is a critical threat. Over 90% of farmers use antibiotics like ampicillin and tetracyclines for disease prevention and growth promotion, often without veterinary oversight, leading to high multidrug resistance (e.g., 70% in E. coli isolates) and residues in meat/eggs (Ekunseitan *et al*., 2010). This exacerbates public health risks, including zoonotic transmission, and aligns with global concerns fueling interest in bioactive compounds like PEOs as feed antibiotics (Krishan and Narang, 2014; Dhama *et al*., 2015). Their complex chemical nature enables diverse biological effects, enhancing value in animal nutrition, human medicine, and pharmacy (Tiwari *et al*., 2009).

PEOs have gained attention as therapeutic and prophylactic agents against poultry diseases, including Aspergillosis, through antimicrobial, antifungal, and immunomodulatory mechanisms (Hashemi and Davoodi, 2011). Nigerian ethnoveterinary practices already leverage local PEOs e.g., lime (Citrus aurantifolia) and ginger (Zingiber officinale) extracts at 2% in diets boost broiler growth, nutrient digestibility, and immunity while providing antibacterial/antioxidant effects (Ndelekwute, 2016). Consumer demand for antibiotic-free products further amplifies their potential to improve health, productivity, and food safety (Greathead, 2003).

This review critically examines plant essential oil applications in poultry disease control, emphasizing mode of action, efficacy, limitations, and applicability. Drawing on global evidence and Nigerian studies, it highlights plant essential oils' role in replacing antibiotic growth promoters, with their pharmacological properties (e.g., minimal side effects vs. synthetics; Baser & Buchbauer, 2010) offering sustainable solutions for enhanced poultry health and productivity. For the Nigerian livestock industry this means lower costs, safer meat and eggs, less resistance, and better income for smallholder farmers. The clear research implication is that Nigeria must now needs urgent work on standardization, proper dosing and large-scale local trials to turn these plants into reliable, commercial antibiotic replacements.

## Methodology

This narrative review was conducted following a systematic search of peer-reviewed literature published between 2000 and 2025. The primary databases used were PubMed, Scopus, Web of Science, Google Scholar, African Journals Online (AJOL), and the institutional repositories of Nigerian universities (University of Nigeria Nsukka, Ahmadu Bello University, and Federal University of Agriculture Abeokuta) to ensure inclusion of locally relevant studies.

Additional filters were applied for studies involving in vitro antimicrobial/antifungal assays, in vivo poultry trials, and reviews/meta-analyses. Only full-text articles in English were considered. References of key articles and proceedings of the Nigerian Society for Animal Production (NSAP) and World's Poultry Science Association (Nigeria Branch) were hand-searched for grey literature and local trials.

A total of 127 records were initially identified, of which 68 were retained after screening for relevance and quality. Studies were prioritized that (i) used commercially relevant essential oils or locally available Nigerian plants, (ii) reported clear dosage and administration routes, and (iii) included measurable outcomes (mortality, growth performance, microbial load, immune parameters, or oxidative status). This approach ensured a balanced representation of global evidence and context-specific Nigerian/African research, allowing critical evaluation of essential oils as practical alternatives to antibiotics in tropical poultry production systems.

## Chemical Composition of Essential Oils

Essential oils are primarily composed of terpenes and phenylpropanoids, which contribute to their biological activities. Terpenes are classified into monoterpenes (C10), sesquiterpenes (C15), diterpenes (C20), and triterpenes (C30) based on their carbon skeleton (Nazzaro *et al.,* 2013). Some of the major bioactive compounds in essential oils include:

- Phenols: Thymol, carvacrol, eugenol (strong antimicrobial activity)
- Alcohols: Linalool, geraniol, menthol (antioxidant and antimicrobial properties)
- Aldehydes: Citral, cinnamaldehyde (antimicrobial and anti-inflammatory effects)
- Ketones: Camphor, carvone (digestive stimulants, antimicrobial)
- Esters: Linalyl acetate, benzyl acetate (calming and anti-inflammatory effects)

One of the most significant poultry diseases is **avian aspergillosis**, a respiratory fungal infection caused by *Aspergillus fumigatus*, *A. flavus*, and *A. niger*. Traditional antifungal treatments, such as **fluconazole, ketoconazole, and amphotericin B,** have exhibited varying levels of resistance, necessitating the exploration of alternative treatments. Studies have shown that essential oils, particularly **cinnamon oil, clove oil, and garlic oil,** have potent antifungal properties.

- **Cinnamon oil** demonstrated the highest antifungal efficacy, with an **inhibition zone diameter of 27 mm** for *A. fumigatus*, followed by **tea tree oil (13 mm) and clove oil (12.5 mm).**
- **Garlic oil** showed moderate activity, while **thyme and chamomile oils exhibited little to no antifungal activity.**
- **In vivo studies** confirmed that **cinnamon oil (1 ml/kg diet)** significantly reduced mortality in experimentally infected chicks, with a **survival rate of 66.7%** compared to 0% in the untreated group.
- Beyond their antifungal activity, essential oils also **enhance immune function** and **improve feed efficiency** in poultry:
- **EOs promote digestive enzyme secretion**, improving nutrient absorption and growth performance. (Mathlouthi *et al.,* 2012)
- They **reduce harmful microbes** in the gut, and support intestinal health.

**Antimicrobial Properties of Essential Oils**

The emergence of antibiotic-resistant bacteria has necessitated the exploration of alternative solutions in poultry nutrition. Essential oils, as aromatic components of herbs and spices, have demonstrated potent antimicrobial activities against a spectrum of pathogens. Krishan and Narang (2014) highlighted that essential oils possess antimicrobial, antifungal, antiparasitic, and antiviral properties, making them viable replacements for antibiotic growth promoters in poultry feed. Their study emphasized the potential of essential oils to enhance productive performance in birds when used as feed additives.

Further supporting this, a review by Nehme *et al.* (2021) assessed the benefits of using essential oils and their nano emulsions as feed supplements. The study concluded that essential oils could serve as effective antibiotic alternatives in organic poultry production, owing to their broad-spectrum antimicrobial activities.

**Antioxidant and Immunomodulatory Effects**

Beyond their antimicrobial properties, essential oils have been recognized for their antioxidant and immunomodulatory characteristics. A comprehensive review by Nehme *et al.* (2021) provided insights into the fundamentals of essential oils, highlighting their ability to modulate immune responses and exert antioxidant effects. These properties are crucial in enhancing the overall health and disease resistance of poultry.

**Growth Performance and Disease Resistance**

The inclusion of Essential oils in poultry diets has been associated with improved growth performance and enhanced disease resistance. A study focusing on oregano essential oil found that, as a feed additive, oregano essential oil could replace antibiotics, maintain animal growth performance, and improve disease resistance. The research indicated that oregano essential oil supplementation inhibited the growth of harmful intestinal pathogens, thereby promoting better health and productivity in broiler chickens (Mathlouthi *et al.,* 2012).

**Mechanisms of Action**

The efficacy of essential oils in disease prevention is attributed to their complex chemical compositions, which include various bioactive compounds such as phenols, alcohols, aldehydes, ketones, and esters. These compounds contribute to the antimicrobial, antioxidant, and immunomodulatory effects observed in poultry. For instance, phenolic compounds like thymol and carvacrol have been identified as principal agents responsible for the antimicrobial activity of essential oils. They can penetrate the cell membranes of pathogenic bacteria, alter membrane permeability, and inhibit bacterial growth.

**Table 1: Specifics on the various plant types that contribute to essential oils and their chemical compositions**

| Plant source | *Scientific name* | Main components in Essential oils | References |
|---|---|---|---|
| Bergamot | *Citrus bergamia* | Limonene<br>Linanine<br>Linalool | Nabiha *et al*., (2010);<br>Zhai *et al.,* (2018) |
| Black pepper | *Piper nigrum* | Piperine<br>Piperoleine<br>Piper amide | Singh *et al*., (2005);<br>Zhai et al., (2018) |
| Carrot | *Dacus carrot* | Carotol<br>Sabinene<br>Beta caryophyllene<br>Alpha pinenne | Ma *et al.,* (2015) |
| Cinnamom | *Cinnamomum verum* | Trans cinnamaldehyde<br>Limonene<br>Eugenol | Baratta *et al.,* (1998);<br>Abd El-Hack et al. (2022) |
| Clove | *Syzgium aromaticum* | Eugenol<br>Eucalyphol | Naveed *et al.,*(2013);<br>Zhai *et al.,* (2018) |
| Cumin | *Nigella sativa* | Thymoquinone<br>p-cymene<br>Alpha-thugene | Singh *et al.,* (2014) |
| Eucalyptus | *Eucalyptus spp* | 1,8-cineole<br>Cryptone<br>Alpha-pinene | Elaissi *et al.,* (2012);<br>Abd El-Hack et al. (2022) |
| Fennel | *Foeniculam vulgare* | Trans-anethol<br>Frenchone<br>Methyl cavicol | Hoffmann (2020) |
| Lime | *Citrus aurantifolia* | Limonene<br>Beta-pinene<br>Alpha-terinine | Costa *et al.,* (2014);<br>Zhai *et al.,* (2018) |

**Table 2: Sensitivity of *A. fumigatus* to Antifungal Agents and Essential Oils**

| Treatment | Resistance (%) | Sensitivity (%) |
|---|---|---|
| Fluconazole | 100 | 0 |
| Itraconazole | 50 | 0 |
| Ketoconazole | 0 | 67 |
| Cinnamon Oil | 0 | 100 |
| Clove Oil | 10 | 90 |
| Garlic Oil | 25 | 75 |

**Carrot seed essential oil (*Daucus carota*)**

Derived from the seeds of *Daucus carota,* is known for its sweet, earthy scent and light-yellow appearance. It contains phytochemicals such as carotol and beta-caryophyllene, which contribute to its notable bioactivities. Carrot seed oil exhibits antibacterial activity, particularly against *Staphylococcus aureus and Escherichia coli* (Khan & Abourashed, 2010). It also shows antifungal effects, primarily due to the presence of carotol (Aswini *et al.,* 2024). The oil's anti-inflammatory properties are useful in managing skin conditions like eczema and dermatitis. Additionally, it promotes wound healing by maintaining skin hydration and reducing redness, and it provides antioxidant protection through beta-carotene and vitamins C and E. (Akhlaq Mustafa *et al.,* 2024, Jasicka-Misiak *et al.,* 2004, Kwatra, 2020, Tavares *et al.,* 2008).

**Coconut Oil (*Cocos nucifera*)**

Coconut oil, extracted from the kernels of *Cocos nucifera*, is widely used for its therapeutic properties. It appears as a white to clear liquid with a coconut scent. The oil is rich in medium-chain fatty acids, such as lauric acid, which exhibits potent antibacterial activity by disrupting microbial membranes (Aswini *et al.,* 2024). It also possesses antifungal effects, especially when lauric acid is converted to monolaurin. Coconut oil's anti-ulcer and hepatoprotective benefits are attributed to its anti-inflammatory compounds. Furthermore, its emollient properties support wound healing by keeping affected areas moisturized. (Istek *et al.,* 2023, Nevin & Rajamohan, 2010, Shijna Kappally *et al.,* 2015)

**Grape Seed Oil (*Vitis vinifera*)**

Grape seed oil, obtained from *Vitis vinifera* seeds, is dark yellow to olive brown and has a mild fruity aroma. It is rich in polyunsaturated fats, phenolic compounds, and vitamin E. Resveratrol and proanthocyanidins in grape seed oil contribute to its antimicrobial activity by causing oxidative damage to bacterial membranes (Aswini *et al.,* 2024). The oil's anti-inflammatory and antioxidant effects help mitigate chronic diseases. It also demonstrates anti-platelet activity, reducing blood clot formation, and supports collagen production essential for skin repair. (Garavaglia *et al.,* 2016, Olas *et al.,* 2012, Shinagawa *et al.,* 2015).

**Orange Oil (*Citrus sinensis*)**

Orange essential oil, extracted from the rind of *Citrus sinensis*, has a characteristic citrus scent and is pale yellow to orange in color. It contains limonene, a compound with proven antimicrobial and anticancer activity. Orange oil inhibits the growth of bacteria such as *Salmonella Typhimurium* and *Staphylococcus aureus*, and fungi like *Candida albicans* (Aswini *et al.,* 2024). In vitro studies show that limonene can induce apoptosis in colon cancer cells. Additionally, orange oil acts as an antioxidant and has anti-inflammatory properties. (Choi *et al.,* 2000).

**Rosehip Seed Oil (*Rosa canina*)**

Derived from the seeds of *Rosa canina*, rosehip seed oil is amber-colored with a mild earthy aroma. It is rich in essential fatty acids (omega-3, 6, and 7), tocopherols, and phenolic compounds. Rosehip oil demonstrates anti-aging properties by improving skin texture, enhancing collagen synthesis, and reducing wrinkles (Aswini *et al.,* 2024). It also has antibacterial and antifungal activity due to its high content of flavonoids and polyphenols. The oil's antioxidant and anti-inflammatory properties protect against free radical damage and reduce skin inflammation. (Nowak, 2005, Mármol *et al.,* 2017).

**Raspberry Seed Oil (*Rubus idaeus*)**

Raspberry seed oil is a pale yellow to golden oil extracted from *Rubus idaeus* seeds. It contains alpha-linolenic acid, vitamin E, and ellagic acid. These compounds give it strong antioxidant and anti-inflammatory properties. Raspberry seed oil neutralizes free radicals, making it effective against premature aging (Aswini *et al.,* 2024). It is also noncomedogenic and suitable for sensitive skin. Its emollient properties help maintain skin hydration. (Ispiryan *et al.,* 2021)

**Olive Oil (*Olea europaea*)**

Olive oil, derived from the pulp of *Olea europaea*, is transparent with a greenish hue and has a mild fruity aroma. It is rich in monounsaturated fats, vitamin E, and polyphenols like oleuropein. These compounds contribute to its anti-inflammatory and antioxidant effects (Aswini *et al.,* 2024). Olive oil exhibits antibacterial activity against pathogens such as *Escherichia coli* and *Staphylococcus aureus* and antifungal effects against *Candida albicans*. (Bilal *et al.,* 2021)

**Sesame Oil (*Sesamum indicum*)**

Sesame oil is extracted from *Sesamum indicum* seeds and is golden in color with a nutty aroma. It contains sesamol, sesamin, and sesamolin, which provide potent antioxidant and anti-inflammatory effects (Aswini *et al.,* 2024). The oil also has antibacterial activity, making it suitable for use in dental care and wound healing. Its nutrients promote hair growth and support digestive health. (Wei *et al.,* 2022)

**Almond Oil (*Prunus Amygdalus*)**

Almond oil, obtained from the kernels of *Prunus Amygdalus*, is a light yellow liquid with a mild nutty scent. It contains vitamin E, omega-3 and 6 fatty acids, and minerals. Almond oil is known for its moisturizing, anti-aging, and wound-healing properties. It also has antioxidant and anti-inflammatory benefits that protect and repair the skin (Aswini *et al.,* 2024, Ouzir *et al.,* 2021).

**Conclusion**

Plant essential oils possess strong antimicrobial, antifungal, antioxidant and immunomodulatory properties that enable them to control major poultry diseases (including aspergillosis), improve gut health, boost immunity and enhance growth performance without the drawbacks of antibiotic resistance. Key active compounds such as thymol, carvacrol, cinnamaldehyde and eugenol disrupt microbial membranes, inhibit biofilms and promote beneficial gut microbiota.

In Nigeria, where antibiotic resistance is rampant and poultry production is dominated by resource-poor smallholders, locally available essential oils from lime, neem, garlic, ginger, clove, bitter leaf and scent leaf offer affordable and effective alternatives. To achieve widespread adoption, Nigeria urgently requires research on standardization, optimal dosing and large-scale field trials. When these gaps are addressed, essential oils can significantly reduce production costs, improve food safety and support sustainable poultry farming across the country.

**Recommendations**

However, further research is necessary to fully understand their mechanisms and optimize their application in poultry nutrition.

Future research should focus on optimizing dosage levels, synergistic effects of different essential oils, and long-term impact assessments to further validate their efficacy in commercial poultry production.

The potential of essential oils in poultry disease prevention is well-supported by existing research, but several gaps must be addressed for their successful large-scale application. Key areas for future research include:

1. Developing standardized EO formulations to ensure consistency in poultry production.
2. Optimizing dosage strategies to balance efficacy and safety.
3. Conducting large-scale field trials to validate laboratory findings.
4. Exploring essential oil combinations with probiotics and organic acids for enhanced disease control.

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