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## Phytogenic Feed Additives in Poultry Nutrition: Preparation, Mechanisms of Action and Applications for Sustainable Production

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The worldwide ban on the use of antibiotic growth promoters has stimulated research on phytogenic feed additives as natural alternatives to improve chicken health and production. Phytogenic additives are herbs, spices, botanicals, plant extracts and essential oils that are rich in physiologically active substances such as terpenoids, polyphenols, flavonoids, alkaloids and sulfur-containing metabolites. These chemicals have antibacterial, antioxidant, immunomodulatory, digestive-stimulatory and stress relieving activities. Inclusion of these products in poultry diets has been related with improved feed utilization, gut microbial balance, immunological responsiveness, growth performance, carcass parameters and product quality. The present review is aimed to give a detailed account of herbal feed additives including their classification, mode of action, functional properties and their use in poultry nutrition, highlighting their potential contribution towards sustainable and antibiotic-free poultry production systems.

**Keywords:** Antioxidants; essential oils; growth promoters; gut health; Medicinal herbs; Phytogenic feed additives; Poultry nutrition

### Introduction

Poultry production worldwide is one of the fastest expanding industries of livestock production and plays a vital role in satisfying the increasing demand for high grade animal protein. In recent years, customers have shown a growing preference for poultry meat and eggs that have been grown without antibiotic growth promoters. This has led to an increased demand for safe, natural and sustainable feed additives that can improve production and improve animal health (Lestari et al., 2020). As the problem of antimicrobial resistance increases, the Food and Agriculture Organization highlights the need to reduce the use of antibiotics in food-producing animals. However probiotics and prebiotics are considered as alternatives but phytogenic feed additives have been received particular interest because of their broad spectrum of biological activity (Quideau et al., 2011). Medicinal plants such as tulsi, cinnamon, thyme, ginger, ashwagandha, moringa are known to exhibit antibacterial, antioxidant, and immunomodulatory activities owing to their bioactive ingredients. These characteristics are advantageous for poultry health and may be related to improved quality of meat and eggs (Rahul et al., 2014).

### Herbal feed additives

Herbal feed additives include herbs, spices, botanicals and essential oils for animal feed. These additives are obtained from different sections of plants, such as leaves, roots, bark, fruits and seeds. Herbs are herbaceous plants which are non-woody and are valued for their medicinal, aromatic and flavourful qualities. Spices are fragrant compounds obtained from

plants and used for seasoning and preservation (Manach et al., 2004). In contrast, botanicals are therapeutic medicines derived from particular plant parts. Essential oils are volatile aromatic compounds extracted from medicinal plants and largely used in the pharmaceutical, culinary and animal feed sectors. Plants synthesize several secondary metabolites which are natural defensive compounds. The main categories into which these metabolites are classified throughout the categorization process are terpenoids, phenolic compounds, alkaloids and sulfur containing substances. Many of these chemicals have antibacterial and antioxidant capabilities and have a positive effect on the metabolic processes of animals, the health of their intestinal tract and their productivity as a whole (Quideau et al., 2011).

### Functional Importance of Herbs

The bioactive elements are the main determinants of the biological efficiency of phytogetic feed additives. Compounds such as cinnamaldehyde, thymol, eugenol, carvacrol, citral and flavonoids affect the physiology of the digestive system, microbial ecology and immunological function. These chemicals increase feed palatability, promote digestive secretions and improve the digestion and absorption of nutrients. Essential oils have antibacterial properties through disturbance of bacterial cell membranes and cellular metabolic processes. Due to their lipophilic nature they penetrate the membrane structures, causing leakage of the cellular contents and finally to the death of the microbes. In addition, phytogetic chemicals display antioxidant action, scavenging reactive oxygen species and protecting tissues against oxidative stress. Improved gut architecture, increased nitrogen utilization, stimulated immune responses and regulation of intestinal microbiota, together promote growth performance (Hammer et al., 1999). Herbal products are known for their antibacterial, immunomodulatory, anti-inflammatory and therapeutic activities. Polyphenols and flavonoids of plants possess antioxidant, antimicrobial and health-promoting properties. Terpene-rich essential oils have been observed to boost growth performance, reduce pathogenic bacteria populations and improve feed efficiency (Burt and Reinders, 2004). Carotenoid-rich plant products also enhance skin pigmentation, antioxidant status and immunological function.

**Table 1: Beneficial effect of some important herbs**

Plant	Used Parts	Active Component	Function
Nutmeg ( <i>Myristica fragrans</i> )	Seed	Sabinene	Digestion stimulant, antidiarrhoeic
Cinnamon ( <i>Cinnamomum zeylanicum</i> )	Bark	Cimetaldehyde	Appetite and digestion stimulant, antiseptic
Cloves ( <i>Syzygium aromaticum</i> )	Cloves	Eugenol	Appetite and digestion stimulant, antiseptic
Cumin ( <i>Cuminum cyminum</i> )	Seed	Cuminaldehyde	Digestive, carminative, galactogogue
Coriander ( <i>Coriandrum sativum</i> )	Leaves and seed	Linalol	Digestion stimulant
Pepper ( <i>Piper nigrum</i> )	Fruit	Piperine	Digestion stimulant
Capsicum ( <i>Capsicum annuum</i> )	Fruit	Capsaicin	Digestion stimulant
Ginger ( <i>Zingiber officinale</i> )	Rizome	Zingerone	Gastric stimulant
Mustard ( <i>Brassica Nigra</i> )	Seed	Allyl izotiociana t	Digestion stimulant
Garlic ( <i>Allium sativum</i> )	Bulb	Alkin	Digestion stimulant, antiseptic
Fenugreek ( <i>Trigonella foenum-graecum</i> )	Seed	Trigonelline	Appetite stimulant
Mint ( <i>Mentha piperita</i> )	leaves	Menthol	Appetite and digestion stimulant, antiseptic

### Relevance in the Era of Antimicrobial Resistance

The rising prevalence of antimicrobial resistance and multidrug-resistant infections, along with the adverse effects of antibiotic usage, has heightened the need for alternative therapeutic approaches. Herbal medications are gaining recognition as a viable alternative, owing to their rich supply of bioactive compounds that exhibit antibacterial, antioxidant, and

gut health-promoting properties. Beneficial lactic acid bacteria within the gut microbiota are crucial for maintaining gut health and preventing the colonization of pathogens. In contrast to traditional antibiotics, herbal feed additives have shown the ability to specifically target and inhibit harmful bacteria like *Escherichia coli*, while preserving the beneficial gut flora. The bioactive elements present may contribute positively to gut health by engaging in antibacterial and antioxidant processes (Rahul et al., 2014; Nono et al., 2017). Furthermore, it has been noted that herbal supplements enhance immunological function, oxidative stress, growth performance, and meat quality in poultry. Herbal-based antimicrobial agents present a sustainable and effective alternative to traditional antibiotics in poultry production.

### Applications of Herbs in Poultry Nutrition

The Indian broiler business has undergone a phenomenal rise due to the increasing demand of poultry meat which is known to be cost effective and nutritionally balanced source of animal protein. The application of medicinal plants and herbal feed additives in broiler diets is becoming more important due to their growth stimulating effects and their possible role in reducing antimicrobial resistance. In chicken production, essential oils are recognized as good natural growth promoters. Herbal oils from plants such as *Thymus vulgaris*, *Rosmarinus officinalis* and *Origanum majorana* have antibacterial qualities that help digestive health, improve the quality of meat and extend its shelf life. The positive effects are mainly related to phenolic compounds and polyphenols, which show antibacterial, antioxidant, anti-inflammatory and lipid-lowering activities (Alberto et al., 2004; Cubuk et al., 2006). Carotenoids are commonly used to increase the pigmentation of broiler skin, an important quality trait affecting consumer choice. In addition to boosting pigmentation, carotenoids have antioxidant, anti-inflammatory and immunomodulatory activities that contribute to better poultry health and performance (Chew and Park, 2004).

**Table 2. The beneficial effects of herbal supplementation on broiler chickens**

Herbal supplements	Delivery routes	Optimum dose	Impacts on broilers	References
<i>Dill seed and hemp</i>	Feed	0.3 % Hemp: 0.3 Dill seed	It improved bird intestinal health and serum lipid profile.	Mayur et al., 2019
<i>Decocted turmeric</i>	Drinking water	25-100% of drinking water	Improved immune competences (leukocyte profile) and stress response (H/L ratio) of broilers	Isroli et al (2017)
<i>Combination of Moringa oleifera leaf powder and garlic powder</i>	Feed	1% of feed	Reduced ileal Enterobacteriaceae population and abdominal fat content and of broilers	Sugiharto et al (2018)
<i>Nigella sativa powder</i>	Feed	4% of feed	Increased carcass weight of broiler exposed to heat stress	Zulkifli et al (2018)
<i>Aloe vera</i>	Feed	0.75% of feed	Improved growth performance, feed efficiency and carcass traits of broilers	Sunu and Abdurrahman (2019)
<i>Curcuma xanthorrhiza and garlic</i>	Feed	Maximum of 2% of feed	Improved growth performance of broilers	Lestari et al (2020)
<i>Curcuma longa and Zingiber officinale</i>	Feed	1.5% of diets	Improved hematological profiles and reduce the stress level in broilers	Maksudi et al (2020)

### Conclusion

Phytogenic feed additives represent a scientifically sound and sustainable approach for enhancing poultry production in antibiotic-free systems. They improve digestion, immunity, gut microbiota, oxidative state, and general productivity due to their numerous bioactive contents. The synergistic interactions of phytochemicals in a multi-herbal combination often make it more beneficial to the body than any one plant product could on its own. We should expect to see more commercial use of phytogenic feed additives in contemporary chicken

production as long as research into their safety, efficacy, dosage optimization, and mechanisms of action continues.

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