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UTILIZATION OF SPICES IN POULTRY NUTRITION: A REVIEW

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ABSTRACT

The poultry industry has grown significantly due to its high nutritional value. Growth-promoting feed additives have been explored to further optimise production. Equally, the ban on antibiotic growth promoters has led to a search for natural alternatives. This review focuses on six spices which can serve as potential natural alternatives: Coriandrum sativum, Thymus vulgaris, Cinnamomum verum, Cuminum cyminum, Foeniculum vulgare and Ocimum gratissimum. Bioactive compounds from spices have historically played a crucial role in supporting both human and animal health by offering essential nutrients, enhancing immune function, and serving as natural healing agents. In the face of rising antibiotic resistance and emerging pathogens, they are increasingly recommended as alternative or complementary therapies to conventional antibiotics. These spices possess diverse phytochemical compositions, including alkaloids, essential oils, flavonoids, and phenolics, with reported antimicrobial and growth-promoting properties. Coriander, Thyme, Cinnamon, Cumin, Fennel and Scent leaf have shown promising effects on poultry growth, nutrient utilisation, and disease prevention. Understanding these spices' active ingredients and traditional uses can serve as potential natural alternatives to synthetic conventional growth promoters in poultry diets.

Keywords: Bioactive compounds, Feed additives, Growth promoters, Nutrition, Poultry, Spices

INTRODUCTION

The use of poultry products as a food source is increasing regularly, and the reasons for this are high production of chickens at relatively low cost in a short period, high nutritional value, and low capital input, all of which lead to the economic development of farmers. The primary goal of the poultry industry nowadays is to transform low-value nutrients into high-value ones (Parks *et al*., 2000; Ahmed, 2015). As a result of the development in the poultry industry in the past few years, chicken meat represents 80 per cent of all meat production in the poultry industry. This development has played a vital role in increasing the production of eggs and meat (Waziri *et al*., 2023).

Growth-promoting feed additives are the ingredients that are very rarely added to chicken feed, but which can accelerate the growth process and weight gain, and also have a significant influence on egg production, nutrition utilisation efficiency and reducing mortality rate to bring out desirable features or to minimise weak characteristics (AL-Zuhairi *et al*., 2018). Although the European Union banned antibiotics as growth promoters since January 2006 (Waziri *et al*., 2023), feeding additive antibiotics as health and growth promoters has played a significant role in animal production.

Spicy bioactive compounds have long served as a lifeline for both livestock and humans, providing them with vital nutrition, acting as potent immunomodulatory agents and healing remedies, and are suggested for adjunctive usage as an alternative to antibiotics in the era of emerging drug resistance as well as countering emerging pathogens (Uddin *et al*. 2021; Kumari *et al*. 2022). Animals in the wild and other scavenging species are frequently instinctively self-medicated by eating plants known to have therapeutic effects. Farmers began utilising antibiotics and vaccinations to combat disease-causing organisms, increasing animal morbidity and mortality (Chandran 2021). Examples of such spices are *Coriandrum sativum, Thymus vulgaris, Cinnamomum verum, Cuminum cyminum, Foeniculum vulgare and Ocimum gratissimum*

DISCUSSION

Description of Coriander (*Coriandrum sativum*)

Coriandrum sativum belongs to the *Apiaceae* (*Umbelliferae*) family, which is herbaceous and grows annually, with a height of 20-70 cm. *Coriandrum sativum* is known as "Coriander" or "Chinese parsley" in English (Mandal *et al*., 2015; Al-Snafi, 2016; Prachayasittikul *et al*., 2018). The leaves are green with a variable lanceolate shape and glabrous surfaces, while the flowers are white or pink in umbels with asymmetrical shapes (Mandal *et al*., 2015). Meanwhile, the seeds are dry schizocarps with two mericarps with oval-shaped globules. Furthermore, the stems of *Coriandrum sativum* are pale green with hollow branches and a glabrous surface (Al-Snafi, 2016).

Phytochemical composition of Coriander (*Coriandrum sativum*)

Recent studies revealed that different varieties of alkaloids, essential oils, fatty acids, flavonoids, phenolics, reducing sugars, sterols, tannins, and terpenoids were extracted from *Coriandrum sativum* (Chauhan *et al*. 2012; Wei *et al*., 2019). In particular, the leaves were reported to have abundant folates, ascorbic acid, gallic acid, caffeic acid, ferulic acid, and chlorogenic acid (Mahleyuddin *et al*., 2022). Additionally, the investigation of the water-soluble components of *Coriandrum sativum* seeds showed the presence of 33 compounds, including monoterpenoids, monoterpenoid glycosides and glucosides, and aromatic compound glycosides such as noncarotenoid glucoside (Ishikawa *et al*., 2003). In the leaf and stem of the *Coriandrum sativum*, different phenolics and flavonoids were detected in significantly high concentrations, such as quercetin diverse glycosides (405.36–3296.16 mg/kg), kaempferol 3-O-rutinoside (320.86 mg/kg), in addition to ferulic acid glucoside and pcoumaroylquinic acid (Barros *et al*., 2012). Another study of the polyphenolic contents of coriander grass showed that a 40% ethanol extract contains many flavonoids (0.13 % to 10.71 %), coumarins (1.4 % to 6.83 %), and phenolic carboxylic acids (7.24 % to 13.51 %) (Oganesyan *et al*., 2007). Anthocyanin was also characterised in coriander leaves, and the concentration was influenced by salicylic acid, nitrogen, phosphorus, potassium, and zinc fertilisers (Rahimi *et al*., 2013).

Active Ingredient present in Coriander (*Coriandrum sativum*)

Shahwar *et al*. (2012) reported that the major active compounds in coriander seed were linalool (55.59 %), γ-terpinene (7.47 %), α-pinene (7.14 %), camphor (5.59 %), decanal (4.69 %), geranyl acetate (4.24 %), limonene (3.10 %), geraniol (2.23 %), camphene (1.78 %), and D-limonene (1.36 %). The composition of coriander seed essential oil was different in different places around the world. Gil *et al*. (2002) studied the chemical composition of Coriander. They found that the linalool (the main component in coriander seed essential oil) was 72.3 % (Argentinean) and 77.7 % (European), while α-pinene was 5.9 % and 4.4 %, γ-terpinene 4.7 % and 5.6 %, camphor 4.6 % and 2.4 %, limonene 2.0 % and 0.9 %, in Argentinean and European Coriander, respectively. Smallfield *et al*. (2001) found that linalool, α-pinene, γ- γ-terpinene, camphor, and limonene were 65.8, 6.8, 6.1, 5.1, and 2.7 %, respectively, in coriander seed essential oil. Misharina (2001) found that linalool is 68.00 % in Russian coriander seed essential oil. Studies also showed that the composition of coriander seed essential oil may be affected by duration and condition of storage (Misharina, 2001).

Uses of Coriander (*Coriandrum sativum*)

Coriandrum sativum was used as one of the earliest spices by humans. *Coriandrum sativum* seeds were traditionally consumed to relieve pain, rheumatoid arthritis, and inflammation (Nair *et al*. 2013). In contrast, the decoction of Coriander was believed to treat mouth ulcers and eye redness (Paniagua-Zambrana *et al*., 2020). In countries such as Saudi Arabia, Jordan, and Morocco, Coriander was also known to lower blood glucose levels (Tahraoui *et al*., 2007), and is reported to also have antimicrobial properties against food-borne pathogens such as *Salmonella*, in addition to aphrodisiac and analgesic power (Chaudhry and Tariq, 2006). Furthermore, Coriander has been used traditionally in Turkey and India to ease indigestion (Ugulu *et al*., 2009); increase water excretion; and prevent seizures, anxiety, and sleeplessness (Emamghoreishi and Heidari-Hamedani, 2006). Moreover, it has been documented that *Coriandrum sativum* in Morocco is traditionally used to treat diabetes, indigestion, flatulence, insomnia, renal disorders, loss of appetite, and as a diuretic (Aissaoui *et al*., 2008).

Role of Coriander (*Coriandrum sativum*) in Livestock (Poultry)

Gazwi *et al*. (2022) opined that dietary supplementation of *Coriandrum sativum* seed extracts could enhance broiler chickens' growth, carcass characteristics, liver function, lipid profile, and antioxidant status. More so, it was further observed that these extracts could be utilised as natural feed additives and growth promoters for broiler chickens. Jang (2011) reported that adding coriander oil to broiler chickens' diets significantly increased weight. Khubeiz and Shirif (2020) reported that including coriander seed powder at 1.5% positively impacted the dressing percentage without skin, biochemical blood profile, and immune response. Similarly, Hosseinzadeh *et al*. (2014) reported that including 2.0 % coriander powder in broiler chickens' diets lowered total cholesterol. Also, the researchers observed a noticeable improvement in antibody titre against Newcastle disease, infectious bronchitis, and infectious bursal disease in birds receiving coriander extract in water. In their study, Taha *et al*. (2019) observed that supplementing broiler diet with 0.4 % coriander seed powder significantly enhanced growth performance, haematological parameters, organ development, and economic efficiency compared to the control group. The researchers also observed the highest economic efficiency in the group supplemented with 0.4 % coriander seed powder, which showed a 13.06% increase over the control group. Gurram *et al*. (2022) in a study demonstrated that dietary supplementation with combinations of probiotic (0.01 %), chicory root powder (1.0 %), and coriander seed powder (1.5 %) significantly enhanced weight gain, feed conversion ratio, antioxidant enzyme activity, gut microbiota balance, and intestinal morphology in broilers compared to the control and antibiotic-supplemented groups. The study suggests that such natural combinations are effective alternative antibiotics for improving broiler performance and gut health.

Description of Thyme (*Thymus vulgaris*)

Thyme is indigenous to the Mediterranean, especially Northern Africa, and is widely cultivated in Egypt (Abdel-Hamid *et al*., 2021). Thyme is a perennial flowering aromatic plant. The Greek word for 'thyme' means 'to fumigate', for it is one of the sweet-smelling herbs (Patil *et al*., 2021). The genus Thymus is composed of about 215 species that have been utilised as a food supplement or as an herbal remedy for medicinal properties, such as antispasmodic, digestive, carminative, antiseptic, antitussive, and expectorant (Ruzzi *et al*., 2022).

Phytochemical Composition of Thyme (*Thymus vulgaris*)

Thymus vulgaris. Consists primarily of various chemical compounds categorised as phenolic compounds, terpenoids, flavonoids, steroids, alkaloids, tannins, and saponins (Patil *et al*., 2021). *Thymus vulgaris* contains alkaloids, flavonoids, tannins, saponins, sterols, triterpenes, and cardiac glycosides (Adam, Adam, and Almostafa, 2019). Selim *et al*. (2023) reported that thyme extracts contain protocatechuic acid, p-hydroxybenzoic acid, rosmarinic acid, catechin, caffeic acid, apigenin, kaempferol, ferulic acid, and rutin as active components with a high polyphenolic content that have antimicrobial properties against gram-positive bacteria (*Bacillus cereus* and *Staphylococcus aureus*), gram-negative bacteria (*Escherichia coli*). Banerjee *et al*. (2019) assessed polysaccharide content using aqueous extraction of the alcohol insoluble residue of *Thymus vulgaris* L. leaf and reported the presence of four types of polysaccharides; they include homogalacturonan, starch, cellulose and a unique type of polysaccharide known as rhamnogalacturonan I (RG-I).

Active Ingredient in Thyme (*Thymus vulgaris*)

Thymol, carvacrol, *para*-cymene and linalool were reported to be the main components of the thyme essential oils (Mahboubi *et al*., 2017). In many thyme species, rosmarinic acid is the main component (Selim *et al*., 2023).

Uses of Thyme (*Thymus vulgaris*)

Lamiaceae plants, mainly thyme, have long been traditionally used as medication against infections and commercialised due to their biological activities (Thakur *et al*., 2021). The thyme plant has been shown to treat several intestinal diseases, as well as unicellular and multicellular fungi, and pathogenic gram-positive and gram-negative bacteria (Abdel-Hamid *et al*., 2021). Schött *et al*. (2017) reported that the derivatives of flavones, such as apigenin and luteolin, were identified. The antibacterial potential of apigenin has been tested against many bacterial species and various strains within the same species. Apigenin has been shown to possess antibacterial, antiviral, antifungal, and antiparasitic activities (Wang *et al*., 2019). Besides gallic acid, its derivatives are also widely used in the food, chemical, pharmaceutical and cosmetic industries (Selim *et al*., 2023). Some studies indicate that these substances possess therapeutic potential, particularly as antimicrobials, in addition to acting as reactive oxygen species scavengers (Lima *et al*., 2016).

Role of Thyme (*Thymus vulgaris*) in Livestock (Poultry)

Attia *et al*. (2017) reported that the essential oil present in thyme at an inclusion level of 1.0 g/kg diet may be used as a potential growth enhancer for broiler chickens living in warm weather conditions. Extract of Thyme at 5 mg/mL reduced faecal shedding and caecal counts of *Salmonella enteritidis* in broiler chickens (Elmi *et al*., 2020). Similarly, Zhu *et al*. (2014) suggested that administering essential oil from thyme at 0.1 and 0.25 mg/kg promotes protein metabolism, enhances lipolysis, and strengthens immune function. Furthermore, essential oil from thyme were reported by Abdel-Fatah *et al*. (2020) to improve the symptoms induced by *Candida albicans* and increased packed cell volume percent, Alanine aminotransferase and Aspartate aminotransferase levels, with a decrease in erythrocyte count and total leukocyte count in chickens when administered at 200 ml/kg in diet for 10 days. Dietary supplemental thyme oil (250 mg/kg diet) has a favourable effect on feed intake, weight gain, and body weight values (Noruzi *et al*., 2022). Shabaan (2017) reported that diets supplemented with thyme (0.2 %) were observed to decrease nitrogen excreted in broilers significantly. This assertion was attributed to the effect of thyme on microbes, which improved FCR and finally increased nitrogen retention. Moreover, the researcher observed that thyme could decrease reactive oxygen, thereby reducing protein damage, which in turn leads to a reduction in total nitrogen in the litter. Ragaa *et al*. (2016) observed an improvement in villus height in broilers fed thyme (1 g/kg) in their study. They also reported that thyme exerts significant positive effects on broiler performance and immunity parameters. Similarly, a mixture of essential oils of thyme, anise, oregano, carvacrol, yucca extract and cinnamaldehyde was reported by Abudabos *et al*. (2018) to increase villus height and width in broilers infected with *Clostridium perfringens*.

Description of Cinnamon (*Cinnamomum verum*)

Cinnamon (*Cinnamomum verum*) is a member of the family *Lauraceae* and is known as Ceylon Cinnamon, *Cinnamomum zeylanicum* Nees, and true Cinnamon. It is a tropical evergreen plant and is considered one of the finest sweet spices in the world (Shahidi *et al*., 2018). It is indigenous to China, Southeast Asia, and Saudi Arabia and is also found in Australia, Indonesia, Thailand, South America, and the West Indies. This plant can grow up to 50 ft high with long, leathery, bright green leaves and yellow flowers. The fruit is ovoid, purple, and contains a single seed. The bark powder, bark, leaf essential oil, bark essential oil, and oleoresin of cinnamon are used as spices (Nabavi *et al*., 2015).

Phytochemical Composition of Cinnamon (*Cinnamomum verum*)

Cinnamon contains a wide range of phytochemicals, including cinnamaldehyde, cinnamyl acetate, cinnamyl alcohol, eugenol, eugenol acetate, linalool, benzaldehyde, methyl eugenol, monoterpene, hydrocarbon, benzyl benzoate, caryophyllene, pinene, phellandrene, safrole, cymene, and cineol (Yashin *et al*., 2017). The biological properties of cinnamon are attributed to its high polyphenol content, which includes major phenolics such as vanillic acid, caffeic acid, and ferulic acid (Muchuweti *et al*., 2007). Abeysekera *et al*. (2013) reported that the ethanolic extracts of cinnamon leaf and bark had high phenolics (44.57 ± 0.5 and 33.43 ± 0.51 mg GAE/g, respectively) and flavonoids (12.0 ± 0.37 and 3.07 ± 0.24 mg QE/g) contents, which were more than those of dichloromethane/methanol extracts. Additionally, phytochemicals such as glycosides, steroids, alkaloids, saponins, anthraquinones, tannins, terpenoids, and coumarins have also been identified in cinnamon extracts (Shreya *et al*., 2015; De Soysa *et al*., 2016).

Active Ingredient in Cinnamon (*Cinnamomum verum*)

The major constituents of cinnamon bark are essential oil (up to 2.8%), with cinnamaldehyde (60-90%) as a major component (Shahidi *et al*., 2018). Marongiu *et al*. (2007) reported the major constituents to be trans-cinnamaldehyde (77.1%), trans-β-caryophyllene (6.0%), γ-terpineol (4.4%), and eugenol (3.0%). In addition, the significant components of the root bark, flower, and fruit oils are camphor, trans-cinnamyl acetate, and linalool, respectively (Parthasarathy *et al*. 2008).

Uses of Cinnamon (*Cinnamomum verum*)

Cinnamomum verum bark and essential oil extracts have demonstrated potent antimicrobial activity against a wide range of bacteria and fungi (Yap *et al*., 2015). The barks and leaves of *Cinnamomum verum* are commonly used in foods as seasoning and flavouring agents (Schmidt *et al*., 2006). In the traditional Chinese system, cinnamon is regarded as a potent neuroprotective agent (Khasnavis and Pahan, 2012) and a medicinal treatment for type 2 diabetes mellitus (Kim *et al*., 2006). Cinnamon has been utilised in a variety of culinary applications for thousands of years. It has been employed as an antiemetic, antidiarrhoeal, anti-flatulent, and stimulant in Ayurvedic medicine due to its high healing importance. It was employed by the Egyptians for mummification (Pathak and Sharma, 2021). It's used to make chocolate, beverages, spicy candies, and liquors, among other things (Jakhetia *et al*., 2010).

Role of Cinnamon (*Cinnamomum verum*) in Livestock (Poultry)

A study conducted by Al-Kassie (2009) showed that broiler chickens fed on 200 ppm dietary cinnamon essential oil had significantly lower cholesterol concentrations and Heterophils/Lymphocytes (H/L) ratio. In contrast, total protein, haemoglobin, red blood cell counts, white blood cell counts, and packed cell volume were all increased. However, Ciftci *et al*. (2010) reported that serum levels of glutathione peroxidase, catalase enzyme activities, total unsaturated fatty acids, ω-6 fatty acids and phagocytic activity of blood were significantly increased in broiler chicks fed on diets supplemented with 1000 ppm cinnamon essential oil. Sang-Oh *et al*. (2013) observed that the inclusion of dietary cinnamon significantly increased serum immunoglobulin levels in broiler chickens. Similarly, positive impacts have been confirmed regarding the improved digestibility of nutrients in broiler chickens administered cinnamon essential oil (Garcia *et al*., 2007).

Additionally, the bioactive compounds in cinnamon affect lipid metabolism by facilitating the transport of fatty acids in the digestive tract of broiler chickens (Ali *et al*., 2021). Zhai *et al*. (2018) further revealed that cinnamon essential oil has positive effects on the secretion of digestive enzymes and improves the digestibility of nutrients in the gut. Qaid *et al*. (2022) reported that the use of cinnamon as an alternative to anticoccidials and ionophore coccidiostats can mitigate the effects of *Eimeria tenella* infection, which exerts a negative impact on growth performance, slaughter weight, carcass yield, and most carcass characteristics of broiler chickens. The researchers further noted that the addition of cinnamon improved specific physicochemical properties without compromising the quality of the meat.

Description of Cumin (*Cuminum cyminum*)

Cumin (*Cuminum cyminum* L.) belongs to the family *Apiaceae* and is known by various names, including *Cuminum odorum* Salisb, *Selinum cuminum* L., *Ligusticum cuminum* L., Crantz, and Krause. Cumin is indigenous to the eastern Mediterranean region, northern Egypt, and India and is also widely grown in Iran, Syria, Pakistan, and China. It is a glabrous annual plant that can grow up to 2 feet high, featuring blue-green, linear leaves. This slender herb features white or pink flowers and ovoid, brownish-yellow fruits that contain a single seed. The seeds (ground or whole), essential oil, and oleoresin are the major products of this herb (Charles, 2013).

Phytochemical Composition of Cumin (*Cuminum cyminum*)

Numerous phytochemicals such as α-pinene, β-pinene, cuminaldehyde, carvone, γ-terpinene, p-cymene, β-carotene, 1,8-cineole, β-sitosterol, carvaol, caffeic acid, carvacrol, geranial, p-coumaric acid, kaempferol, limonene, quercetin, thymol, and tannin have been reported in Cumin (Embuscado 2015; Leja and Czaczyk 2016). Abdelfadel *et al*. (2016) reported that hot extracts of cumin seed showed significantly higher content of phenolics compared to cold extracts (299.0 and 270.3 mg GAE/100 mL, respectively). In contrast, Ereifej *et al*. (2016) showed that the methanolic extracts demonstrate the highest phenolics (43.8 mg GAE/100 g) than ethanol and acetone extracts at 20 °C.

Active Ingredient in Cumin (*Cuminum cyminum*)

The essential oil of cumin roots, stems and leaves. Flowers are 0.03, 0.1, and 1.7 %, respectively, and the major compounds of these oils are bornyl acetate (around 23 %), α-terpinene (about 34 %), and γ-terpinene (nearly 51 %) (Bettaieb *et al*. 2010). Besides, the constituents of cumin essential oil vary from region to region; thus, the major components in Turkish and Syrian Cumin are cuminaldehyde, p-mentha-1,4-dien-7-al, and γ-terpinene, whereas the Egyptian cultivars have aldehyde and tetradecene. Tunisian cumin contains cuminaldehyde and γ-terpinene, Indian varieties have trans-dihydrocarvone and γ-terpinene, Chinese Cumin contains cuminal and cuminic alcohol, and Iranian cumin has thymol and γ-terpinene (Al-Snafi 2016).

Uses of Cumin (*Cuminum cyminum*)

Cumin seeds are a common Ayurvedic remedy for a wide variety of mild to moderate conditions, including diarrhoea, dyspepsia, flatulence, colic, abdominal distension, oedema, bronchopulmonary disorders, puerperal disorders, analgesia, and cough (Vinod *et al.,* 2022). The effects of cumin are multifaceted, and it can improve eyesight, muscular endurance, and lactation (Prakash *et al*., 2021). In traditional medicine, cumin seeds have been used to treat a variety of conditions, including toothache, dyspepsia, epilepsy, and jaundice (Vinod *et al.,* 2022). Their pharmacological actions include anti-diabetic, immunomodulatory, anti-tumour, and antibacterial functions. Furthermore, Vinod *et al*. (2022) report that essential oils extracted from cumin have been successfully used to treat a variety of medical issues, including epilepsy, indigestion, wounds, jaundice, and several respiratory and gastrointestinal disorders.

Role of Cumin (*Cuminum cyminum*) in Livestock (Poultry)

Studies have shown that feeding animals a diet that includes cumin seeds increases their efficiency in digesting and using inherent nutrients (Kumar *et al*. 2017). Cumin seeds had no unfavourable effect on the palatability of the diet, as evidenced by no change in dry matter intake and milk composition of lactating goats (Heidarian *et al*. 2013). Broiler chickens fed a meal supplemented with cumin oil have been reported to gain considerably more weight than the control chickens (Vinod *et al.,* 2022). Similarly, it has also been reported that including 2% cumin in the diet of heat-stressed broiler chickens helped mitigate the detrimental effects of heat stress and improved growth performance (Vinod *et al.,* 2022). Increases in body weight gain, feed intake, and feed conversion ratio were observed in broiler chickens fed diets containing 0.75% and 1% cumin and turmeric mixture, respectively (Al-Kassie, 2009). Yilmaz and Gul (2022) report that cumin essential oil has a dose-dependent positive effect on specific genes in the tissues of heat-stressed broilers, and downregulates (except for Bcl-2) these genes. In vivo studies on broilers by Jabbar *et al*. (2024) demonstrated that cumin essential oil nanoemulsion has a positive impact on growth performance and intestinal microbiota, further highlighting its potential as a growth promoter and gut health enhancer in poultry farming.

Description of Fennel (*Foeniculum vulgare*)

Fennel (*Foeniculum vulgare* Mill) belongs to the family *Apiaceae*, and its most common synonyms are *Foeniculum capillaceum, Foeniculum officinale, Anethum Foeniculum*, fenkel, sweet fennel, and common fennel. It is indigenous to southern Europe and the Mediterranean region and is cultivated worldwide, particularly in China, India, Egypt, Turkey, Central Europe, Argentina, and the United States. It is a perennial plant that can grow up to 6 feet high, characterised by green leaves and yellow flowers on short pedicles. The seeds are grooved, slightly curved, yellowish, and oval in shape. The seed, herb, and essential oil are used as spices (Shahidi *et al*., 2018).

Phytochemical Composition of Fennel (*Foeniculum vulgare*)

Numerous phytochemicals have been characterised in fennel, of which trans-anethole, estragole, fenchone, α-pinene, 1,8-cineole, myristicin, limonene, β-carotene, β-sitosterol, cinnamic acid, ferulic acid, fumaric acid, benzoic acid, caffeic acid, p-coumaric acid, vanillic acid, kaempferol, quercetin, rutin, and vanillin are important (Badgujar *et al*., 2014; Rather *et al*., 2016). Other studies have also shown that the phytochemicals in fennel extract contain alkaloids, flavonoids, saponins, glycosides, phenols, terpenoids, and tannins (Bano *et al*., 2016). Similarly, Ghanem *et al*. (2012) opined that cultivated fennel had a high content of terpenes compared to wild fennel (Conforti *et al*., 2006). Similarly, cultivated fennel had the highest amount of phenolics (3.1 %) and flavonoids (1.6 %) compared to wild fennel.

Active Ingredient in Fennel (*Foeniculum vulgare*)

Miraldi (1999) reported that the main components in fennel are trans-anethole, limonene, estragole, and fenchone. Furthermore, essential oil, mainly composed of monoterpenes, including α-pinene, α-terpinene, β-myrcene, and limonene, whose contents varied significantly during the maturation stages, was reported by Telci *et al*. (2009). Similarly, Anwar *et al*. (2009) observed maximum (3.5 %) and minimum (2.8 %) essential oil content in the mature and immature fruit, respectively. This includes the presence of trans-anethole (65.2, 69.7, and 72.6 %), limonene (3.5, 4.7, and 7.8 %), fenchone (8.8, 10.0, and 11.0 %), and estragole (6.9, 6.9, and 7.2 %), as the major constituents at immature, intermediate, and mature stages, respectively.

Uses of Fennel (*Foeniculum vulgare*)

Fennel seed, according to the Romans, might enhance eyesight (Noreen *et al*., 2023). The various plant components are now utilised to treat a variety of illnesses, including digestive system discomfort. Additionally, it is highly effective in treating kidney stones, bronchitis, diabetes, and persistent cough (Dheebisha and Vishwanath, 2020). Noreen *et al*. (2023) opined that the plant is used to treat kidney and bladder disorders due to its diuretic properties; it is also used to stop vomiting and ease nausea. Additionally, the herbs help treat chronic fever as well as obstructions in the hepatic, gastrointestinal, respiratory, and urinary tracts. In addition to these, it is also utilised in the treatment of breastfeeding women as a galactagogue agent (Bettaieb Rebey *et al*., 2019).

Role of Fennel (*Foeniculum vulgare*) in Livestock (Poultry)

AL-Sagan *et al*. (2020) in their study postulated that 3.2% of fennel seed powder could be used as an agent to enhance broiler chickens' tolerance during chronic heat stress conditions from 19 to 41 days of age. Similarly, Waziri *et al*. (2023) in their study opined that experimental groups receiving 2 and 3 grams of fennel seed powder per kilogram of diet not only consumed less food overall but also had the best feed conversion ratio and the most significant weight gains ($p < 0.01$). The researchers further concluded that, as a natural growth promoter, feeding broiler chicks 2-3 grams of ground fennel seed per kilogram of diet yields the best effects on growth performance. Furthermore, Lemrabt *et al*. (2019) reported that 750 g of fennel seed powder + 50 kg diet had a significant impact on broiler chickens' body weight gain. In a similar study carried out by Ahmed (2015), 3% fennel seed powder was reported to have a significant effect ($p < 0.05$) on the feed intake, feed conversion ratio, and body weight gain of broiler chickens. Safaei-Cherehh *et al*. (2018) opined that adding fennel extract to the diet of broilers enhanced Newcastle vaccination efficiency on day 35 and immunoglobulin synthesis on day 42, resulting in improved immunity against bacteria, viral infections, and new infections. Khan *et al*. (2022) documented that fennel also possesses potent antiviral, antibacterial, and anti-inflammatory properties that may help to enhance gut health and remove infections. Essential oils (methyl chavicol, limonene, anethole, fenchone, phellandrene, anisic acid, camphene, palmitic, oleic, linoleic, pinene, and petroselenic acids, volatile chemicals, and flavonoids) are abundant in fennel seed powder. They may lead to possible growth improvements in poultry (Gharaghani *et al*., 2015).

Description of Scent Leaf (*Ocimum gratissimum*)

Scent leaf, with the scientific name *Ocimum gratissimum*, is a plant that is frequently grown for both culinary and medicinal purposes in West Africa, typically in and around village huts and gardens. The leaves, which have a potent scent, are frequently used to season meat, particularly game, and to flavour soup. The leaves are widely used as an essential seasoning in soups, particularly pepper soup, and other similar dishes in the southeastern part of Nigeria and beyond (Edo *et al*., 2023). It is a common perennial herbaceous plant with a potent aroma that is also commercially viable. Scent leaf is found in Africa, Asia, and South America, and it is a member of the *Lamiaceae* family (Ugbogu *et al*., 2021).

Phytochemical Composition of Scent Leaf (*Ocimum gratissimum*)

Scent leaf, which is widely grown as a perennial herb in tropical Africa, and is rich in phytochemicals such as alkaloids, tannins, phytates, flavonoids, oligosaccharides, thymol and saponin, has been studied for its antimicrobial and antioxidant properties (Olobatoke and Okaragu, 2021). Aluko *et al*. (2012) reported that the phytochemical analysis of the plant revealed high concentrations of flavonoids (10.00%), saponins, and tannins, but low levels of phenolics and alkaloids. Similarly, Alexander (2016) demonstrated that phytochemical screening of the leaves, using standard methods followed by further analysis with high-performance liquid chromatography (HPLC), revealed the presence of tannins, saponins, flavonoids, alkaloids, phlobatannins, terpenoids, steroids, and cardiac glycosides.

Active Ingredient in Scent Leaf (*Ocimum gratissimum*)

The essential oil of *Ocimum gratissimum* leaf contains significant amounts of eugenol, thymol, camphor, pinene, limonene and other chemical components (Akpoghelie *et al*., 2022). Edo *et al*. (2023) opined that the leaf contains eugenol, thymol, and rosmarinic acid, which have been shown to possess anti-inflammatory, antimicrobial, and antiviral properties

Uses of Scent Leaf (*Ocimum gratissimum*)

In various regions of the world, scented leaves are used as ingredients in cuisine, including salads, soups, pastas, vinegars, and jellies. It is well known to the Thai people, as they use it as a flavour enhancer in their food (Amit *et al*., 2017). Aside from being frequently utilised in modern medicine, scent leaf extracts are also traditionally used to treat ailments such as fever, cough, and body aches (Ghaleb-Dailah, 2022). *Ocimum gratissimum* (scent leaf) is most commonly utilised for its leaves in food (Edo *et al*., 2023). Similarly, various parts of the leaf are used for the treatment of diseases such as headache, fever, asthma, and others (Taur and Patil, 2011). Moreover, Okoduwa *et al*. (2017) reported that it contains calcium and Magnesium, both of which work to lower blood sugar. Scent leaf extract has been traditionally used to treat ulcers due to its anti-inflammatory, analgesic and anti-ulcer properties (Agholor *et al*., 2018).

Role of Scent Leaf (*Ocimum gratissimum*) in Livestock (Poultry)

Nte *et al*. (2017) observed in their study that Scent leaf aqueous extracts could be safely administered to broiler chicks at 100 ml/L in drinking water to improve their performance during the starter phase. Obasi (2020) observed that weight gain of broiler chicks on extracts of Scent leaf were higher than the weight gain of birds without any extract up to 30 ml/L; similarly, the mortality rate of the chicks on Scent leaf extract were observed to be less than in chicks without the Scent leaf extract up till the level of 30 ml/L. Similarly, scent leaf meal in the diets of cockerels significantly improved the growth performance of the birds. It dose-dependently reduced the blood cholesterol level without any deleterious effect on blood and serum parameters (Olobatoke and Okaragu, 2021). Ogunleye (2019) reported on the efficacy of Scent leaf in improving feed utilisation and reducing mortality due to coccidiosis in broiler chickens. Moreover, Odoemelam *et al*. (2018) stated that scent leaf meal can effectively replace synthetic antibiotics, as its effects are similar to those of antibiotics. Olumide *et al*. (2018) further observed that scent leaf meal fed to broiler chickens at 400 g/100kg improved the livability of the birds. Olumide and Akintola (2020) in a study observed that the inclusion of *Ocimum gratissimum* in broiler diets had no adverse effect on performance or carcass characteristics. Instead, it significantly improved body weight, feed intake, livability, and meat acceptability. Similarly, the researchers observed that birds fed diets supplemented with 300g/100kg feed achieved the best livability (100%), while those on 400g/100kg feed produced meat with the most desirable colour. Olumide and Akintola concluded that *Ocimum gratissimum* is a beneficial natural supplement for enhancing the performance and consumer appeal of broilers.

CONCLUSION

The pursuit of sustainable growth and disease prevention in the poultry industry has led to a shift toward natural alternatives to antibiotics and growth promoters. Spices like *Coriandrum sativum, Thymus vulgaris, Cinnamomum verum, Cuminum cyminum, Foeniculum vulgare and Ocimum gratissimum* offer a rich source of bioactive compounds with documented health benefits, including antimicrobial, anti-inflammatory, and immunomodulatory properties. Incorporating these spices or their extracts into poultry diets has shown promising results in terms of growth promotion, nutrient utilisation, and disease resistance. However, further research is needed to optimise formulation, dosage, and application methods for maximum efficacy and safety in poultry production. Overall, harnessing the potential of spicy additives represents a sustainable and environmentally friendly approach to enhancing poultry health and productivity.

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