OPEN ACCESS

J. Adv. Vet. Anim. Res., 1(4): 156-162.
Available at- *http://bdvets.org/JAVAR*

MINI REVIEW   Volume 1 Issue 4 (December 2014)

DOI: 10.5455/javar.2014.a36

Use of essential oils in poultry nutrition: A new approach

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ABSTRACT

Emergence of antibiotic resistant bacteria has created the necessity of replacement of antibiotic with other products like prebiotics, probiotics, organic acid botanicals, and herbal essential oils. Essential oils (EOs) are important aromatic components of herbs and spices, and are used as natural alternatives for replacing antibiotic growth promoters (AGPs) in poultry feed as these have antimicrobial, antifungal, antiparasitic, and antiviral properties. Beside, other beneficial effects of EOs include appetite stimulation, improvement of enzyme secretion related to food digestion, and immune response activation. Recently, use of EOs in broiler chickens has drawn attentions. EOs are generally used as blend with a carrier oil or combination with other plant oils in the feed to enhance the productive performance of birds. Conclusively, EOs can be used in poultry feed, but there are still questions concerning their action, metabolic pathway and optimal dosage in poultry, which are to be explored in detail. This mini-review describes the expanding horizons in the research on EOs in poultry nutrition.

Keywords

Antimicrobial activity, Egg production, Essential oils, Growth performance, Poultry nutrition

Received : 28 July 2014, **Revised**: 11 August 2014,
Accepted : 17 August 2014, **Published online**: 18 August 2014.

INTRODUCTION

Feed additives have been widely used to increase the performance of animals, and are now used in poultry feeding practices extensively (Collington et al., 1990; Khan et al., 2007) not only to stimulate the growth and feed efficiency but to improve the health and performance of birds (Scott et al., 1982; Fadlalla et al., 2010; Abouelfetouh et al., 2012). In past, several antibiotic growth promoters had been used in poultry feed aiming to prevent disease, to improve growth performance, and to increase some useful microorganism in intestinal microflora. However, because of emergence of bioresistance, researchers are now focusing for alternatives in place of antibiotics; for this, spices, plant extracts and herbs received increasing attentions. Essential oils (EOs) are found to have antibacterial ability, and also exhibit antioxidant, anti-inflammatory, anticarcinogenic, digestion stimulating, and hypolipidemic activities (Viuda-Martos et al., 2010). Thus, EOs can be used as growth promoters in animal production (Cross et al., 2007; Kirsti et al., 2010).

ESSENTIAL OILS

The EOs are mixture of fragrant and volatile compounds, which are usually originated from plant, and are named with the aromatic characteristics considering the origin of plant (Oyen and Dung, 1999). The term 'essential' was proposed by Paracelsus in his theory of 'quinta essentia', and described that this quintessence could be an effective element for medical use (Oyen and Dung, 1999). But, the term 'volatile oil' had been proposed in medieval pharmacy (Hay and Waterman, 1993). The use of EOs in enhancing productivity may give promising effects as growth and health promoter. The chemical composition and concentration of EOs are variable.

Table 1: Antibacterial activity and minimum inhibitory concentration (MIC, ppm) of essential oils.

Microorganisms	MIC values (ppm)			References
	Carvacrol	Thymol	Cinnamadehyde	
Escherichia coli	450	450	396	Helander et al. (1998)
Escherichia coli	225	225	NT	Cosentino et al. (1999)
Staphylococcus aureus	450	225	NT	Cosentino et al. (1999)
Candida albicans	150	150	NT	Ali–shtayeh et al. (1997)
Candida albicans	113	113	NT	Cosentino et al. (1999)
Candida albicans	200	NT	200	Ferhout et al. (1999)
Pseudomonas aeruginosa	500	500	NT	Ali–shtayeh et al. (1997)
Pseudomonas aeruginosa	>900	>900	NT	Cosentino et al. (1999)
Salmonella typhimurium	150	150	396	Helander et al. (1998)
Salmonella typhimurium	225	56	NT	Cosentino et al. (1999)
Streptococcus mutans	125	250	250	Didry et al. (1994)
Streptococcus mitis	125	125	125	Didry et al. (1994)

NT = Not tested.

PHYSICAL PROPERTIES OF ESSENTIAL OILS

Essential oils could be obtained through various methods like fermentation, extraction or expression; however, steam distillation is used as the most common method for commercial purpose. The EOs possess characteristic odor, and are soluble in organic solvents. Most of the oils are lighter than water with a specific gravity between 0.8-1.17. These oils are sensitive to heat and light, therefore should be stored in dark bottles and cool places.

CLASSIFICATION OF ESSENTIAL OILS

Most EOs consist of mixtures of hydrocarbons, oxygenated compounds, and a small percentage of non-volatile residues (paraffin, wax, etc.). Chemically, EOs are basically comprised of two classes of compounds; these are terpenes and phenylpropenes. Terpenes are sub–divided based on the 5–carbon isoprene unit (building block) into mono ($C_{10}H_6$), sesqui ($C_{15}H_{24}$) and diterpenes ($C_{20}H_{32}$), while the phenylpropenes consist of 6-carbon aromatic ring having a 3-carbon side chain (C_6-C_3 compounds). More than 1,000 monoterpenes and 3,000 sesquiterpenes are identified, as reported so far (Clegg et al., 1980; Cooke et al., 1998).

PROPERTIES AND ACTIVITIES OF ESSENTIAL OILS

***Antimicrobial activity*:** The antimicrobial properties of the diverse chemical compounds present in EOs are not the result of one specific mode of action, but a cumulative effect on many different targets in various parts of the cell (Burt, 2004). It has been reported that their effectiveness might depend on pH, chemical structure, concentration or the individual bioactive compound, along with the population and types of affected microorganisms. The antimicrobial mechanisms include different activities, such as membrane disruption by terpenoids and phenolics, metal chelation by phenols and flavonoids, and effect on genetic material by coumarin and alkaloids that are thought to inhibit growth of microorganisms (Cowan, 1999). EOs are marginally more effective against Gram-positive as compared to Gram-negative food pathogens (Burt, 2004) because they have an outer membrane surrounding the cell wall which limits the intrusion of hydrophobic compounds through its lipopolysaccharide structures (Vaara, 1992). Many EOs stimulate growth of beneficial microbes and limit number of pathogenic bacteria in poultry (Wenk, 2000). Cerisuelo et al. (2014) showed a clear effectiveness of low doses of EOs and sodium butyrate in *Salmonella* control in broilers. **Table 1** shows the *in vitro* studies of EOs for its antimicrobial activity and minimum inhibitory concentration (MIC, ppm). The blend of thymol and cinnamaldehyde is proven to have selective antibacterial properties inhibiting the growth of yeast and fungi (Bento et al., 2013).

***Antiparasitic activity*:** Several plants and their EOs have been reported to have antiparasitic properties. For example, EOs and seeds of garlic (*Allium sativum*), onion (*Allium cepa*) and mint (*Mentha spp.*) are found to be effective against gastrointestinal parasitism. The birds infected once with coccidia, grow slower than non-infected ones even after intaking similar feed.

Carvacrol and thymol, the main ingredients of oregano oil, have anticoccidial action against *E. tenella* (Giannenas et al., 2003) and mixed *Eimeria spp*. infection (Oviedo-Rondón, 2003). In several other *in vivo* and *in vitro* studies, it was reported that phenols, in particular, can be used as ocysticides against *E. tenella* (Williams, 1997).

***Antioxidant activity*:** The antioxidant mechanisms of EOs are based on both their ability to donate a hydrogen or an electron to free radicals, and their ability to delocalize the unpaired electron within the aromatic structure (Fernandez-Panchon et al., 2008), thus protecting other biological molecules against oxidation. Phenolics are found to be more potent antioxidants as compare to vitamins E and C, and carotenoids (Rice-Evans et al., 1997). Karadas et al. (2014) found that dietary combination of EOs including carvacrol, cinnamaldehyde and capsicum oleoresin show antioxidant potential by improving the hepatic concentration of carotenoids and coenzyme Q_{10} when fed to broiler chickens.

***Anti-inflammatory activity*:** Essential oils contain phenolic compounds that are known to possess strong anti-inflammatory properties. The major EOs substances having anti-inflammatory abilities are the terpenoids and flavonoids. These substances suppress the metabolism of inflammatory prostaglandins (Craig, 2001). Some examples of plants having anti-inflammatory potential are chamomile, marigold, liquorice and anise (Srinivasan, 2005).

***Immunomodulatory activity*:** The immunomoduling potential of various EOs, for example, those from garlic and oregano has been examined by several researchers. Szigeti et al. (1998) stated that the incorportation of a modified product containing garlic in chicken diets increased antibody production against *Salmonella enteritidis*, *Pasteurella multocida* and *Leptospira pomona*. Hanieh et al. (2010) suggested that the immunomodulatory effect of garlic could be the result of its ability to enhance the production of interleukins, tumor necrosis factor (TNF-α), interferon (INF-γ). Also, garlic can increase phagocytosis of peritoneal macrophages, secretary metabolism of macrophages, antioxidant function, and antigen presenting cells (APC). Rahimi et al. (2011) stated the inclusion of garlic in broiler diets at 0.1% improved antibody response against Newcastle disease virus, increased weight of spleen and bursa of Fabricious, and augmented hypersensitivity cutaneous basophilic response.

***Stimulation of digestion*:** Essential oils favourably affect gut functions by stimulating digestive secretions *e.g*. bile and mucus, and enhanced enzyme activity (Platel, 2004; Manzanilla et al., 2004). In broilers, EOs enhance the secretion of trypsin, amylase and jejunal chyme (Jang et al., 2007), and reduce the adherence of pathogens (for example, *E. coli* and *Cl. perfringens*) with intestinal wall (Jamroz et al., 2006). Craig (1999) reported that the herbs and its EOs have a role in cholesterol lowering activity and by doing so they provide protection against cancer. The hypocholesterolemic effect of lemongrass oil is due to the inhibition of 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase activity which acts as a key regulatory enzyme in the cholesterol synthesis process (Elson et al., 1989; Cooke et al., 1998; Crowell, 1999).

FACTORS AFFECTING EFFECTIVENESS OF ESSENTIAL OILS

Factors that may affect the quality of EOs in plants include soil type, climate, use of chemical (fertilizers), genetics, harvesting, age of the plant, chemotype, and method of extraction. In many cases, the antimicrobial activity results through a complex interaction between different classes of compounds such as aldehydes, ketones, phenols, esters, alcohols, hydrocarbons or ethers found in the EOs. It was reported that EOs having phenols or aldehydes, for example, cinnamaldehyde, carvacrol, citral, thymol or eugenol as major components could show considerable antibacterial activity (Dormans and Deans, 2000). The efficacy of EO mixture also depends upon the compatibility with the other ingredient(s) of the mixture in the feed (Wang et al., 1998).

USE IN POULTRY NUTRITION

The replacement of antibiotic growth promoters with other safe and natural alternatives can be an important objective for the poultry industry. There are some promising results on the use of EOs and other natural products as performance enhancers. Typical performance parameters for poultry rearing are body weight, growth, feed intake, feed conversion ratio and egg production.

Broilers: The EOs as single or mixture may be used as a growth promoter in broiler production. Many studies have shown positive effects of dietary EO on body weight gain. Supplementing the dietary EOs would stimulate the growth performance of broilers (Cross et al., 2002; Bampidis et al., 2005). Broilers supplemented with a mixture of laurel, oregano, sage, citrus and anis EOs, or a mixture of EOs significantly improved feed conversion (Cabuk et al., 2006a). Also, in a broiler trial that examined mixtures of oregano, cinnamon, cayenne pepper, thyme, and combination of organic acids and plant extracts in comparison to nutritive antibiotic avilamycin in broiler chickens, the birds supplemented with the plant extracts showed higher body weight gain and increased feed consumption as compared to the other groups. Rezaei–Moghadam et al. (2012) has also reported that supplementation of turmeric increases serum antioxidant levels and immune status of the birds (Madpouly et al., 2011). Elagib et al. (2013) reported that addition of 3% garlic as feed additive could significantly enhance growth and performance of broiler chicks. Addition of a blend of EO from basil, caraway, laurel, lemon, oregano, sage, tea and thyme in a diet meeting the nutrient requirements of broilers would improve the body weight gain with positive effects on feed to gain ratio (Khattak et al., 2014).

Layers: In order to maintain or improve egg production and quality, optimum nutrition, environmental practices, and management are considered as the prerequisites. There are many reports examining the possible beneficial effects of garlic on egg production and quality. Plant extracts and spices as single compound or as mixed preparations can play a role in supporting both performance and health status of animals (Alcicek et al., 2004; Cabuk et al., 2006a). Feeding of garlic powder to the laying hen in the diet leads to increased egg production (Khan et al., 2007; Canogullari et al., 2010), and increased egg weight (Yalcin et al., 2006). The inclusion of EO mixture dosed at 24 mg/kg diet significantly improved egg production, feed efficiency, and reduced the percentage of cracked/broken eggs (Cabuk et al., 2006b). In a study conducted on laying quails, Cabuk et al. (2014) found that essential oil mixtures (EOM) had beneficial effects on egg production and feed conversion rate (FCR) when it was used as a dietary supplement. Summer stress leads to drop in egg production, more egg breakage and mortality. Essential oil mixture and organic acid supplementation in commercial layer diets under heat stress is beneficial to egg weight and immune function (Ozek, 2011).

CONCLUSION AND FUTURE ASPECTS

Many researchers have conducted their works to explore the nature and use of EOs in the poultry nutrition with variations among the results. The EOs and their compounds have proved their *in vitro* efficacy as antimicrobial, hypolipidemic, immunomodulating and anti-inflammatory agents, whereas the toxicological effects are observed only at higher inclusion levels. The antioxidant property of these oils reduces the loss in the meat processing plants. The chemical properties and biological activities of these compounds and their combinations should be extensively examined. The efficacy of EOs applications in animals depends on many factors. In general, EOs have positive effects, but the knowledge of their use in poultry nutrition is still insufficient and demands for further researches to clarify its mode of action, as well as the exact supplementation level and their interaction with feed ingredients for desired effects.

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