Essential oils and their benefits in poultry

- Technical Team
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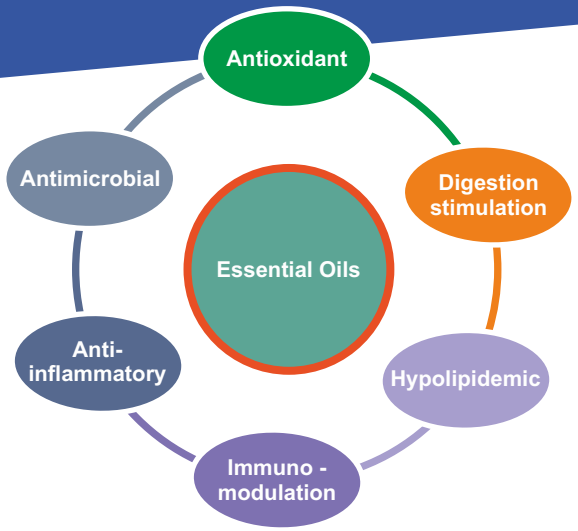


Fig. 1. Actions of essential oils

Introduction

Resistance of pathogenic bacteria to commonly used anti-microbials has forced the poultry industry to explore alternative solutions like prebiotics, probiotics, organic acids, bacteriophages, anti-microbial peptides, lysozymes, lactoferrins, phytogenics / essential oils (EOs), etc.

One of the safest and efficient alternatives is essential oils, also called as zoo-technical additives. Essential oils are less toxic and typically more residue-free compared to synthetic antibiotics, thereby ensuring animal welfare and food safety. Recently, use of essential oils along with short chain fatty acids (SCFAs) in broilers, layers and breeders has gained importance.

OVERVIEW OF ESSENTIAL OILS

The term "essential" does not mean that these are essential (Oyen and Dung, 1999) but denotes the essence (flavour) they obtain from different parts of the plants like root, stem, bark, fruit, flower, etc. Currently, there are over 3,000 known essential oils with approximately 300 being commercially relevant (Diaz-Sanchez *et al.*, 2015).

Quality of essential oils depends on environmental condition, climate, harvesting time, part of the plant, soil type and extraction method. Essential oils can be obtained through various methods like fermentation, extraction or expression but most common method is steam distillation (Raut and Karuppayil, 2014).

Essential oils are a mixture of fragrant and volatile compounds, sensitive to heat and light and are chemically comprised of two major classes, namely terpenes and phenylpropenes (Cooke *et al.*, 1998).

Essential oil constituents are quickly absorbed after oral administration and are either metabolized or eliminated by the kidneys in the form of glucuronides or exhaled as CO_2. Their accumulation in the body is unlikely due to rapid clearance and short half-lives (Lee *et al.*, 2004). Essential oils are found to have antibacterial, antifungal, antiviral and also exhibit antioxidant, anti-inflammatory, anti-carcinogenic, digestion stimulating & hypolipidemic activities (Viuda-Martos *et al.*, 2010). Besides, other beneficial effects of essential oils include appetite stimulation, improvement of endogenous digestive enzyme secretion and immune response activation.

Recently, essential oils along with SCFAs are used to improve body weight gain, feed conversion, egg production and disease resistance in poultry. As essential oils are highly reactive and possess strong odour & taste, they need to undergo micro-encapsulation process which will help them in sustaining pelleting temperature and increasing their shelf life.

PROPERTIES & ACTIVITIES

Antimicrobial activity

Antibacterial activity is not an outcome of a specific mode of action but it is a cumulative effect of various mechanisms which are dependent on pH, chemical structure, presence of functional groups (Farag *et al.*,1989), dose of active ingredient and quorum of microbes (Burt, 2004). Essential oils are very effective against Salmonella, *E. coli*, Clostridium and other pathogenic bacteria, (Cosentino *et al.*,1999) virus and fungi (Smith-Palmer *et al.*, 1998). Cinnamaldehyde, Carvacrol, Citral, Thymol and Eugenol exerts fair antibacterial effect (Dormans and Deans, 2000). Essential oils can potentially reduce the incidence of Salmonella in broiler carcasses and in the broiler house with a positive impact on food safety (Bento *et al.*, 2013).

Table 1. Actions of Essential Oil Components

Components	Mode of Action
Terpenoids & Phenolics	Bacterial Cell membrane disruption
Phenols & Flavonoids	Metal ion chelation
Alkaloids	Bacterial growth inhibition

(*Cowan, 1999*)

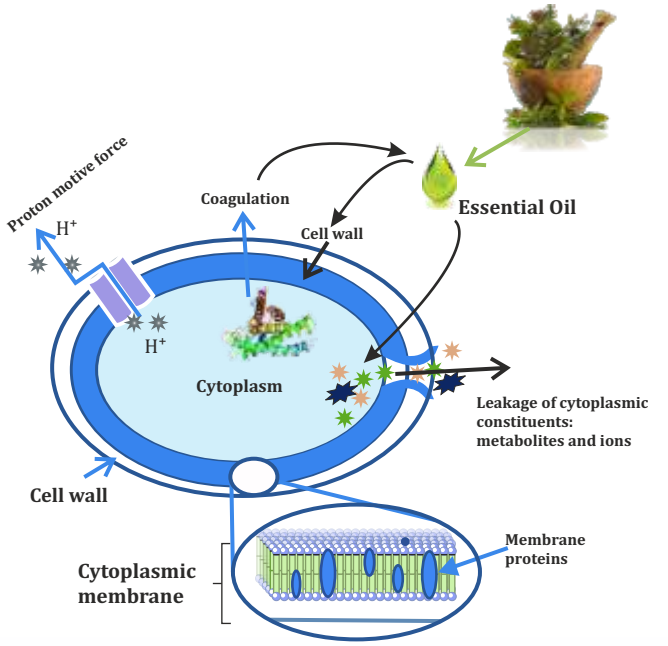


Fig. 2. Antimicrobial activity, by affecting different elements of the pathogen

Cinnamaldehyde exerts antifungal activity by acting on sulfhydryl groups (Kurita *et al.*, 1979) and inhibits fungal cell wall synthesis (Bang *et al.*, 2000) which is necessary for fungal growth. Microbes use quorum-sensing to orchestrate collective population behaviour including bio-film formation and/or virulence factors secretion which is dependent upon the production and release of specific chemicals / signals at a population-wide scale. Phytochemicals derived from medicinal plants of the Myrtaceae family like Clove, Guava, Eucalyptus (Musthafa *et al.*, 2017) and Cinnamaldehyde (Pande *et al.*, 2013) inhibit quorum sensing and overcome the increasing virulence factors of pathogenic bacteria.

Antiparasitic activity

Essential oils are potent botanical products which either interfere directly with parasitic metabolism or indirectly by enhancing the host immune response and antioxidant defence system for the effective control and eradication of parasitic invasion. They also help in reducing intestinal lesions and faecal oocyst shedding in the litter. Phenols have oocysticidal action, control coccidiosis infection (Williams, 1997) and endoparasites in the gut.

It has been suggested that EOs are an effective alternative to coccidio-stats, on the basis of improvements in performance & significant reduction in the post infection faecal blood discharge. Carvacrol and Thymol have anti-coccidial action against *E. tenella* and mixed *Eimeria spp.* infection (Oviedo-Rondon, 2003).

Antioxidant property

Essential oils have an inherent ability to donate electrons to the free radicals produced during the process of lipid peroxidation (Fernandez-Panchon *et al.*, 2008). They increase the keeping quality of meat by attenuating oxidative injury and improving redox balance in blood, muscles and tissues. They also influence the in vivo antioxidant defence systems such as Superoxide dismutase and Glutathione peroxidase. Phenolic EOs have potent antioxidant activity than Vitamin E, Vitamin C & Vitamin A and improve the hepatic concentration of Coenzyme Q10 (Rice-Evans *et al.*,1997). Thymol, Carvacrol and other essential oils can act as antioxidants in egg and meat of chickens when introduced in the diets (Lee *et al.*, 2004). Supplementation of Carvacrol, Capsaicin and Cinnamaldehyde can increase the number of goblet cells and secretion of mucin on the surface of villi, providing better protection against invading infectious agents.

Stimulation of Digestion

Essential Oils improve digestion by stimulating secretion of bile, mucus and various digestive juices like trypsin, amylase and jejunal chyme (Manzanilla *et al.*, 2004). They significantly increase the villus width and surface area, indicative of improved nutrient absorption (Geyra *et al.*, 2001) and performance (Choct, 2009) and reduce the adherence of pathogens. Cinnamaldehyde helps to increase the bile secretion (Harada and Yano,1975).

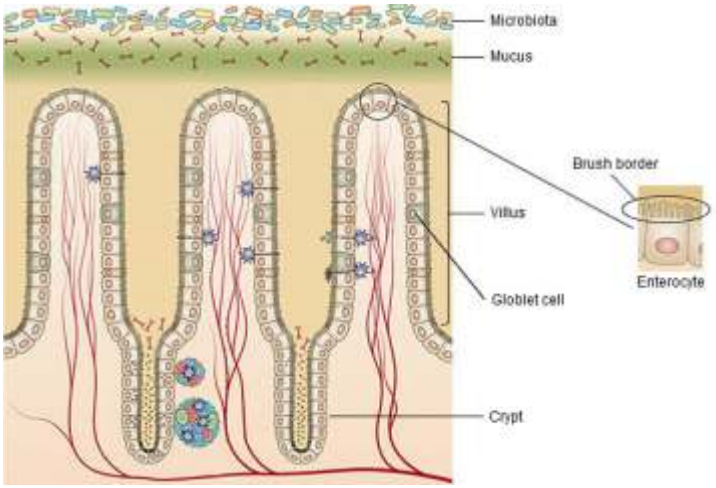


Fig. 3. Stimulation of digestion by improving villi and microvilli growth

Anti-inflammatory activity

Essential oils have been used traditionally for centuries to alleviate symptoms associated with eczema, dermatitis and other pronounced irritations (Kamatou and Viljoen, 2010). The major EO substances having anti-inflammatory abilities are the terpenoids and flavonoids. They suppress metabolism of inflammatory prostaglandins and reduce inflammatory conditions (Craig, 2001). Other essential oils (eucalyptus, rosemary, lavender, millefolia) and other plants (pine, clove and myrrh) have been used in mixed formulations as anti-inflammatory agents (Darsham and Doreswamug, 2004). They contain phenolic compounds that are known to possess strong anti-inflammatory properties. These substances suppress the metabolism of inflammatory prostaglandins.

Lipid metabolism

The hypolipidemic effect of essential oils is carried out through the inhibition of HMG-CoA reductase activity, a key regulatory enzyme in cholesterol synthesis (Crowell, 1999). Essential oils significantly reduce serum cholesterol level of broilers (Gopi *et al.*, 2012).

Immunomodulatory activity

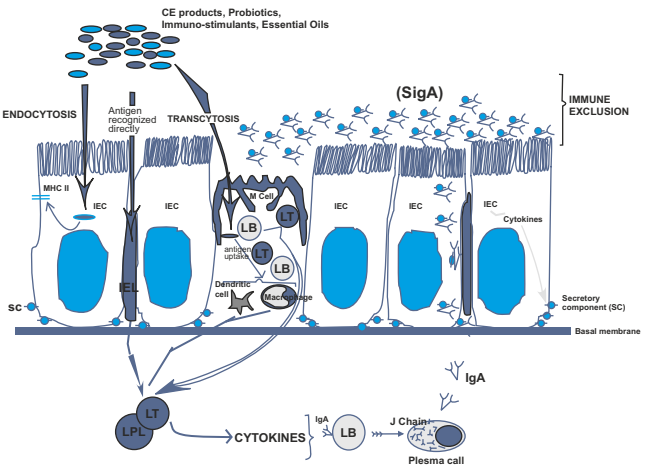


Fig. 4. Immunomodulatry activity of Essential Oils

This activity is a result of optimizing production of interleukins, γ interferons and TNF α. Essential oils increase phagocytic activity of macrophages and Antigen Processing Cells (APC) (Hanieh *et al.*, 2010). Another mode of improving immunity is through increasing weight and activity of immune organs like bursa of fabricius and spleen (Rahimi *et al.*, 2011).

There will be an increase in IgG, IgA, IgM, CD3 and CD4 serum levels and ND titre values when birds are provided with essential oils (Rezaei–Moghadam *et al.*, 2012). It is well known that many diseases, that have immunomodulated components, can be treated by administration of biological compounds that activate key pathways in the immune system. They strengthen the defence and immune mechanisms of the body and can be used for stimulating the non-specific immune response (Awaad *et al.*, 1999).

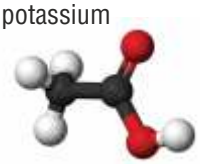
Positive effect on gut microbiota

Many essential oils stimulate growth of beneficial microbes and reduce the number of pathogenic bacteria in gut (Wenk, 2000). Similarly, Capsaicin, Carvacrol and Cinnamaldehyde will have a positive impact on gut microbiota and growth performance (Jamroz *et al.*, 2005). Activity of intestinal microbiota leads to synthesis of SCFAs as a result of digestion of indigestible fibre which provides additional source of energy for the host (Li *et al.*, 2012). Essential oils also increase the proportion of SCFAs, butyrate in the caecum which is known to provide energy to colonic mucosa (Roediger, 1980) and thus have potentially important implications for intestinal immunity (Hamer *et al.*, 2008).

Effect on Growth Performance

Dietary essential oils may act not only on intestinal microflora, but also on nutrient utilization (Bento *et al.*, 2013) in broilers, layers and breeders. Essential oils improve growth performance by stimulating the secretion of digestive enzymes leading to improved nutrient digestion, rate of gut passage or feed intake (Jamroz *et al.*, 2005).

SHORT CHAIN FATTY ACIDS



Short chain fatty acids (SCFA) with sodium, potassium and calcium salts are commonly used for controlling susceptible pathogenic bacteria particularly gram negative ones. Butyric, propionic, formic and acetic acids are commonly used SCFAs in poultry for performance elevation. Salts / uncoated SCFAs will get neutralized easily in the foregut and very less antibacterial activity will be retained due to their dissociation but gut acidification will be taken care to some extent.

Coated or esterified SCFAs / organic acids are used which are more resistant against being neutralized in the foregut and provide good action in the hind gut against susceptible bacteria but acid available in undissociated form in the hind gut is highly variable. The use of organic acids has been reported to protect the young chicks by competitive exclusion (Mansoub *et al.*, 2011), enhancement of nutrient utilization, growth, feed conversion efficiency, immunity and performance in broiler and laying hens (Luckstadt and Mellor, 2011). SCFAs are also involved in prevention of diarrhoea (water and Na^+ absorption), pH control within the gastrointestinal tract, and defence against pathogens (colonization resistance). SCFAs are helpful in decreasing intestinal *E. coli* and *Salmonella spp.* (Hassan *et al.*, 2010).

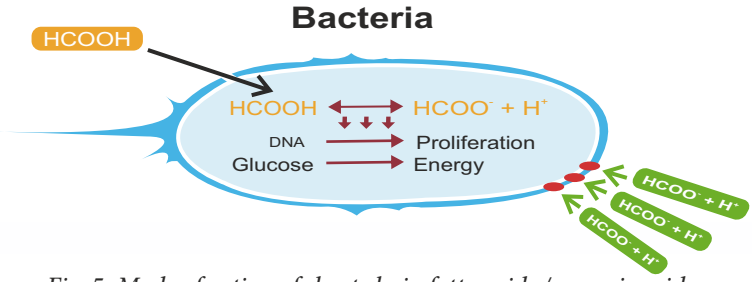


Fig. 5. Mode of action of short chain fatty acids / organic acids

It has been shown that SCFAs inhibit the growth of Salmonella (Van Immerseel et al., 2003), Aspergillus (M.A. Coaker et al., 2006) and Penicillium (Mariko ERA, 2015). SCFAs reduce cytoplasmic pH and stop metabolic activities of susceptible bacteria. SCFAs will cause death of susceptible organisms by acting on cytoplasmic membrane by neutralizing its electrochemical potential and increasing its permeability. Once hydrogen ion is injected through the lipopolysaccharide layer on the cell wall of susceptible bacteria, pH of intracellular contents will be reduced and this process consumes a great amount of energy to maintain intracellular homeostasis and causes bacterial cell death. SCFAs will improve gut health by reducing damage of intestinal cells by pathogenic bacteria and improve birds' performance in terms of body weight gain, FCR, maintain egg production, reduce egg shell contamination, and reduce litter contamination in broiler, layer and breeders.

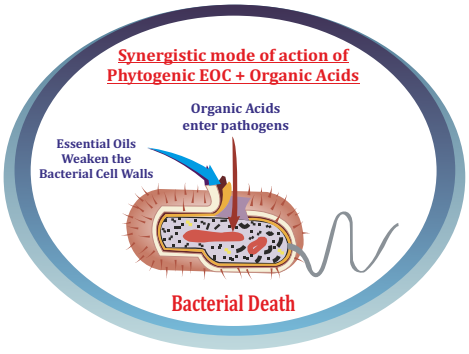


Fig. 6. Synergistic action of Essential oils and short chain fatty acids

MEDICINAL ACTIVITY OF COMMONLY USED HERBS AS EOs

Name of the Herb	Major Active Ingredient	Medicinal Property	Reference
Oregano *Origanum vulgare*	Carvacrol & Thymol	Anti-bacterial, anti-fungal, anti-parasitic, anti-viral, anti-inflammatory, immuno-stimulant, hepatoprotectant and anti-oxidant activity	Joseph Nordqvist, 2017
Cinnamon *Cinnamomum verum*	Cinnamaldehyde	Immuno-modulatory, anti-oxidant, anti-viral, anti-microbial, lipid-lowering, anti-inflammatory, anti-tumor, gastroprotective, neuroprotective and blood purifying properties.	Steiner, 2010; Toghyani *et al.*, 2011
Clove *Syzygium aromaticum*	Eugenol	Anti-microbial, anti-fungal, anti-inflammatory, anti-carcinogenic, anti-parasitic and anti-oxidant effects	Mitsch *et al.*, 2004; Kamel, 2001
Eucalyptus *Eucalytpus globulus*	Cineole	Anti-microbial, anti-viral, expectorant, decongestant, mucolytic, immuno-modulatory and activity against heat stress	Farhadi *et al.*, 2016
Capsicum *Capsicum frutescens*	Capsaicin	Improves stimulation of pancreatic, intestinal enzymes and bile acid secretion	Abdel Salam *et al.*, 2005; Platel and Srinivasan, 2004,
Ginger *Zingiber officinale*	Gingerol	Digestion stimulation, anti-oxidant, anti-microbial and immune stimulation	Morakinyo *et al.*, 2011
Pepper *Piper nigrum*	Piperine	Anti-microbial, anti-inflammatory, digestive stimulant, anti-oxidant, immune stimulant and hypolipidemic	Khalaf *et al.*, 2008; Mittal and Gupta, 2000; Reddy *et al.*, 2004
Garlic *Allium sativum*	Allicin	Anti-bacterial, anti-fungal, anti-parasitic, anti-viral, anti-oxidant, anti-cholesteremic, anti-carcinogenic and vasodilator characteristics	Hanieh *et al.*, 2011
Turmeric *Curcuma longa*	Curcumin	Anti-oxidant, anti-protozoal, anti-microbial, anti-inflammatory, anti-carcinogenic, liver health and immuno-modulatory	Amalraj *et al.*, 2017
Cumin *Cuminum cyminum*	Cuminaldehyde & Thymoquinone	Anti-inflammatory, anti-carcinogenic, immune stimulatory, gastroprotective, digestive stimulant, hepatoprotective, nephroprotective, and neuro-protective activities.	Srinivasan, 2018
Peppermint *Mentha x Piperita*	Menthol	Anti-coccidial, anti-stress, anti-microbial, insect-repellent, analgesic and anti-oxidant	Arab Ameri *et al.*, 2016

CONCLUSION

Controlling of gut pathogens can be done by using essential oils and its main purpose is to attain good gut health and keeping the stressor agents at bay. Synergistic effect of essential oils with SCFAs will exert broad spectrum antimicrobial effect and help in reducing clinical and sub clinical infections caused by Salmonella, *E. coli*, Staphylococci and Clostridium in the gut as well as systemically. In broilers, it helps in improving bird performance, health status, immunity and feed conversion. In layers and breeders, it is employed for improving egg production and egg quality, health status of birds, feed efficiency, immunity and reduction in the percentage of cracked / broken eggs. Application of essential oils with SCFAs in the poultry diet could be used as antimicrobial, antioxidant, immuno-modulating and anti-inflammatory agents to produce low cholesterol meat, juicy and tender meat, fortified eggs and improved productivity with better survival rate.

Essential oils serve as an effective performance enhancer and an excellent alternative to AGPs due to their unique, traditionally used components like herbs / spices and thus play a huge role in the poultry industry development. The efficacy of any performance enhancer is partially dependent on other factors like effective rotation / shuttle programme of coccidiostats in feed, hence proper attention should be paid towards coccidiosis control programme. No agent is ideal unless proper management, feeding, brooding conditions, feed form (pelleted / mash), preventive vaccination and strict bio-security are maintained at farm level.

References are available on request.