

Review Article

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Essential oils and Organic Acids: Feed Additive in Broiler Chickens

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ABSTRACT

The escalating concern over the antibiotic residues in animal and poultry products among the consumers made the hour a prime time to find an alternative to antibiotic growth promoters (AGPs) and it have increased a lot over the past decade. New alternatives of antibiotics are essential oils and organic acids. Essential oil usage in animal feeding has been practiced for their role as antibacterial, antiviral, antifungal, antioxidant, digestive stimulant, immune-modulator, hypolipidemic agent and also heat stress alleviator. Organic acids have gained significant attention due to their high nutritional value and antimicrobial benefits. Organic acids and their salts are generally regarded as safe and have been approved by most member states of the EU to be used as feed additives. Thus, the purpose of this paper is to review the potential of using essential oils and organic acids as feed additives in broiler chickens.

Keywords

Poultry, Feed additives, Organic acids, Essential oils

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Introduction

The integrity of the gastrointestinal tract (GIT) and the gut microflora play significant roles in nutrition absorption, development of immunity, and disease resistance in broiler chicken. Any alterations in the may have adverse effects on feed efficiency, productivity, and health of chickens. Several feed additives including antibiotic growth promoters (AGPs) are included in poultry

feeds to improve the efficiency of production, product quality and to prevent diseases (Brenes and Roura, 2010). The poultry industries are currently transforming towards decreased use of AGPs due to increased concerns regarding development of antibiotic-resistant bacteria and transfer of residues of AGPs in meat and eggs, which may cause side-effects in humans. In 2006, the European Union (EU) approved a resolution to ban the use of antibiotics as growth promoters for

animals. Myriad biological products, such as enzymes, probiotics, prebiotics, synbiotics, organic acids and plant extracts (phytobiotics) have been increasingly assessed as substitutes to antibiotic feed additives in diets for monogastric animals (Wenk, 2003).

Essential oils

Essential oils are natural substances having a protective function against harmful pathogenic microorganisms (Zeng *et al.*, 2015). Essential oils or volatile oils are aromatic oily liquids extracted by distillation from plant parts, such as flowers, buds, seeds, leaves, twigs, bark, wood, fruits and roots. Chemically, essential oils are complex and highly variable mixtures of constituents that belong to two groups: terpenoids (monoterpenes and sesquiterpenes), aromatic compounds (aldehyde, alcohol, phenol, methoxy derivative, and so on) and terpenoids (isoprenoids) (Bakkali *et al.*, 2008; Nazarro *et al.*, 2013).

Biological effects of essential oils

Antimicrobial activity of essential oils

The antimicrobial activity of essential oils has been explored in many *in vitro* assays which showed that thymol, eugenol and carvacrol have high antimicrobial activity against pathogenic bacteria such as *Escherichia coli* and *Salmonella typhimurium*, (Bassole and Juliani, 2012; Franz *et al.*, 2010). Thymol, eugenol and carvacrol are structurally similar, and have been proved to exert synergistic or additive antimicrobial effects when combined at lower concentrations (Bassole and Juliani, 2012). In *in vivo* studies, essential oils used either individually or in combination have shown clear growth inhibition of *Clostridium perfringens* and *E. coli* in the hindgut and ameliorated intestinal lesions and weight loss than the challenged control birds (Jamroz *et*

al., 2005; Jerzsele *et al.*, 2012). Previously, in a study the antimicrobial properties of 29 essential oils were investigated against 59 microorganisms (Deans and Ritchie, 1987). The antimicrobial property of these essential oil differs with the family it belongs, like Lavandin, Tea tree and Peppermint oils have shown a little or no antimicrobial property but Cinnamon, Oregano, thyme have shown great antimicrobial activity, while Juniper shows an antifungal activity (Dorman and Deans, 2000). The exact anti-microbial mechanism of most of the essential oils is poorly understood. However, it has been suggested that their lipophilic property (Conner, 1993) and chemical structure (Frag *et al.*, 1989) could play a role. It was thus suggested that terpenoids and phenylpropanoids can penetrate the membrane of the bacteria and reach the inner part of the cell because of their lipophilicity, but it has also been proposed that structural properties, such as the presence of the functional groups (Frag *et al.*, 1989), and aromaticity are responsible for the antibacterial activity. It is thought that membrane perforation or binding is the principle mode of action (Shapiro and Guggenheim, 1995; Stiles *et al.*, 1995) leading to an increase of permeability and leakage of vital intracellular constituents, resulting in impairment of bacterial enzyme systems (Frag *et al.*, 1989). The mechanism of antifungal action of cinnamaldehyde has been investigated and it was proposed that it takes place through the reaction with sulfhydryl groups, which are indispensable for the fungal growth, and that the formation of charge transfer complexes with electron donors in the fungus cell could lead to inhibition of cell division and thus interferes with cell metabolism. It was also reported that cinnamaldehyde inhibits the fungal-cell-wall synthesizing enzymes (Bang *et al.*, 2000). It is of note that Gram negative bacteria are more tolerant to the actions of essential oil than Gram-positive bacteria due to their

hydrophilic constituents in the outer membrane (Giannenas *et al.*, 2013). Coccidiosis, a common parasitosis disease caused by protozoa of the genus *Eimeria*, leads to malnutrition and performance depression in poultry. The supplementation of essential oils led to a significant reduction of coccidian oocyst excretion and an alleviation of intestinal lesions in chicks (Alp *et al.*, 2012; Bozkurt *et al.*, 2014; Barbour *et al.*, 2015). However, the underlying mechanisms still need to be elucidated.

Effect on digestive processes

Many studies were conducted concluding that, dietary essential oils addition could improve the digestion process (Mellor, 2000). They enhance the activity of some digestive enzymes like trypsin and amylase (Jang *et al.*, 2007). The pungent compound in essential oils like curcumin, capsaicin and piperine have been found to stimulate the digestive enzyme activities of both intestinal mucosa and also in pancreas (Platel and Srinivasan, 2000). Some studies have reported that the spices or its active components increased the bile salt secretion (Sambaiah and Srinivasan, 1991). Cinnamaldehyde increased the bile secretion in the rat (Harada and Yano, 1975). Lee *et al.*, (2003) reported that cinnamaldehyde in diet had a role in the digestion process while thymol is not involved in these processes. Kreydiyyeh *et al.*, (2000) observed that there was an increase in the absorption of glucose in the intestine of rats when they were fed with anise oil. The hypocholesterolemic effect of lemongrass oil is due to the inhibition of hepatic 3-hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase activity which is a key regulatory enzyme in cholesterol synthesis (Elson *et al.*, 1989). In poultry, a 5% inhibition of HMG-CoA reductase activity will lead to lowered serum cholesterol by 2%.

Effect on immune system

Some essential oils positively influence the avian immune system, since they promote production of immunoglobulins, enhance lymphocytic activity, and boost interferon- γ release (Awaad *et al.*, 2010; Faramarzi *et al.*, 2013; Gopi *et al.*, 2014). Supplementing of essential oils in diet positively influenced the activity of the intestinal lymphatic system. Placha *et al.*, (2014) suggested that the supplementation of 0.5 g of thyme oil per kg of feed significantly increased IgA levels. Awaad *et al.*, (2010) revealed that adding eucalyptus and peppermint essential oils to water in the amount of 0.25 ml L⁻¹ results in an enhanced both cell-mediated and humoral immune response. Saleh *et al.*, (2014), who applied thyme and ginger oils observed an improvement in the chicken immunological blood profile through an increased antibody production. Moreover, the oils alleviate the stress caused by vaccination (Barbour *et al.*, 2011; Faramarzi *et al.*, 2013; Gopi *et al.*, 2014). Essential oils promote the production of antibodies, thus enhancing the efficacy of vaccination (Awaad *et al.*, 2010; Faramarzi *et al.*, 2013).

Antioxidant activity

Chicken body antioxidative stability could be improved by essential oils. Karadas *et al.*, (2014) supplemented diet of chicken with a blend of carvacrol, cinnamaldehyde, and capsicum oleoresin, and found a significant increase in the hepatic concentration of carotenoids and coenzyme Q10 at d 21 of age. Habibi *et al.*, (2014) and Placha *et al.*, (2014) observed that malondialdehyde concentration in liver, duodenal mucosa, and kidney was significantly decreased by supplementing ginger powder and thyme oil to broiler diet. Poultry products are particularly prone to oxidative deterioration due to their high concentrations of polyunsaturated fatty acids.

High efficacy in inhibiting oxidation of fatty emulsions was demonstrated for thyme (88.0%), rosemary (78.8%), sage (73.9%), and lavender (72.5%) oils (Amorati *et al.*, 2013). The reviews by Lee *et al.*, (2003) and Khan *et al.*, (2012) showed that thyme oil is effective in retarding oxidant degradation in poultry derived products, such as meat and eggs. The mechanism of action might be the antioxidant activity of the phenolic OH group which acts as a donor of hydrogen interacting with peroxy radicals during the initial process in lipid oxidation and leading to inhibiting or retarding the hydroxyl peroxide formation (Lee *et al.*, 2003).

Organic acids

Organic acids are any organic carboxylic acid of the general structure R-COOH including fatty acids and amino acids. Not all of these acids have effects on gut microflora. Short chain fatty acids (SCFA) are recognized as potential alternative to antibiotic growth promoter (Paul *et al.*, 2007). Short chain monocarboxylic acids such as citric, propionic, fumeric and formic acids etc. are used in poultry as feed additives.

Biological effects of organic acids

Antimicrobial activity

As pathogenic microbes or bacteria multiply in GI tract, they not only damage the villus but also make the intestinal membrane thick due to cell proliferation which causes the infiltration of nutrients tough leading reduced growth performance. The protonated form of organic acids penetrates across bacterial cell wall which then dissociates into its conjugated base form with reduction in cellular pH. Low pH creates a stressful environment which leads to cellular dysfunction and reduced bacterial multiplication. Recently in a study, it was

documented that pathogenic bacterial loads such as coliforms and Clostridia were lesser in Broiler chickens fed diets containing organic acid blends while on the contrary they have higher beneficial bacteria such as Lactobacilli in the ileum compared with those fed diets containing antibiotic growth promoters (Khan 2016). Higher Lactobacilli count may be due to less susceptibility to pH changes while coliforms are more sensitive to pH reductions than Lactobacilli in the GIT (Kim *et al.*, 2009). Organic acids has property of lowering the pH of the gastrointestinal tract of birds thus may also prevent bacterial transfer from the diet or environment (Kil *et al.*, 2011).

Effect on gastrointestinal tract (GIT)

In poultry industry it is a well established fact that success goes through gastrointestinal tract of poultry. Many researchers have documented positive effects of organic acid supplementation in terms of the villus height, width and area of small intestine (Rodríguez Lecompte *et al.*, 2012). Pelicano *et al.*, (2005) stated higher villus height in the ileum with the diet based on organic acid salts in comparison to the diet fed without mannan oligosaccharide (MOS) plus organic acids. Several other reports indicate that broilers fed diets containing formic acid had the longest villi compared with control *i.e.* 1088 μm . Short-chain fatty acids (SCFA) have been demonstrated to stimulate the proliferation of normal crypt cells, enhancing healthy tissue turnover and maintenance Leeson *et al.*, (2005) and Panda *et al.*, (2009) reported that butyrate, irrespective of concentrations (0.2%, 0.4% or 0.6%) in the broiler's diet had improved the villus length and crypt depth in the duodenum. Adil *et al.*, 2010 in another study concluded that the highest duodenal, jejuna and ileal villus heights were recorded in the birds fed diets supplemented with 3% butyric acid, 3% fumaric acid and 2% fumaric

acid, respectively. These pathogen substances cause disturbances in the normal micro-flora or in the intestinal epithelium, may alter the permeability of this natural barrier, thus facilitating the invasion of pathogens resulting in modification of the metabolism i.e. ability to digest and absorb nutrients which leads to chronic inflammatory processes in intestinal mucosa (Khan, 2013).

Effect on nutrient digestibility

To achieve more returns in terms of lower feed conversion ratios one of the most logical approach seems to increase the nutrient digestibility. In a study by Ao *et al.*, 2009 concluded that 2% citric acid in the broiler diet increased the retention of DM, CP and neutral detergent fibre. Similarly, Ghazala *et al.*, (2011) reported that dietary 0.5% of either fumaric or formic acid and 0.75% of acetic or 2% citric acid improved crude protein (CP), ether extract (EE), crude fibre (CF) and nitrogen-free extract (NFE) of broiler diets. More-over, Hernandez *et al.*, (2006) and Garcia *et al.*, (2007) reported that supplementation of formic acid (0.5%) in broiler finisher diet improved apparent ileal digestibility of DM and CP as compared with control. According to Jongbloed *et al.*, (2000) reduced pH in the upper part of the GIT may increase nutrient digestibility in diets.

Effect on immune system

Several studies on organic acids have demonstrated stimulatory effect on natural immunity in poultry. Lohakare *et al.*, (2005) in his study measured titers of infectious bursal disease (IBD) post vaccination showed significantly higher IBD titres in Vitamin C (0.2%) supplemental group. There was significant increase in CD4 and TCR-II cells in the 0.1% Vitamin C group as compared with control and these cells participate in the

immune response to the exogenous antigen, stimulating the synthesis of Interleukin-2, which activates CD8, natural killer (NK) cells and B cells. In a study by Ghazala *et al.*, (2011) birds fed an organic acid supplemented diet had heavier immune organs (bursa of Fabricius and the thymus) and higher level of globulin in their serum as well. Houshmand *et al.*, (2012) found that dietary addition of organic acids resulted in significant increases in antibody titres against Newcastle disease in broilers.

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