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Review Article

UTILIZATION OF ESSENTIAL OILS IN POULTRY DIET – A REVIEW

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Abstract: Essential oils are volatile oils obtained from plants. Essential oils are very complex mixtures of compounds and their chemical composition and concentration of individual compounds are variable. Essential oils are found to have antibacterial property and also exhibiting antioxidant, antiinflammatory, anticarcinogenic, digestion stimulating and hypolipidemic activities. The impact of pH on the biological activity of essential oils and their ability of affecting the bacterial growth of some undesirable bacterial species makes them ideal candidates as gut bacterial modulators. The antimicrobial mechanism of essential oils is their lipophilic properties and chemical structures. Essential oils not only can they function individually, but their effects can also be enhanced through synergistic effects both between individual essential oils and in combination with other feed additives.

Introduction

An essential oil is a mixture of fragrant, volatile compounds, named after the aromatic characteristics of plant materials from which they can be isolated (Oyen and Dung, 1999). Essential oils are obtained from plants, normally by steam and/or water distillation. Their active compounds can also be produced in 'nature-identical' form- with identical chemical structure to the naturally occurring raw materials and their extracts. In order to achieve a recognised 'nature-identical' level under food legislation, these products must be at least 99.5% identical to the natural materials (Williams and Losa, 2001). Because of the large variation in composition, the biological effects (Deans and Waterman, 1993), if any, of essential oils may differ. This diversity of essential oils urged us to select four pure principles, i.e. thymol, cinnamaldehyde, beta-ionone and carvacrol, for evaluating their possible role as alternatives to antibiotics in poultry production. The need for the use of antibiotics to decrease the spread of disease (Waldroup *et al*., 2003) and as a growth enhancer is increasing day by day to sustain the growth of poultry production (Roura *et al*., 1992).

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The opportunistic pathogens that are normally inhabitant of the intestinal tract may reduce the growth rate and is related with the microbial load of the chicken's environment (Thomke and Elwinger, 1998). Antibiotics act on pathogenic intestinal bacteria that will produce toxins that harm the birds either in terms of livelihood or production performance. Antibiotics used in this way get accumulated in the tissues of birds leading to antibiotic resistance in human through food chain ultimately ending up in therapeutic failure (Levy and Marshall, 2004).

As a results, the inclusion of essential oils in animal diets could potentially minimise the occurrence of intestinal diseases caused by undesirable bacteria, and could favour the growth of beneficial gut microbiota supporting growth performance (Bento *et al*., 2013).

Classification

Essential oils basically consist of two classes of compounds, the terpenes and phenylpropenes (Lee *et al*., 2004). Depending on the number of 5-carbon building blocks (isoprene units), terpenes can be sub-divided into mono-, sesqui-, and di-terpenes in which the number of isoprene units are 2, 3 and 4, respectively. Further derivatives of terpenes are typified by the presence or absence of a ring structure, double bond, addition of oxygen or stereochemistry. It is estimated that there are more than 1000 monoterpenes 3000 sesquiterpenes (Phenylpropenes consist of a 6-carbon aromatic ring with a 3-carbon side chain (C_6-C_3 compounds) (Gopi *et al*., 2014).

Synthesis

Terpenes and phenylpropenes are synthesized by the mevalonic and shikimic pathway, respectively. The 6-carbon mevalonic acid, which is formed by condensation of three acetate units and by HMG-CoA reductase, is converted to 5- carbon isopentenyl pyrophosphate (IPP) and then to dimethyl allyl pyrophosphate (DMAPP), which are the activated 5-carbon units of isoprene. IPP and DMAPP are then combined in a 1:1 molar ratio to generate 10- carbon geranyl pyrophosphate (GPP) which is the precursor of monoterpenes. The addition of IPP to GPP produces the 15-carbon sesquiterpene compound, farnesyl pyrophosphate (FPP). Thymol and carvacrol are derived from GPP and classified as monoterpenoids or isoprenoids. On the other hand, -ionone is derived from FPP and thus classified as either sesquiterpene or isoprenoid.

The shikimic acid pathway produces th aromatic amino acid phenylalanine, the products of which are cinnamic acid and *p*-coumaric acid with trans configuration (Seigler, 1998). Among the important phenyl propene compounds are eugenol, trans-cinnamaldehyde, safrole and also the pungent principles, capsaicin and piperine. These are classified as phenylpropenoids (Gopi *et al*., 2014).

Essential oil in poultry diet

The essential oil have wide range of activities in system like antibacterial, antioxitant,digestive stimulant, growth promoter, immunomodulator, antimycotic, antiparasitic, antitoxigenic antiviral and insecticidal (Gopi *et al*., 2014).

Biological effects of essential oils

Anti-microbial activities

Essential oils have long been recognized because of their anti-microbial activity (Smithpalmer *et al*., 1998; Hammer *et al*., 1999). The exact anti-microbial mechanism of essential oils is their lipophilic property (Conner, 1993) and chemical structure (Farag *et al*., 1989) could play a role. Terpenoids and phenylpropanoids can penetrate the membrane of the bacteria and reach the inner part of the membrane of the bacteria and reach the inner part of the cell because of their lipophilicity (Helander *et al*., 1998), but it has also been proposed that structural properties, such as the presence of the functional groups (Farag *et al*., 1989), and aromaticity (Bowles and Miller, 1993) are responsible for the antibacterial activity.

Antioxidant effects

High antioxidant activity of thymol is due to the presence of phenolic -OH groups which act as hydrogen donors to the peroxy radicals produced during the first step in lipid oxidation, thus retarding the hydroxy peroxide formation. Thymol and carvacrol can act as antioxidant in egg and meat of chickens when introduced in to the diets (Lee *et al*., 2004).

Essential oil as flavour

Essential oils and their pure components are also used as flavor in human foods. Carvacrol can be used in non-alcoholic beverages up to the level of 26 ppm and in baked goods upto 120 ppm (Furia and Bellanca, 1975). Cinnamaldehyde can be used at low as 8 ppm in ice cream products and as high as 4900 ppm in chewing gum (Furia and Bellanca, 1975). Thymol and beta- ionone are also used as flavoring agents in foods (Lee *et al*., 2004).

Effects on Digestion

The dietary pungent principles, i.e. curcumin, capsaicin, and piperine, have been shown to stimulate digestive enzyme activities of intestinal mucosa and of pancreas. The pungent principles, capsaicin and piperine and cinnamaldehyde share their synthetic pathway (shikimic pathway) (Platel and Srinivasan, 2000).

Effects on lipid metabolism

The pure components of essential oils inhibit hepatic 3- hydroxy-3-methylglutaryl coenzyme A (HMG-CoA) reductase activity (Crowell, 1999) which is a key regulatory enzyme in cholesterol synthesis. As a result, a hypocholesterolemic effect of essential oils can be expected. A 5% inhibition of HMC-CoA reductase lowered serum cholesterol by 2% in poultry (Case *et al*., 1995). Correlation between HMG-CoA reductase activity and either total or LDL cholesterol in chicken, but not with HDL cholesterol (Qureshi *et al*., 1983).

A variety of essential oil compounds, such as borneol, cineole, citral, geraniol, menthone, menthol, fenchone, fenchyl alcohol, and -ionone suppress hepatic HMG-CoA reductase activity (Yu *et al*., 1994).

Mode of action

The hypocholesterolemic effects of essential oils are mediated by down-regulating the regulatory enzyme, HMG-CoA reductase, post- transcriptionally without changing the enzyme mRNA levels (Qureshi *et al*., 1996). The inhibitory action of essential oils on hepatic HMG-CoA reductase is independent of the diurnal cycle of the enzyme, and of hormones such as insulin, glucocorticoids, triiodothyronine, and glucagon (Middleton and Hui, 1982). The complete inhibition of cholesterol synthesis requires two regulators, i.e. cholesterol derived from LDL and a non-sterol products derived from mevalonate, both of which modulate HMG-CoA reductase activity (Goldstein and Brown, 1990). Thymol, carvacrol and -ionone might induce a putative regulatory non-sterol products (Elson, 1996).

Effect of on growth performance in chickens

As essential oils are also flavours, they are expected to stimulate appetite, which is particularly crucial for young animals to thrive. Dietary essential oils may act not only on intestinal microflora, but also on nutrient utilization (Bento *et al*., 2013).

Moreover, it seems that isomers can have different effects on growth performance. The importance of the gut microbiota and their fermentation profiles on the immune status and growth performance of the host (Li *et al*. 2012). Essential oils improve growth performance because they stimulate the secretion of digestive enzymes leading to improved nutrient digestion, rate of gut passage or feed intake (Jamroz *et al*.2005).

The beneficial impact of essential oils in the modulation of gut microbiota is interlinked with health and immunity, and as a consequence will affect growth performance and welfare (Bento *et al.*, 2013).

Modulation of gut microbiota and their fermentation metabolites

The blend thymol and cinnamaldehyde (TC blend) has antibacterial properties by inhibiting the growth of some bacterial species that could be potentially harmful in animal production. A synergy between the single activities of thymol and cinnamaldehyde in promoting a healthy gut microflora and inhibiting potentially harmful bacteria (Bento *et al.*, 2013).

Similarly, a positive impact on gut microbiota and growth performance was seen with capsaicin, carvacrol and cinnamaldehyde (Jamroz *et al.*, 2005). The composition of the bacterial community and the metabolites produced by the gut microbiota has an effect on health and subsequent nutritional status of the host. Activity of the intestinal microbiota can be indicated by their fermentation products, such as the short chain fatty acid (SCFA), branced chain fatty acid (BCFA) and biogenic amine concentrations. These bacterial fermentation products are derived either from carbohydrates (i.e. SCFAs) or proteins (i.e. BCFAs, biogenic amines) reflecting digestion and fermentation processes in the gastro-intestinal tract. SCFAs provide a valuable source of additional energy for the host from undigestible fibres (Li *et al.*, 2012).

The TC blend increased the proportion of SCFA butyrate in the caecum which is known to provide energy to colonic mucosa (Roediger, 1980) and thus has potentially important implications for intestinal immunity (Hamer *et al.*, 2008)). TC blend, which 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).

Effect on gut microflora and fat digestibility

Dietary essential oils could have growth enhancing effects due to their actions on the intestinal microflora. This implies that the efficacy of essential oils their on animal performance could be affected by the acids microbial status.

Besides the putative, positive antimicrobial effect of essential oils affecting fat digestibility in chickens fed on diets containing soluble fiber, by direct effect of essential oils on either secreting or synthesizing bile acids. innamaldehyde, a phenylpropanoid and a major essential oil component of cinnamon essential oils, shares a common synthetic pathway with capsaicin and piperine and thus affect bile acid metabolism (Lee *et al.*, 2004).

Metabolic path way of components of essential oil

Essential oil constituents are quickly absorbed after oral, pulmonary, or dermal administration and that most are metabolized and either 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).

Insecticidal properties

Essentil oil compounds are added to mixtures of grains they can exert insecticidal and repellent effect against flour beetles. *origanum acutidens* oils (carvacrol, thymol and P-cymene),when added to grain mixtures, have shown insecticidal effects against *sitophilus granaries* and *T.confusum,,* causing 68% and 37% mortality , respectively , in adult insects (Kordali *et al*., 2008). The toxicity of cinnamaldehyde and methylchavicol against the infestation of *O.surinamensis*, *S.granaries*, *S.oryzae* and *Callosobruchus chinensis* in grain mixtures showed high efficacy of these oils as contact insecticides and repellents (Ojimelukwe and Adler, 2001).

Conclusion

The increasing pressure on the livestock industry to reduce or eliminate feed -antibiotics as growth enhancers has initiated new research to search safe and efficient alternatives. This new generation of feed additives includes herbs and essential oils. The beneficial effects of most herbs, spices and their bioactive compounds have been recognised since antiquity and their properties reported in foods and experimental animals. The characteristic flavour, antioxidant properties and stimulation of digestive process of essential oils might play role in poultry performance. The hypolipidemic and immunomodulatory properties of these oils are gaining more interest in formulation of poultry diet.

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