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Review Article

Phytobiotics: Could the Greens Inflate the Poultry Production

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Abstract

The ever increasing consumer's awareness and their concern over the presence of antibiotic residues in poultry products necessitate looking for an alternative to antibiotic growth promoters. Among the numerous alternatives like probiotics, prebiotics, acidifiers, the plant origin compound attracts more interest than else. The phytochemicals consists of various natural products that may be nutritional, non-nutritional or anti-nutritional in nature. These phyto-chemicals also act as an antibacterial, antiviral, antifungal, antioxidant, digestive stimulant, immune-modulator, hypo-lipidemic agent and also heat stress alleviator. A compound of multi-functional can be considered as additive in animal production system. Their anti-oxidant activity and hypo-lipidemic property of these plant derived compounds will be attributed for the improvement of shelf-life of various animal or poultry products. Their hypolipidemic properties are used in production of lean meat production. These phytobiotics also impart readily acceptable flavour to the products especially meat and eggs. They aid in digestive process by stimulating the digestive secretions throughout the gastro-intestinal tract thereby increasing the overall digestibility of the nutrients and reduce the environmental pollution. Moreover, these botanical products are becoming more prominent in insect and pest control strategies due to their availability and cost. With their wide range of activities, these phytobiotics will go to be a new group of feed additives for better growth rather than simply as another alternate to in-feed antibiotics in food production industry.

Key words: Phytobiotics, poultry, antimicrobial, alternate, digestive stimulant, flavouring agent

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INTRODUCTION

Phytogenic feed additives (phytobiotics or botanicals) are commonly defined as plant-derived compounds incorporated in to diets to improve the livestock productivity through amelioration of feed properties, improvement of nutrient digestibility, absorption and elimination of pathogens in the gut[1,2]. Pthytogenic compounds included or incorporated in diet to improve the animals' production performance and improving the quality of food derived from those animals[3]. According to their origin and treatment variety of plant derivatives used such as herbs (flowering, non woody and non-persistent plants), spices (herbs with an intensive smell or taste commonly added to human food) like cinnamom, coriandor, pepper, chilli, rosemary, oregano, anise, thyme and garlic. Essential oils (volatile lipophilic compounds derived by cold expression or by steam or alcohol distillation), or oleoresins (extracts derived by non-aqueous solvents)[4]. Some of the other compounds extracted from fruits such as flavonoids, are water soluble in nature, as this type of fruit extraction compound also used in poultry feed as additive[5]. Within phytogenic feed additives, the content of active principles in products may vary widely, depending on the plant part used (e.g., seeds, leaf, root or bark), harvesting season and geographical origin. The technique for processing (e.g., cold expression, steam distillation, extraction with non-aqueous solvents etc.) modifies the active substances and associated compounds within the final product.

Properties of phytobiotics: Plant extracts have antimicrobial action, immune enhancement, anti-stress property[6], antioxidant and gut microflora manipulation[7], nutrigenomics effects[8], digestibility enhancer[9], stress lowering effect[10], cholesterol-lowering effect[11]. The plant herbs have these kinds of properties to increase the animal's health and performance (Fig. 1).

Phytogenic effects have been proven in poultry for feed palatability and quality (sensory aspects), growth promotion (improved weight gain and feed conversion ratio, reduced mortality), gut function and nutrient digestibility (improved growth), gut microflora (less diseases of the GIT, improved growth, reduced mortality), immune function (improved health) and carcass meat safety and quality (reduced microbial load, improved sensory[12].

ANTIBACTERIAL AND ANTIVIRAL ACTIVITY

Phytobiotics especially spices and herbs exert well known antimicrobial activity *in vitro* including some major pathogens and fungi[13]. A common growth enhancing and digestion modifiers present in hawthorn fruit, this is having more than seventy organic chemicals, bioactive, active components and some unidentified growth factors. In phytobiotics, having some complex active molecules that exhibits synergistic effect to increase the enhancement of growth as well as contain antimicrobial property[14,15]. Tannic acid phytochemical compound it have the antimicrobial

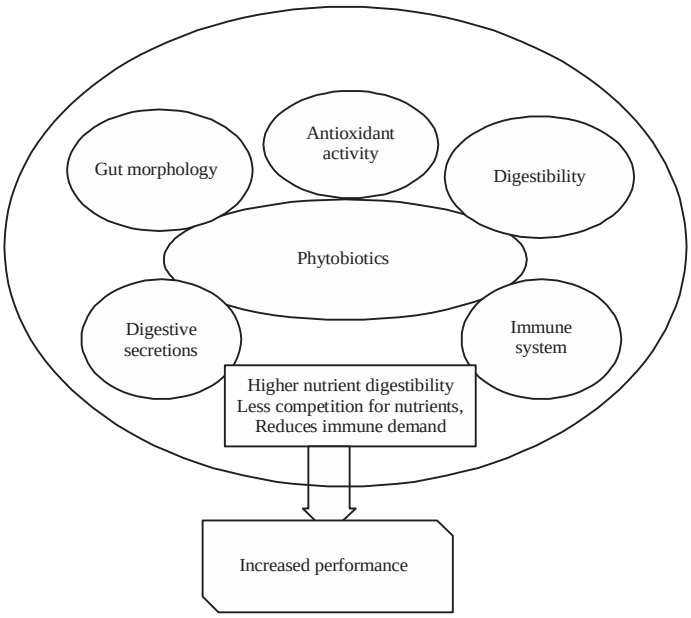

Fig. 1: Activities of phytobiotics in poultry system

property to inhibit the intestinal bacteria such as *Clostridium perferingens*, *E. coli*, *Enterobactor cloaceae* and *Bacteriodes fragilis*[16]. The DNA synthesis was inhibited by phytochemical compound alkaloid which is act as a intercalator or DNA inhibitor[17]. Saponin is another phytochemical compound, have antimicrobial property through its ability to form complexes with sterols present in the microorganisms membrane, it cause membrane damage and followed by collapse of cells[18]. Essential oils much their potential as alternative to antibiotics in broiler chicken and potent it has antimicrobial effect[19]. Some of the essential oils have potent anti-microbial effect against *Clostridium perfringens* and *E. coli*[20,21]. The essential oils act as antimicrobial action through their lipolytic property[22] and chemical structure[23]. In this mechanism of essential oils like terpenoids and phenylpropenoids have the lipolytic property it penetrate the bacterial membrane and reach the cells inner part[24] and aromaticity[25] also responsible for essential oils anti-microbial property. Using *Achillea millefolium*, *Hypericum peforatum* and *Levisticum officinale* was efficiently used as substitute for antibiotics and also this diet favourably affected meat sensory characteristics[26].

The antimicrobial mode of action is considered to arise mainly from phytobiotics through the potential of the hydrophobic essential oils to have the ability to forcefully enter into the bacterial cell membrane; this will cause structural membrane disintegration hence its leads to leakage of ions. The properties of anti-microbial action have shown the ability to improve the carcass keeping quality through maintaining the microbial hygiene of carcass. Phytobiotic compound like oregano have antimicrobial properties it reduces the pathogens specifically salmonella and total viable bacteria on broiler carcass[27]. Some of the non-phenolic compounds extracted from limonene and extract of *Sanguinaria canadensis* have anti-bacterial activity[28,29]. Phytogenic substances show a clear antimicrobial activity *in vivo*[30]. Pepermint oil also showed strong anti-microbial activity[31]. In broilers fed with essential oils of oregano and garlic through the diet and observed that the oregano and garlic oil reduced the small intestinal *Clostridium* counts[32]. Marinating chicken breast filletes treated with the extract of lemon green tea and turmeric showed effective against *Salmonella enteritidis* and *Campylobacter jejuni*. The combination of these three essential oils was found to be most effective against both the microbes[33].

PHYTOCHEMICAL ACTS AS ANTIFUNGAL

Chemical control of fungi and mycotoxins also result in environmental pollution, health hazard and affects the natural ecological balance[34]. Use of plant products informs of plant extracts and essential oils provide an opportunity to avoid synthetic chemical preservatives and fungicide risks[35]. Essential oil oregano has antifungal activity[36].

Some phytochemicals are injurious to fungi and could be used to protect crops, animals, humans, food and feeds against toxigenic fungi and mycotoxin[37]. Phyto-fungicides could be prepared or formulated from the leaves, seeds, stem bark or roots of plants of pesticidal significance and could be applied in form of extract, powders and cakes or as plant exudates[38,39]. Phytochemicals vary in plants depending on their growing conditions, varietal differences, age at harvest, extraction methods, storage conditions and age of sample. *Allium sativum* has a wide antifungal spectrum, reached abou 60-82% inhibition in the growth of seed borne *Aspergillus* and *Penicillium* fungi[40]. This was attributed to phytochemical properties of garlic plant, allicin which could decompose into several effective antimicrobial compounds such as diallyl sulphide, diallyl disulphide, diallyl trisulphide, allyl methyl trisulphide, dithiins and ajoene[41,42]. Aflatoxins refer to a group of four mycotoxins (B1, B2, G1 and G2) produced primarily by two closely related fungi, *A. flavus* and *A. parasiticus*. Aflatoxin contamination of crops is a worldwide food safety concern. Neem extract have an inhibitory effect on biosynthesis of aflatoxins (groups B and G) in fungal mycelia[43]. More than 280 plant species have been investigated for their inhibitory effect on toxigenic *Aspergillus* and nearly 100 of these plants had some activity on their growth or toxin production. The inhibitory effect of crude extracts from mint, sage, bay, anise and ground red pepper on the growth of *A. parasiticus.* Plants like *Ocimum gratissimum*, *Cymbopogon citratus*, *Xylopia aethiopica*, *Monodora myristica*, *Syzygium aromaticum*, *Cinnamomum verum* and *Piper nigrum* are effective in inhibiting formation of non sorbic acid, a precursor in aflatoxin synthesis pathway[44]. In addition lemon and orange oils (at concentrations of 0.05-2.0%) affected more than a 90% reduction in aflatoxin formation by *A. flavus*[45]. Marjoram essential oil culture broth reduced the growth of fungal species *Aspergillus flavus*, *A. niger*, *A. ochraceus* and *A. parasiticus* by up to 89%[46].

ANTIOXIDATIVE ACTION

Herbes and spices have well known for its anti-oxidative property[47]. Among variety of plant constituents possessing anti-oxidant activities, plants such as rosemary plant have phenolic compounds like rosmarinic acid and rosemarol, thymol and carvacrol derived from thyme and oregano[48]. Pepper (*Piper nigrum*) and red chilli (*Capsicum frutescens*) also have antioxidant properties. Fruits and some of the

plants like ginger, curccuma, anise, coriander and green tea (rich in flavonoid) these plants are having well known effect on their antioxidative action[49]. The mode of antioxidative properties of the plant additives through their effect (protection) of feed lipids from Reactive Oxygen Species (ROS), this is main compound for formation of free radicals, it leads to lipid per oxidation, for this reason, the bioactive compounds reduce the ROS formation and prevent lipid peroxidation and prevent the feed/product damage. Some of the researchers found that phytobiotics have phenolic compounds, have the ability to improve the oxidative stability of the product derived from animals like poultry meat[50-52] eggs[53] and pork[54]. Addition of rosmary and garlic oil in broiler diet act as anti-oxidant property and have positive effect on glutathione redox system of liver in chickens[55]. Feeding fenugreek, garlic and pepper 10 g kg^{-1} to broilers diet, reduced the tyrosine and thiobarbituric acid reactive substances in broiler meat, because garlic act as a antioxidant that inhibit the synthesis of fatty acid in the liver and lipid oxidation[56].

PHYTOCHEMICAL ACTS AS INSECTICIDE

Chemicals have been intentionally fed to chickens for the purpose of controlling house fly (*Musca domestica* L.) larvae infesting poultry manure. Polybor 3 and trolene (ronnel) in the laying mash of hens and observed the effect on the fly population. Oregano exhibits insecticidal activity[57]. *Musca domestica* L. (Diptera: Muscidae), is a serious health threat to human beings and livestock by transmitting many infectious diseases[58]. High cost of chemical pesticides and the environmental hazards as a result of pesticide usage have encouraged scientists to seek less hazardous and cheaper pesticide groups. Considerable efforts have been made to synthesize an alternative to overcome this problem[59]. Botanical products have become more prominent in assessing current and future pest control alternatives. Over the past two decades, surveys of plant families have discovered sources of new botanical insecticides, which could possibly meet some of this demand. For instance, the potential of neem products is being conducted internationally and these products are widely used. Accordingly, botanical insecticides based on natural compounds from plants, are expected to be a possible alternative. They tend to have broad-spectrum activity, relative specificity in their mode of action and easy to process and use. They also tend to be safe for animals and the environment[60].

Some of the herb's having the larvicidal activity against the housefly, *Musca domestica* L. such as, *Azadirachta indica*, *Cichorium intybus*, *Citrus× aurantiifolia*, *Conyzaa egyptiaca*, *Eucalyptus globulus* (fruits and leaves), *Opuntia vulgaris*, *Piper nigrum*, *Punica granatum*, *Saccharum* sp., *Salix mucronata*, *Sonchus oleraceus* and *Zea mays* and also the *Piper nigrum* was the most toxic (LC_{50} = 50.1 ppm) and the *Punica granatum* extract (LC_{50} = 213.9 ppm) has the least toxic toxic to *Musca domestica*[61].

PHYTOBIOTICS AS FEED ADDITIVES IN POULTRY

Nowadays plant derived products used alternative or replace to antibiotic growth promoter. The extract from thyme, rosmery, sage and the carvacrol blend capasacinin, cinnamaldehyde using this bio active compounds can improved feed digestibility in broilers[62]. Plant based bio active components have digestion stimulating properties, antimicrobial activity, increase enzyme secretion it leads to improve digestibility of nutrients, increase feed intake.

The mode of action of phytobiotics is described through their potential effect on gut microbial population, through their potential reduction in pathogenic microorganism. Improve the digestive capacity of intestine may be the indirect effect of stabilizing the intestinal microbes. Components from the phytobiotics reduce the animal's immune stress during dangerous situation and increase the availability and absorption of essential nutrients from intestine, thereby improve the intake of feed, feed conversion efficiency and increased the growth rate. Supplementation of essential oils related to birds growth performance is still controversial[62]. Even though feeding of birds with essential oils among different age groups improved the growth performance[9,22,63]. Effect of cinnammon and thyme in broilers diet have positive effect on birds feed intake, feed conversion efficiency, health status, live weight gain and performance traits[64].

Plant bioactive components like polysaccharide extracted from mushroom and herbs increased the growth of immune organs such as spleen thymus and bursal weight in both normal and immune-inhibition treated chickens[65]. Some of the plant derivative polysaccharides are extracted from mushrooms and herbs (*Tremella fuciformis* and *Lentinus edodes* and *Astragalus membranaceus* Radix) acts as potential alternatives for health and antimicrobial growth promoters. Feeding garlic, ginger and their combination to broilers, 1% garlic significantly ($p>0.05$) increased body weight gain[66]. Supplementation of garlic and black pepper combination significantly ($p>0.01$) increased feed intake, weight gain and feed efficiency in broilers[67].

GROWTH-PROMOTING EFFICACY

The growth promoting feed additives helps to reduce the stress in critical situation and helps to improve the immune

status of host animal and increase the absorption of nutrients which can help to improve the better growth of birds. Phytobiotic feed additives stabilize the feed hygiene and beneficially affect the intestinal microbial ecosystem through controlling the harmful pathogens[68]. A mixture of essential oils from anise, oregano and citrus peels along with an antibiotic growth promoter and noticed decreased microbial activity in terminal ileum, cecum and colon, reduced chyme content of volatile fatty acids, reduced bacterial colony count as well as biogenic amines. Relief from the microbial activity and its related product from small intestine because production of volatile fatty acids counteracts intestinal pH stabilization and required for digestive enzyme activity. Formation of biological amines is causing toxicity via decarboxylation of limiting essential amino acids such as cadavarine from lysine and scatol from tryptophan[69]. Using phytogenic feed additives can alter the morphological changes in intestinal tissues and possible benefits to the digestive tract. Phytogenic feed additives increased the villi length and reduced crypt depth in the jejunum and colon in broilers[70,71]. In small intestine digestive capacity was improved due to use of these feed additives, this has the indirect side effect that stabilizing the microbial eubiosis in the gastro intestinal system. Organic acids and antibiotics an improved pre-cecal digestive capacity reduces the flux of fermentable matter into the hindgut and thus lessens the post ileal microbial growth and the excretion of bacterial matter in faeces in turkey[72]. As bacterial protein is the dominant fraction of total fecal protein, an improved pre-cecal digestive capacity may result indirectly in an increased apparent digestibility of dietary protein. Improvement in feed efficiency was concluded by adding a medicinal mixture (including 10 g kg^{-1} oregano, 5 g kg^{-1} *Ziziphora* and 5 g kg^{-1} peppermint) to broilers diet that can show the improvement of feed conversion ratio is related with improvement of crude protein digestibility[73]. Addition of 4 g kg^{-1} black seed to broilers diet improved FCR without affecting body weight gain[74]. Hydrophyllic extract of liquid fresh green tea at the level of 0.1 or 0.2 g kg^{-1} in broiler diet it increased body weight, feed efficiency, carcass weight and dressed weight[75]. Adding green tea by products in broiler and layer diets improved the productive performance and in serum and yolk it reduces the cholesterol content[76]. Inclusion of thyme essential oil in Japanese quail diet may increase the cumulative body weight gain, cumulative feed intake and cumulative feed conversion efficiency[10]. The active principle of thyme oil act as digestibility enhancer, maintain the important microbial flora content in gut system, stimulate the endogenous digestive enzyme secretion and thus improving the growth performance in poultry. Inclusion of ginger powder (0.5, 1 and 1.5%) in broiler diet showed increased breast and thigh muscle yield and reduced abdominal fat content at 1.5% ginger powder inclusion level[77]. Dietary thyme essential oil inbroiler diet showed higher weight gain at 0.15 mL L^{-1} of water[78]. Inclusion of black pepper, fenugreek and garlic in broiler diet at 10 g kg^{-1}, black pepper fed group showed higher eviscerated percentage due to digestive stimulant effect and fenugreek reduced abdominal fat content in broiler meat, due to the anti-cholesterimic effect[79].

GUT MORPHOLOGY

Broilers supplemented with peppermint essential oil had higher duodenal crypt depth[80]. Thyme essential oil in Japanese quail diet can help to increased *Lactobacillus* and decreased *E. coli* in the ileum[10]. The essential oils (carvacrol, 24.5%), 1,8-cineole (20.1%), camphor (12.1%) and thymol (6.0%) in broiler diet showed longer intestine and heavier caecal weight[81]. Oregano (*Origanum vulgare* L.) essential oil in broiler diet at the rate of (300, 600 and 1200 mg kg^{-1} of diet) showed increase the useful bacteria (latic acid bacteria) 1200 mg kg^{-1} dose and reduce the harmful bacteria (*Escherichia coli*) at 300 mg kg^{-1} oregano essential oil[82]. Thyme and cinnamom at 0.5 and 1% inclusion level favourably altered antimicrobial balance (reduced total bacteria count and coli form group in jejunum and large intestine) in broilers gastro intestinal tract[66]. Addition thyme essence in water had positive increase in desirable bacteria and reduced unfavourable bacteria[78]. Dietary supplementation of ginger, garlic at 1% level, villus height, length, crypt and depth ratio was significantly ($p<0.05$) increased at 1% ginger. It increased intestinal absorptive area[66].

ANTI COCCIDIAL ACTIVITY

Photobiotic are having anticoccidial activity. *Eimeria* (an intracellular protozoan) belonging to the phylum Apicomplexa cause avian coccidiosis, which is an economically important disease in the poultry industry[83]. In five week old chicken with supplementation of green tea at 0.5 and 2% level it reduces the oocytes in faecal material at 38.5 and 51.5% level[63].

IMMUNE STIMULATORY EFFECT

Certain plant derived polysaccharides have (adjuvant effect) immunostimulatory substances[84]. Phytogenic compounds have prebiotic effect it helpful to improve or beneficial effect on gut health by improving the gut associated lymphoid tissue response (immunological effect)

directly or short chain fatty acid mediation such as lactic acid producing bacteria[85]. Polysaccharide compounds derived from mushroom (*Tremella fuciformis*, *Lentinus endodes*) and herbs (*Astragalus membranaceus* Radix) used in broiler chicken, these compounds act as immune modulator or enhancer to improve the innate or adaptive immunity or specific immunity (both cellular and humoral immunity[65]. Dietary fructo-oligosaccharide changes the intestinal microflora environment and leads to regulate the secretion of immunoglobulin A (IgA) in murine payers patches cell in intestinal mucosa[86].

CONTROL OF OCHRATOXIN BY PHYTOCHEMICAL

Azadirachta indica (neem) extracts had effect on mycelial growth, sporulation, morphology and OTA production by *P. verrucosum* and *P. brevicompactum*[87]. Sesquiterpenes are high in volatile essential oils of lemon balm plant and have a bitter principal to them. These compounds have been found to have very high anti-fungal properties.

BLOOD CHARACTERISTICS

Supplementation of 20 g kg^{-1} black cumin in broiler diet it reduces the triglyceride and cholesterol level in blood. Raising the level of green tea from 0.25-0.75% significantly decreased blood lipid fractions and increased high-density lipoprotein (HDL) in Japanese quail[88] and reduced LDL-cholesterol content in broilers[89]. Dietary inclusion of thyme oil to Japanese quail reduces the serum glucose, triglycerides and total cholesterol. Blood glucose level is a biochemical indicator of stress from in this thyme oil reduced the blood glucose, so it could be justified that stress lowering effect[10]. Thyme essential oil reduce synthesis of hepatic 3-hydroxy-3-methylglutaryl coenyzme A (HMGCoA) reductase this is the enzyme responsible for cholesterol synthesis[11]. Dietary inclusion of ginger root powder in broilers diet at the level of 2% reduces the serum cholesterol level[90]. Dietary inclusion of ginger in broiler diet (0.2%) lowering the effect on blood serum cholesterol, triglycerides and glucose also potent effect antioxidant action and antistress effect[35]. Inclusion of1.5% ginger powder in broiler died reduced the serum glucose, triglyceride and cholesterol level[77].

SAFETY ISSUES OF PHYTOBIOTICS

Phytobiotics contain many pharmacologically active components which play a major role in the defence system of the plant. From this point of view safety concerns cannot be excluded, although, phytobiotics are generally assumed as Generally Recognized As Safe (GRAS)[91]. Phytobiotics contain as well irritating ingredients which may be harmful to both animals and humans. Furthermore, undesired residues may not be excluded in a natural product. In several experiments it was observed that bioactive ingredients or their metabolites may be transferred to tissues[92]. Some, concerns are reported for capsaicin (cancer causing), cyanide containing ingredients, carvacrol (in oregano) and glycosides. The content of capsaicin in chilli (paprika) is limited by EU regulation (only regulated for paprika as food additive E160c,<250 mg kg^{-1}; EU, 1995) due to probable toxic effects. Few information is available on metabolites deposited as residues to tissues resulting in impaired sensory attributes. In general, for probable negative effects the dose is important. High inclusion levels of oregano may affect the Minimum Inhibitory Concentration (MIC) for antibiotics[12]. For rats the LD_{50} value was reached for oregano oil for a dose 100 times the normal supplementation level in feed. The observed results indicate the necessity to check phytobiotics thoroughly for potential safety issues.

CONCLUSION

The anti-microbial more specifically the anti-bacterial spectrum activity of phyto-chemicals is well documented worldwide; although, their mechanism of action is not clearly described yet. Their antioxidant activity and hypo-lipidemic property of these plant derived compounds are being explored now in both animals as well as in human nutrition. These phytobiotics also impart readily acceptable flavour to the products especially meat and eggs. They also aid in digestive process via stimulating the digestive secretions throughout the gastro-intestinal tract thereby increasing the overall digestibility of the nutrients and reduce the environmental pollution. Their antifungal activity can be used in preservation or improving the keeping quality of the raw as well as the finished feeds free of mycotoxin contamination and insects attack. These phytobiotics favourably alters the gut microbial population and improves the overall performance of the individual. They also improve the shelf life of products mainly of preserved meat and eggs. With their wide range of activities these phytobiotics can be considered as a new group of feed additive for better growth rather than simply looking them as an alternate to antibiotics in food production industry.

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