



Phytogenic Substances as Safe Growth Promoters in Poultry Nutrition

MA Mohamed and HMA Hassan*

Department of Animal Production, National Research Centre, Dokki-12622, Giza, Egypt

*Corresponding author: husseinhma@yahoo.com

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ABSTRACT

Antibiotics growth promoters (AGPs) have been used in poultry feed to improve gut health and growth performance for a long time. Increasing concerns about the negative impact of AGPs have led to research on the use of natural feed additives in poultry feed to ascertain better performance and safety in the food chain. Herbs and substances of plant origin (garlic, oregano, thyme, anise, rosemary, and cinnamon) are defined as phytogenics, phytobiotics or botanical natural feed additives. Numerous studies on such substances in poultry production have shown more beneficial effects such as antimicrobial, antiviral, antioxidant, enhancing gut function, etc. These substances have several advantages over commonly used as growth promoters; they are residue-free and safe. Phytogenic substances gained much attention to be ideal growth promoters in poultry nutrition. However, evaluation methods of their effects and interactions with other medical treatments have to be improved. In general, phytogenic substances could be natural and safe growth promoters in animal and poultry feeds.

Key words: Phytogenic, Growth promoters, Poultry, Gut health, Growth performance.

INTRODUCTION

The main objective of feeding poultry is to maximize the production of meat and eggs that are safe for consumers. Meat and egg production of poultry has increased consistently over the years. Nowadays, high levels of poultry production and efficient feed conversion ratio are needed. Genetic continuous improvement in poultry strains, understanding the fundamentals of nutrition and control of diseases are the most important factors that contributed to the consistent growth in poultry production. Using antibiotic growth promoters (AGPs) in animal diets is beneficial to improve growth performance and production, control of intestinal microflora and prevention of some diseases. However, usage of large amounts of AGPs led to resistance of microbes to antibiotics and the accumulation of antibiotics as remain in poultry meat and eggs. This situation needs to restrict using AGPs in animal and poultry nutrition. To control intestinal pathogenic bacteria, the gut health of birds is strongly dependent on AGPs (Wallace et al. 2010). To avoid the great damage in birds to gut complaint and application from hard laws using antibiotics there is a demand for alternative resources to control diseases and improve gut health so, decrease using AGPs (Mirzaei-Aghsaghali 2012). Studies on various safe growth promoters to improve gut health and production of animals had been reported such as essential oils (Zhai et al.

2018), organic acids (Ricke et al. 2020), probiotics, prebiotics (Al-Khalaifah 2018), exogenous enzymes (Torres-Pitarch et al. 2019) and competitive exclusion products (Schneitz and Hakkinen 2016). Phytogenic substances can increase the activity of digestive enzymes and nutrient absorption. Utilization of their antioxidant, antimicrobial, antiviral activity anti-inflammatory, antifungal and anti-infectious have been demonstrated. Using phytogenic feed additives in poultry feeds, proved to be a positive effect on growth performance, blood parameters, carcass quality and immune responses. Phytogenics contains several enzymes, vitamins and minerals that are required for animals (Karásková et al. 2015). This review aims to make an overview of using phytogenic substances as natural and safe growth promoters in poultry nutrition to improve feed utilization and maximize production.

Role of Gut Health in Poultry Production

The enhancement of growth performance is the predominant goal in poultry. Genetic, nutrition, management and control of diseases are major factors for the ideal performance of poultry. Gut health has been a subject of intense researches in poultry production (Rintila and Apajalahti 2013). The gastrointestinal tract is an important part that mediates nutrient input and use by means of the birds. Also, it is a primary site of capability

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publicity to environmental pathogens (Yegani and Korver 2008). Thus, a properly functioning and intestine is of great importance for the optimum performance of poultry. When gut characteristics are damaged, utilization of nutrients are impaired and as a consequence health and growth of birds are affected. The intestinal mucosa of birds performs an important role in providing an effective barrier between the hostile luminal content and the host internal tissues. Thus, the intestinal mucosa is an important determinant of gut health and performance of chickens (Rinttila and Apajalahti 2013). Gut microbiota plays an important role in nutritional, physiological, health status and it is the first barrier against pathogens and protective functions of poultry (Yeoman and White 2014; Raheel et al. 2021). Gut microbiota is divided into beneficial bacteria (Lactobacilli and Bifidobacteria) and pathogenic bacteria (E.coli, Campylobacter and Salmonella) effects on the host (Li et al. 2009). Gut microbiota actions of pathogen inhibition include competition for nutrients, production of toxic materials (volatile fatty acids and low pH), competition for sites of binding on the gut epithelium and stimulation of the immune system (Patterson and Burkholder 2003). Gut epithelium with the mucus works important line of defense against pathogens (Gaggia et al. 2010). So, description of microbial communities in the gut is significant for developing safe feed additives and suitable manipulation of diets to enhance performance and gut health status. The microbial in the gut have a significant effect on the availability and activity of nutrients through efficient nutrient consumption and storage. It also affects the host's ability to combat infection, and mainly serves to contribute to the host's health and performance (Rinttila and Apajalahti 2013; Raheel et al. 2021).

Antibiotic as Growth Promoters in Poultry Feeds

The chemical substances applied in poultry feed to get better growth performance are known as Antibiotic Growth Promoters. It holds the stability of ecosystem in the intestine and control or prevents some diseases (Chowdhury et al. 2009). In terms of improving performance, the use of antibiotics as growth promoters in germ-free birds has not been of much value. So, their mode of action is originally due to antibacterial activity rather than having any direct effect on physiological function (Dibner and Richards 2005). The main function of antibiotics is to adjust and maintain the optimal balance of intestinal microflora. Throughout stress or digestive disorders, the number of pathogenic microbes increases, resulting in an alteration of the balance of bacteria. Gram-negative microorganisms colonize more in the intestine, attaching to the intestinal epithelium and causing inflammation of gastrointestinal mucosa which consequently reduces the absorption of nutrients and thus negatively affects the productivity of birds (Dhama et al. 2014). The AGPs could alter mucin biosynthesis and dynamics and affects gut function and health and can alter nutrient absorption. So, in practical conditions antibiotics are included in feed or water as a precaution to eliminate chances of imbalance (Jones and Ricke 2003). Using anti-coccidian along with AGPs improves birds' growth and immunity in polluted environments (Lee et al. 2012). The use of antibiotics when birds are not infected has the potential to develop antibiotic resistance to strains of

pathogenic microorganisms and suppress natural delicate bacteria in the gut. The routine addition of antibiotics may result in antibiotic residues in meat and egg. Apart from that, due to increases in resistant bacteria using of AGPs become a great concern and had been blocked by the European Commission (Huyghebaert et al. 2011; Devirgiliis et al. 2013). Alternatives of AGPs are necessary to get a health intestine and improve poultry production. Many feed additives gained attention on balancing microflora in the gut to enhance gut function and control of diseases, such as phytogetic substances, probiotics, prebiotics, organic acids and enzymes (Dhama et al. 2014).

Phytogetic Substances

Herbs and plant extracts (substances of plant origin) are defined as phytogetic, phytobiotics, phytochemicals or botanicals. Incorporation of these substances in poultry feed leads to improve production by the improvement of nutrient availability and reducing pathogenic bacteria in the gastrointestinal tract (Athanasidou et al. 2007). Wang et al. (2008) characterized phytogetic substances as natural, less toxic, residue free plant derived materials. It has been proven as safe additive in poultry nutrition because there are varying degrees of growth enhancing nutrient components. Phytogetic substances include an extensive variety of active substances which can be extracted from various plant sources. Active substances of phytogetic include phenolic, tannins, glycosides and alkaloids (Huyghebaert et al. 2011). Phytogetic substances are classified into botanicals, herbs, essential oils and oleoresins. One of the most economically important forms of phytogetic substances is essential oils which contain active materials. Essential oils showed an important role in the protection of plants acting against bacteria, viruses, fungi and insects (Bakkali et al. 2008; Abudabos et al. 2018; Radwan et al. 2022).

Mode of Actions of Phytogetic Substances

Phytogetic substances have an effect on small intestine microflora by controlling potential pathogens. It increases the ability of the digestive system in the gastrointestinal tract may be an indirect side effect on the stability of gut microbiota. This increases the availability of essential nutrients in the intestine for absorption and helps to improve performance (Hashemi and Davoodi 2010). Vidanarachchi et al. (2013) explanation of the proposed mechanisms through which the botanicals powder and extract effects. They concluded that botanical powder disrupts the cell membrane of microbes, affects the surface properties of microbial cells, enhances the growth of beneficial bacteria, enhances immune stimulants, encourages growth of villus and crypt in the gut and stimulates the production and activity of the digestive enzymes. Therefore, phytogetic agents showed broad antimicrobial activity against various pathogenic bacteria. However, information about the actual mode of action is rather scarce. It is difficult to assess the biological effects if the composition of a test substance is unclear or variable. Volatile oils obtained from medicinal or aromatic plant materials that have the odor or flavor properties of the source plant are essential oils (Tomer et al. 2010; Degla et al. 2022). Essential oils improve the secretion of digestive enzymes in the intestine and reduce nutrients available for

the growth of pathogenic microorganisms (Steiner 2006). Antimicrobial activities of essential oil have not been clearly understood. It may alter the lipid solubility on the surface with hydrophobic components. This may break or break down the outer membrane of bacteria (Dorman and Deans 2000). Essential oils interact with the cytoplasmic membrane causing disruption through lipophilic properties (Fig. 1). Javed et al. (2021) reported that carvacrol has powerful anti-inflammatory, antiviral, and immunomodulation properties to reduce the severity and progress of diseases that may expand logical speculation of its use in COVID-19. The potential mechanisms of carvacrol on infection, immunity and inflammation are shown in Fig. 2. These disruptions expanded membrane, increase its fluidity and permeability, inhibit respiration, alter transport, impair essential processes in the cell, collapse the membrane potential, inhibit ATP synthesis and finally death cell (Ultee et al. 2002). The conflicting results regarding different mode of action in published studies show the need for further investigations to ensure a precise use of phytochemical substances as safe growth promoters in poultry nutrition.

Beneficial Effects of Phytochemical Substances

Most phytochemical substances are still not fully understood, but activities as antimicrobial, antioxidative, antiviral, antifungal, enhanced immunity and gut function of poultry have been reported (Dhama et al. 2014; Mohammadi Gheisar and Kim 2018). Some phytochemical substances and their effects are shown in Table 1 and Fig. 3.

Phytochemical Substances as Antioxidants

Antioxidant properties of phytochemical substances have been reported by Wei and Shibamoto (2007). Most antioxidant activities found in phytochemical are due to phenolic and terpenes components such as rosmarinic acid. Also, phytochemical substances act as antioxidants such as thyme, oregano, green tea and pepper that contains thymol and carvacrol and flavonoids (Rahim et al. 2011). Antioxidant properties of some phytochemical substances may be involved in protecting dietary fat from oxidation. Botsoglou et al. (2003) showed that supplementation of oregano extract to feed turkey significantly decreased fat oxidation in meat. So, phytochemical substances may improve the meat quality of poultry products. Luna et al. (2010) found that the addition of carvacrol or thymol to chicken diets significantly reduced lipid oxidation compared to commercial antioxidants addition such as ascorbic acid and vitamin E. Therefore, phytochemical substances can be used as an antioxidant in animal and poultry nutrition without adverse effects on performance. High antioxidants content in phytochemical substances may positively alter the antioxidant capacity (Zhang et al. 2015) and peroxidation state. Also, due to their high content of antioxidant, the use of phytochemical as feed additives may help to overcome the impacts of heat stress (Karásková et al. 2015; Kiczorowska et al. 2017). Mean that, using phytochemical substances in poultry diets instead of chemical antioxidants is possible.

Phytochemical Substances as Antimicrobials

Several studies assessing the impacts of different types of phytochemical substances against microorganisms, the majority viable antibacterial form are mixtures of essential

oils (Bakkali et al. 2008). The antimicrobial effects of essential oils are due to the existence of phenolic materials, like thymol, carvacrol and eugenol that are presented in essential oils of thyme, oregano and clove. Antimicrobial effects of phenolic components could be referred to as reactions between the viable materials and microbial cell membrane then connected with the hydrophobicity of these materials and can damage both cell wall and cytoplasm (Nazzaro et al. 2013). Koscova et al. (2006) showed that using a mixture of thymol, and carvacrol could be working against *C. perfringens* in broiler gut and reduce the effect of necrotic enteritis outbreak. Using anise grains to birds diet enhanced blood measurements and improved phagocytes action and the numbers of lymphocytes (Soltan et al. 2008). Also, cinnamaldehyde, carvacrol and thymol had strong effects on reducing *Salmonella enterica*, whereas slightly effect on *E. coli* bacteria (Ouweland et al. 2010). Ansari et al. (2012) reported that neem oil contains many active components that enhance immune response through stimulating macrophages and lymphocytes. Khan et al. (2012) reported that thyme, oregano and garlic gave highly impact against many types of microorganisms. Arsi et al. (2014) found that supplementation of 1% carvacrol oil or a mixture of carvacrol and thymol significantly reduced campylobacter counts. Singh et al. (2021); Alagbe (2021) reported that phytochemical substances such as flavonoids, phenols and alkaloids are capable of reducing the activities of pathogenic bacteria through competitive exclusion and promoting the proliferation of beneficial bacteria like *Lactobacillus* sp., thus playing a role of a probiotics. So, phytochemical substances have provided sufficient evidence to be safe and natural alternatives of AGPs in poultry diets to prevent microorganisms' contamination of human food and to prevent many diseases.

Phytochemical Substances as Antivirals

Many phytochemical substances have properties acting as antiviral. Using *Artemisia annua* could inhibit the growth of Newcastle virus in embryos (Liu et al. 2009). Barbour et al. (2011); Jiang et al. (2012) found that the addition of a mix of essential oils to broiler diet enhanced the immune responses against H5N1 and H9N2 vaccines. Also, Lee et al. (2012) reported that adding green tea extract to broiler feed or water decreased the growth of the H9N2 virus. These activities may be due to the inhibition of viral RNA synthesis. Makau et al. (2013) found that *Alchemilla mollis* extract has antiviral activity by inhibition of influenza virus replication. The inhibitory effects were observed against H1N1, H3N2 and H5N2 influenza viruses. Protocatechuic acid and 4-hydroxycinnamic acid as natural active materials have been established as effective against infectious bursal disease virus via enhancing the protection and increasing the immune response of birds. El-Shall et al. (2020) addition a mixture of essential oils containing oregano, carvacrol, thyme, eucalyptus, thymol, eucalyptol and acacia surfactant in the drinking water of broiler chickens resulted in an immune-stimulating response to Newcastle disease (ND) and infectious bursal disease vaccines, antiviral effect against ND virus.

Phytochemical Substances as Anti-coccidiosis

Coccidiosis is a parasitic disease that severely affects poultry health leading to impairment of growth performance

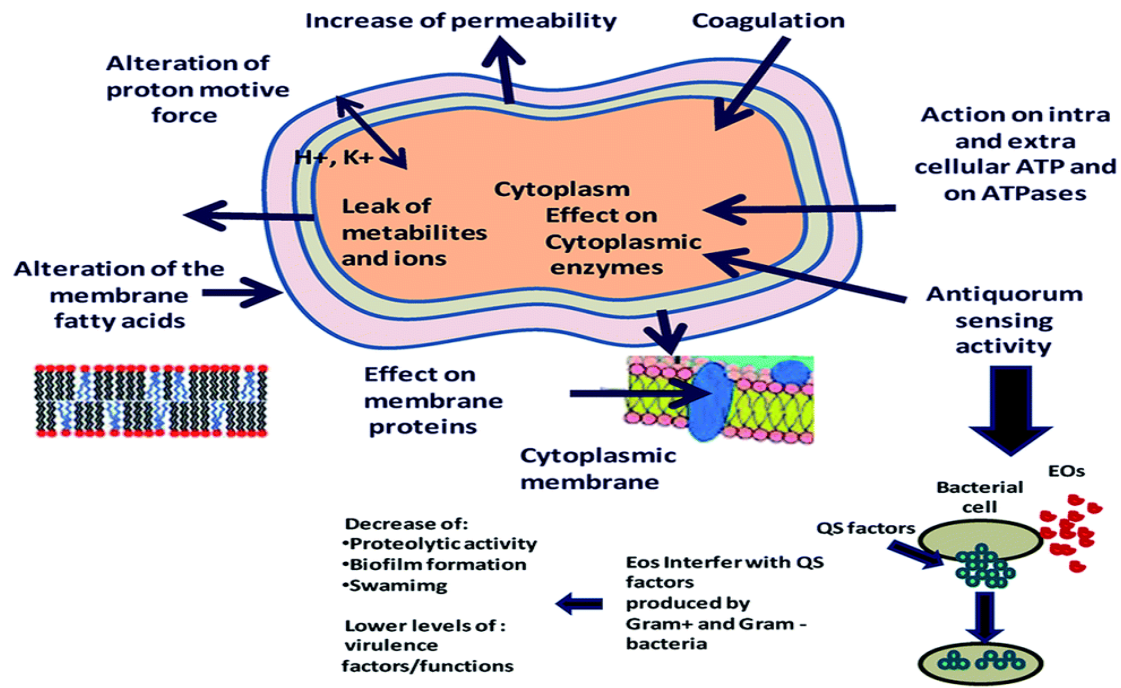


Fig. 1: Mode of action of essential oils (Ultee et al. 2002).

Table 1: Some phytogetic substances and their effects

Phytogetic	Active components	Some effects	Dose	References
Anise (<i>Pimpinella anisum</i>)	Anethole, chavicol, methylether	Improved performance and increased lymphocyte counts.	0.5-0.75g/kg	Soltan et al. (2008)
Basil (<i>Ocimum basilicum</i>)	Citronellol, linalool, terpineol	Active against <i>E. coli</i>	3g/kg	Sienkiewicz et al. (2013)
Black cumin (<i>Nigella sativa</i>)	Thymoquinone	Enhanced immune response in broiler	0.7-2.8%	Al-Mufarrej (2014)
Black pepper (<i>Piper nigrum</i>)	β -pinene, sabinene,	Increase the digestive enzymes of pancreas	200-600 mg/kg	Riyazi et al. (2015)
Clove (<i>Syzygium aromaticum</i>)	Eugenol, acetyl eugenol	Antioxidant, antimicrobial	200-600 mg/kg	Mukhtar (2011)
Cinnamon (<i>Cinnamomum</i>)	Cinnamaic aldehyde	Antioxidant, Improved FCR of broiler	1%	Hossain et al. (2014)
Fennel (<i>Foeniculum vulgare</i>)	Anethole, fenchone,	Improve weight gain and FCR of broiler chicks	1-3g/kg	Mohammed and Abbas (2009)
Garlic (<i>Allium sativum</i>)	Allicin, 1-propene, diallyl tetra sulphide	Improved performance and reduced the <i>Clostridium</i> and <i>E. coli</i> .	0.5-2%	Suriya et al. (2012)
Ginger (<i>Zingiber officinale</i>)	Geranial, bornyl acetate, β -eudesmol	Improve performance and gut structure.	1%	Karangiya et al. (2016)
Green Tea (<i>Melaleuca alternifolia</i>)	Terpinen-4-ol, terpinen	Antimicrobial, and antioxidant	1-3 g/kg	Lee et al. (2012)
Oregano (<i>Origanum vulgare</i>)	Carvacrol, thymol, terpinene	Antimicrobial, antifungal and antioxidant.	0.5-1%	Bozkurt et al. (2013)
Peppermint (<i>Mentha piperita</i>)	Menthol, menthyl acetate,carvacrol,	Growth promoters. Anticoccidiosis	70mg/kg	Remmal et al. (2011)
Rosemary (<i>Rosmarinus officinalis</i>)	linalool; bornyl acetate, rosmarinic acid	antioxidant, improve performance and egg production	0.02% of oil	Abd-El-Latif et al. (2013)
Thyme (<i>Thymus vulgaris</i>)	Thymol, carvacrol	Inhibit growth <i>E. coli</i> . Improve performance	0.01-0.03%	Abbas et al. (2012)
Turmeric (<i>Curcuma longa</i>) extract	Curcumin, eucalyptol, β -caryophyllene,	Enhance immunity and performance	0.5-1%	Kim et al. (2013)

and feed efficiency. Also, it is leads to increase feed cost for vaccination and incorporation of anticoccidial drugs into feed. To overcome these major problems, safe alternative anticoccidial such as phytogetic substances are necessary for handling and controlling poultry coccidiosis (Dhama et al. 2014). Several phytogetic substances have been reported as active materials against parasites (Arczewska-Wlosek and Swiatkiewicz 2012; Sobhy et al. 2021). Naidoo et al. (2008) Showed that oocysts production decreased in birds with *Tulbaghia violacea* addition in their diet, thus it may be applied in animal feed as prophylactic anticoccidial agent. Many studies have been reported that garlic act as anticoccidial

activity (Kim et al. 2009). Hady and Zaki (2012) showed that the inclusion of neem oil and *Artemisia annua* in the broiler diet had significant effects on performance and possess anticoccidial potency against *Eimeria tenella*. Also, Dragan et al. (2014) reported that inclusion of a mixture of neem extract (*Azadirachta indica*), leaves extract of *Musa paradisiacal* root and green tea, in broiler diet reduced bloody diarrhea symptoms and oocysts excretions of birds. Hussein et al. (2021) reported that combinations of peppermint, chamomile and prebiotic yeast cell wall were as effective as salinomycin in preventing the decline in the weight gain and performance of coccidiosis-challenged broilers.

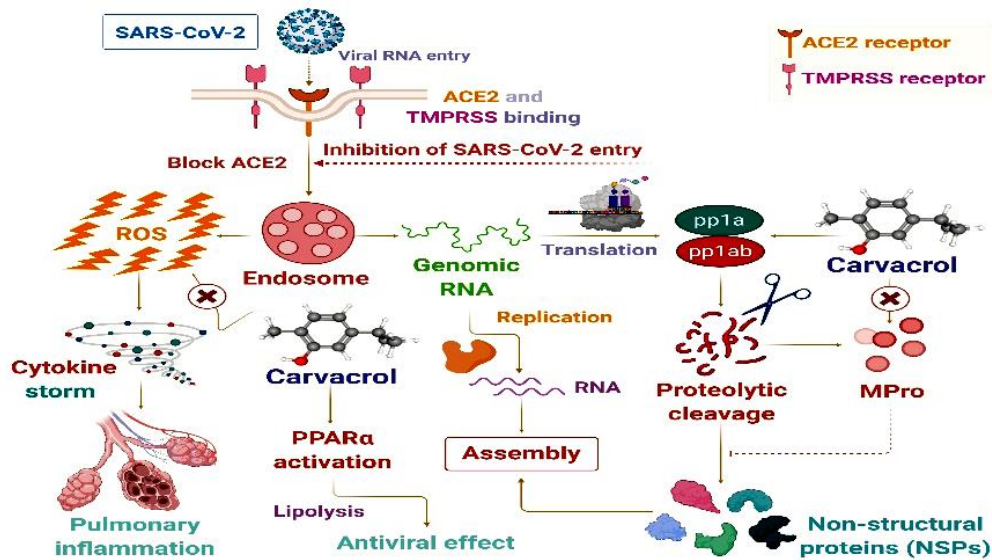


Fig. 2: The possible mechanisms of carvacrol on infection, immunity and inflammation.

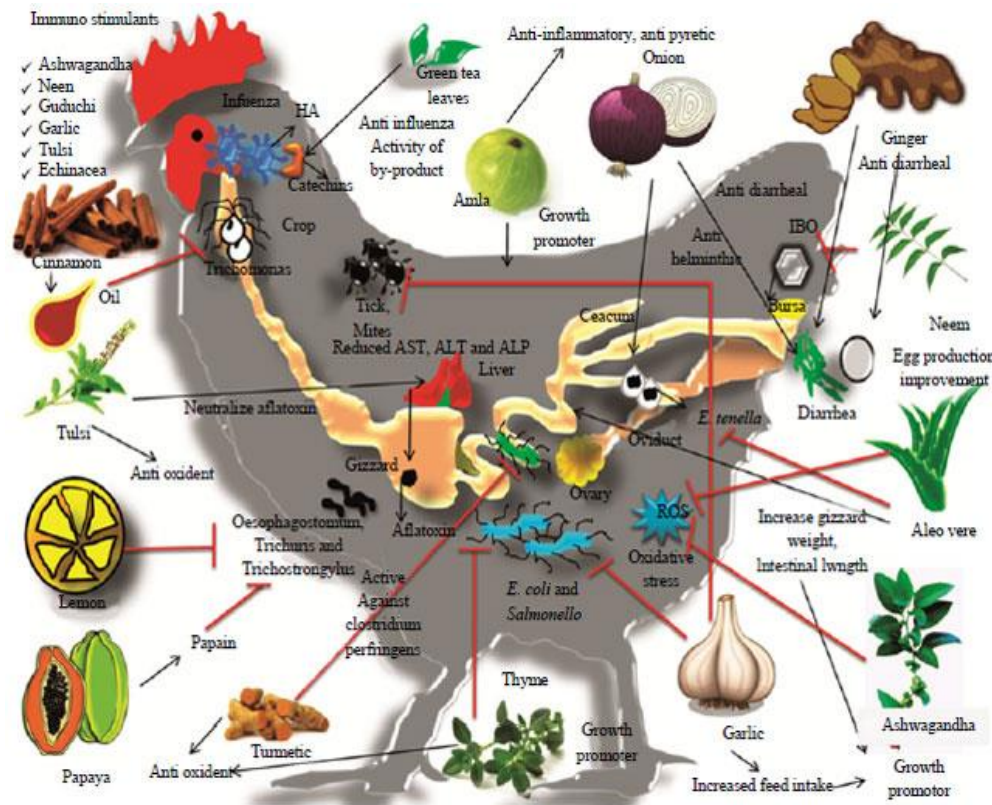


Fig. 3: Some beneficial effects of phytochemical substances in poultry (Dhama et al. 2014).

Phytochemical Substances as Growth Promoters

Nowadays, phytochemical substances have gained much attention for their possibility as an alternate to AGPs in poultry nutrition. Enormous studies recommended a potential part of phytochemical as safe growth promoters in poultry nutrition. Phytochemical possesses some substances to enhance performance, production, gut health and its functions and dietary palatability. Thyme, cinnamon and oregano contain essential oil maybe work as growth promoters to prevent infection of coccidia and reduce the damaging impact of the wall gut. Stabilizing effects of phytochemical substances on the gut environment and the role

of microbiota of poultry impact the activity of microflora in the gut (Hashemi et al. 2008). Vukić-Vranješ et al. (2013) concluded that supplemental phytochemical additives had a positive effect on broiler performance, jejunum morphology measures and reducing the number of pathogenic bacteria. Riyazi et al. (2015) supplemented basil oil, probiotics and avilamycin to broiler diets and found that basil oil treatment resulted in a similar performance of those recorded with avilamycin. Karangiya et al. (2016) concluded that supplementation of garlic to broiler diet at 1% significantly improved the growth performance and gut. Sanguranine phytobiotic induced

elevation in growth performance and health status of poultry (Hassan et al. 2018). Ahsan et al. (2018) found that addition mix of essential oils to the broiler diet significantly improved gut villus height and width and decreased crypt depth compared with birds fed diet without addition. From previous results, it could be concluded that garlic, basil, Ashwagandha, thyme and cinnamon for example, of phytogetic substances a suitable alternative to AGPs in poultry diets.

Effects of Phytogetic Substances on: Gut Health and Functions

Gut health is a central role in poultry to get optimal performance and production of meat and egg. A common cause of gastrointestinal disorders is an injury to the intestinal mucosa. Use of phytogetic substances contributes to preventing such intestinal disorders. Many of phytogetic substances have been shown some useful effects on gut microflora and digestive enzymes activity (Chrubasik et al. 2005). Digestive secretions and improvement of enzyme activity are important factors that affect gut function, thus leading to improve nutrient digestibility. Some studies reported beneficial effects on amylase and trypsin activity with essential oils supplementation to broiler diets (Jamroz et al. 2005). Steiner (2006) reported that improving nutrient availability in broiler diets with the addition of phytogetic products may be indicated to improve villus length. Adibmoradi et al. (2006) showed linearly enhanced villus height and crypt depth of gut with inclusion garlic in broiler feed from 0.125 to 2%. Also, Oladele et al. (2012) studied the effect of garlic meal at 0.125, 0.25 and 0.5% levels on the absorptive surface of the small intestine of broiler and reported that 0.125% garlic meal supplementation improved villus length, width and cryptal depth, resulting in an increased absorptive area of the intestine and improved performance. Saeid et al. (2013) concluded that intestinal morphological characteristics (villi length and small crypt) improved in broiler feeding 0.5% garlic powder containing diet compared to the control. The improvement of performance may be because garlic has positive effects on gut flora by reducing pathogenic bacteria. Immune promotion was considered as pronouncing action through that phytogetic have beneficial impacts on gut health (Fallah et al. 2013). Karangiya et al. (2016) concluded that supplementation of ginger to broiler diet at 1% significantly ($P < 0.05$) increased villi length, width and cryptal depth, indicating increased absorptive surface area.

Immuno-modulation

Enhancements of poultry immunity lead to prevent of several infectious diseases and increase production. Several factors can affect poultry immunity including overuse of antibiotics, vaccination failure and infectious diseases. Phytogetic substances have been reported that improve the immune response of broiler and could prevent infectious diseases. Therefore, it could play sensible roles in strengthening the defense system of birds against attacks by infectious organisms (Acamovic and Brooker 2005). Several phytogetics have been identified for pharmacologic capabilities and their effects are wide ranging. Ginseng, with its steroidal saponins, has immune-stimulating properties through an effect on the production

of macrophages and lymphocytes (Tan and Vanitha 2004). Lillehoj et al. (2011) reported that addition of a mix of thymol, carvacrol, cinnamaldehyde and capsicum oils to broilers diet significantly improved immune response, villi characteristics, and mucos and decreased diseases. Silveira et al. (2013) reported that using some phytogetic substances including antioxidant activities can enhance immune response and increase vitamin C activity. Also, Hashemipour et al. (2013) found that supplementation of a mix of carvacrol and thymol essential oils to broiler diets significantly improved immune responses and growth performance compared with the control group.

Nutrient Digestibility

Phytogetic substances affect the function of the gastrointestinal tract through passage time and promote digestive enzyme secretions and activities, these effects will improve nutrient digestibility and absorption surface area. Hernandez et al. (2004) using mixtures of essential oils ((oregano, cinnamon and pepper) and (sage, thyme and rosemary)) in broilers diet showed significant improvement in nutrients availability. Theron and Lues (2007) reported that supplementation of oregano, anise and citrus as a mix to broiler feed significantly enhanced the availability of starch. Amad et al. (2011) reported that the addition of thyme and anise extract to broiler diets at 150, 750 or 1500 mg/kg increased nutrient digestibility of protein, fat, ash, calcium and phosphorus. Hassan et al. (2015) concluded that crude protein and crude fiber digestibility was significantly improved with the addition of artichoke extract to broiler diet. Also, the activities of phytochemicals in ginger and garlic extracts have been proven to stimulate functions of the intestinal tract to improve digestive secretions, nutrient absorption and metabolism (Alagbe and Oluwafemi 2019).

Poultry Performance and Production

The improvement of poultry performance and production is the major objective of many studies. Effects of phytogetic substances on poultry performance have shown promising results. Several species of phytogetic substances have been evaluated in broiler chickens with the expectation of improving performance and feed utilization, or just enhancing meat quality. A few studies have reported inconsistent effects of phytogetic substances on growth performance of birds (Mamoun et al. 2014; Singh et al. 2015). Lewis et al. (2003) showed that addition of garlic oil (*Allium sativum*) to broiler feed gave positive effects on the growth performance. Ertas et al. (2005) found that addition of anise, oregano and clove as a mix to broiler diets at 200 and 400 mg/kg feed improved BWG by about 16% and FCR by about 12% compared to the control. Jamroz et al. (2005) showed that supplementation of carvacrol and capsicum extract to broilers diet significantly enhanced FCR. Soltan et al. (2008) addition of anise seed meal to birds feed significantly improved performance and the percentage of growth rate. Mohammed and Abbas (2009) found that addition of fennel extract to broiler diets at 1, 2 and 3 g/kg significantly enhanced BWG by about 6% at level 1g/kg and FCR by about 16% at level 2g/kg. Toghyani et al. (2010) concluded that supplementation of thyme extract at 5 and 10 g/kg to broiler diet significantly enhanced BWG

by about 6% and FCR by about 4% than the control. Amad et al. (2011) reported that addition of thyme and anise extract to broilers diets at 150, 750 or 1500 mg/kg linearly improved FCR compared to the control group. Khan et al. (2012) reported that inclusion extract of garlic, thyme and coneflower to broiler diets enhanced BWG and FCR compared with the control diet. Hashemipour et al. (2013) concluded that addition of a mixture of essential oils (thymol and carvacrol) to broiler diets at 60, 100 and 200 mg/kg feed significantly enhanced performance; it could be due to improve in enzyme activity and antioxidant properties. Mamoun et al. (2014) reported that addition of fenugreek seeds powder meal to broiler diets significantly enhanced feed conversion ratio, which may be associated with morphological changes in the tissues of gastrointestinal tract. Hassan et al. (2015) reported that addition of *Cynara scolymus* extract to broiler chickens diet significantly improved BWG by 6% and FCR by 7%. Karangiya et al. (2016) showed that addition of garlic or ginger at 1% to broiler diets significantly increased values of BWG. Younan et al. (2018) found that supplementation of olive leaves extract (1 and 1.5 ml/kg diet) could be successfully saved and useful for growing rabbits during the growing period. Gaikwad et al. (2019) found that 1% of fenugreek (*Trigonella foenum-gracum*) seed powder in broiler diets can be used as natural feed additive to enhance growth performance and feed conversion. El-Ashram and Abdelhafez (2020) concluded that addition of essential oils of thyme and star anise in broiler diets had a positive effect on growth performance. Ali et al. (2021) indicated that supplementation of 1.5% fenugreek seeds meal to broiler diet was significantly ($P < 0.05$) improved body weight gain and feed efficiency compared with the control group. Oluwafemi et al. (2021) found that inclusion of ginger (*Zingiber officinale*) and garlic (*Allium sativum*) oil mixture in broiler diet up to 0.4% was significantly improved growth performance. Improvements in growth performance with inclusion of plant materials (phytogenics) in broiler diets could be a result of increased digestibility of nutrients and enhanced digestive enzyme activity and reduction of pathogenic microbial that lead to improvements in gut function.

Meat Quality

Using rosemary powder and oil, sage extract, oregano powder and oil, and garlic powder indicated useful effects on the meat quality of broiler chicken. Such improvement could be due to antioxidant activities that may lead to decreasing lipid oxidation (Stanacev et al. 2011). Also, reduction of microbes in the carcass and improved conservation quality, is related to antimicrobial properties and antioxidant in phytogenic substances (Aksit et al. 2006). Soltan et al. (2008) indicated that supplementation of essential oils, herbs or spices to poultry products; reduces microorganisms in the products and ensures safe food and quality storage of the raw and cooked meat. Stanacev et al. (2011) reported that inclusion of phytogenic substances in feed could lead to safe food products. It could be related to inhibition of pathogen microorganisms in the gut, thus stimulating gut function and decreasing carcass contamination. Hong et al. (2012) added a mix of essential oils to broiler diets increased the survival rate by approximately 10% and reduced cholesterol levels and

made breast and thigh muscles taste and juicier. Supuka et al. (2015) report that supplementation of agrimony extract (*Agrimonia eupatoria*) to broiler diets significantly decreased total cholesterol and increased dry matter in meat compared to the control.

Egg Production

Effects of phytogetic substances on egg production and quality were reported in some studies. Bolukbasi and Erhan (2007) found that supplementation of thyme to laying hen diets at 0.1 and 0.5% significantly enhanced feed conversion ratio and egg production. Abd-El-Motaal et al. (2008) reported that fed Hy-Line layers on commercial diets supplemented with 0.3% eucalyptus improved FCR by 9.1%. Moreover, the number of egg production, egg mass, and egg breaking strength were significantly higher. Also, using a mix of oregano, citrus and anise oil significantly increased egg production and shell thickness of poultry (Nichol and Steiner 2008). Khan et al. (2012) reported that adding garlic, thyme and coneflower extracts in chicken diet improved egg quality and production. Saki et al. (2014) showed that supplementation of 12 g/kg of garlic, thyme and fennel to hen diet significantly increased egg weight, whereas egg production, egg quality parameters were not affected. Abou-Elkhair et al. (2018) found that addition of tomato powder, thyme, oregano and garlic extracts in the laying hen diet significantly increased egg production. The improvement in egg production may be because of the effect of phenolic compounds in extracts, which improve the digestion and absorption of the nutrients by increasing enzymatic activity. Sharma et al. (2020) concluded that the addition of Alquernat Nebsui in drinking water of laying chickens gave more improvement in feed conversion ratio and egg production. Samani et al. (2020) inclusion of fenugreek powder in laying hens increased feed intake and improved feed conversion ratio and enhanced egg yolk color compared to the control group.

Feed Cost

The use of phytogetic substances in broiler feed has been shown to have an economic advantage when considering the cost of feed. Amad et al. (2011) inclusion of phytogetic substances to broiler diets significantly enhanced FCR. It could be related to improving nutrient digestibility and thus, lead to improving economic efficiency. Eevuri and Putturu (2013) reported that addition of phytogetic products to broiler diets had positive effects on lowering feed cost/kg live weight. Hossain et al. (2014) found that supplementation of 1% garlic and 1% cinnamon to broiler diets have higher profitability of production and benefit cost ratio. Hassan et al. (2015) reported that inclusion of *Cynara scolymus* extract in chicks feed significantly improved economic efficiency. Singh et al. (2015) observed a significant lowest feed cost /kg body weight of broiler fed garlic powder inclusion and the highest feed cost /kg body weight were observed in the control group. Karangiya et al. (2016) concluded that addition of garlic, ginger alone or in combination to broiler diet at 1% lowered feed costs compared with the control diet. Toaha et al. (2016) found that addition of fenugreek seeds to broiler diets was useful for efficient and economic production.

Conclusion

Phytogenic substances have different properties: antioxidant, antimicrobial, antiviral and immune stimulant effects in poultry production. The antimicrobial effects contribute to a depression of gut pathogens by repression of adhesion in the mucosa. It has an important goal to enhance gut health that improves digestion and absorption capacity. Nowadays, phytogenic substances are introduced as a new class of feed additives that could be used in poultry nutrition to improve performance and to protect the quality of food derived from poultry and animals. Phytogenic substances have beneficial effects on gut function, performance, and nutrient digestibility. So, it may be possible to use phytogenic substances in animals and poultry feeds as safe and natural promoters to enhance performance and therefore production efficiency. These substances can be considered as alternatives to synthetically feed additives and have positive tools to enhancing production capacity and meat quality.

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