Chapter

Phytogenic Feed Additives as An Alternative to Antibiotic Growth Promoters in Poultry Nutrition

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Abstract

Phytoadditives in animal nutrition have attracted a lot of attention for their potential role as alternatives to antibiotic growth promoters. Phytoadditives are feed additives originated from plants or botanicals that are used in poultry nutrition. This chapter provides an overview about the potency of alternative additive from plants as a basis for exploring it as a phytoadditive for poultry. These substances are derived from herbs, spices, and other plants and their extracts. They are natural, less toxic, residue free and ideal feed additives for poultry when compared to synthetic antibiotics. There efficacy of phytogenic applications in poultry nutrition depends on several factors, such as composition and feed inclusion level of phytogenic preparations, bird genetics, and overall diet composition. Addition of 100 mg/kg feed essential oils consist of carvacrol, thymol and limonene in matrix encapsulation improved performance and apparent ideal digestibility of nutrients of broiler chickens. Besides enhancing performance, phytogenic also has antioxidant, the effects of which are associated with essential oils (EOs) and their components. Administration of eucalyptus and peppermint oil blends by oral (0.25 ml/L drinking water) and spray route (0.1 ml/20 ml water) reduced Newcastle disease infection in broilers. Phytoadditives have antimicrobial, antifungal, antiviral, antitoxigenic, antiparasitic and insecticidal properties. The benefits of using phytoadditives in poultry nutrition are increased feed intake, stimulation of digestion, increased growth performance, reduced incidence of disease, improved reproductive parameters, feed efficiency, profitability. Based on the latest scientific findings presented in this chapter, the following main conclusions have been drawn that phytomolecule and that bioactives have potential to be developed as an alternative additive for poultry, and that promote health.

Keywords: antioxidant activity, nutrition, phytoadditive, phytogenic, broiler chickens, layers

1. Introduction

All animals need to receive a nutritious diet in order to maintain good health and production. Diets for poultry generally consist of cereal grain and a protein sources. The nutritional quality of a feed depends on feed presentation, antinutritional factors, microbial contamination, palatability, digestibility, and intestinal healthfulness, and a variety of feed additives are important too.

Feed additives are nonnutritive products added to the based diet, and are minor components of the animal diet. Feed additives are products used in animal nutrition for the purposes of improving the quality of feed and the quality of food from animal origin, improve the animal's performance and health, e.g. providing enhanced digestibility of the feed materials. Feed additives promote ingestion, absorption, assimilation of nutrients, growth, and health by affecting the physiological processes, such as immune function and stress resistance. Feed additives include immunostimulants, prebiotics, probiotics, acidifiers, essential oils, or others. Some of the commonly feed additives in animal diets include enzymes, pro- and prebiotics, antioxidants, antibiotic growth promoters, and coloring agents. These ingredients are aimed to enhance digestibility or availability of nutrients, improve animal gut health and food product quality, and promote environmental protection.

Alternative feed additives (phytogenic feed additives = phytoadditives) derived from herbs, spices or aromatic plants are have gained considerable attention in the recent years (**Figure 1**). Phytogenics were classified according to botanical origin, processing, and composition. For example, phytogenic feed additives like herbs and non-woody flowering plants have medicinal properties; spices, herbs with an intensive smell or taste, commonly added to human food; essential oils, aromatic oily liquids derived from plant materials such as flowers, leaves, fruits, and roots; and oleoresins, extracts derived by non-aqueous solvents from plant material. This chapter aimed to review the phytogenic feed additives as an alternative to antibiotic growth promoters in poultry nutrition.

	Phytoadditive		Major Component and Potency
	Gedi (*Abelmoschus manihot L. Medik*) leaves	Parts of plant (leaves)	flavonoid, phenolic compound, antioxidant activity
	Lemon basil (*Ocimum × citriodorum*) leaves		caffeic acid, flavonoid, antioxidant and antimicrobial activity
	Leilem (*Clerodendrum minahassae* L.) leaves		flavonoid, phenolic compound, antioxidant activity
	Bitter leaves (*Vernonia amygdalina*)		flavonoid, phenolic compound, antioxidant activity
	Cucumber (*Cucumis sativus*) seeds	Parts of plant (seeds)	lipid lowering, antioxidant activity
	Pumpkin (*Cucurbita moschata*) seeds		phenolic compound, antioxidant activity
	Cinnamon (*Cinnamomum verum*)		Cinnamic acid and cinnamaldehyde, antioxidant activity
	Nutmeg (*Myristica fragrans*)	Spices	Essential oils
	Candlenut (*Aleurites moluccanus*)		polyphenols content
	Celery (*Apium graveolens*)	Aromatic plants	natural antioxidants (especially vitamins, flavonoids, and unsaturated fatty acids)
	Lemongrass (*Cymbopogon citratus*)		antioxidant activity

Figure 1.
Several alternative Phytoadditive from herbs, spices, and aromatic plants.

2. Phytogenic feed additive in poultry

Phytogenics, also referred to as plant secondary metabolites, phytochemicals, phytobiotics or botanicals, are plant-derived products/extracts and include a wide range of substances such as herbs, spices, and essential oils reported to exhibit growth promoting and/or therapeutic properties [1, 2]. The use of phytogenics as an alternative prevent the risk of pathogens resistant to antibiotics in poultry. The ability of phytogenics to contribute to the health of poultry production is well documented, however, the exact mechanisms by which phytogenic exerts its effects remain speculative [3, 4].

Plant derived products are residue-free unlike synthetic antibiotics and are also considered safe to be used as the ingredients in the food industry as well as in animal diet as an ideal growth promoter. The herbs and plant extracts used as feed additives include many different bioactive ingredients such as alkaloids, bitters, flavonoids, glycosides, mucilage, saponins, tannins phenolics, polyphenols, terpenoids, polypeptide, thymol, cineole, linalool, anethole, allicin, capsaicin, allylisothiocyanate, and piperine [5]. The effects expected of herbs and plant extracts are also various. Other factors that influence the potency of the phytogenic may include the plant parts, the genetic, age and harvest time of the plant, and extraction method [6].

The concerns about antibiotic resistance cause it to explore alternatives antibiotics which have growth-promoting effects. This antibiotics as feed additive is expected not to induce resistance to bacteria and have no potential side effects to animals. Some feed additives, pro/prebiotics, organic acids, enzymes and phytogenics, are used as a replacement for AGP [7–10]. Phytogenic feed additive has been reported to enhance performance, feed conversion ratio, carcass meat safety and quality in animals [9, 11]. Besides enhancing performance, phytogenic also has antioxidant property, the effects of which are associated with essential oils (EOs) and their components [12]. Phytogenic has beneficial effects on nutrient utilization possibly by stimulating digestive enzymes and improves gastrointestinal morphology [10].

Several alternatives to AGP have been proposed, such as organic acids, probiotics, herbs and herbal products. Organic acids and medicinal plants as natural feed additives are recently used in poultry diet to enhance the performance and the immune response of birds. Yang et al. [13] reported that the lipophilic nature of phytogenic compounds limits the efficient delivery of these compounds to the gut. This problem could be resolved by microencapsulation and combination with other compounds. Hafeez et al. [14] reported that 100 mg/kg feed essential oils matrix encapsulation with active ingredients carvacrol, thymol and limonene improved performance and apparent ideal digestibility of nutrients of broiler chickens.

The use of feed additives to improve the efficiency of growth, eggs production, prevent disease and improve feed utilization is a strategy to improve the efficiency of the poultry industry.

The use and development of enzymes, phytogenics, prebiotics and probiotics has gained momentum in poultry feeding. Enzymes are of interest to improve nutrients digestibility, particularly in young animals. Phytogenics are an alternative to in-feed antibiotics to prevent the risk of developing pathogens. Probiotic which is consist of one single strain or a combination of several strains of bacteria, and prebiotics which are non-digestible food ingredients, such as fructooligosaccharides, xylooligosaccharides, mannanoligosaccharides and galactooligosaccharides, are also used in feeds to protect poultry against pathogens. Needs to be understanding how these additives can be used to improve the efficiency of poultry production [15]. In **Figure 1** showed the several alternative phytoadditive from herbs, spices, and aromatic plants.

According to Abudabos et al. [16] dietary supplementation of different feed additives in 10 treatments (**Table 1**) improved growth performance and gut health by mitigating the negative effect of the disease.

Treatment	p Value						
	FI(g)	BWG (g)	FCR	PEF	Villus height (μm)	Villus width (μm)	Total area (mm^2)
Negative Control							
Positive Control							
T1							
T2							
T3	0.0001	0.0001	0.0001	0.0001	NS	0.0001	NS
T4							
T5							
T6							
T7							
T8							

T1: Maxus; T2: CloSTAT; T3: Sangrovit; T4: CloSTAT +Sangrovit; T5: Gallipro Tect; T6: Saccharomyces boulardii; T7: Oregano; T8: Varium.

Table 1.
The effects of treatments on feed intake (FI), body weight gain (BWG), feed conversion ratio (FCR), body weight (BW), performance efficiency factor (PEF), villi height (L), width (W), and villi total area (TA) of broiler chickens [16].

Antimicrobial growth promoters (AGPs) are the most frequently used chemical agents, which enhance feed conversion ratio and reduce chicken mortality [17]. The use of AGPs has been associated with acquired resistance and meat residues that jeopardize human health [18]. Consequently, in many advanced countries, the unlimited use of these AGPs has been discouraged, therefore, the poultry producers are looking for alternative to antibiotics such as phytogentics [16, 19]. These natural products mostly originate from plant sources are potent source of improved growth performance and health in broilers [20–22]. Plants derived extract, polyphenol and oils enhance the absorption of nutrients, secrete the digestive enzymes, improve the immune response and antioxidant status in broiler [23].

The essential oils (EOs) present in phytogenic feed additive (PFA) contain most of the bioactive substances of the plant which include carvacrol, eugenol, thymol, capsaicin, cineole and so on are well known for their antibacterial, antifungal, antiviral and anticoccidial properties [24, 25]. In a study, supplementation of phytogenic feed additive 250 mg/kg EOs of thyme and anise improved growth performance, reduced blood total cholesterol, and also inhibited *C. perfringens* and *E. coli* prolification in small and large intestines in broiler chicks under oral *C. perfringens* 5 mL (10^7 cfu/mL) culture challenge [26]. Administration of eucalyptus and peppermint oil blends by oral (0.25 mL/L drinking water for 12 hours/day) and spray route (0.1 mL/20 mL water/10 birds) reduced Newcastle disease infection in broilers [27].

Since long time herbal and traditional plants had been used to prevent and control many diseases and health problems on a small scale such as in heavy metals toxicity [28, 29], ectoparasites [30], reproductive and renal toxicity [31, 32], heat stress [28, 29], and viral disease [33, 34]. People in the world are now aware of the advantageous use of natural derived products such as and botanicals [33, 35]; microalgae [36–43], and rare earth elements [42], over synthetic drugs and chemical in term of lower cost, toxicity and adverse effects and very low resistance [44].

Herbal medicine is gaining more importance in the anti-influenza research owing to their widespread availability and easy application in the diet [45].

Interesting in alternative products with antibacterial or anti-inflammatory activities has increased. Such products usually searching for among secondary plant metabolites, are flavonoids [46, 47]. Flavonoids are the largest and the most important single group of polyphenols. Molecular mechanisms of polyphenol health-promoting properties were related to their antioxidant properties [48]. Natural substances (flavonoids, polyphenols and isoflavones) in plants present an anti-inflammatory and antioxidative activity. Inflammatory reactions play a role of many conditions related to respiratory system [49].

The poultry industry plays a vital role in supply of healthy meat products to the public. Botanical extract were positively influenced broiler physiology, improved meat quality aid health-beneficial meat production shown by the higher meat content of essential amino acids, lower meat levels of saturated fatty acids and higher level of UFA, MUFA, PUFA, and omega-3 and optimal fatty acid ratios. These natural botanical antioxidants are good modulators of amino acid and fatty acid contents in broiler meat [50]. The supplementation of plant-derived (basil and chamomile) rich in antioxidant compounds in broiler feeds improved growth parameters in broiler chicks and had blood lipid-lowering effects by reduced serum levels of total lipids, triglycerides, and cholesterol [51]. Hashemipour et al. [52] reported dietary supplementation of phytogenic product containing an equal mixture of thymol and carvacrol at 4 levels (0, 60, 100, and 200 mg/kg of diet), thymol + carvacrol enhanced BW gain and feed efficiency, and reduced feed intake. Also, the additive increased antioxidant and digestive enzyme activities and improved immune response, which may beneficially affect health and performance of broiler chickens.

For the alleviation of diseases, modulation of immune response has been great pointed to researchers [53]. The supplementation of poultry feed with anise as reported to improve lymphocyte counts [54]. The increase in IgG in broilers was noted with the inclusion of 0.1% of herb mixture consisting *Phlomis umbrosa* Turez, *Cynancum wilfordii* Hem, *Zingiber officinale* Rosc and *Platycodi radix* in broiler [55].

Some studies reported that administration of *Withania somnifera* extract 10–30 g/L to broiler chicks improve their feed intake, body weight gain, hematological profile and immunological status [56]. That *W. somnifera* root extract has antiviral property against Infectious Bursal Disease Virus [57]. Studied on the immunomodulatory potential of the herbs such as *W. somnifera*, *T. cordifolia* and *A. indica* were suggested to combat depressed hematological parameters and stunted growth in chicks during chicken infectious anemia virus (CIAV) [58].

Alhajj et al. [59] reported that supplementation 1 or 2 g of star anise/kg of diet improve body weight, daily weight gain and feed conversion ratio. Supplementation 6 g kg^{-1} had higher antibody titers against NDV and IBV whereas the diet containing 1 g kg^{-1} had the highest antibody titers against IBDV. That Chinese star anise could be used as a natural additive to improve the immune responsiveness and performance of broiler chickens. A heat-stable encapsulated essential oils consisting of 4.5 g cinnamaldehyde and 13.5 g thymol in the diet could substitute zinc bacitracin and resulted in enhanced growth performance, production efficiency index and immune responses of broilers [60].

3. Impact of phytoadditives on the composition of digesta and its consequents on health status and performance of birds

Gut microbiota and their metabolic products improve nutrient digestion, absorption, metabolism, and overall health and growth performance of poultry [61].

Antibiotics are either synthetic drugs or are obtained from natural sources are used to kill or inhibit the growth of microorganisms in a broad sense, but these antibiotics also play some beneficial role in the gut. Administering 0.8 mg amoxicillin per bird per day in drinking water for a period of 24 h to the normal early life microbial colonization of the jejunum in 1-day old chickens is important to early life microbial colonization of the gut in relation to immune development and to modulate the early life colonization of 'beneficial' microbiota [62]. Because antibiotics reduce the gut microbiota and their toxic metabolites, antibiotics have been widely incorporated into the poultry industry for decades. Now, the use as the prophylactic dose in animal feed has been banned in some jurisdictions [61].

Feed additives that can modulate the broiler gastrointestinal tract (GIT) and provide benefit to bird performance and health have recently received more interest for commercial applications. They can also limit foodborne pathogen establishment in bird flocks by modifying the gastrointestinal microbial population. Prebiotics are known as non-digestible carbohydrates that stimulate the growth of beneficial bacteria, thus improving the overall health of the host. Other gut activities occur due to the presence of the prebiotic, including generation of short-chain fatty acids and lactic acid as microbial fermentation products, a decreased rate of pathogen colonization, and potential bird health benefits [63].

The emergence of antibiotic resistance in pathogens identified as public health risks has led to the curtailment of routine antibiotic supplementation for agricultural use and outright banning in some parts of the world [64, 65]. A wide range of feed additives have been explored for potential application in poultry including phytobiotics, organic acids, probiotics and prebiotics, and these have been extensively discussed in a number of reviews [66–70].

Prebiotics, as being indigestible by the host, are hydrolyzed and utilized by the GIT microorganisms present in various compartments of the avian GIT. Dietary fibers as undigested dietary material generally transit through the upper parts of the GIT and reach the ceca as substrates for the resident cecal microbial population [71]. Foodborne pathogens such as *Salmonella* can also reside in the ceca and the production of SCFA would presumably be antagonistic to their presence [69, 72]. The ceca have several potential roles associated with bird function, including electrolyte and water reabsorption [71].

To improved GIT and host health benefits, prebiotics offer a dietary means to select for GIT bacteria that can potentially serve as a barrier for colonization by foodborne pathogens such as *Campylobacter* and *Salmonella* [72–74]. Low energy content in the diet can decrease broiler performance, lower AME value and nutrient digestibility. Supplementing phytonutrients to a low energy diet can maintain FCR thus increase economic profit of broilers apparently via improved gut health [75].

Phytogenics and probiotics have the ability to stabilize the intestinal environment and provide positive advantages to the colonization and proliferation of Lactobacilli and reducing pathogenic organisms. Also the use of medicinal plants is safer and cheaper. It could also serve as a way of bridging the gap between food safety and production as well as reducing mortality in animals [76].

3.1 Impact of phytoadditive on digestibility of nutrients

Beneficial effects on nutrient digestibility using different phytogenic feed additive (PFA) in some previous researches have been observed in poultry [10, 77]. The reason for improvement in nutrient absorption may be partly explained due to stimulation in secretions of saliva, bile and enhanced enzyme activity [78]. The improved nutrient digestibility consequently enhances the health status of animals.

The inclusion of 100 and 200 mg/kg thymol and carvacrol in broiler chickens' diet improved villus surface, villus height, villus height to crypt depth and muscular layer of jejunum and ileum [52]. The addition of *Euphorbia hirta* (7.5 g/kg) increased the villus height compared to the control birds [79]. The dietary supplementation with 2.0 and 2.5% of *Boswellia serrata* resin to broiler led to a significant increase in the length of the duodenum and total intestine [80].

Feeding broilers a diet supplemented with 200 mg/kg EO from peppermint led to the increase of crude protein digestibility [81]. Pirgozliev et al. [4] defined that phytogenic did not affect dietary ME, but caused a significant improvement in the utilization of dietary energy, which did not always relate to growth performance. Inclusion of menthol and anethole meal at 150 mg/kg in diet had no effect to performance and apparent ileal absorption of phosphorus, however, addition of essential oils of caravacol, thymol, and limonene in encapsulated form 100 mg/kg improved performance and apparent digestibility of nutrients in broilers possibly due to improved secretion of digestive enzymes [14]. Mandey et al. [82] (**Table 2**) reported that broiler chickens which got gedi leaves juice in drinking water had the value of AME for 20 and 30 ml/L were significantly lower than control diet and 10 ml/L.

Several studies documented the use of PFA as a growth promoter [83, 84]. The supplementation of fenugreek seeds (1, 2 and 3%) significantly improved feed conversion ratio of broiler chickens [85]. Another study reported that supplementation of 1 or 2 g of anise seed in broilers diet improved body weight, daily weight gain and feed conversion ratio but had no effect on feed intake [86]. The use of herbal mixture supplement in diet had a beneficial effect in the treated chicks, improved egg productivity, vitality and health condition [87].

Dietary supplementation with thymeoil extract, especially at the level of 100 ppm, can improve immunological responses of broiler chicks [88]. The supplementation of chicken diet with extracts Curcuma and Scutelleria effectively decrease gut inflammation and increase chicken performance [89]. Using 2.5% wood vinegar in quails diet increased weight gain, decreased feed conversion ratio and increased production efficiency factor. Addition of 2.5% wood vinegar in quails diet is recommended [90]. Al-Kassie et al. [91] reported that the inclusion of mixture of hot red pepper and black pepper at a level of 0.75 and 1% in the diets significantly improved the dressing percentage of broilers.

The feed supplemented with thyme essential oil at 100 mg/kg resulted in improved dressing yield and cut up parts of carcass viz. breast yield, thigh yield and

Variables	**Treatments in Drinking Water (DW)**				***P value***
	0 mL/L DW	**10 mL/L DW**	**20 mL/L DW**	**30 mL/L DW**	
AME (Kcal/kg)	2844 ± 81.44c	2775 ± 139.60c	2534 ± 27.90b	2081 ± 108.79a	<.001
NR (g)	6.4 ± 0.51	6.1 ± 0.65	4.7 ± 0.11	2.7 ± 0.38	
AMEn (Kcal/kg)	2788 ± 77.00c	2722 ± 134.20c	2488 ± 28.37b	2057 ± 105.50a	<.001
ACP Digestibility	55.2 ± 4.29b	62.7 ± 6.61c	54.5 ± 1.22b	34.9 ± 4.70a	<.001
ACF Digestibility (%)	42.1 ± 5.55b	43.9 ± 9.93b	40.8 ± 1.58b	28.7 ± 5.14a	0.020

Source: Mandey et al. [82]; [a,b,c] the difference between means with different superscript letters in the same row is significant (P<0.05)

Table 2.
Effect of Gedi leaves juice in drinking water on nutrients digestibility.

back yield. However, giblet and thigh yield were not affected by addition of different doses of thyme oil in broilers diet [92]. Ragaa et al. [93] reported significantly higher breast yield and thigh yield in birds fed diet thyme 1 g/kg. The improved carcass traits might be due to utilization of nutrient from diet. Amino acids especially lysine is critical for muscle development such as breast muscle.

Broilers fed diets including EOs in150 mg/kg of the diet significantly boosted BWG compared to broilers fed the control diet [94]. The supplementation of EOs significantly increased dressing percentage [95]. Yang et al. [6] reported improvements in FCR with EO supplementation. Supplementation of Chinese herbs extract in drinking water improve growth performance, blood biochemistry parameters, immune organ weight and immune indexes of broiler [96]. Phyo et al. [97] also observed the effect of dietary garlic and thyme seed supplementation on the production performance and gut microbial population of broiler chickens. The diet with cucumber in drinking water up to 30 g per liter water (**Table 3**) was significantly decreased abdominal fat percentage, increased blood LDL-cholesterol and feed conversion value, but were no affected to final body weight, giblet, the value of blood HDL-cholesterol, and kept the good value of carcass percentage [98].

Aloe vera and clove supplementation improved the dressing percentage and breast weight without adversely affecting the meat composition and serum enzymes. These can be used as a growth promoter in Japanese quails [99]. The inclusion of medicinal herbs, spices, vegetables, plants, seeds, and edible fungi, as ingredients of natural origin, in diet of Japanese quail improved carcass and meat quality [100].

The phytobiotics compounds such as alkaloids, anthraquinones, flavonoids, tannins, steroids and saponins in guava, avocado and malunggay leaves extract is beneficial as alternative feed additives for enhancing the growth of broiler chicks in the poultry industry. Thus, could possibly eliminate the chemical residues that may cause harmful effect to the health of the consuming public [101].

Besides immune enhancing, antimicrobial, and performance enhancing effects, phytogenics also have antioxidant property. The excellent plant derived

Variables	Treatments				SEM	p Value
	0 g CSJ	10 g CSJ	20 g CSJ	30 g CSJ		
Feed Intake (g)	2144.64	2048.24	2041.36	2039.78	21.42	.23
Average Feed Intake (g)	76.59	73.15	72.49	72.85	.76	.25
Water Intake (ml)	4285	4298	4279	4290	.71	.56
Slaughter Weight (g)	1249.97	1251.20	1273.60	1300.10	14.21	.59
Weight Gain (g)	1131.89	1137.68	1159.68	1187.78	14.21	.70
Carcass Weight (g)	764.8	787.4	780.8	798.2	9.07	.65
Carcass Percentage (%)	66.78	67.60	67.33	67.74	.34	.80
FCR	1.89^{a}	1.80^{ab}	1.76^{ab}	1.72^{b}	.02	.07
Abdominal Fat (%)	2.47^{a}	2.09^{b}	2.05^{b}	1.94^{b}	.07	.02
Total Cholesterol	118.4	120.4	118.8	112.0	2.29	0.62
HDL-Cholesterol	94.4	99.8	99.0	99.0	0.89	0.13
LDL-Cholesterol	17.2**a**	20.6^{b}	29.4**c**	28.4**c**	1.28	0.00
Triglyceride	29.8	28.2	24.8	24.2	1.07	0.19

Notes: CSJ = cucumber seed juice; ^{a,b,c} the difference between means with different superscript letters in the same row is significant (P<0.05).

Table 3.
Effect of treatments in drinking water on the performance of broiler chickens [98].

antioxidants are obtained from rosemary, olive leaves, thyme, marjoram, sage, oregano, etc. [61]. Some other common herbs, spices and fruits that have antioxidant property are ginger, turmeric, garlic, plum, pine bark extract, berries, pomegranate, caraway, cinnamon, clove. The effects of which are associated with EOs and their components [102, 103]. The demand for natural antioxidants in food is increasing due to their health benefits against oxidative stress and several diseases [104–106].

The oxidative stability of meat obtained from broilers, hens or turkeys in a series of studies have been reported to increase with the use of dietary supplementation of EOs. Dietary supplementation of 100 mg/kg EO blends with 5% carvacrol, 3% cinnamaldehyde and 2% capsicum oleoresin as active constituents improved the concentration of antioxidants in the liver of broiler chicken [107].

The supplementation of thymol (80 mg/animal/day) helped to reduce fear responses in quail when exposed to stressful situations [108]. Study by Ghazaghi et al. [109] noted that supplementation of *Mentha spicata* (1–4%) in the diet improved meat quality of Japanese quail. The study on the effects of PFA on egg quality is limited and variable. Abdel-Wareth and Lohakare [110] reported that 20 g/kg dry peppermint leaves in diet of laying hens can be used as an effective feed additive to improve performance.

The use of antibiotics has been minimized and replaced by effective dietary supplements such as probiotics and/or prebiotics that are claimed to enhance growth and positively modulate the immune response. The economic analysis data obtained from probiotic studies in broilers indicated that probiotic supplementation may not always be more feasible and economical to obtain maximum profitability from broiler production and hence further research in the field is currently ongoing [111]. Herbs, spices, and various other plant extracts are being evaluated as alternatives to antibiotics and some do have growth promoting effects, antimicrobial properties, and other health-related benefits [112].

Phytogenic feed additives should be used as an alternative feed additives in poultry production to maximize the overall performance of poultry because of they have no side effects, residual effects, non-hazardous and eco-friendly [113].

4. Conclusion

Based on the results presented in this chapter, the following main conclusions can be drawn:

1. Phytoadditives are natural, less toxic, residue free and ideal feed additives for poultry when compared to synthetic antibiotics.

2. Phytoadditives have antimicrobial, antifungal, antiviral, antitoxigenic, antiparasitic and insecticidal properties.

3. Besides immune enhancing, antimicrobial, and performance enhancing effects, phytogenics also have antioxidant property.

4. The benefits of using phytoadditives in poultry nutrition are increased feed intake, stimulation of digestion, increased growth performance, reduced incidence of disease, improved reproductive parameters and feed efficiency.

5. That phytomolecule and that bioactives have potential to be developed as an alternative additive for poultry, and that promote health.

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