

HONEYBEE AND MEDICINAL PLANTS PRODUCTS IN POULTRY POSTANTIBIOTIC ERA PRODUCTION

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ABSTRACT: The quality and safety attributes of poultry products have attracted increasing attention and interest from the scientific communities and the public worldwide. Recently, as natural and safe alternatives to synthetic and artificial chemical drugs such as antibiotics, botanical products are used in poultry farms more than 60% for producing organic products. Medicinal plants, and honeybee products, are natural substances, and they were added to poultry diets in a small amount between 1 and 3% as a source of nutrition and to provide health benefits for poultry. In addition, they have several biological functions in the poultry body and may help to enhance their welfare. In the current review, critical effects and functions of the use of bee products and botanicals, as natural and safe alternative feed additives in poultry production, such as antioxidants, sexual-stimulants, immuno-stimulants, and for producing healthy products were elaborated.

Key words: *honeybee, medicinal plants, quality, poultry*

INTRODUCTION

The poultry industry has recently faced many challenges, including economic recession, climate change, diseases, and overuse of antibiotics. Enhancing animal welfare, production, and health is a significant request for all poultry farms and provides safe and organic products to consumers. Organic production refers to the final product quality and extending to the whole production process under high quality and security control (Tasić, 2018). Therefore, today's global trend is to reduce the use of synthetic prophylactic and therapeutic drugs, such as antibiotics in poultry farms, and find safer and healthier natural alternatives. For decades, antibiotics were commonly used in poultry farms to maintain the balance of the ecosystem in the gut and improves chicken growth. The overuse of these antibiotics in poultry farms, as growth promoters for improving feed conversion ratio and growth, has resulted in several adverse effects such as the development of antimicrobial resistance (AMR) and transference, and the residues remained in consumed meat (Paphitou, 2013). Several strategies have been applied to deal with this global trend. One of these strategies is to use botanicals as natural substances in poultry production to improve poultry welfare and produce organic meat and eggs. The botanical products can be defined as a natural substance derived from natural products such as plant extracts, fruits, and bee products, added to the animal diet to provide medical or health benefits, including preventing or treating a disease (Eteraf-Oskouei & Najafi, 2013; Ghosh & Playford, 2003). Botanicals appear to

have a wide range of applications in the nutrition and production of poultry (Windisch et al., 2008). They differ from other dietary supplements in several aspects, such as their ability to play many positive biological roles in an animal's body and their capability to improve its health status without leaving any residues in consumed meat (Lee et al., 2017). The probable mechanism of action of plant products has been found to be through their beneficial effect on gut microflora by reducing the number of pathogenic organisms, resulting in increased nutrient availability for the host (Cross et al., 2007; Yang et al., 2009). Due to their nutritional and medical properties, herbal and bee products are now used as dietary supplements in poultry production on a large scale (Abioja et al., 2016; Oke et al., 2016; Raza et al., 2015). Additionally, they are progressively used *in vivo* feeding techniques as multiple functions nutrients for growth and immune stimulation in young chicks (Puvača et al., 2013).

BIOLOGICAL FUNCTIONS OF MEDICINAL PLANTS

Botanicals, in general, are natural chemical components that have a role in modifying and maintaining normal physiological functions that support the health of host (Santhosha et al., 2013). Sugiharto (2016) found that gut health could be affected by various factors, and when gut health and function are damaged, the digestion and absorption of nutrients are impacted, and this, in turn, impacts the growth and productivity of poultry, while when they are enhanced, growth and productivity of poultry are improved. Sugiharto (2016) also concluded that botanicals could improve the gut ecosystem and the immune functions of poultry and result in growth promotion and prevention or treatment of enteric infections. Botanicals can positively affect the balance of intestinal microbiota, which plays a vital role in regulating metabolism, intestinal epithelial proliferation, and vitamin synthesis (Possemiers et al., 2011). Many botanicals in the form of prebiotics, probiotics, and symbiotics are used to promote poultry gut health but appear to influence other vital organs' functionality favorably (R. Aluko, 2012). Additionally, these natural products could help in protecting the host against infectious diseases (Khan et al., 2014). In general, previous literature focused on botanicals biological activities has shown that most studies have only discussed the concept of their using as growth promoters and anti-inflammatory and antibacterial agents. Our review discussed other critical biological functions using recent natural products as safe alternative feed additives in poultry production and health. The recent findings and applications concerning the botanical (Table 1) products as natural supplementations adding in poultry diets for improving poultry productive performance are summarized and their mechanisms of action.

Table 1. Effects of dietary addition of botanicals in broiler chicken's production.

Additive	Obtained results
Fenugreek	Improved production results of chickens with the dietary addition of 1 to 3% of fenugreek seed powder
Black cumin	Improved broiler performance and meat quality by enhancing antioxidant activities and suppressing lipid peroxidation in meat.
Ginger	Improved oxidative status
Thyme	Possibility to replace antibiotics in the diet of chickens; Reduction of fat in chicken carcass

HONEYBEE PRODUCTS AND THEIR EFFECTS ON POULTRY PRODUCTIVITY

Honeybee products are natural substances, such as royal jelly, propolis, bee pollen, and bee venom, synthesized in honeybees (*Apis mellifera*). These products have unique structures rich with active components of enzymes and peptides that have several pharmaceutical characteristics besides their high nutritional value and their significant impact on poultry's physiological and productive performance. These kinds of nutritional and therapy alternatives have been used for centuries. According to the results of Babaei et al. (2016), the critical active nutrient components of bee products may increase body weight gain, body weight, lymphoid organ weight, and antibody titer of Japanese quails. Rabie et al. (2018) indicated that it is imperative to add bee products such as propolis (400 mg/kg diet) or bee pollen (2000 mg/kg) to broiler diets and bee venom (2 mg/L) to broiler's water as alternatives to antibiotics in poultry production. The bioavailability of bee products is greater than that of artificially produced preparations. Research on the use of bee products as nutritional supplements for poultry has generally shown their positive impact on the health and productivity (Shalman & Shivazad, 2005). A wide range of research concentrated mainly on the propolis supplementation of layers and broilers, in various conditions and age groups. Research concerned primarily the immune response of the birds, physiological parameters and weight gain in broilers, as well as the parameters of egg-laying activity and the quality of eggs (Table 2).

Table 2. Effects of dietary addition of bee products in daily poultry production

Additive	Poultry	Obtained results
Royal jelly	Laying hens	Increased egg production, improved welfare, and improved immunity
Bee venom	Broilers chickens	Improved production results, fatty acid composition, and antioxidant capacity; Better early development of chickens' digestive system and a helpful tool against short bowel syndrome
Bee pollen	Laying hens	Improved production results, and biochemical blood parameters with the dietary addition of 500 mg/kg
	Broilers chickens	Enhanced immunity of chickens with dietary addition in the concentration of 1.5%
Bee propolis	Broilers chickens	The dietary concentration of 200 to 400 mg/kg improves blood lipid status
	Laying hens	Increase body weight, egg production, and stimulate immunity

ROYAL JELLY, BEE VENOM, BEE POLLEN, AND BEE PROPOLIS

Royal jelly is one of the popular bee products widely used as natural food for humans and animals due to its high content of essential nutrients. It is an excellent source of B vitamins, vitamin C, folic acid, and phenolic acids. Royal jelly is also a good source of minerals. It has several important biological functions in the living being, including its effects as an antioxidant, immuno-stimulant, and growth promoter. The antioxidant activity of royal jelly is primarily due to the presence of polyphenolic compounds. It can be used in poultry production to improve the growth, gut health, and immune response

and produce high-quality and safe poultry meat. El-Tarabany (2018) have conducted an experiment to elucidate the impact of royal jelly on behavioural patterns, feather cover, egg quality and some blood haematological indices in laying hens (58–64 weeks of age). A total of 108 Tetra Brown laying hens were used in the trial. The pure royal jelly was prepared as injection subcutaneously as 100 mg/kg, and 200 mg/kg, respectively. El-Tarabany (2018) revealed that the eating and drinking activities in the 200 mg/kg group were significantly ($p = 0.009$ and 0.015 respectively) higher than the control and 100 mg/kg groups. Furthermore, the aggressive pecks, feather pecks and threatening behaviour in the 200 mg/kg group were significantly ($p = 0.005$, 0.001 and 0.039 respectively) lower than the control and 100 mg/kg groups. Effect of ethanolic extract of royal jelly, propolis, honey and bee pollen in comparison with virginiamycin (as growth promoter antibiotic) as regards the performance and immune system of Japanese quail were investigated in research of Babaei et al. (2016). A total of 256 mixed-sex quail chicks in a completely randomized design by eight treatments, including control, ethanolic extract of propolis 1000 and 5000 mg/kg, pollen powder 1000 and 5000 mg/kg, royal jelly 100 mg/kg, honey 22 g/L of drinking water and virginiamycin 150 mg/kg, was used in a trial for 42 days. Babaei et al. (2016) have recorded positive effects of all used bee products compared to antibiotics in Japanese quail chickens nutrition. Royal jelly is product from bees that is used to feed larvae in the hive as well as a main nutritional source for the queen honey bee (Saeed et al., 2018). It can be used for the improvement of growth performance, gut health and quality and safety of animal products in poultry due to its antioxidant and immune modulating properties. Studies conducted on supplementation with royal jelly in poultry diets have shown a significant increase in body weight, egg production, and immune levels and is especially useful in organic production. Supplementation of royal jelly at the level of 10 and 15 mg/kg in layer diets positively influenced egg weight (by 5.0% and 4.8% respectively), egg production (10.5% and 11.0% respectively), weight gain of hens (7.0% and 6.5% respectively) and yolk pigmentation (9.5% and 9.7% respectively) (Saeed et al., 2018). Supplementing poultry diets with royal jelly offers an opportunity to maximise profit from safe and high-quality poultry production. Bee venom also is one of the bee products, synthesized in the venom gland of honeybees, and has several pharmaceutical and medical characteristics. It consists of various substances, including peptides and enzymes, whereas melittin is the most effective component. It also contains other essential substances, such as apamin and adolapin, which have various medicinal effects as anti-inflammatory and antibacterial. Therefore, bee venom could be added to the animal diet to provide productive and health benefits, including preventing and treating disease. Rabie et al. (2018) have conducted trial to evaluate the effects of propolis, bee-pollen and bee-venom as eco-friendly alternative on productive and physiological performance of broiler chickens. A total of 408 unsexed one week old, Cobb 500 broilers were randomly divided into 8 experimental treatments. The first treatment was fed basal diet without any additives and served as a control. The second treatment was fed the basal diet supplemented with the growth promoter Biox-Y® 0.5g per kg of diet. The third and the fourth treatments were fed basal diet supplemented with propolis (200 or 400 mg/kg diet). The fifth and the sixth treatments were fed basal diet supplemented with bee-pollen (1 or 2 g/kg diet). The seventh and the eighth treatments were fed the basal diet and their water was supplemented with bee-venom (1 or 2 mg/L water). The chicks fed diets containing propolis (200 or 400 mg/kg diet) or bee-venom (2 mg/L water) or bee-pollen (2 g/kg diet) showed significantly lower plasma cholesterol and

LDL-cholesterol concentration compared to the control and Biox-Y® treatments. Consequently, propolis (200 or 400 mg/kg diet) treatments and bee-pollen (2 g/kg diet) treatment had significantly higher plasma HDL cholesterol concentration than the control treatment. Broilers fed propolis (200 or 400 mg/kg diet) for 6 weeks had significantly lower serum AST and ALT concentrations compared to the control treatment (Rabie et al., 2018). Bee pollen is a new type of feed additives and is characterised by a variety of nutritional and bioactive properties (Haščík et al., 2017). It may enhance the immunity of poultry, promote animal growth, protect the intestinal tract health and improve the quality and safety of animal products. Various research papers have focused on the use of bee pollen in poultry feeds, and have reported that it is, as a natural feed additive, a promising alternative to antibiotics and coccidiostats. Most papers have focussed on doses of 400 or 800 mg/kg feed, however limited dose response work has been done (Haščík et al., 2017). Effective dose rates, dose responses and standardised products need to be established. If such consistent products can be produced, then their efficacy in terms of meat performance, carcass traits, meat quality, immunity, and blood parameters of broiler chickens can be verified, along with costs and returns on investment for producers, to establish the usefulness as an alternative to antibiotics growth promoters. Moreover, supplementation with bee pollen under stress conditions has been shown to reduce oxidative stress markers and improve the animal's antioxidant system (Ketkar et al., 2015). Research has revealed that bee pollen as a natural antioxidant can be used as a supplementation in laying hens diets (1000 to 2000 mg/kg) to improve hens' production performance, increased egg production by 4.5%, and enhance egg yolk quality with the decreased total cholesterol concentration by 45%, which resulted in producing healthy products for consumers (Mohdaly et al., 2015). Furthermore, it is recommended to use bee pollen in roosters' diets (1000 mg/kg) to improve the ejaculate volume, progressive motility, live sperms, concentrate per ejaculate, and decrease the sperm abnormalities (Khafaji et al., 2018). In research of Farag and El-Rayes (2016), one-day-old Hubbard broiler chicks were fed basal diet supplemented with bee-pollen at the rate of 0% (control), 0.2, 0.4 or 0.6% for a period of 6 weeks with an aim to use them in broiler nutrition as a natural growth promoting substance. Significant ($p < 0.01$) differences in live body weight and body weight gain were found between broiler chicks fed the basal diet and those having bee-pollen in their diets during the experiment period. Broiler receiving 0.6% bee-pollen had the highest significant ($p < 0.01$) body weight and body weight gains. Based on the obtained results Farag and El-Rayes (2016) concluded that supplementation of bee-pollen to the diets of broiler chicks improved the performance, carcass traits and blood parameters. Bee propolis is a natural resinous substance rich in active enzymes, and it has been recognized for its medicinal and therapeutic properties (Viuda-Martos et al., 2008). Aromatic compounds, flavonoids, and phenolics are the core components responding to the biological functions of propolis (Ahangari et al., 2018). Working on propolis as one of the bee products used in poultry production, researchers have reported that it could be effectively added to the Japanese quail diet (500 to 4000 mg/kg) to improve growth performance and improve egg quality. It could optimize the lipid profile in egg yolk and reduce the total cholesterol concentration by more than 3.5%, respectively (Zweil et al., 2016). Moreover, it positively affects the antioxidative status of poultry, especially under summer conditions (Mehaisen et al., 2017). Abdel-Kareem and El-Sheikh (Abdel-Kareem & El-Sheikh, 2017) in their research have investigated the impact of supplementing diets with propolis on productive performance, egg quality traits and some haematological

variables of laying hens. One hundred and twenty-eight, 28-weeks-old Lohmann LSL hybrid layers were used in this experiment, which lasted 12 weeks. Commercial diet supplemented with 250, 500 and 1000 mg propolis/kg diet was used during the experiment respectively. Abdel-Kareem and El-Sheikh (Abdel-Kareem & El-Sheikh, 2017) concluded that the supplementation of 250 mg propolis/kg diet is highly recommended to improving egg production, blood constituent and haematological parameters of the commercial laying hens.

FENUGREEK, BLACK CUMIN, GINGER, TURMERIC, AND THYME

Fenugreek seeds are known as medicinal seeds that have several therapeutic properties such as antibacterial and anti-inflammatory. They are also rich in protein, fat, carbohydrates, and minerals and contain biotin and trimethylamine, which tend to stimulate the animals appetite. Abdouli et al. (2014) have performed to evaluate the effects of ground fenugreek seeds given to laying hens at 2, 4 or 6 g/hen/day on laying performance, egg quality characteristics, serum and egg yolk cholesterol concentrations. Total of forty, 52-week-old, Lohmann White laying hens were fed for 7 weeks in the experiment. Results of Abdouli et al. (2014) have showed that ground fenugreek seeds reduced blood serum cholesterol, but it did not affect egg yolk cholesterol. Authors have pointed out that ground fenugreek seeds given to Lohmann White laying hens at up to 6 g/hen/day had no effect on feed intake, laying production performance and egg quality but reduced hen's serum cholesterol (Abdouli et al., 2014). A research study was conducted by Abbas (2010) to find the effect of fenugreek, parsley and sweet basil seeds as natural feed additives on broiler performance. Experiment was performed on a total of 120 day-old chicks were reared for 42 days. Chicks fed basil diets had significantly ($p < 0.05$) heaviest body weight than those fed the fenugreek diets. Carcass characteristics had no significant differences. Significant reduction occurred in serum cholesterol as compared to control diets. Abbas (2010) suggested that the supplementation of broiler chicks diets with (3 g/kg) basil or parsley seeds improves productive performance. Black cumin seeds are also known for their medicinal and pharmaceutical properties. They contain alkaloids, volatile oils, antioxidants, and several pharmacologically active substances such as thymol. Rahman and Kim (2016) indicated that black cumin supplementation could improve broiler chickens' production and meat quality by improving antioxidant activities and suppressing lipid peroxidation in meat. Boka et al. (2014) performed a study to investigate the effects of different levels of black cumin seeds on performance, intestinal *Escherichia coli* count and morphology of jejunal epithelial cells in laying hens. A total of 100 Leghorn laying hens (Hy-Line W-36) of 49 weeks old were used in experiment where hens were supplemented with 0, 1, 2 and 3% of dietary black cumin. Boka et al. (2014) came to a conclusion that supplementation with black cumin improves ($p < 0.05$) eggshell quality and Haugh unit, and feed conversion ratio. Boka et al. (2014) have highlighted that this improvement was due to the increase ($p < 0.05$) in egg mass and contemporaneous decrease ($p < 0.01$) in feed consumption. The present results indicated that regardless of supplementation level, dietary inclusion of black cumin decreased *E. coli* enumeration in ileal digesta and improved serum lipid profile and eggshell quality, whereas the best intestinal health indices and laying hens' performance were obtained by at least 2% black cumin seeds. Previous study conducted by Aydin et al. (2008) with total of 80 laying hens fed with dietary addition of 1, 2, or 3% black cumin, respectively. Zhang et al. (2009) have used a

level of 5 g/kg ginger powder in broiler diets as nutritional supplementation, it led to enhancement of antioxidant capacity and serum metabolites. Growing Japanese quails fed with ginger supplemented diet (0.125 g/kg) have obtained the best results in feed conversion ratio and humoral immunity. Oleforuh-Okoleh et al. (2015) performed the experiment to evaluate the growth performance, haematological and serum biochemical response of broiler chickens to aqueous extract of ginger and garlic. Experiment lasted 56 days and was performed on a total of 80-day-old Marshal Strain broiler chickens supplemented with 50 mL of ginger, and garlic in a 1:1 ratio mixture in drinking water, respectively. All the investigated parameters were significantly improved at the end of the experiment. On the other hand, a study using 144 one-day-old Arbor Acres broilers was conducted to assess the effects of dried ginger root that was processed to particle sizes of 300, 149, 74, 37, and 8.4 μm on growth performance, antioxidant status, and serum metabolites of broiler chickens by Zhang et al. (2009). Results of these investigation revealed that with the reducing particle size of ginger powder linearly reduced ($p < 0.05$) cholesterol (d 21) and linearly increased ($p < 0.05$) glutathione peroxidase (d 21), total superoxide dismutase (d 42), and total protein (d 21 and 42). Supplementation of ginger at the level of 5 g/kg improved antioxidant status of broilers and the efficacy was enhanced as the particle size was reduced from 300 to 37 μm (Zhang et al., 2009). Other study has been conducted to investigate the effect of ginger extract combined with citric acid on the tenderness of duck breast muscles. Even added as marinade, ginger have express positive effects and significantly increased ducks breast meat tenderness which could be attributed to various mechanisms such as increased myofibrillar fragmentation index and myofibrillar protein solubility (He et al., 2015). In their review Khan et al. (2012) have pointed out that in the last decade, there has been growing interest in the use of natural herbs and medicinal plants as feed additives in poultry diets to maximise their potential output. They have highlighted that the ginger is one potential rhizome with a wide range of medicinal effects. In broilers and layers, this plant has been used in different forms, doses and durations. Also, authors have documented effects of ginger in poultry feed on feed intake and feed conversion ratio, growth and weight gain, carcass yield, egg production and quality, antioxidants and blood biochemistry, with their possible mechanisms of action (Khan et al., 2012). Turmeric is a rhizomatous herbaceous plant belonging to the ginger family (Ajitomi et al., 2015). It has been described as a natural polyphenol nutraceutical substance and is widely known for improving oxidative stress and fixing oxidative damage (Mythri & Srinivas Bharath, 2012). It can also be used in animal diets to mitigate heat stress (Akhavan-Salamat & Ghasemi, 2016). Turmeric or curcumin can eliminate free radicals such as reactive oxygen species (ROS) and reactive nitrogen species (RNS) by activating glutathione (GSH), catalase, and superoxide dismutase (SOD), triggering better responses in the antioxidative mechanisms and inhibiting or neutralizing enzymes generators of ROS (Miriayala et al., 2007). Therefore, it becomes an important antioxidant and medical additive in poultry diets, particularly in tropical regions, where high temperatures throughout the year can lead to reduced egg production, delayed growth, increased disease outbreaks, and mortality (Priyadarsini, 1997). All these problems intensify when the poultry is under heat stress (Swathi et al., 2016). Sadeghi and Moghaddam (Sadeghi & Moghaddam, 2018) found that the addition of turmeric powder (0.5%) into broiler diet under heat stress increased serum concentrations of thyroxine (T_4) and triiodothyronine (T_3), the consumption of feed, the average daily gain, and decreased the feed conversion rate of birds. Furthermore, El-Maaty et al.

(2014) observed that turmeric powder (0.5 g/kg diet) could improve the final body weight (12%), the feed conversion ratio (19%), the digestibility of crude protein (5%), and the high-density lipoprotein (HDL) level (29%), as well as decrease the levels of creatinine, triglycerides, cholesterol (17%), low-density lipoprotein (LDL) (38%), during the heat stress conditions in broiler chickens. Algawany et al. (2015) performed a study to evaluate the effects of turmeric for protection against alterations resulted from exposure to endosulfan in broiler chicks. A total of 180 day old chicks were supplemented with 5 g turmeric, 10 g turmeric, 30 mg endosulfan, 30 mg endosulfan plus 5 g turmeric and 30 mg endosulfan plus 10 g turmeric/kg diet during the experiment. The results showed that endosulfan significantly decreased the levels of Total Protein (TP), albumin (ALB), globulin (GLB), HDL-cholesterol, catalase (CAT), superoxide dismutase (SOD) activity and reduced glutathione (GSH) concentration but significantly increased albumin/globulin (A/G) ratio, total cholesterol (TCHO), LDL-cholesterol, triglyceride (TRG), malondialdehyde (MDA) concentration and hepatic transaminases (alanine amino-transferase, ALT and aspartate amino-transferase, AST) and exhibited different alterations to the hepatic structure in comparison with control and both turmeric groups. Algawany et al. (2015) based on their results have recommended that regular consumption of turmeric in the diet of broiler chicks provides a constant supply of potential antioxidants that could reduce these alterations. Also, positive effects of black pepper, turmeric powder and coriander seeds and their combinations as feed additives was recorded on growth performance, carcass traits, some blood parameters and humoral immune response of broiler chickens (Abou-Elkhair et al., 2014). Thyme is one of the most common, worldwide used herbal and aromatic medicinal plant, belongs to the *Lamiaceae* family (Swamy & Sinniah, 2015). It contains phenolics and some biphenolic and flavonoids, which have been shown to have an antioxidative effect and other benefits to poultry (Aziz & Karboune, 2018). Thyme extracts are recommended to improve the egg quality, particularly the fatty acid profile in the yolk (Ding et al., 2017). Additionally, investigations have found that dietary thyme supplementation (0.1 to 1%) can play as a growth promoter in broiler diets to improve feed intake, conversion ratio, and body weight gain (Haselmeyer et al., 2015). Hashemipour et al. (2013) reported that phytogetic products containing thymol and carvacrol improved performance, digestive enzyme activities, antioxidant enzyme activities, immune response, and retarded lipid oxidation in broiler chickens. Pournazari et al. (2017), performed an investigation to evaluate the effects of the prebiotic, probiotic, and thyme essential oil on growth, organ and carcass traits, and hematology of Ross broiler chicks during 42 days on a total of 560 broilers. Results have showed an increase in body weight gain and feed intake when thyme essential oil at 1 g/kg was used (Pournazari et al., 2017). El-Ghousein and Al-Beitawi (2009) have found that the antibacterial activity of thyme could be associated with improved broiler productivity. In addition, Hernandez et al. (2004) observed that broilers fed with thyme supplemented diet had improved their productive performance, which may be attributed to the improvement of apparent total fecal digestibility and crude protein digestibility.

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