BEE POLLEN AN ALTERNATIVE TO GROWTH PROMOTERS FOR POULTRY PRODUCTION-A REVIEW

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Abstract. Globally, the use of natural products as remedies for poultry health calls for a systematic exploration of their potential. Furthermore, there is an increasing popularity and utilization of bee-based products due to their inherent benefits. The current review was aimed at analysing empirical results, biological activities and secondary metabolites of bee pollen that are beneficial to the poultry industry. Eligible literature was retrieved from different databases. The findings from the literature search indicated that bee-collected pollen has received attention from researchers owing to its positive effects as a possible growth promoter in poultry production. It contains antioxidants, antimicrobials, emulsifiers, vitamins and minerals which can meet the biochemical and functional needs of poultry flocks. We identified a minimum of 17 research articles that captured various observations on the effects of bee pollen in poultry. The most common observations were on growth performance and gastrointestinal morphology. The search results also indicated that there are several factors such as floral species, climatic conditions and soil types which influence the nutritional composition of bee pollen. Studies gathered revealed that the antioxidant properties found in bee pollen are due to the phenolic compounds it possesses. Overall, there is a lack of empirical evidence on the health effects of supplementing bee pollen indicating a major knowledge gap that requires more research.
Keywords: *antimicrobials, antioxidants, beekeeping, gastrointestinal, growth performance*

Introduction

Antibiotics have been in use for many years as targets against enteric microorganisms in an effort to improve the health and performance of chickens (Babaei et al., 2016). The inclusion of antibiotics in poultry diets was reported to improve feed utilisation, thereby improving growth among other positive attributes. However, use of antibiotics at sub-therapeutic doses is associated with the development of antibiotic resistance (WHO, 2017). Antibiotic resistance is a worldwide problem which affects the animal production industry (Selaledi et al., 2020). This concern caused the European Commission in 2006 to ban the use of antibiotics as growth promoters. The ban did cause implications such as an increase in the incidence of animal diseases and reduced livestock production (Cheng et al., 2014).

There is an increasing risk of bacteria developing resistance to synthetic antibiotics in food animal production (Masud et al., 2020). Bacteria such as *Acinetobacter spp*, *Eschericha coli*, *Klebsiella spp* and *Salmonela spp* are tremendously resistant to most synthetic antibiotics (Carlet et al., 2012). *Salmonella serovars* and *Campylobacter spp* are most common in poultry meat and are well-known causes of zoonotic diseases (Hafez and Attia, 2020). Frequent use of synthetic antibiotics promotes the development of antimicrobial resistance which therefore affects the health of animals, consumers, the quality of the product and promotes an unsafe environment (CDC, 2021). Concerns

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associated with the continued and unregulated use of antibiotics have been raised in several countries including Brazil, Russia, India, China and South Africa (Willams-Nguyen et al., 2016). Over the recent past years, research has focused on natural antibiotics such as plant extracts as alternatives and a possible solution to the challenge of antibiotic resistance in the poultry industry (Seal et al., 2013). Plant extracts are commonly known as phytogenic feed additives due to the various biological properties they have (Gheisar and Kim, 2017; Selaledi et al., 2020). Specifically, the metabolites found in bee pollen possess biological properties such as antioxidant, antibacterial, anticarcinogenic activity, hepatoprotective and cardioprotective (Li et al., 2018).

Literature reports have revealed that bee pollen has positive effects on the immunity, growth, gut health as well as improving the quality and safety of food production (Wang et al., 2007; Cheng, 2009; Hashmi et al., 2012; Haščík et al., 2013). Due to the high bioactive compounds, phytochemicals from plants have also shown possibilities in treatment of coronaviruses that are infectious to animals and also humans (Attia et al., 2020). Bee pollen as a natural agent could be a possible candidate to treat such diseases (Ali and Kunugi, 2021). Furthermore, bee pollen has been reported to have protective actions on the gastrointestinal of poultry (Liu et al., 2010). Bee pollen increases growth performance as well as the population of *Lactobacillus spp* and *Enterococcus spp* in the caeca of broiler chickens. Supplementation of bee pollen in chicken diets increases the weight and length of the small intestine (duodenum, jejenum and ileum) in chickens (Wang et al., 2007). According to Babaei et al. (2016), supplementation of bee pollen in Japanese quails improves their growth performance. Such findings can be used to improve development of chickens at an early age through supplementation of bee pollen (Hascik et al., 2017). These findings may suggest that bee pollen could be a possible natural antibiotic candidate to substitute synthetic antibiotics in poultry production. Therefore, this review aims to provide a comprehensive understanding of the potential use of bee pollen in poultry production.

Materials and methods

The literature search was facilitated using the key words such as “antibiotics”, “pollen”, “bee collected pollen”, feed additives, natural substances, “poultry”, “immunity”, “microbial health”, “processing techniques”. The literature was acquired from recent articles from (2017-2021) that were published in different journals. However, there are articles that are years older but were used in the recent articles from the above time range. We focused on peer reviewed articles published on bee pollen use in poultry production. Databases were accessed using electronic data sources such as Research gate, Science direct, Cross Ref and Google scholar. In addition, phytochemical, antioxidant, phenolic and antibacterial effect were used to generate data for the biological activity and phytochemical aspects of this review.

Results and discussion

Anatomy and structure of bee pollen

Bee pollen is considered to be a natural substance which is acquired from the pollen of different botanical plants through the mixture of bee saliva and nectar (Oliveira et al., 2013; Attia et al., 2014). There are male reproductive organs in the pollen which are

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located in the anthers of botanical plants (Bogdanov, 2016b). Within the anthers of the seed, there is about 2.5-250 μm grain of bee pollen (Komosinska-Vassev et al., 2015). It is called “the life giving dust” by the ancient Egyptians due to its nutritional value (Bishop, 2002).

This grain is surrounded by doubled layer of cell wall. The cell contains a rich cellulose cell which includes an inner cell (intine) and outer cell (exine) which extremely has a hard outer cover (Komosinska-Vassev et al., 2015; Bogdanov, 2016). Plant species of pollen grains are usually different in terms of size, colour, weight and shape (Shubharani et al., 2013). Pollen grains are usually bright yellow to black in colour. This may be due to the different plant species that honey bees collect their pollen from Dubtsova (2009). Since bee pollen is harvested from different plant species, the overall composition of bee pollen varies and is affected (Hsu et al., 2021). This also goes to the taste, bee pollen has a sweet and floral taste depending on the plants that bees gather pollen (Johnson, 2021). However, according to our understanding, studies on whether different kinds of pollen may affect poultry production are limited. There is about 10% nectar bee pollen collected from plants containing an average of 20-30 g water per 100 g like any other freshly collected plant extract spoilage occurs from humidity and freezing is a required method for bee pollen preservation, and drying is best done with an electrical oven (Bogdanov, 2016b).

Economic effects of bee pollen supplementation in poultry diets

According to Elahi et al. (2022), feed costs account for approximately 60% to 80% of the total production cost encountered in poultry farming. Therefore, there is a need to find ways to reduce such high costs. The use of alternative feed ingredients from locally available and affordable sources can help to lower the costs of poultry feeds. Insect based meals such as bee pollen can be a sustainable solution for the poultry industry (Al-Qazzaz and Ismail, 2016). According to Elahi et al. (2022) the use of lower doses of bee products in poultry feeds could bring a beneficial effect on the growth and health of poultry. Ricigliano et al. (2022) and Mazorodze (2020) reported that bee keeping plays vital roles which include it being an excellent tool for the eradication of poverty especially in rural based communities. Land requirements for beekeeping practices are very limited thereby making this practice to be ideal for small holder farmers with limited resources. However, beekeeping has its fair share of challenges such as the emergence and transmission of diseases, pets and changes in climate factors which may adversely affect the viability of beekeeping (Masehela, 2017). The use of bee pollen as a feed supplement for poultry production can help to reduce production costs since it can be produced with locally available resources thereby also boosting local economies (Gratzer et al., 2021). Furthermore, there is a high local demand for bee based products in most developing countries (Hilmi et al., 2019). In some African countries, bee products such as bee pollen may the main source of income for impoverished families. To the best of our knowledge, there is limited information on the economic benefits of supplementing bee pollen in poultry diets.

Supplementation of bee pollen in poultry production

Natural products in poultry feeds have received a great amount of attention and have been encouraged to be incorporated in poultry feed ingredients (Farag and El-Rayes, 2016). Bee pollen has, however, shown positive effects in the growth performance of poultry (Hascik et al., 2017). Additionally, bee pollen includes vital nutrients that are beneficial to the health and growth performance of animals and humans (Hsu et al., 2021).

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Health issues in humans such as prostrate problems have shown to ease with the use of bee pollen (Shoskes, 2002). Damaged tissues are easily repaired also reducing toxicity in the body (Moria et al., 2011). It has been reported that bee pollen is able to support the immune system of human and also have anti-aging effects (Estevinho et al., 2012). The vital nutrients that bee pollen contains such as the high protein content, essential amino acids, fats, unsaturated fatty acids, carbohydrates and minerals may be the reason behind health and growth improvements in poultry (Farag and El-Rayes, 2016). During the early development of growth bee pollen has shown to affect the villi of the small intestine in the size and length (Wang et al., 2007). Such information may prove that the digestive system may be improved during early stages of a chick's life (Hascik et al., 2017). Published data has indicated that bee pollen contains nutrients to assist broilers during periods of heat stress (Hascik et al., 2017). The mechanism of bee pollen action may be attributed to its strong antibacterial action, also with the high amount of micronutrients that have a positive effect on the health and metabolism of chickens (Viuda-Martos et al., 2008). The use of natural substances as possible candidates to replace synthetic antibiotic has received great attention over the past decades (Seal et al., 2013). Several studies have shown that bee pollen includes vital nutrients such as minerals, vitamins and proteins are beneficial to the health and growth performance of humans and animals (Haščík et al., 2013; Abdelnour et al., 2018; Kostic, 2019; Lika et al., 2021).

Wang et al. (2007) stated that bee pollen could be a promising alternative as a beneficial supplement in poultry diets to counteract the challenges that occur during the early stages of a chick. Furthermore, it has been reported that bee pollen increases animal growth, promotes quality and safe products and improves the immunity and health of poultry (Haščík et al., 2017). Haščík et al. (2012) reported that supplementation of bee pollen could increase the weights of the body, carcass and giblets in broiler chickens. Positive results were recorded with fatty acid composition in quail meat (Seven et al., 2016). Improvements on blood parameters and reduced serum uric acid, creatinine triglycerides as well as cholesterol have been reported following supplementation of bee pollen in broiler diets (Farag and El-Rayes, 2016).

Nutritional profile and chemical composition of bee pollen

Nowadays consumers are quite observant about the quality and safety of poultry products (Abdel-Moneim et al., 2020). Supplements from phytogenic feed additives have positive effects that are essential in the growth performance and health of animals through polyphenol content found in plant extracts (Batiha et al., 2020). Polyphenol compounds are found in several parts of plants including grains, flowers (Abdel-Moneim et al., 2020). Bee pollen consists of important nutrients, trace elements and polyphenols including flavonoids (Li et al., 2018). Polyphenol compounds found in bee pollen consists of immunomodulators, anti-flammantory, antioxidant, antimicrobial activities (Lipinski et al., 2017). These compounds in natural substances have improved the growth (Luo et al., 2018) and egg quality in poultry (Galli et al., 2018). Gut health and antioxidant levels in poultry have increased through the use of natural products consisting of polyphenols (Nm et al., 2018). There are several factors that the chemical composition of bee pollen such as the plant species that are used to make the bee pollen and geographical location (Liolios et al., 2019; Mayda et al., 2020). Notable metabolites in bee pollen include an average of 22.7% protein content (Khalifa et al., 2020), 30.8% carbohydrates, 5.1% lipids as essential fatty acids, 1.6% phenolic compounds, 0.6% vitamins and 1% carotenoids (Komosinska- Vassev et al., 2015).

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The composition of bee pollen is dependant also on the type of soil and beekeeping practices (Nogueira et al., 2012; Urcan et al., 2017). Soil that is healthy should consist of balanced nutrients having the correct pH, enough water holding capacity, a high microbial activity and should be free from toxins of pesticides and herbicides (Magdoff and Van Es, 2021). However, there are new methods such as the use of organic matter on the improving of the quality of soil (FAO, 2005). Literature reviewed indicates that the average digestibility of carbohydrates in bee pollen is 4% and 53% digestibility for the proteins (Franchi, 1997). Freshly collected pollen contains 15-30% water content (Castagna et al., 2020). When bee pollen grains are dissolved in water, nutrient availability as well as digestibility are increased by 60-80% (Kieliszek et al., 2018). Total dry matter digestibility of bee pollen at freshly collected is 62%, enzymatic pretreatment, 85%, dry thermal pretreatment, 89%, wet thermal pretreatment 92% and alkaline pretreatment digestibility, 98% (Benavides et al., 2017). Nutritional profiles and chemical compositions of bee pollen are presented in *Table 1*.

Table 1. *Nutritional profiles and chemical compositions of bee pollen*

Chemical analysis	Percentage (%)	Authors
Component		
Dry matter	90.32 97.17	Farag & El-Rayes, 2016 Zeedan *et al*., 2017
Moisture	19.0 ~20-30	Hsu *et al*., 2021 Luo *et al*., 2021
Lipids	5.1 4.09 3 4-7	Khalifa *et al*., 2020 Farag & El-Rayes, 2016 Bogdanov, 2016b Bogdanov, 2016a
Protein	19.23 22.7 15-29.07 16-29 5-60	Farag & El-Rayes, 2016 Addi, 2018 Kedzia & Holderna- Kedzia, 2012 Odoux *et al*., 2012 Bogdanov, 2016a
Carbohydrates	30.8 62.82 13-55	Kedzia & Holderna-Kedzia, 2012 Farag & El-Rayes, 2016 Bogdanov, 2016a
Ash	1.27 3.28 2.83	Kedzia & Holderna-Kedzia, 2012 Farag & El-Rayes, 2016 Zeedan *et al*., 2017
Fibres	0.90 1.17 0.3-20	Farag & El-Rayes, 2016 Zeedan *et al*., 2017 Bogdanov, 2016a

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Phenolic compounds in bee pollen

Bee pollen contains polyphenolic compounds such as phenolic acids and flavonoids which are responsible for the numerous biological activities possessed by bee pollen (Rocchetti et al., 2019). The total content of the polyphenols in bee pollen range from 3-5% depending on the plant origin (Campos et al., 2005). The high polyphenols properties found in bee pollen protect health and immunity in poultry (Ali and Kunugi, 2021). Phenolic acids (0.19%) and flavonoids are polyphenols which are responsible for the numerous biological activities found in bee pollen (Rzepecka-Stojko et al., 2015).

The bio- availability of phenolic compounds in bee pollen is beneficial to the health of animals and humans (Omar et al., 2016). Flavonoids have been reported to constitute about 1.6% of the polyphenolic content of bee pollen with the most common ones being catechins, leucothocyanidins, quercetin, kaempferol and isorhamnetin. Flavonoids are well known for their high antioxidants properties (Pascoal et al., 2014; Komosinska–Vasser et al., 2015; Kostić, 2019). The most common phenolic acids in bee pollen are p-coumaric, chlorogenic and ferulic acids (Kocot et al., 2018). The antiproliferative properties of polyphenols found in bee pollen set a balance on cell proliferation (Preemratanachai and Chanchao, 2014). Glycosides are usually in occurrence as flavonoids in bee pollen and they can be 2.5% in total content (Kieliszek et al., 2018). The composition of phenolic compounds in bee pollen largely depends on the plant species that are used to make the pollen as well as the geographical conditions such as soil types among other factors (Addi, 2018). Absorption of polyphenols depends on the physicochemical properties. The best absorption takes place in the gastrointestinal tract in forms that are soluble in water. However, absorption of polyphenols is based on the structural type of both phenolic acids and flavonoids (Rzepecka-Stojko et al., 2015).

Within the structure of phenolic acids, benzoic and cinnamic acid are the most common. However, cinnamic acid contains antioxidants that are more effective. Hydroxyl groups play an important role in determining the total amount of antioxidant activity (Rzepecka-Stojko et al., 2015). The presence of phenols enhance taste, texture and nutritional content of the diet and this help maximize the growth, health and safety of the animals (Batiha et al., 2020). However, the low bioavaliabity and slow absorption in the gut should further be investigated in poultry production (Abdel-Moneim et al., 2020).

When poultry birds are under stressful conditions, this affects their chromosome causing no production of free radicals such as reactive nitrogen species (RNS) and reactive oxygen species (ROS) (Lipinski et al., 2017). The most effective polyphenols to help with production of free radicals are flavonoids, which are essential since they prevent injuries to occur in poultry bodies (Prochazkova et al., 2011)

Effects of bee pollen in poultry feeds on growth performance and gut morphology

Several studies have emphasized on the use of bee pollen in poultry diets to improve nutrition, health and growth performance while decreasing toxins (Hegazi et al., 2012). The antioxidant compounds, known to be free radical scavengers in bee pollen eliminate toxins in the animal body (Campos et al., 2003). The high levels of polyphenols and tannins that bee pollen possess play a vital role as protective agents and antioxidants that are key to the health of animals (Ali and Kunugi, 2021). Studies have shown that bee pollen can help to reduce stress levels in birds through the reduction of oxidative stress markers thereby enhancing the capacity of the antioxidant system of birds (Ketkar et al.,

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2015). Early chick nutrition is important during the early stages of a chick's life for optimal growth (Riva and Panisello, 2020). *In vivo* feeding trials conducted in chicks to explore the nutritional properties of bee pollen reported that bee pollen can play an important role in early chick nutrition through improved growth and immune stimulation (Malayoˇglu et al., 2010). Bee pollen is rich in essential amino acids, unsaturated fatty acids, carbohydrates and minerals which act as catalysts in improving body weight gain in birds (Farag and El-Rayes, 2016). Reports have revealed that bee pollen supplementation in diets of birds can enhance the initial development of the gastrointestinal tract and the process of digestion (Toman et al., 2015; Haščík et al., 2017).

Bee pollen is composed of several nutrient components such as amino acids, vitamins, hormones, minerals, enzymes and coenzymes that are important for digestion and production of cells (Wang et al., 2007). The glands of the small intestine play an important role in absorption of nutrients which therefore increases development and growth of the gut (Wang et al., 2007). Bee pollen contains enzymes which assist in the process of digestion to improve feed conversion ratio and due to its palatability it increases feed intakes in broiler chickens (Haščík et al., 2012). Feed conversion improvement in broilers may be due to the vitamins, amino acids, hormones and minerals found in bee pollen (Farag and El-Rayes, 2016).

Further findings show that bee pollen consists of nutrients that are essential for improved digestion and growth of cells in broiler chickens (Wang et al., 2007). Basim et al. (2006) and Kročko et al. (2012) evaluated the effects of bee pollen supplementation on the crop of chickens and reported reduced counts of bacteria of the *Enterobacteriaceae* family which supports the antibacterial properties of bee pollen. Similar observations were found for the ileum and caecum (Haščík et al., 2013). According to several literatures, decrease in *Enterobacteriaceae* counts in the gastrointestinal tract of chickens may be due to the antibacterial properties of bee pollen (Kumova et al., 2002; Basim et al., 2006). However, there is scarce literature on bee pollen antibacterial properties on poultry gut health. Several studies have reported the effect of bee pollen supplementation on growth performance and gut morphology in poultry diets. *Table 2*, *Table 3* and *Table 4* present findings from several studies that investigated the effects of bee pollen supplementation in poultry diets on growth performance, gut morphology and gut health.

The potential for large scale bee pollen production and processing technologies in developing countries

Apiculture is an agricultural practice that can be carried out with minimum pollution to the environment (Kohsaka et al., 2017; Paray et al., 2020). Beekeepers are developing business skills and using new innovations in the beekeeping industry. Apiculture can thrive in environments where plant production is not sustainable due to factors such as land type (Paray et al., 2020). Bee products can contribute to income generation, development and sustainability of food security strategies in developing countries around the world (FAO, 2018; Zheng et al., 2018). Pollen sources for bee pollen production varies in different countries and regions due to environmental impacts. In South Africa, pollen sources include purple echium, macadamia, maize and pine trees. Protein content for eucalyptus species differ from 17%-30% (Louw, 2022). China, Australia and Argentina are the biggest producers of bee pollen (Estevinho et al., 2012). According to CNCAGR 2011, China has 6 million *Apis mellifera* colonies. The total amount of honey produced yearly is 450,000 metric tons which a third is exported to countries like Japan, United Kingdom, Belgium and Spain (Fang, 2015, 2016). In Africa, Ethopia is amongst

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the top producers of honey (CSA, 2020) with a total of 53782 tons of honey (FAO, STAT, 2020). South Africa is a diverse country with several landscapes consisting of several plants and pollinators (Mittermeier et al., 2011). In 2017, South Africa has produced a total amount of 1500 tons of honey. However, several factors that are playing a role in low production of bee products include the high prevalence of pathogens, low and erratic rainfall and veld fires and this is why it is mostly imported from other countries such as China (Langenhoven, 2018). South African production and marketing of bee products is still at a very low level for it to be able to meet the consumer demands (Preuss, 2019; Hall, 2020). This therefore makes South Africa a net importer of bee products from China and the neighbouring African countries (Hall, 2020).

Table 2. *Observations on the effect of bee pollen supplementation in poultry diets on growth performance*

Poultry species	Levels	Observations	Authors
Broiler chicken	2%	There was an increase in average daily gain by 15.6%	Hosseini *et al.*, 2016
Broiler chicken	0.6%	Improved body weight gain	Farag & El-Rayes, 2016
Japanese quails	0.5%	Increase in growth performance and weight gain	Babaei *et al.*, 2016
Broiler chickens	0.5-1.5%	Improved growth performance and carcass traits	DeOliveria *et al.*, 2013
Broiler chickens	0.04%	Bee pollen increased growth performance and body weights in broilers	Haščík *et al.*, 2012
Broiler chickens	0.2%, 0.4%,0.6%	Improved body weight gain by 8.14%, 8.86% and 11.65% compared to the control birds	Abdelnour *et al.*, 2018
Broiler chicken	0.05-0.15%	Average daily feed intake were increased	Hosseini *et al.*, 2016
Broiler chicken	0.002%	No increase in feed conversion ratio under high ambient temperature	Hosseini *et al.*, 2016
Broiler chicken	0.6%	Improved feed conversion ratios under high ambient temperature compared to the control group	Farag & El-Rayes, 2016
Laying hens and quails	0.05-0.15%	Egg production and performance was improved	Abuoghaba,2018; Desoky & Kamel, 2018

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Table 3. *Observations on the effects of bee pollen supplementation in poultry diets on gastrointestinal tract morphology*

Poultry species	Levels	Observations	Authors
Broiler chicken	0.001%	Improved length and weight of intestinal villi	Wang *et al.*, 2007
Broiler chicken	0.1-1.5%	Increased villus length and villus length: crypt length	Fazayeli-Rad *et al.*, 2015
Broiler chicken	1.5%	Jejenum crypt depth was increased	Fazayeli-Rad *et al*, 2015
Broiler chicken		The lengths of small intestine were longer	Haščík *et al.*, 2013
Broiler chicken	1.5%	Weights of spleen increased in broiler diets	Wang *et al.*, 2005
Broiler chicken	0.6%	Weights of the gizzard and liver increased by 2.21% and 2.07%	Song *et al.*, 2005; Wang *et al.*, 2007
Broiler chicken	0.6%	Increased weights thymus, bursa and spleen	Farag & El-Rayes, 2016

Table 4. *Observations on the effects of bee pollen supplementation in poultry diets on gastrointestinal tract health*

Poultry Species	Levels	Observations	Authors
Broiler chicken	0.6%	High levels of bee pollen supplementation revealed low bacterial colonization in the crop	Kročko *et al.*, 2012
Broiler chicken	0.6%	Reduction of bacterial colonization in the ileum and caecum	Haščík *et al.*, 2013
Broiler chicken	4.5%	Low number of Enterobacteriaceae family in the ileum and caecum than the control and other experimental groups	Kročko *et al.*, 2012

Generally, there is an increase in innovative drying technologies that conserve the good quality of bee products in most part of the world. However, processing techniques that can effectively improve the nutritional value and quality of the product are still highly required (Luo et al., 2021). This is why bee pollen after collection should be processed to avoid microbial development and help keep the physicochemicals (Palla et al., 2018). To maintain the nutrition value of bee pollen and other products, different processing techniques are critical such as drying (Thakur and Nanda, 2018), pulverization (Kostić et al., 2017), freeze drying (Ghosh and Jung, 2020), use of vacuum to extract impurities (Thakur and Nanda, 2018; Mayda et al., 2020), storage in bags at 4°C (Zuluaga-Dominguez and Quicazan, 2019) and in areas that are dark at ±20°C (Araujo et al., 2017). Bee pollen as a feed ingredient requires to understand ways on storing and preserving to avoid losing all the nutrients it possess (Kostic et al., 2020). Factors such as humidity, temperature, gas atmosphere and pressure of oxygen affects the viability of pollen

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(Stanely and Linskens, 1974). For the poultry bodies to function and the chemical process to take place, there is a certain amount of nutrients required in diets of animals which are antioxidants, antimicrobials, emulsifiers, vitamins and minerals (Kostic et al., 2020). Of these techniques, drying is a very important technique that controls the moisture and new drying techniques such as IR radiation which influences the quality and colour of bee pollen are being developed (Luo et al., 2021).

Conclusion and recommendation

Bacterial resistance to commercially available antibiotics is a global concern. Naturally available products such as bee pollen have potential to replace commercial antibiotics. The high safety margin of natural products as compared to commercial remedies has made them popular as animal feed additives particularly in the developing countries in an effort to strike a balance between profitability and the safety of animal products. Bee pollen has shown that it can be a promising natural growth promoter to improve growth, performance, quality and safe products in poultry production. It contains bioactive ingredients with various properties that have revealed to play a vital role in development and growth in poultry. A few studies have been conducted showing different levels of supplementation in poultry diets. Bee pollen supplementation of 0.6% showed to have a tremendous outcome on the body weights and improvement of gut morphology of broiler chickens. This level of supplementation could be recommended in poultry diets. However, more studies should be conducted to further investigate improvements in growth performances on poultry birds. Diverse beekeeping strategies need to be introduced especially in developing countries so as to be able to meet the demands for bee pollen and other related products.

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