

Possibility of Using Bee Bread (Perga) as an Alternative Feed Additive in Poultry Nutrition

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ABSTRACT

Livestock industry has an indispensable position in providing a source of protein for humans. It is vital for the future of humanity to produce healthy animal products for the needs of the increasing world population and to offer them for consumption day by day. However, so as to meet the request of animal products rapidly, industrialization has been increased by developing mass production methods, these changes in the sector have worried by some consumers and reservations have even increased with disinformation. Depending on this possible food safety and public health concern, people have become conscious of nutrition with natural products in progress of time and new searches have been embarked. On the other hand, due to the prohibition of the inclusion of antibiotics as feed additives in animal nutrition diets, alternative feed additives to antibiotics have been researched in order to increase performance and eliminate diseases. The fact that the quality and health of products such as meat, milk, eggs obtained from livestock are directly related to nutrition provides a better understanding of the value of feed and feed additives. Indeed, it is seen that the popularity of honey bee product bee bread, which has been known to be used as a curative product since ancient times, has increased in recent years in treatment with bee products called apitherapy. Concordantly, the use of bee bread as an alternative feed additive in animal health and nutrition has become increasingly common in recent years. In this review, it is aimed to give information about the possibility of using bee bread (perga), which has been shown by scientific studies to be natural and rich ingredient, as an alternative feed additive in poultry nutrition.

INTRODUCTION

The use of natural additives in nutrition is gaining importance in animals as well as in human beings due to increase for the demand of chicken meat and eggs from animal foods and the awareness of healthy nutrition in recent years. Although it is known that bee products, which are natural additives, have been being used to improve human, animal and plant health since ancient civilizations, it is seen that their value has increased even more nowadays. The treatment method made with medicinal products such as honey, bee pollen, propolis, bee bread, bee venom, royal jelly and beeswax, which are the products of the honey bee (*Apis Mellifera L.*), is called "Apitherapy" in the medical literature. Apitherapy, which has accelerated since 2014, is a traditional practice that

supports and complements medical treatment in human medicine. These bee products, which are known to have many rich properties such as antioxidant, antibacterial, antiviral, antifungal, anticarcinogenic, antirheumatic, antitumoral, antiallergic, immunomodulator, hepatoprotective, are also very important resources for animal health and nutrition as well as human health. As it is known, with the prohibition of antibiotics use as feed additives in many countries in 2006, research on the using of alternative natural feed additives has become widespread. In this context, various studies are carried out on different application forms, doses and mixtures for the using of bee products in agriculture and food sectors depending on the increase in the reliability of bee products. In studies with bee products, it is seen that it has

positive effects on performance by increasing the appetite, live weight gain and feed efficiency of animals, and also provides great contributions in terms of health. In this review, studies on the use of bee bread (perga) as an alternative feed additive in poultry nutrition, which has a very special place among bee products, but is generally confused with bee pollen and whose value is still not understood enough were evaluated.

Poultry Digestive System and Nutrition

High performing and economical poultry production starts with understanding the nutritional characteristics of the animal, planning a diet suitable for production aspects and characteristics, and having in-depth knowledge of the animal's digestive system and physiology (Kutlu et al., 2005). The digestive system of poultry, which is in the category of granivores (or omnivores) in terms of nutritional characteristics, is quite different from the digestive system of ruminants and more resembles that of reptiles. Poultry animals do not have teeth and their digestive system consists of mouth, crop, stomach, gizzard, small intestine and large intestine (Kutlu, 2015). Even though their digestive systems are shorter than other animals, they have crops and gizzards. It is also striking that there are two large cecum in the digestive system. Poultry with different anatomy and nutrition among other farm animals are animals with higher metabolic rates and energy requirements due to their body temperature of average 41 °C (Çetingül et al., 2018). Poultry animals are more affected by stress factors because of their high metabolic activity (Özdoğan and Sarı, 2001). The fact that the diets of these animals, on which a concentrated feeding program is applied, contain easily digestible, abundant and various nutrients is due to these different characteristics (Çetingül et al., 2018). Digestion and absorption events are the whole of digestive events that are affected by the anatomical structure of the digestive system as well as the structure of basic nutrients such as water, electrolytes, proteins, carbohydrates, fats, minerals and vitamins in the chemistry of the feed taken. On the other hand, benefiting from a feed whose chemical content is known depends on the efficiency of the digestion of the feed, the mechanical and enzymatic breakdown in the digestive system, the rate of intestinal transit and absorption, and the activation of the intestinal microbiome (Kutlu, 2015). Poultry intestines have a complex and energetic structure which mostly made up of bacteria and called the microbiome (Diker and Kaya, 2015). The microbiome provides many affirmative impacts on the host, acts as a protective barrier versus transient bacteria, assists in nourishment breakdown and energy gain from the meal, supplies nutritional intermediates for enterocytes, and plays an effective role in modulating host immunity (Ackerman, 2017). Commensal or pathogenic bacteria in the microbiome are influenced by host elements as well as basal diet and additives (Diker and Kaya, 2015). Thanks to various additives added to the feed, the number of bacteria in the microbiome can be changed in the direction of commensal bacteria, and healthy animals can be raised by increasing the feed efficiency (Şen, 2018).

Feed Additives and Alternative Solutions

Modern poultry farms are jammed and stressful environments at the present time. Even the smallest yield increases in such production areas can bring enormous economic benefits to the herd. For this reason, so as to achieve high productivity and profitability, it is necessary

to provide maximum benefit from the feed as well as to protect animal health. Adding and using feed additives to the diet serves to maximize benefits and improve animal health (Kocabağlı and Alp, 2015). The improvements, expectations and strategies in recent years have created changes in the use of growth promoting substances supplemented to the diet. One of these is the forbidden of using antibiotics for feed additives, and the other is the common using enzymes that increase the nutritional value of feed raw materials and reduce cost of feed (Ravindran, 2012). The determination of the harmful effects of antibiotics and hormones now encourages countries to protect human life and health at the highest level, so directs them to regulatory steps that take into account animal health and welfare, plant health and the environment. Considering that the consumption of organic and natural products for a healthy lifestyle is an unavoidable reality, increasing productivity without having a negative impact on human and animal health will affect both our health and the livestock work economy. In this context, considering the intense global search for alternative additives, it is necessary to explore whether these additives can be used as environmentally friendly additives (Öztürk, 2009). Decreasing supply and ever-increasing raw material prices will make more pressure for getting per unit energy and nutrients from feed ingredients. Accordingly, a series of additives are supposed to play an increasingly important role (Ravindran, 2012).

It is seen in studies that mostly aromatic plants, probiotics, prebiotics, essential oils, organic acids, toxin binders and enzymes are tested as alternative feed additives. Besides it is also known that natural bee products have been used to improve human, animal and plant health since ancient times. Researches conducted in the last few years indicate that bee products whose use in human life (apitherapy) has increased, can be an alternative natural feed additive for emphasized in terms of both animal health and growth factors in the veterinary field (Topal et al., 2015).

Beekeeping and Bee Products

Beekeeping is a profession that produces goods such as honey, propolis, royal jelly, pollen, bee venom and living things such as queen, pack and cluster by using bees, plants and intensive labor for the purpose of health, nutrition, protection and treatment since the birth of human beings (Fıratlı et al., 2000). Beekeeping provides income, employment and healthy nutrition opportunities for rural populations in developing countries. Because of these qualities, beekeeping has a special place in animal husbandry and bee products which are food of animal origin are undoubtedly precious for human's health and diet (Burucu and Gülse Bal, 2017). Türkiye is a country with great potential for beekeeping because of its different natural and climatic conditions, millions of hives, rich lands, and genetic diversity of plant and bee species. Beekeeping which has made rapid progress in Türkiye as in other countries of the world is a rather particular field of activity that ensures the balance of nature and the sustainability and productivity of agriculture. The main factors in bee breeding and production are climatic conditions, geographical structure and honey vegetation, and the presence of 75% of the currently seen honey plant species and varieties in Türkiye is an enormous source of natural wealth (Sıralı, 2010). Bee products like bee pollen, bee bread, honey, propolis, royal jelly, bee venom obtained from beekeeping activities have antimicrobial,

antioxidant, anticarcinogen, immune system stimulant etc. qualifications has been used for many years (Premratanachai and Chanchao, 2014). Increasing awareness of natural nutrition in recent years has led to an increase in the attractiveness of the mentioned bee products. Consumers are increasingly showing interest in superfoods and functional foods on account of their great nutritional value as well as their ability to raise and improve human health and well-being. While there is no question that bee pollen and bee bread qualify as superfoods. However, more thorough investigation is still required before bee pollen and bee bread can be used as resources of antimicrobials in clinical exercise and make health assertions (Didaras et al., 2020). There is a requirement to increase the quantity and quality of scientific research supported by the sector for the identification, production, processing and use of bee products in terms of animal health. Using bee products will undoubtedly lead to healthier animal production (Topal et al., 2015).

Chemical Structure and Biological Benefits of Bee Bread

The realm of medicine advocates using as few drugs as possible so that pathogenic microorganisms are less likely to develop resistance. One of the best options in this regard are natural foods that contain life-threatening substances for these microorganisms. One of them is bee bread (perga) whose value is not yet understood enough (Karaman et al., 2016). Bees need food in order to continue their lives, and they meet this directly from pollen and nectar in nature. While bees use nectar to procure their carbohydrate and energy needs, pollen is used to procure their protein, vitamin and lipid needs. Worker bees need a food which has especially characteristics of a winter food source that has a higher nutritive protein and lipid value than pollen. They produce this food namely bee bread by combining pollen they collect from nature with their own secretions and undergoing a series of biochemical changes (Silici, 2015). This bee bread which is the most basic food for the baby bees and the queen bee meets the first nutritional needs of the baby bees for five days after the pupa period, therefore, it is also called "Bee Baby Food" (Karaman et al., 2017). Bee bread is actually a little-known bee product that is often confused with pollen. Bee bread, the main ingredient of which is pollen and known as "Perga" abroad, is a hive product in the form of fresh pollen mixed with nectar and bee secretions, fermented naturally through different chemical processes depending on the effect of certain enzymes, microorganisms, yeasts, humidity and temperature, and stored in honeycomb cells (Karaman et al., 2016; Karaman et al., 2017; Detry et al., 2020; Karlıdağ et al., 2021). Little is also known about how the fermentation process acts on bee pollen ingredients when producing bee bread, and in particular with regard to phenolics, which are the main components of such bee products. There is still necessity for research relating pharmacological ingredients with their mechanisms of action to prove the effectiveness of these nutritionally and medically important bee products (Baky et al., 2023). As far as is reported that due to the presence of lactic acid that provides fermentation, its acidity rate is higher than pollen and its pH is between 3.8-4.3. Since the pollen walls, which cannot be destroyed by gastrointestinal fluids, are partially destroyed during the fermentation of bee bread, the energy bioavailability and functionality of bee bread is better than bee pollen with rich content

(Campos et al., 1997; Fatrcová-Šramková et al., 2010). Lactobacillus and Bifidobacterium bacteria which are the most important representatives of lactic acid bacteria widely used as probiotics in human and animal health were isolated from digestive system of honey bees, bee bread and pollen. Lactobacillus was the dominant bacteria of 90.9% of all bacteria in honey, 74.6% in pollen, 83.9% in bee bread and 93.3% in royal jelly (Asama et al., 2015). Bee bread stored in honeycomb cells is fixed to the hive with honey and beeswax (Barene et al., 2014; Zuluaga et al., 2015). The moisture content of bee bread may decrease to 13-14% depending on post-harvest drying (Mutsaers et al., 2005). Bee bread, which is a product resulting from the lactic acid fermentation of pollen collected by bees from different plant sources, ordinarily contains carbohydrates, proteins, amino acids, fatty acids, organic acids, enzymes, vitamins, phenolic compounds, minerals, phytochemicals, carotenoids and volatiles (Baky et al., 2023; Şimşek et al., 2023). The chemical composition of bee bread may vary based on botanical, geographical and seasonal origin. The chemical and fatty acid composition of five citrus bee bread samples obtained from various geographical regions in Türkiye were examined, and the ash content was found between 1.86-2.4%, moisture 11.0-16.4%, protein 18.6-21.6% and fat 7.0-13.4%. Palmitic, arachidic, oleic, stearic, erucic, linoleic, and eicosanoic acids were the most common acids in all samples, and a total of 37 fatty acids (FA) were identified. The ratios of unsaturated and saturated fatty acids varied between 1.28 and 2.23. This result showed that citrus bee bread is a good source of unsaturated fatty acids (Kaplan et al., 2019). Čeksterytė et al. (2008) determined 24 fatty acids in bee bread collected in spring and summer, subsequently reported that the most common unsaturated fatty acids were arachidonic and oleic acids. Although polyunsaturated fatty acids (PUFA) such as Alpha-linolenic (ALA), Eicosapentaenoic (EPA) and Docosahexaenoic (DHA) are essential in the human diet, the human body cannot synthesize these acids in the digestive system (Maclean et al., 2004). Studies on the beneficial effects of unsaturated fatty acids in humans have been reported that ethyl esters of DHA and EPA reduce the level of triglycerides in serum (Von Schacky and Harris, 2007). It has been stated that DHA and EPA which reduce triglyceride and cholesterol in the blood, have anti-inflammatory, cardioprotective, antiarrhythmic and antithrombotic effects due to these abilities (Artemis and Simopoulos, 2004). As it can be seen from the existing literature studies, bee pollen and bee bread are excellent sources of polyunsaturated fatty acids (PUFA) which are very valuable for human dietary and cannot be produced by the body. Bee bread which has a different chemical composition compared to plant pollen (Silici, 2015) contains simple sugars, amino acids, a wide variety of vitamins and minerals, enzymes and plant hormones in its basic structure apart from fatty acids. About 20-22% protein, 1.6% fat, 24-35% carbohydrate, 35% sugar, 2.43% mineral, 1.6% lipid and 3.5% lactic acid are all present in bee bread (Bildir et al., 2022). In addition to essential amino acids that the human body cannot biosynthesize, there are proteins, vitamins such as C, B, B2, E, H, P, nicotinic acid, folic acid, pantothenic acid, pigments, enzymes such as sucrose, amylase, phosphatase, flavonoids, carotenoids and hormones. These complexes are extremely effective and beneficial for the body's immune system (Haydak and Vivino, 1950; Isidorov et al., 2009). Bee bread proteins containing less protein than bee pollen are easier to digest. Bee bread contains six times

more lactic acid than bee pollen. This feature ensures its own structure preserved and not yeast growth exposed as in pollen. Moreover, bee bread which has better taste qualities compared to bee pollen is easily absorbed through the body (Mutsaers et al., 2005). Bee bread's biological active compounds content such as isorhamnetin, apigenin, kaempferol, two forms of quercetin, p-coumaric were carried out by means of high performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS) analysis methods (Baltrušaitytė et al., 2007b; Isidorov et al., 2009). In addition to previously referred compounds, Isidorov et al. (2009) identified little amount of chrysin and naringenin, ferulic and caffeic acids. Similarly, Markiewicz-Żukowska et al. (2013) identified small amounts of phenol compounds such as kaempferol and apigenin, Tavdidishvili et al. (2014) identified quercetin, naringin and rutin as 20% of the total flavonoids in Georgian bee bread, Suleiman et al. (2021) identified totally nine phenolic compounds including phenolic acids such as trans-ferulic acid, gallic acid, caffeic acid, trans 3-hydroxycinnamic acid, caffeic acid, 2-hydroxycinnamic acid, and including flavonoids such as mangiferin, quercetin, apigenin, kaempferol via HPLC analysis method. On the other hand, Hryniewicka et al. (2016) determined lipophilic antioxidants such as coenzyme Q10 and α -tocopherol which play essential regulatory and metabolic functions in each cell of living organisms. It has been showed that bee pollen and bee bread of diverse botanic origins have different properties and their antioxidant limit are more linked with certain flavone and phenolic profiles rather than amount of entire flavones (Almaraz-Abarca et al., 2004). Therefore, flavonoids can severely represent as biochemical identifiers of the specific plant origins (Čeksterytė et al., 2016). There have been various publications and reviews addressing methodological studies and extraction techniques on the chemical structure of beekeeping products such as honey, bee pollen and propolis in recent times (Gómez-Caravaca et al., 2006; Sulaiman et al., 2011; Da Silva Frozza et al., 2013; Markiewicz-Żukowska et al., 2012; Mohdaly et al., 2015). However, the chemical composition and antioxidant profile of bee bread samples have still not been sufficiently determined and examined homogeneously. Nevertheless, studies have clearly shown so far that bee bread is characterized by different structure, richer chemical composition, higher nutritional value and better digestibility than pollen (Anđelković et al., 2012; Habryka et al., 2016). Although research on bee bread has been quite limited so far (Didaras et al., 2020), there has been an increasing attention in the antimicrobial properties of bee pollen and bee bread in recent years since antimicrobial resistance emerging by pathogens. Bee pollen or bee bread have been shown to own hepatoprotective, immunomodulatory, anti-radiation, adaptogenic (Bogdanov, 2015), antibacterial (Baltrušaitytė et al., 2007a; Abouda et al., 2011), antioxidant (Nagai et al., 2004; Zuluaga et al., 2015; Tomás et al., 2017), antitumoral (Markiewicz-Żukowska et al., 2013; Sobral et al., 2017), anti-inflammatory, antidiabetic, antiobestic, anticancer (Aylanc et al., 2021) characteristics in *in vitro* and *in vivo* studies. Bee bread can be used more in the future not only in medicine and pharmacology, but also in the food industry and nutrition. Further studies are required to confirm its chemical composition and biological benefits, and *in vivo* tests to evaluate the bioactive components and digestibility properties stably (Markiewicz-Żukowska et al., 2013;

Ivanišová et al., 2015). In summary, with developing analysis techniques, the value of every bee product, notably bee bread, will increase day by day as it is better researched and discovered (Arigül et al., 2023). Researches on bee products show so far that they can be used not only for humans but also for producing natural animal foods and treating animals. The possibility of using bee products in poultry has shed light on many studies and created opportunities for new ones (Akin and Çelen, 2019).

Use of Bee Bread in Poultry Nutrition

In a study conducted by Awad et al. (2013), the supplementation of bee bread at levels of 0.5, 1.0, 1.5 g/kg to the diets of experimental groups consisting of local Sinai hens during laying period (24-47 weeks), it was reported that bee bread can be used in the diet up to 1.5 g/kg as a growth supporter and natural antioxidant in order to improve egg performance, egg quality, hatchability, nutrient digestibility without negative effects on the economic efficiency and viability. Arafa et al. (2016), similar to previous study on laying hens, supplemented different proportions of bee bread, bee pollen and their mixtures as antioxidants to the diet of laying period (27-44 weeks). According to results of the study, it was recorded that 0.2 % bee bread, 0.15 % bee bread, 0.1 % bee pollen, 0.1 % bee bread ratios can be used to improve production performance, nutritional egg quality and welfare in Hy-line hens. Fahim (2018) also examined semen quality and fertilizing ability of Sinai cocks with the supplementation as natural feed additive bee bread to the diet. During the experiment (24-40 weeks of age), it was supplemented 0.5, 1.00, 1.50 g/kg to the diet of Sinai cocks and reported that bee bread supplementation up to 1.5 g/kg to cock diet had positive effects on sperm quality, reproductive performance and hatchability of Sinai cocks.

Pavelková et al. (2020) observed that the use of 2, 4, 6 mg/kg bee bread powder to the diets of Japanese quails during 56-day feeding period had no positive impact on the meat performance. They hence suggested that extra alternative solutions to their application dose should be tested for poultry species including quails. In another study conducted on quails, Hanusová et al. (2021) stated that the addition of bee bread of 2, 4, 6 g/kg into the diets of Japanese quails during laying period (15-27 weeks) positively affected the laying indicators concerning egg quality. However, it was pointed out that the weight of separately egg albumen and yolk as well as the total egg was meaningfully affected by the age of the quail.

CONCLUSION

Türkiye, which is already in good condition in poultry production, is even rich in bee breeding and production of bee products. Despite this situation, let alone the use of other bee products other than honey in apitherapy studies, even their production has unfortunately not reached the desired level. Nowadays, the importance of healthy and natural nutrition is increasing day by day. More original research is needed on the production and consumption of residue-free bee products and their use in medicine, veterinary and animal husbandry in Türkiye. Thus, it will be possible to benefit more from natural bee products that are affordable, healthy and have no adverse effects (Topal et al., 2015). In conclusion, Although it is seen that there are positive effects of bee bread in the literature reviews on the effect on poultry animals regarding both its numerous chemical components and its high bioactive

usefulness, the available information is limited. It is thought that there are not enough studies on poultry nutrition based in bee bread, therefore, new scientific studies supporting previous similar studies should be conducted in a row and the use of bee bread as an alternative natural feed additive should be clarified for poultry. It had better not forget that the bee bread added to the poultry diet is pure, natural and fresh, as well as the amount, form and duration of use are of great importance in obtaining the highest benefit.

Conflict of Interest

The authors declare that they have no competing interests.

Authorship contributions

Concept: F.G., M.A.K., Design: F.G., M.A.K., Data Collection or Processing: F.G., M.A.K., Analysis or Interpretation: F.G., M.A.K., Literature Search: F.G., M.A.K., Writing: F.G., M.A.K.

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