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REVIEW ARTICLE

Bee products as a food supplement in childhood nutrition and health

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Abstract

Complex food supplements rich in vitamins, minerals, proteins, fatty acids, and probiotics are widely available in the market to ensure healthy growth and development of children and to strengthen the immune system of specially school-age children. However, the use of synthetically produced food supplements makes parents uneasy, so the trend towards natural food supplements is increasing day by day. Bee products are natural products with high nutritional value produced by honey bees (*Apis mellifera* L.). Bee products are used as supportive in the treatment of many diseases in adults with the bioactive components they contain and strengthen the immune system. However, when the literature was examined, it was seen that the studies in which the effect of bee products on children is determined are quite limited. In this study, the effect of different bee products such as honey, pollen, propolis, and royal jelly on child health and nutrition was reviewed. Although it was seen that bee products positively affected children's health, it was important to use bee products after allergy testing. In addition, it was noticed that more studies are needed to determine the effect of bee products on child nutrition and health.

Keywords

Royal jelly, propolis, children, honey, bee pollen, food supplement

Introduction

Healthy nutrition for children starts in the womb and continues until the growth is completed (Stephenson et al. 2018). Malnutrition in infancy leads to irreversible disruptions in growth and causes mental and functional disorders (Stephenson et al. 2018). Food supplements are effective in supporting nutrition in children, ensuring growth and development, and teaching proper eating habits. Similarly, healthy snacks are also effective in preventing obesity and chronic diseases such as diabetes, hypertension, cardiovascular diseases and cancer (Garipağaoğlu and Yoldaş 2016). Food supplements are products used to meet nutritional deficiencies or needs, usually vitamins, minerals, amino acids, or other nutrients. These supplements are generally sold in capsule, tablet, powder, or liquid form (Kanak et al. 2021) and are often used to fill nutritional deficiencies or support certain health conditions (Egan et al. 2011). In addition, food supplements are also widely used to strengthen the immune system and accelerate healing processes in disease processes. Food supplements with high bioaccessibility and bioavailability and containing many active ingredients such as enzymes, phenolic compounds, and probiotics are preferred (Egan et al. 2011; Barretto et al. 2024).

Especially for children who are in rapid growth and development from a young age, children may need to use food supplements when necessary to maintain healthy development, protect them from diseases, and accelerate their healing processes in disease processes (Saavedra and Prentice 2023).

The frequency of using food supplements in children may vary depending on the age, health status, eating habits, and needs of the child (Lee et al. 2015). Ideally, the child should get a balanced intake of the nutrients they need from natural foods. However, in some cases, doctors or nutritionists recommend food supplements when they

think a child needs a particular nutrient (Lee et al. 2015). In this case, the doctor's or nutritionist's advice on the dosage and use of these supplements should be taken into account.

Parents' attitude towards food supplements is often focused on protecting and promoting their children's health (Piekara et al. 2020). Some parents resort to food supplements when they think their children do not have adequate eating habits or when they think they need a specific nutrient. However, there may be different opinions and attitudes among parents about food supplements (Van der Walt and Coopoo 2016).

While some parents encourage their children to get essential nutrients through a natural and balanced diet, others may prefer to use food supplements to meet their children's nutritional needs (Andersen and Holm 2018). Parents can often consult with their doctor or nutritionist to determine which supplements are appropriate to best meet their child's nutritional needs.

Although the main purpose of food supplements is to strengthen the immune system and reduce the incidence of illness, parents are particularly concerned about using synthetically produced, commercially available food supplements due to their potential side effects (Kioukia-Fougia et al. 2016; Djaoudene et al. 2023; Fanzo et al. 2023). Therefore, as an alternative to synthetic food supplements, there is an increasing trend towards natural foods or food supplements that strengthen the immune system and help children to continue their lives more healthily (Kioukia-Fougia et al. 2016; Djaoudene et al. 2023; Fanzo et al. 2023).

Bee products are natural products produced by bees by mixing the nectar they collect from nature with their secretions (Kolayli and Keskin 2020). They are important food supplements used by parents for their children and frequently used in order to strengthen children's immunity against diseases. In a study, the prevalence of the use of bee products in pediatric lung patients was evaluated and it was found that 79% of the participants used some kind of bee product to alleviate their children's health problems such as asthma and bronchitis (Živanović et al. 2019). They had a wide range of positive effects on human health. For example, honey strengthens the immune system with its antibacterial and antioxidant properties, while propolis plays an important role in fighting infections and accelerates wound healing (Durazzo et al. 2021). Royal jelly is known for its energy-boosting and hormonal balancing effects, while bee pollen supports overall health with its rich nutrient content and can alleviate allergy symptoms. Regular and conscious use of these products help prevent and treat health problems naturally (Kolayli and Keskin 2020; Durazzo et al. 2021). Except for propolis, products such as honey, pollen, bee bread, and royal jelly are consumed directly as they are harvested from the hive and have positive effects on the health of both children and adults (Kolayli and Keskin 2020).

When the literature was examined, there were many studies about the effects of bee products on adults' health (Schmidt 1997; Münstedt and Bogdanov 2009; Szabat et al. 2019; Liu et al. 2023). This study summarizes the using of bee products as a food supplement in children health. This is the first study that focus on the effect of all bee product on children health.

Honey

Honey is a sweet natural product with a thick consistency that is formed as a result of the collection of nectars in the flowers of plants or the sweet substances secreted by the living parts of plants and some equipped insects by honey bees (*Apis mellifera* L.) changing their composition in their organisms, storing them in honeycombs and maturing there (Kolayli and Keskin 2020). Honey is a functional food that is easy to digest, nutritious, and has protective and therapeutic properties against many diseases due to the various vitamins, minerals, organic acids, and enzymes in its composition (Kolayli and Keskin 2020).

On average, 17.10% of honey is water and the rest is solids. Sugars including fructose, glucose, maltose, and sucrose have an important share in the solid matter. There are also small amounts of protein, some B group vitamins, vitamin C, and various minerals (Bava et al. 2024). Honey is an acidic food due to its organic acids such as butyric, acetic, formic, lactic, succinic, malic, citric, and oxalic acids, especially gluconic acid. On average, its acidity is 0.57% and its pH is 3.9 (Table 1) (Johnson-Ajinwo and Obi 2024).

Table 1. Main compounds of honey (Kolayli and Keskin 2020; Luo et al. 2021; Bava et al. 2024).

Compounds	Average amount (g/100 g)	Compounds	Average amount (mg/100 g)
Water	17.10	Magnesium	0.7–13
Fructose	38.50	Calcium	4–30
Glucose	31.00	Iron	1–3.4
Total Protein	0.30	Phosphorus	2–60
Vitamin C	0.50 mg	Potassium	10–470

It also contains many bioactive substances such as flavonoids (luteolin, quercetin, apigenin, galanin, etc.), phenolic acids (caffeic acid, ferulic acid, etc.), and derivatives of these substances, and such polyphenols that important for health (Kolayli and Keskin 2020; Wang et al. 2024).

Thanks to these biocompounds, honey inhibits the growth of pathogenic bacteria that cause disease in humans. In the literature, studies were reporting the inhibitory properties of honey not only against bacteria but also against viruses, fungi, and parasites (Kolayli and Keskin 2020). In addition to the antioxidant and antimicrobial effects of honey, studies have shown that the metabolites in its composition have positive effects on the digestive system. Honey has been reported to reduce the effect of the disease by inhibiting the development of *Helicobacter pylori* bacteria, the main causative agent of gastric ulcer (Kolayli et al. 2020). It has been stated in studies that honey is a natural food with stops or slows down the development of cancer cells and tumors because it contains natural metabolites of nectar and bee secretions collected from different regions (Kolayli and Keskin 2020). It has been reported that the

inhibitory effect of honey on cancer cells is due to its bioactive components such as phenolic acids and flavonoids and that these compounds inhibit free radical formation and oxidative stress that cause cancer (Simon et al. 2006; Elsass 2017; Friend et al. 2018; Kolayli and Keskin 2020).

Honey is a nutritious food for children and has various positive effects on health. Especially parents often use honey for their children because it is an accessible, traditional and natural product (Özkan and Bancar 2015). In a study conducted with parents, it was determined that 29% of parents with children aged up to five years used honey for their children (Kumar et al. 2011). The effects of honey on health may vary depending on age and the amount of honey. Antioxidants that in honey strengthen the immune system by protecting the body from the harmful effects of free radicals. Regular consumption of honey can help children become more resistant to infections. Honey is known as a natural cough suppressant (Goldman 2014). Especially during colds and flu, honey relieves sore throat and reduces coughing. By coating the throat, honey reduces irritation and helps children breathe more easily. Honey has positive effects on the digestive system (Kumar et al. 2010). Thanks to its antimicrobial properties, it can prevent stomach and intestinal infections. Furthermore, the prebiotic properties of honey promote the growth of beneficial bacteria in the gut and support a healthy digestive system (Kumar et al. 2010). Honey contains natural sugars and is a quick source of energy. Children can benefit from the energy from honey, especially when they are active or playing sports. Honey can speed up the healing process of minor wounds and burns as it has antibacterial properties (Saikaly and Khachemoune 2017). However, this application should be preferred for smaller and superficial injuries, not in cases that require direct medical treatment (Kumar et al. 2010; Goldman 2014). In addition, honey supports meeting the daily requirement in terms of vitamin C (Ay and Yiğit 2016).

However, some issues should be considered when using honey. Babies under 1 year of age should not be given honey. Honey may contain *Clostridium botulinum* spores that can cause a serious disease known as infant botulism (Kumar et al. 2011). Babies may not be able to eliminate the toxins formed because their stomach acid level is low (Arslan and Şanlıer 2016). Therefore, honey should not be included in the diet of children under 1 year of age. Although rare, some children may develop honey allergy (Helbling et al. 1992). Children given honey for the first time should be carefully monitored. Due to the high sugar content of honey, children should not be given excessive amounts of honey. Balanced and moderate consumption is important. In conclusion, honey offers many health benefits for children, but it is important to use it carefully and in an age-appropriate manner.

Propolis

Propolis is a sticky substance with very strong anti-viral, anti-bacterial, anti-fungal and anti-fungal effects, consisting of a mixture of various oils, pollen, special resins, and waxy substances collected by honey bees from the cones and bark of trees, buds, and shoots of plants (Özkök et al. 2021).

Propolis content vary depending on the plant source, bee species, bee breed, and ecological conditions (Kolayli and Keskin 2020). But in general, its structure contains approximately 150 chemical compounds, more than 20 mineral substances, wax, resin, and pollen (Table 2) (Kolayli and Keskin 2020). It is rich in flavonoids, antioxidants, antibiotics, antimycotics, and antiviral substances such as chrysin, galangin, pinocembrin, pinobanksin, *trans*-β-terpineol (Huang et al. 2014). One of the major constituent of propolis is Caffeic acid phenethyl ester (CAPE). It provides inhibition of nuclear factor κ-B; inhibition of cell proliferation; induction of cell cycle arrest and apoptosis (Huang et al. 2014). The amount and distribution of these substances and their pharmacological properties have been revealed by various studies (Kolayli and Keskin 2020). For example, in a study conducted by Neto et al. (2020), propolis was used as a dental varnish in children and antimicrobial effect of propolis was determined on *S. mutans*. It was reported that the microbiological reduction of S. mutans was determined in different concentrations (Neto et al. 2020).

Table 2. Main compounds of raw propolis (Kolayli and Keskin 2020).

Compounds	%
Wax	≤ 50
Balsam	≥ 40
Essential oils	10
Total phenolic compounds	≥ 2.5
Organic compounds and minerals	5

In recent years, especially due to this feature, its extracts are frequently preferred by families for their children. However, direct consumption of propolis is not possible due to its resinous structure. Therefore, propolis should be extracted with a suitable solvent before consumption and the extract obtained should be used (Kolayli and Keskin 2020).

The solvent used must be non-toxic, and consumable, whether it can be removed after extraction, daily intake amounts, absorption in the body, and the products released when metabolized and their excretion are extremely important as well as obtaining a product with high biological activity in making appropriate extraction and obtaining an effective extract (Kolayli and Keskin 2020). For this purpose, water or natural deep eutectic solvents (NADESs) could be used as green solvents for propolis extraction (Trusheva et al. 2019; Tzani et al. 2022) or propolis active compounds could be encapsulated by using different encapsulating agent for consumptions (Keskin et al. 2019; Güneş et al. 2024).

Propolis has antimicrobial, antiviral and antifungal properties. These properties can strengthen the immune system of children, making them more resistant to infections. It can be especially effective in preventing diseases such as colds and flu (Rezende et al. 2008; Ophori and Wemabu 2010; Yuksel and Akyol 2016; El-Allaky et al. 2020). Propolis has anti-inflammatory properties. This

can provide relief in cases of inflammation and pain. It can be used especially in cases such as sore throat and tonsillitis. In a clinical study on the subject, the effect of propolis on upper respiratory tract infections in children was investigated. Accordingly, it was reported that bacterial infections in children with bacterial infections and given propolis supplements improved between 2 and 5 days. As a result, it was determined that propolis supplementation improves such diseases faster by showing antibacterial properties (Di Pierro et al. 2016). Thanks to its antibacterial properties, propolis can speed up the healing of minor wounds, cuts and burns. It can also be used topically for skin problems (e.g. eczema). Propolis can help treat gingivitis and mouth sores. Thanks to its antibacterial properties, it can reduce harmful bacteria in the mouth and support oral health. Propolis can have positive effects on stomach and intestinal health. Thanks to its antimicrobial properties, it can prevent digestive system infections and balance the intestinal flora (Yuksel and Akyol 2016; Rodrigues et al. 2021; Ożarowski and Karpiński 2023).

However, in the use of propolis in children, allergy, the amount of use and the supply of propolis products from reliable and certified producers are important. Giusti et al. (2004) reported that some children were allergic to propolis as a result of an allergy patch test. Poor quality products may cause unwanted side effects. Various products such as mouthwash, cream, and toothpaste containing propolis are available in the market and it is recommended to use them after allergy tests (Giusti et al. 2004).

Bee pollen and bee bread (Perga)

The male gametophyte of flowering plants is called as pollen. When bees visit flowers, they come into contact with this part of the flower and as a result of this contact, flower pollen covers the bee's body (Campos et al. 2008). Honey bees have limbs called pollen baskets on their hind legs due to their physiology, and the pelletized flower pollen is accumulated in pollen baskets (corbicules) (Campos et al. 2008). Bee pollen is collected by beekeepers with grid-shaped pollen traps placed at the hive entrances.

Therefore, although there is no exact standard for the nutritional value of pollen, pollen contains approximately 4–15% water, 7.5–40% protein, 15–82% sugar, 1.3–7% lipids, 1–3.5% vitamins and minerals (Table 3) (Thakur and Nanda 2020). In addition to its nutritional value, bee pollen has shown positive effects on human health with antitumor, chemopreventive/chemoprotective, antimicrobial, antifungal, antioxidant, antiradiation, and anti-inflammatory properties thanks to its biological activity (Komosinska-Vassev et al. 2015; Thakur and Nanda 2024).

Bee bread is an important bee product with its bio-compounds. It mainly contains pollen, honey and secretions of the bees from salivary glands. This mixture stores in honeycombs then secures with wax and honey.

Table 3. Main compounds of bee pollen (Campos et al. 2008).

Compounds	
Carbohydrates	13–55 (%)
Protein	10–40 (%)
Fat	1–13 (%)
Potassium	400–2000 (mg/100 g)
Calcium	20–300 (mg/100 g)
Iron	1.1–17 (mg/100 g)
Ascorbic acid	7–56 (mg/100 g)
Phosphorus	80–600 (mg/100 g)
Niacin	4–11 (mg/100 g)
Folic acid	0.3–1 (mg/100 g)
Biotin	0.05–0.07 (mg/100 g)

Finally, the mixture was fermented by lactic acid bacteria (LABs) and the last product is called as bee bread (perga) (Kieliszek et al. 2018). The pollen stored in the pores ferments in an average of 2 weeks (Kieliszek et al. 2018). It contains less protein but more lactic acid than bee raw pollen (Vásquez and Olofsson 2009). Bee bread contains the mineral vitamins and other phenolic compounds of normal pollen, but it is considered more valuable for human consumption than raw pollen (Vásquez and Olofsson 2009; Kieliszek et al. 2018; Keskin and Özkök 2020). Bee bread is formed when bees ferment pollen with honey and LABs. Since the fermentation process also digests the outer shell of pollen, the nutritional value of bee bread increases, digestion becomes easier, and thus the bioavailability of bee bread increases (Keskin and Özkök 2020). These nutrients strengthen the immune system of children and help them become more resistant to infections. Pollen is a natural source of energy and improves children's physical and mental performance. For active children, pollen supports energy levels and reduces fatigue. Thanks to its prebiotic properties, pollen supports the intestinal flora and helps the digestive system to function properly. Some studies suggest that local pollen consumption may help the body develop tolerance to seasonal allergies. However, this effect may not apply to all children and should be carefully monitored. The nutrients of bee pollen and bee bread contribute to the healthy growth and development of children (Qurratu et al. 2020; El Ghouizi et al. 2023; Dinu et al. 2023).

However, pollen may cause allergic reactions in some children. In children with pollen allergy, pollen consumption may cause severe reactions such as skin itching, rash, shortness of breath, or anaphylactic shock (Zhao et al. 2023; Hu et al. 2023). Therefore, if pollen is to be used for the first time, it should be started with a small amount and monitored carefully. The dosage of pollen should be adjusted according to age and body weight. Excessive consumption of pollen may cause digestive problems or other side effects. Products specially formulated for children should be preferred. It is important to obtain pollen products from reliable and certified manufacturers. Poor quality products may cause unwanted side effects.

Royal jelly

Royal jelly is a special substance secreted by 5–15-day-old worker bees from the sub-pharyngeal glands in their heads to feed the queen and young larvae (Keskin et al. 2020). It has a characteristic odor of white cream color and butter-like consistency. It contains essential fatty acids, amino acids, minerals, collagen, lecithin, and vitamins A, B5, B6, C, D, and E (Table 4) (Keskin et al. 2020). The queen bee feeds only royal jelly every day and it is an important nutrient for the developmental period (Kolayli and Keskin 2020).

Table 4. Main compounds of royal jelly (Keskin et al. 2020).

Compounds	%
Water	57–70
Protein	17–45
Sugar	18–52
Lipid	3.5–19
Minerals and vitamines	2–3

Biological effects of royal jelly such as antibacterial, antitumoral, antiaging, immunomodulatory, respiratory system (allergic rhinitis, asthma), pancreatitis, premenstrual syndrome, anti-ulcerative, accelerating healing in bone fractures, hyperlipidemia, hair growth enhancer, aphrodisiac, spermatogenesis enhancer, antioxidant, antiallergic, cardioprotective, growth accelerator have been determined (Pavel et al. 2011).

While there are many potential benefits in terms of its effects on children's health, there are also some risks and points. Royal jelly can cause allergic reactions in some children. These reactions can manifest as skin itching, redness, rash, shortness of breath, or, in more severe cases, anaphylaxis. Children who are particularly allergic to bee products (honey, pollen, propolis) may also be allergic to royal jelly. Royal jelly can cause digestive problems in some children, such as nausea, vomiting or diarrhea. Such side effects are usually caused by high doses. However, royal jelly has very important health benefits with the components it contains. In a study, royal jelly was found to increase immunity in children and therefore royal jelly consumption was recommended (Collazo et al. 2021). Royal jelly contains many nutrients that strengthen the immune system. It is rich in vitamins (B complex vitamins, vitamin C), minerals, amino acids and antioxidants. These nutrients can increase children's resistance to infections and diseases. Royal jelly can contribute to the healthy growth and development of children with its protein, fat, vitamin and mineral content. Especially amino acids support muscle and tissue development. Royal jelly has energizing properties. Therefore, it can increase children's energy levels and improve their physical and mental performance. Thanks to B vitamins and other nutrients, royal jelly can support the health of the nervous system. This can improve children's learning capacity and concentration. Royal jelly contains antioxidants and anti-inflammatory compounds that help reduce inflammation in the body. These properties can have positive effects on overall health (Zahran et al. 2016; Kolayli and Keskin 2020).

Royal jelly naturally contains some hormones (Ghanbari et al. 2018). These hormones may affect the hormonal balance of children. Therefore, caution should be exercised, especially in pre-adolescent children. The quality and safety of royal jelly products are important. Poor quality or contaminated royal jelly products can lead to health problems. Products from reliable and certified producers should be preferred. In addition, royal jelly has the potential to allergenize children similar to other bee products (Paola et al. 2014).

Conclusion

A healthy diet is important in raising healthy individuals. In addition to a regular and healthy diet, the use of natural food supplements strengthens the immune system and supports better health conditions in both children and adults. Bee products contain bioactive components that make them suitable for daily consumption as natural food supplements. The use of bee products, which are widely used by adults, by children has become widespread in recent years. However, when the literature is examined, it is seen that there is limited data on the place, importance, and effects of bee products in pediatric nutrition. In this study, the potential positive and negative effects of bee products on children's health were compiled. It can be stated that bee products may have many positive effects on children's health but should be used with caution in allergic children.

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