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Propolis and Potential Use in Food Products

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ABSTRACT

Propolis is attracting great interest due to functional effects such as antibacterial, antioxidant and anticancer. Therefore, studies about the use of propolis in food products and increasing propolis consumption in human nutrition have increased in recent years. Propolis contains phenolic compounds, essential oils, aromatic acids and waxes which are responsible for biological effects. Many factors such as plant resources, geographical regions and environmental conditions affect the chemical composition of propolis. Propolis enrichment in food products to improve the nutritional value, quality and functionality of food have been investigated in many studies. Furthermore, it was reported that propolis can meet the demand of consumers about the use of natural food additive in food manufacturing. The aim of the present study was to introduce the physicochemical composition and biological activity of propolis and review the studies about its applications in food products.

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Introduction

Propolis is a bee product that is a mixture of beeswax and resins prepared by the honeybee (*Apis mellifera*) (Casquete et al., 2016). The propolis name comes from two ancient Greek wordings which are pro (in front of, at the entrance to) and polis (city, community) (VS Bankova et al., 2000). The bees produce propolis for the use of as a protective barrier, damage repairer and thermal insulator (Cardoso et al., 2011). Additionally, propolis is used by bees to protect against pathogenic microorganisms (Falcao et al., 2010). Its chemical composition varies depending on plant origins and geographical locations. Therefore, it has been reported in the literature that hundreds of different compounds were detected in propolis (Bankova, de Castro, & Marcucci, 2000).

Propolis has gained attention in recent years because of its possible biological properties such as antiviral, antibacterial, cariostatic, antioxidant, hepatoprotective and anticancer (Burdock, 1998, Moreira et al., 2008, Valente et al., 2011, Silva et al., 2012, Cottica et al., 2015). Therefore, there has been an increased demand in ways to benefit from these potential impacts by enriching the nutritional value, quality and functionality of food products (Moreira et al., 2008). Propolis has been investigated to use in some food products as an antioxidant, antimicrobial and flavoring agent in many studies (Yang et al., 2010, Bernardi et al., 2013, Vargas-Sanchez et al., 2014, Cottica et al., 2015, Casquete et al., 2016).

Physicochemical Composition of Propolis

The source of propolis composition originates from plants, bee metabolites and propolis construction materials. However, the composition of propolis mainly depends on plant materials, plant species, season, climate, genetic diversity in the queen bee (Toreti et al., 2013). Therefore, the chemical composition of propolis is highly variable and affects the variability of plant species growing around the hive and geographic location (Russo et al., 2002, de Groot, 2013).

Generally, propolis is composed of resins (50%), wax and fatty acids (30%), essential and aromatic oils (10%), polyphenols and flavonoids (10%), pollen (5%), vitamins and minerals (5%) approximately (Table 1) (Noori et al., 2012). Furthermore, propolis is the major source of phenolic acids and its esters, flavonoid aglycones, amino acids, ketones, phenolic aldehydes, alcohols, sesquiterpenes, steroids, coumarins, and the inorganic compound. (Burdock, 1998, Sforcin, 2007, Değirmencioğlu, 2018).

Huang et al., (2014) have stated that chemical profiles of common propolis type which is called the poplar type propolis from different countries such as Korea, China, Taiwan, New Zealand and European countries are similar. While poplar type propolis has high-level flavonoids and phenylpropanoids, it is called green and red propolis which is obtained from the tropical zone and rich in coumaric acid and some isoflavonoids.

The studies in the literature have shown that the propolis samples collected from Europe are rich in phenolic compounds, flavonoids, aromatic oil and samples collected from Australia and South America is rich in di- and triterpenes as well as phenolic compounds (Sforcin, 2007, Seidel et al., 2008).

The Biological Activity of Propolis

Several studies have shown that propolis has different biological effects such as antimicrobial (Oliveira et al., 2010, Silva et al., 2012, Bueno-Silva et al., 2017), anticarcinogenic (Kouidhi et al., 2010), anti-inflammatory (Borrelli et al., 2002, De Barros et al., 2008), antioxidant (Kumazawa et al., 2004, Russo et al., 2004, Daleprane & Abdalla, 2013, Zam and Othman, 2018), anticancer (Watanabe et al., 2011, Turan et al., 2015). Havsteen, (1983) has stated that a significant portion of these biological effects is due to flavonoids in propolis. Therefore, the amount of flavonoids in propolis is very important to benefit from the biological activity of propolis.

Propolis is rich in biologically active compounds that have strong antioxidant properties (Değirmencioğlu, 2018). Many compounds such as kaempferol, phenethyl caffeate especially flavonoids and phenolic compounds, are thought to be responsible for the formation of antioxidant effects of propolis (Burdock, 1998, Bankova, 2005). Burdock, (1998) has stated that the antioxidant activity of propolis may be related to flavonoids. Flavonoids in propolis are potential antioxidant compounds that have scavenging ability of free radicals, binding of heavy metal ions and biological polymers. In addition, caffeic acid phenethyl ester in propolis inhibits reactive oxygen species production (Hosnuter et al., 2004). Also, caffeic acid phenethyl ester has superoxide radical scavenger effect and lipid peroxidation inhibitory effect (Russo et al., 2002).

The studies have shown that propolis extracts have antibacterial, antifungal and antiviral activity (Burdock, 1998, Valente et al., 2011, Silva et al., 2012). Silva et al., (2012) and Vardar-Unlu et al., (2008) have reported that propolis has greater activity against Gram-positive bacteria than Gram-negative bacteria. This may be related to the differences in the cell wall of gram-negative and positive bacteria. Takaisikikuni and Schilcher, (1994) have indicated that propolis exhibits antibacterial effects by protein synthesis, cell division and bacterial growth inhibition. Additionally, antibacterial properties of propolis increase in a dose-dependent (Ugur & Arslan, 2004). The antiviral effect of propolis is variable depending on virus types. Propolis inhibits the required enzyme for the multiplication of the DNA virus. Thus, it showed high antiviral activity in DNA/RNA viruses such as influenza and herpes polio (Silva-Carvalho et al., 2015, Yildirim et al., 2016). Flavonoids in the propolis are mainly responsible for the antiviral effect (Silva et al., 2012). Antifungal activity is affected by the chemical composition of propolis (Silva-Carvalho et al., 2015). Quiroga et al., (2006) have indicated that flavonoids such as galangin and pinocembrin are mainly responsible for the antifungal effect.

Propolis, especially caffeic acid phenethyl ester in it, shows the anti-inflammatory effect by preventing the pathways to inflammation. Propolis inhibits the synthesis of leukotriene and prostaglandin and suppresses the expression of transcription factors of the nuclear factor. These are playing an important role in inflammation so that propolis reduces the levels of inflammatory cytokines and interleukins in these ways (Fan et al., 2015, Funakoshi-Tago et al., 2015). On the other hand, in some studies, it has been reported that propolis can prevent specific oncogene signaling pathways and modulate the tumor microenvironment. And this way, it can also decrease the cancer stem cell population as it provides to decrease in cell proliferation (Sawicka et al., 2012, Bhargava et al., 2018, Ishida et al., 2018).

As a result, there are several positive effects on human health such as improvement of ventilatory functions, antibacterial and antifungal activities, gut and throat health, immune system and blood circulation (Duarte et al., 2003, Bankova, 2005, Sforcin, 2007). However, no health claim has been recognized for propolis by the European Food Safety Authority (EFSA) (EFSA, 2010).

Table 1. The chemical composition of poplar type propolis (Burdock, 1998, Barlak, 2009, Değirmencioğlu, 2018)

	Compounds	Amount (%)
Resins	Flavonoids (rhamnocitrin, acacethin, quercetin, macarangin) Terpens (oleonane, lupane, ursane and lanostane) Coumarins Phenolic compounds (Caffeic acid, ferulic acid etc.)	42-58
Wax and oils	Plant waxs Oleic and palmitic acids Essential and aromatic oils	33-47
Pollen	Proteins Free aminoacids (glutamate, proline, aspartate, leucine and lysine) Vitamins (A, B, C, E) Elements (Mn, Cu, Al, Fe, Co, Zn, Ag, Ca, Mg)	3-5
Other components	Ketones Laktons Steroids Sugar	2-5

Table 2. Applications of propolis in food products

Food Products	Properties of Propolis	Results and Comments	References
Fish burgers	Microencapsulated propolis extract	Improving phenolic content and antioxidant activity	Spinelli et al. (2015)
Fish fillet	Propolis extract in water	Improving microbial quality	Duman and Ozpolat, (2015)
Beef patties	Propolis extract in ethanol	Improving lipid oxidation stability during storage Inhibition of mesophilic and psychotropic bacteria	Vargas-Sanchez et al. (2014)
Fermented sausage	Propolis extract in ethanol	Inhibition of Micrococcaceae, yeast and molds on the surface of fermented sausage	Ozturk (2015)
Sausage	Propolis extract in ethanol	Improving lipid oxidation stability Improving sensorial quality	Ali et al. (2010)
Sausage	Propolis extract in ethanol	Improving shelf life	Han and Park (2002)
Salami	Propolis extract in ethanol and microencapsulated propolis extract	Improving shelf life Improving lipid oxidation stability	Bernardi et al., (2013)
Sausage	Propolis extract in ethanol	Antimicrobial activity against some pathogenic microorganisms	Gutiérrez-Cortés and Suarez Mahecha (2014)
Milk	Propolis extract in ethanol	Inhibition of Listeria monocytogenes	Thamnopoulos et al. (2018)
Dairy beverage	Propolis extract in ethanol and water	Improving antioxidant activity	Cottica et al. (2015)
Ice-cream	Propolis extract in ethanol	Inhibition of S. aureus	El-Bassiony et al. (2012)
Yogurt	Propolis	Improving shelf life	Çifci (2015)
Orange juice	Propolis	Antifungal effect	Yang et al. (2017)
Apple, grape, orange juice	Propolis	Antifungal effect	Koc et al. (2007)
Fruits (banana, grapefruit, grape)	Propolis extract in ethanol	Improving textural quality Prevent weight losses	Passos et al. (2016) Ozdemir et al. (2010) Pastor et al. (2011)
Quail eggs	Propolis extract in methanol	Improving shelf life	Akpinar et al. (2015)
Olive oil	Propolis extract in methanol	Improving antioxidant activity and shelf life	Ozcan (2000)
A la piedra' turro´n which is a type of confection	Propolis	0.05 % propolis were determined as suitable for the instrumental aroma profile and the descriptive sensory profile of this confection. Also the level may be improve its health benefits by incorporating into the consumers	(Narbona et al. 2010)

Use of Propolis in Foods

The consumption of propolis should be increased in the human diet in order to provide the positive effects of its biological activities in human health. Also using propolis meets the consumer demand for the use of natural antioxidants and antimicrobials instead of synthetic food additives. Therefore, the enrichment of food products with propolis as a natural food additive and improving food quality has become an interesting subject in recent years (Pobiega et al., 2018). Many of the compounds in propolis have been used as food additives and these are generally recognized as safe (GRAS) substances (Burdock, 1998, Silva-Carvalho et al., 2015). Although it can be said that propolis is safe to consume, adverse effects such as dermatitis may be observed in some people (de Groot, 2013). It is indicated that humans can consume 1.4 mg/kg body weight/day or approximately 70 mg/day as a safe dose (Burdock, 1998). Also, the study aimed at an acceptable amount of propolis in a designed food product with honey and propolis determined the suitable level as a maximum of 0.5% propolis content (Osés et al., 2015).

Studies have reported that propolis generally is used in various food formulations such as meat, dairy, juice, fruits, oils and seafood to improve shelf-life, prevent lipid oxidation and provide health benefits for consumers (Table 2) (Ozcan, 2000, Ali et al., 2010, Vargas-Sanchez et al., 2014, Cottica et al., 2015, Spinelli et al., 2015, V Bankova et al., 2016).

Propolis can be added to food formulation as an ingredient or applied to the food surface (Pobiega et al., 2018). However, the phenolic acid and other volatile compounds of propolis have a strong and incompatible taste and odor which is enough change the sensory properties of food, and so, the use of propolis in food products is still limited (da Silva et al., 2013, Spinelli et al., 2015). Narbona et al. (2010) added different propolis levels (0.040%, 0.050%, 0.060%,0.080%, 0.100%, 0.150% and 0.200%) to "a la piedra' turro´n " which is a type of confection. The suitable level of propolis was determined as 50 mg per 100 g a la piedra' turro´n for the instrumental aroma profile and the descriptive sensory profile.

Vargas-Sanchez et al., (2014) indicated that propolis extracts can be used to improve lipid oxidation stability and inhibit the microbial growth on beef patties during cold storage. Non-commercial propolis treatments (2% w/w) have shown the highest total phenolic content, free-radical scavenging activity and lipid oxidation stability. Furthermore, the growths of mesophilic and psychrotrophic bacteria in patties were inhibited by non-commercial propolis extract during storage. Similarly, it is indicated that *Micrococcaceae*, yeasts and molds on the surface of fermented sausage can be reduced by the use of propolis without adverse effects on its color and aroma properties (Ozturk, 2015). Han and Park, (2002) indicated that the shelf life of meat products by the use of propolis may be longer than potassium sorbate, which is currently used in meat products.

Gutiérrez-Cortés and Suarez Mahecha (2014) evaluated the in-vitro antimicrobial activity of the ethanol propolis extract on some pathogenic bacteria and their influence on the physicochemical and sensorial properties of sausages. The amount of ethanol propolis extract was determined at 0.8 % which had antimicrobial activity against some pathogenic microorganisms and no negative effects on the physicochemical and sensorial characteristics of the product. They also have stated that propolis can be used in meat products as an alternative for nitrites. Spinelli et al., (2015) microencapsulated the ethanolic extracts of propolis to minimize the sensorial problems of propolis and used it to enhance the antioxidant properties of fish burgers. It was reported that the microencapsulation process has been successful to eliminate the strong odor of propolis, and phenolic content and antioxidant activity of fish burgers improved. Similarly, Bernardi et al., (2013) reported that Italian salami can be manufactured using encapsulated propolis as a replacement for sodium erythorbate.

There are many studies about the use of propolis in dairy products in the literature. Cottica et al., (2015) reported that the addition of ethanol and water extracts of propolis in dairy beverages showed the highest antioxidant capacity and the lowest aldehyde production during storage in light. Furthermore, some studies have shown that yogurt can be manufactured with propolis without any significant adverse effects except for some minor negative sensory effects (Çifci, 2015, Bilici, 2017). However, it stated that propolis at certain doses significantly inhibited *Streptococcus salivarius* subs. *thermophilus* bacteria and therefore, yogurt production may be negatively affected (Çifci, 2015). Similarly, the count of methicillin-resistant *Staphylococcus aureus* was reduced by using ethanol extract of propolis in ice cream (El-Bassiony et al., 2012). It is indicated that the propolis ethanolic extract into glycerol showed inhibition effects on *Listeria monocytogenes* at the end of storage time (30 days) (Thamnopoulos et al., 2018).

Post-harvest storage for fruits and vegetables is the most important stage which results in economic and nutritional losses. The causes of these losses are fungal and bacterial growth which can be prevented by propolis applications. Feas et al., (2014), Alvarez et al., (2015) and Alvarez et al., (2017) reported that ready-to-eat vegetables such as lettuces, leek and celery can be sanitized by propolis extracts. Also, propolis has an inhibition effect against some Penicillium species in fruits. Additionally, the use of propolis in some juices such as apple, grape, orange, and mandarin has shown that propolis is effective on mold and yeast as effective as sodium benzoate and potassium sorbate (Koc et al., 2007, Yang et al., 2017).

The antioxidant properties of propolis have also been tried to improve the storage stability of oils. Ozcan, (2000) reported that propolis had better antioxidant activity in olive oil as compared to butylated hydroxyanisole and butylated hydroxytoluene. Furthermore, the coating of quail eggs with propolis was effective for protecting the internal egg quality parameters and may help to slow the decrease in quality during storage (Akpinar et al., 2015).

Conclusion

Propolis is a natural preservative that has antifungal, antioxidant, antibacterial properties. Therefore, propolis can be used for food preservation as a natural preservative. However, strong odor and flavor, allergenic effect and variations in the composition of propolis limit its use in foods. Chemical composition and the dose of propolis are very important criteria for food preservation. So, more studies are needed on the use of propolis in the preservation and nutritionally enrichment of food into consideration the amounts that people can take daily.

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