

## As a Protective Material: Propolis

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### Abstract

Propolis has been a popular agent for food supplementary material for human health. It is a natural, sticky resinous, dark yellow to brown coloured bee product and has phenols and many other preventive agents. Propolis usually contains resins (50%), composed of flavonoids and phenolic acids, waxes (up to 30%), essential oils (10%), pollen (5%) and various organic compounds (5%) such as Fe and Zn, vitamins (B1, B2, B3 and B6), benzoic acid, ketones, lactones, steroids and sugars. Propolis chemical composition differs from climate conditions, origin of plant species, time, vegetation of collection areas and type of bee flora. There are many scientific studies published in different international journals about propolis and its chemical composition, biological activity. But there still have been a requirement to discover all chemical components and possible applications of propolis. The aim of this review is to explore general properties and chemical activities of propolis.

**Keywords:** Propolis, antibacterial, bee

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### 1. Introduction

Recently investigations have shown that people interest for natural preservatives has increased. Honey and propolis have beneficial effect on human health. Propolis is nontoxic. Approximately 1.4 mg/kg *per* day or 70 mg/day are safe concentration for humans. Propolis as an alternative preservative agent has been accepted safe by consumers [1-3]. It has been a popular agent for food supplementary material for human health [4]. Another name of it is bee glue [5]. It is a natural, sticky resinous, balsamic, dark yellow to brown coloured and strongly adhesive bee product and has phenols and many other preventive agents. It has a typical odour and a bitter taste [6]. The odour can change from sample to sample. Even some samples are odourless.

Honeybees (*Apis mellifera* L.) collect extracts from leaves, flowers, buds of certain trees and

plants like pine, oak, eucalyptus, poplar, chestnut, *etc.* and mix it with pollen as well as enzymes. Bees carry them to the hive on their hind legs. Then they produce propolis from these extracts [4, 7-11]. A bee colony produces from 150 to 200 g propolis in a year. But same bees collect less [12]. Interestingly, tropical honeybees such as *Apis mellifera*, *Apis florum* and *Apis dorsata*; African *Apis mellifera* make no use of propolis [13].

### 2. Propolis in History

The word propolis is derived from the Greek pro- and -polis. Pro means 'in front of' or 'at the entrance to' and -polis means 'community' or 'city'. So propolis means a substance in defence of the hive [14]. Propolis has been used as a folk medicine since 300 BC [1]. Propolis has been used by human since early times for different purposes. Bees also use it as an 'embalming' substance to cover the carcass of hive invader which the bees have killed but cannot

transport out of the hive. They cover the invader with propolis and remain are left at the bottom of the hive [15].

Propolis has been known for centuries all around the world. But the first study about propolis and its chemical properties and composition was published in 1908 [3]. Egyptians knew well the antifouling properties of propolis so they used it to embalm cadavers. At the same time the Balkan states was widely using it. The word of propolis took part in French literature since the sixteenth century. Besides this medicinal properties of it was been familiar by Greek and Roman physicians like Aristoteles, Dioscorides and Galen. But the harvesting methods were not known in the ancient world. The Greek *Historia Animalium* referred to substance myths, which was maybe propolis, as ‘a cure for bruises and suppurating sores’. According to Varro in Rome, physicians used the propolis for making poultices. Because of this reason it brings even a higher price than honey on Via Sacra [15, 20].

Propolis was used with Vaseline to heal the wounds during the Anglo-Boer War, in South Africa. So many soldiers’ lives were safe. Otherwise most of soldiers could have died, because antibiotics not yet available [16].

In the Middle Ages propolis was not very popular but Arab physicians used propolis as an aseptic and cicatrizing in wound treatments. So this uses being maintained among them. Other people unrelated to the Old War civilizations recognize that propolis could have used as an antifebrile agent. So London pharmacopoeias listed propolis as an official drug in the seventeenth century. Then it became very popular in Europa on account of its antibacterial properties between seventeenth and twentieth centuries [17].

Different civilizations have accepted propolis as a one of ‘natural drugs’ for a long time [17]. But nowadays some products of propolis are being commercialized all around the world, for example; candies, chocolate bars [18].

The first study about propolis was in 1903, indexed by *Chemical Abstracts*. And the publications on propolis reached 3.880 in journals until 2013. At the same time China, Japan and

Russia hold most of the patents. Because they are the largest producers of propolis. 6% of patents filed by 2012 refer to the use of propolis for dental treatments. So this is one of the most widely studied applications of propolis worldwide [19].

### 3. Chemical Composition of Propolis

Propolis usually contains resins (50%), composed of flavonoids and phenolic acids, waxes (up to 30%), essential oils (10%), pollen (5%) and various organic compounds (5%) such as Fe and Zn, vitamins (B1, B2, B3 and B6), benzoic acid, fatty acid esters, ketones, lactones, steroids and sugars [20-23]. The components are rich in vitamins and mineral elements.

Bees collect the resin nearby hives; they also collect pollen and nectar for feeding in the same places. It is also used as a chemical weapon against pathogen microorganisms and its colour differs from yellow-green to dark brown [4, 24].

When propolis is heated, it became soft, pliable and sticky. But when it cooled or particularly frozen, it became hard. Typical propolis became liquid at 60 to 70°C. But same samples need a high temperature such as 100°C for melting [13]. When propolis is burnt, it exhibits a smell of aromatic resins of great value [25].

Many studies have been conducted on the chemical composition and biological activities of propolis. More than 300 compounds like volatile organic compounds, flavonoid aglycones, phenolic acids and their esters, alcohols, ketones, steroids, terpenoids, amino acids have been isolated from propolis and new ones still being recognized. Of all, flavonoids take much more attention to research [26-29]. Terpenoids have an important property. They help the bees to determine which vegetal species to visit for producing propolis. Most of these compounds of propolis have important protective effect against oxidation reactions. For this reason propolis has been used in traditional medicine, cosmetics and food industry due to its antibacterial [30], antioxidant, antiviral [31] and antifungal activities [1, 13, 23, 24, 26]. Besides these propolis has cytotoxic, free radical scavenging, inflammatory and anti HIV activities [32].

Propolis prevents the cell division. So it inhibits the bacterial growth. Propolis disorganized the

cytoplasm, cytoplasmic membrane and the cell wall. This caused a partial bacteriolysis and inhibited protein synthesis [33].

The antibacterial and antifungal activity of acetone and dimethyl sulfoxide (DMSO) extract was investigated by Ugur and Arslan [34]. They used 45 different propolis samples collected from Mugla province of Turkey. They found that the antimicrobial effect of all propolis samples were different from each other. This is because the antimicrobial activity of propolis was affected by propolis sample, dosage of propolis and the extraction solvents.

Effects of propolis extracts on 75 bacterial strains were examined. These bacteria were isolated from cows with mastitis and 69 of them were identified as *Staphylococcus ssp.* and *Streptococcus ssp.* It was found that propolis extract had a strong effect on all the strains. The effect was the same or higher than that of the standard strain *Staphylococcus aureus* 209P [35].

Ethanol extract of propolis completely inhibited the growth of *S. aureus*, *Enterococcus spp.* and *Bacillus cereus*; partially inhibited growth of *Pseudomonas aeruginosa* and *E. coli*; had no effect on *Klebsiella pneumoniae*. The antimicrobial activity mechanism is complex and could be referred to the synergistic activity between phenolic and other compounds such as flavonoids, pinocembrin, galangin and pinobanksin [17, 36, 37].

There has been a study about antifungal activity of propolis on 80 strains of *Candida* yeasts. Hydroalcoholic propolis extracts showed inhibitory effect on *Candida* yeasts for patients with full dentures [38].

Propolis takes attention because of its antioxidant activity. The antioxidants play an important role in its immunomodulatory properties. The flavonoids are powerful antioxidants [3].

The existence of inflammatory processes and healing failure have been a concern for years, especially for the people with healing diseases e.g. diabetics [16]. The antibacterial, antibiotic and antifungal activities of propolis have been investigated and it has been reported that propolis has been shown to have antimicrobial effect

against *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli*, *Salmonella*, *Penicillium digitatum* [39] and has shown effect on fungi such as *Aspergillus niger*, *Candida albicans* and *Botrytis cinerea* [10, 40-42].

Propolis has had fungicide effect on *Candida famata*, *C. glabrata*, *C. kefyr*, *C. pelliculosa*, *C. parapsilosis* and *Pichia ohmeri*. The flavonoids were been the reason of this fungicide effect. Propolis has the highest antifungal activity as testes with 40 yeast strains of *C. albicans*, *C. glabrata*, *C. krusei*, and *Trichosporon spp.* [43-45].

Some flavonoids like chrysin and kaempferol have antiviral effect on some viruses such as herpes simplex. For example the growth of Streptococcus was inhibited by ethanol extract of propolis from different regions in Brazil [46]. Regarding this, propolis is active against Gram-positive bacteria but it has showed limited activity against Gram-negative bacteria and also ethanolic extract of propolis has inhibitory effect on anaerobic bacteria [48-49]. Similarly gallic acid, a component of propolis, derivate has shown inhibitory effect against Gram-positive and Gram-negative bacteria [50].

It has been reported that flavonoid and esters of phenolic acids are generally regarded to be responsible for the antimicrobial activity of propolis [51]. It is also known that flavonoids have antioxidant effect to the oxidation in the cell membrane like ascorbate [28]. Similarly caffeic acid phenethyl ester blocks the production of reactive oxygen types [52]. Kedzia et al. [47] found that the mechanism of propolis antimicrobial activity is complicated and could be attributed to synergism between flavonoids hydroxyacids and sesquiterpenes. It has been shown antibiotic effect against *Salmonella*, *Staphylococcus aureus*, *P. vulgaris* and *E.coli* [23, 53]. For this reason propolis is used in foods to improve health and prevent diseases such as heart disease, cancer, diabetes [24, 54]. Due to antibacterial properties of propolis, it is used for protection of various agricultural products during storage [11].

Propolis chemical composition differs from climate conditions, origin of plant species, the season in which propolis is produced, vegetation of collection areas and type of bee flora [4, 11, 28, 29, 55]. Same places that propolis is collected from, can be effected

by the seasonal variations. So this propolis may have different chemical composition. Beside some contaminations e.g. pesticide, copper, magnesium, asphalt powder can be collected and unexpectedly added to propolis [56-58].

Propolis samples collected from Europa, South America and Asia have different chemical component [59]. Europa and Chinese propolis have flavonoids and phenolic acid esters [26] but Brazilian propolis has terpenoids and prenylated derivatives of *p*-coumaric acids [61, 62]. Because of these differences in chemical components of propolis, its biological activities from different areas are also different [55]. For example; German propolis have high antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*; but Austrian propolis have high activity against *Candida albicans* [63].

The extraction method and solvent is used, can change the chemical composition of propolis extract. Commercial products e.g. capsules, tablets are prepared with ethanolic extract. Some diversity of propolis can be solved in water [64]. At the same time chemical components of propolis and its biological activity enable the standardization of the application of propolis [28]. It was found that the differences in chemical components of propolis from different plants change the spectrum of propolis' biological activity [55]. Some works have been conducted with this, but there has been not a real result yet [65].

#### 4. Usage Area of Propolis

Bees also store propolis inside their hives and use it to cover inside of the hive and use it as a protective barrier against their enemies. They also use it to seal the cracks and crevices; sterilize the queen-bee posture site. So small animals or some part of them are found wrapped within propolis in perfect states of conservation [59, 66]. These uses are important because propolis prevent hive colonization from diseases [61]. They mix propolis with beeswax and the collected propolis with the 13-glicosidase enzyme found in their saliva, hydrolysing flavonoids glycosides into flavonoid aglycones [16]. The aim of this is to build the combs to protect the colony and larvae from pathogen microorganisms [1,29,55]. Then the collected materials are reproduced with enzymatic

and salivary secretions. Propolis has important healing properties among the other bee products; honey, pollen, etc. [59].

Propolis is known in folk medicine since ancient times but it has taken much more attention in recent years as a useful ingredient applied in medicine, domestic products and food products since it has various biological properties [7]. Recent studies have been shown that propolis has much positive effect like increase in feed intake (FI), body weight increase, flavonoid content, taste improvement [8]. Although reports of allergic reactions are not uncommon, propolis is relatively non-toxic, with a non-observed effect level (NOEL) of 1400 mg/kg body weight/day in a mouse study. Propolis with its useful properties is recognised as Generally Recognised as Safe (GRAS) [24]. Because of this propolis make an attractive candidate as a natural preservative in new food applications. Propolis satisfy the demand for natural antioxidants and antimicrobials, fuelled by the increasing consumer awareness for natural, minimally processed foods with traditional preservatives absent or at very low concentrations [61, 66].

A propolis is a hard resinous substance; it cannot be consumed in its natural form. Its usual way of preparation is by powdering the resinous, followed by an extraction in alcoholic or aqueous medium.

#### 5. Preparation of Propolis Extract

There is increasing interest on propolis. Commercial formulations are researched. Propolis has a complex structure so different solvents are tried to get propolis extract. Ethyl ether, water, methanol, chloroform can be used for extraction and identification of propolis but generally the best solvent is ethanol [69]. At the same time three different propolis extracts used to prepare various commercial products, were determined; ethanolic, aqueous-ethanolic, aqueous-glycolic.

One of the properties of propolis composition is geographical region but the second one is the method of extraction. So the solvent should be carefully chosen [59, 70].

Aqueous extract of propolis has higher activity than ethanolic extract of it. It has been taught that reason of this situation is propolis' higher polyphenols content [71]. Activity of the main biologically active

constituent in propolis is changed by using different solvents [34].

## 6. Is Propolis a Food Supplement or Medicine?

The National Food Institute accept propolis as a diet supplement in 1995 (file 2110-00375-4 in the Argentina Food Code) [72].

## 7. Conclusion

Consumers want to have natural foods (don't have any chemical ingredients and minimally processed) and they want the foods can be stored for a long time. Propolis is a resinous, natural, balsamic, dark yellow to brown coloured bee product. It has antimicrobial, antioxidant, antiviral activity because of especially flavonoids in propolis. So it was found propolis has no negative effect on human health. Many countries have used it for healing the wounds for centuries. But they didn't use it for foods. It can be used as protective substance for increase the shelf-life of products. But there is not enough study about this. So it has to be studied about applying propolis in foods.

**Compliance with Ethics Requirements.** Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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