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A New Antibacterial Agent: Propolis

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ABSTRACT

As textile products are being used widely in Daily life, their antibacterial characteristics gain more importance. The necessity of antibacterial agents used due to the importance given to today's health and alternative products provided by natural routes has also revealed the necessity of this context. This work focuses on the usage of propolis as an antibacterial agent. On the other hand, it aims to gather information on the use of propolis for the purpose of giving antibacterial properties to textile materials.

Keywords: *Propolis, Antibacteriality, Extract, Flavonoid*

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1. Introduction

Because of the increasing population and many other environmental effects, antibacterial effect has become one of the most important topics nowadays. Instead of using synthetic chemicals, using natural ways has drawn unprecedented attention. Propolis which is a bee secretion, has been used in researches since the ancient times however ongoing research on its usability has still been continuing. For health, unlike other bee products such as honey, royal jelly and pollen, the usage of propolis is yet to be widely introduced to people.

1.1 Propolis

Because of their nature, all animals act according to their protective instinct against the external factors. Similarly, many plants produce gummy matter in order to survive adverse environmental conditions (cold, heat, soak etc.) and to prevent microbial invasions. Propolis means “usage of the city” in Greek. It is produced by worker bees by blending their special secretion and plant extract (e.g. resin). It is fragile when cold and very sticky when warm[1,2,3]. Bees use propolis in order to protect their hives from disease, to get rid of the smell of the dead bees and to maintain a hygienic living space. Its usage by people dates long ago. For example, ancient Egyptians used it to heal the wounds and to mummify the dead[4].

It is a well-known fact that lots of plants and animals participated in the improvement of science. Similarly, it was thought that if bees use propolis in their hives, it can also benefit people with the same purpose, especially for disease protection and curing. On the other hand, propolis is known to prevent cells from oxidative damage as an antioxidant. Many vegetables and fruits were studied in those aspects, among which propolis was superior[5,6,7]. One of these studies indicated that the antioxidant capability of propolis was 62 and 120 times of that of pomegranate and tomato, which were previously recognized as the most effective antioxidants[8].

Konig et al. profiled the color range of propolis and its solubility in solvents. They found that the raw propolis colored from yellowish green to brown, and alcohol was the best solvent which isolated propolis from wax. Its context changed according to the physiochemical conditions of bee hives and its chemical structure had not been studied yet[9]. Previously, honey was the main source of flavonoids. Since they were both common in honey and propolis, an idea was brought open that flavonoids could also be extracted from propolis[10].

1.2 Chemical Composition of Propolis

Depending on the vegetation where bees inhabit and the time when propolis is gathered, context of propolis varies. It is stated that wax also affects the composition of propolis. According to published findings, propolis consists of hundreds of compounds, including aromatic compounds (e.g. phenols, terpene), sugar, minerals, amino acids, and ~180 flavonoids which were believed to confer the antibacterial effects of propolis[11,12]. See Table 1 for detailed propolis chemical composition.

In propolis, while there are abundant manganese and zinc, also mercury, fluorine, nickel, sodium, potassium, chlorine, phosphorus, cobalt, silicon, molybdenum, lead, silicon, aluminum, and copper are found. There are also 8-17 different amino acids depending on the place where the propolis is sampled[13].

Among the identified aromatic compounds, there are 29 phenolic compounds, including 12 phenolic acids, 13 flavonoids and 4 phenolic acid esters. They are: 3,4-dihydroxybenzaldehyde, vanillic acid, caffeic acid, vanillin, p-cumaric acid, ferulic acid, isoferric acid, benzoic acid, 3,4-dimethoxycinnamic acid, cinnamic acid, 4-methoxycinnamic acid, dinamylideneacetic acid, benzylcafate, benzyl p-comarate, cinnamylcinnamate, 5-methoxypinobutyric acid, quercetin, alpinein, kaempferol, apigeninisorhamnetin, pinochembrine, pinobanksin-3-o-acetate, krisin, galanjin, pinostrobin, and tektosiricein[15].

Another research studied propolis collected from 12 different provinces of China. Except the one collected from Yunnan province, the rest 11 samples had antioxidant characteristics and were rich in caffeic acid, ferulic acid and caffeic acid phenyl esters. In particular, propolis from Yunnan and Hainan Province had location-specific compounds that could not be found elsewhere[16]. Sarıkaya et al. analyzed the contents of phenolic matter of 12 propolis samples, 2 from Turkey and 10 from Yazıcıoglu. The former was between 313-476 mg GAE/g in the form of propolis, and the latter was between 115-210 mg GAE/g[17,18].

In general, propolis consisted of 50% resin (vegetal balsam), 30% wax, 10% volatile oil, 5% pollen and minor other matters. Types and contents of these compounds differed from vegetation and locations where propolis was sampled. What's more, propolis was found to have a polar structure [4].

Compounds	No. of kinds
Flavonoids	180
Hydroxy flavon	27
Minerals	22
Amino acids	17
Sinamil and sinamic acid derivatives	14
Benzoic acid and its derivatives	12
Hydroxy flavonones	11
Sekuterpen and triterpen hydrocarbons	11
Acids	8
Alcohols, ketones, phenols	8
Sugar	7
Sterols and steroid hydrocarbons	6
Esters	4
Chalcocites	2
Benzaldehyde derivatives	2

Table 1. Number of the compounds in propolis [14].

1.3 Anti-Bacterial Effect of Propolis

In many studies, propolis exhibited anti-bacterial, anti-fungal, anti-viral and anti-inflammatory characteristics, which predominantly resulted from the flavonoids [19,20]. A study in 2005 indicated that propolis collected in the habitats of *Populus nigra* (black poplar) and *Populus euphratica* (fırat poplar) exhibited the highest antibacterial activities [21,22]. Another study in 2015 suggested that antibacterial activity was proportional to the hydrophobicity of the propolis that the more polar groups the flavonoids had, the weaker activity was observed. In addition, an increase of the ratio of phenylpropanoids over caffeic acid derivatives was associated with higher antibacterial activity [23]. Species of bees also had an impact on the antibacterial activity of propolis [24].

Microorganisms have colonized every corner of this world, including textile products, which is usually undesired. So textile products with anti-bacterial characteristics would help to prevent microbial colonization. Propolis inhibiting microbial cell division should be its strategy against microbial invasion, during which the effective compounds were flavonoids, cinnamylidene acetic acid, benzyl p-coumarate and caffeic acid esters such as pinocembrin, galangin and pinobanksin [25, 26, 27]. A clinical trial by Kumova et al. suggested that dissolving propolis in 70% alcohol together with antibiotics would increase its anti-oxidative and medical efficacy, seen from the positive results on the treatment of a second-degree burning wound [28]. Several studies indicated that ethanol extracts of propolis was very effective on bone healing [26,29]. Bone formation was considered as histofomerical. Propolis was effective on early bone formation and it did not work on late bone formation[30]. Active matters in propolis such as flavonoids and derivations of caffeic acid inhibited blastomycetes that might cause skin diseases[31].

1.4 Anti-Oxidative Effect of Propolis

In a study, antioxidant activities of honey and propolis were compared in the tests of total phenolic matter, Fe(III) reducing power (FRAP), Cu(II) reducing power (CUPRAP) and DPPH radical purification capacity. Results of the Fe(II) and Cu(II) reducing tests were comparable that both chestnut honey and propolis had anti-oxidative potentials. In addition, ethanol extracted propolis exhibited higher anti-oxidative activity than methanol extracted propolis [32].

Recent years, propolis was also proved able to eliminate free-radicals. Members of the flavonoid family such as galangin, isoalpine, kaempferol, camphoridramnocin, ramnetin, isorhamnetin, quercetin, pinocembrin and pinobanksin, all had the antioxidant characteristics, so as vitamin E, histidine and active redox compounds [33].

1.5 Medical efficacy of Propolis

Some studies concerned cell regeneration of propolis. For example, Quercetin as one of the major effective contents of flavonoids in particular, showed antioxidative effects such as accelerating and increasing tissue regeneration, re-activating some of the enzymes of elderly patients[34]. Amino acid contents of propolis (such as arginine and pyrimidine) induced mitotic division and protein synthesis, therefore accelerating cell regeneration. In addition, pyrroline facilitated the synthesis of collagen and elastin[27].

Propolis was rich in CAPE (caffeic acid phenethyl ester), which was found to suppress tumor growth after 100 days when injected into rats carrying tumors[35]. In another study CAPE was found to inhibit cancer metastasis[36]. Therefore, propolis is now being used for enhancement of the immune system and for dealing with fungal, bacterial and viral infections. It is reported that propolis has also a healing effect on skin wound, burning wound, skin inflammation and other skin diseases. In most cases, flavonoids and phenolic acids compounds were the effective compounds [37].

Propolis collected from the Elazıg region was highly active against both gram-positive and negative bacteria. A study indicated that the ethanol extract of propolis which was gathered from different regions of Turkey, was not effective on *Klebsiella pneumonia* (clinical isolate) or *Morganella Morganii*, but strongly inhibited *E.coli* (gram-negative) [38]. Generally speaking, gram-positive bacteria were more sensitive to propolis than were gram-negative bacteria [39].

1.6 Solubility of Propolis

While difficult to resolve in organic solvents, propolis easily dissolves in alcohols [40]. Extracts of Turkish propolis collected from the Trabzon province were prepared with water, ethanol, glycerol, acetone and DMSO. Its total polyphenol and flavonoid context, Fe(III) reductive strength and total antioxidant status attributions were examined to identify the optimal solvent. Results showed that it dissolved most in the DMSO and least in the water. It wasn't sorted since the peaks clustered closely and tailing occurred during the solvation of ethanol, glycerol and acetone[41].

In the study of Karakaş, solubility of propolis was examined in corn oil, hazelnut oil, sunflower seed oil and olive oil, among which olive oil was identified the optimum, followed by corn oil, hazel nut oil and sunflower seed oil[42].

2 Conclusion

The long-term usage of propolis provides an advantage approach against harmful bacterial invasion[43]. Antibacterial effect of propolis has been examined in various studies. In general, records are about the medical benefits. There are many compounds in propolis. Phenols and flavonoids co-regulate the antibacterial activity. In the aid of the flavonoids, propolis not only inhibits gram (+) and gram (-) bacteria, but also benefits the bone structure by providing minerals, amino acids, esters etc. It is also used for treating human diseases such as cancer. Because of the vitamin E it contains, it shows a positive effect on skin lesions. Such a miraculous secretion has been drawing increasing attention and researches about it are emerging day by day.

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