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## PROPOLIS – BEEKEEPING MEDICINAL PRODUCT

### PROPOLIS – LECZNICZY PRODUKT PASIECZNY

#### Abstract

The paper presents the healing properties and biological activity of propolis, commonly known as bee glue. Propolis is a natural product collected by bees from buds of plants and bark of trees, then moistened with bee enzymes. Propolis is widely used for general treatment, skin affections, and as an anti-inflammatory agent for ulcers and hard-to-heal wounds. Propolis, due to its properties, is called an antibiotic of the 21<sup>st</sup> century.

*Keywords: propolis, apitherapy, medicinal properties*

#### Streszczenie

W artykule zostały zaprezentowane lecznicze właściwości oraz biologiczna aktywność propolisu, powszechnie znanego jako kit pszczeli. Propolis to naturalny produkt, który jest zbierany przez pszczoły z pączków kwiatów i kory drzew, a następnie zostaje zwilżony wydzieliną, pochodzącą z gruczołów pszczoły. Propolis znajduje szerokie zastosowanie w ogólnym leczeniu, w schorzeniach skóry oraz jako środek przeciwwzapalny na owrzodzenia i trudno gojące rany. Ze względu na swoje właściwości propolis nazywany jest antybiotykiem XXI wieku.

*Słowa kluczowe: propolis, apiterapia, lecznicze właściwości*

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## 1. Introduction

Products of natural origin are at present a promising source of new discoveries in the field of pharmacy. Propolis, also known as bee glue, is an adequate example due to its properties, which are utilized by bees. The word 'propolis' derives from Greek *pro* – 'for' or 'in defence of' and *polis* – 'city', that is 'defence of a city' (in this case 'defence of a beehive'). It is a substance used to strengthen the construction of the beehive, as well as to protect and insulate its inside against the expansion of microbes. It also constitutes a binding material for both attaching a honeycomb to frame walls and repairing any damages to the beehive. Bees apply bee glue to polish and disinfect cell insides in honeycombs before laying new eggs, and also eliminate intruders inside the beehive [1, 2].

Propolis is made by bees from tar-like and balsamic substances gathered from buds of some trees and bushes and from resin found in slots of tree bark. Propolis gathered by bees undergoes modification – during the process of formation bees moisten it with the secretion from their mandibular and hypopharyngeal glands and add small quantities of pollen and wax. In the final phase of its formation propolis constitutes a sticky resin-balsamic substance whose colour varies between green, red, and dark brown. It possesses a specific scent, demonstrates sticky properties, and is characterized by non-homogeneous and varied chemical composition dependent on numerous factors, such as the type of plant of origin (poplar, birch, coniferous trees). Bee glue is obtained by careful scraping of places where frames contact the beehive, of frames themselves, and of bars of frame or brood frames. As much as 50g of pure raw material can be obtained from one beehive. Its production can be increased by leaving more slots and more empty spaces. Also special bee glue traps are used [3–7].

## 2. Chemical composition of propolis

Latest research has led to the identification of approximately 300 substances which are present in the chemical composition of propolis. These include among others polyphenols, flavonoids, phenolic acids, aromatic esters, phenylethyls, ketophenols, coumarins, lipid and wax substances, bioelements, vitamins, protein compounds and others. Thanks to such a varied chemical composition and a synergistic interaction of all microbiologically active substances propolis is characterized by numerous medicinal properties as well as an antiseptic, antifungal, bacteriostatic, astringent, anti-inflammatory and antioxidizing effect [5–7].

A high degree of similarity can be confirmed while analyzing in detail the chemical structure and quantitative composition of propolis chemical compounds coming from different sources. The same groups of compounds, that is sesquiterpenes, aromatic acids and flavonoids are present in all their varieties. Propolis is composed of 50% resinous substances, 30% bee wax, 10% volatile substances, 5% pollen, and 5% mechanical admixtures. According to literary sources, raw propolis contains on average 41% resins, 17% bee wax, 6% plant wax, 14% volatile substances, 10% tannic substances, and 14% mechanical admixtures (including 11% pollen) [1, 8]. According to research, the propolis originating from the temperate climate zone (Europe, Asia, North America), where bees gathered propolis primarily from leaf buds of various poplar species (*Populus sp.*), contained a high amount of aromatic acids,

aromatic esters, and flavonoid aglycones. The propolis also contained small amounts of such groups of compounds as aliphatic acids (including fatty acids), terpenes (and other volatile compounds), other aromatic compounds (including alcohols, ketones), hydrocarbons, amino acids, enzymes, sugars, vitamins and bioelements [9–12].

Of 25 aromatic acids present in propolis the most common ones are: caffeic, benzoic, ferulic, p-coumaric, 3,4-dimethoxycinnamic, isoferulic, and cinnamic. The content of caffeic, p-coumaric and ferulic acids in liquid ethanol extracts of propolis, total dry ethanol extract of the product ranged within 1.59–4.38% (on average 2.63%). The presence of p-coumaric acid was identified in the biggest amount (on average 1.98%), and ferulic acid in a smaller amount (on average 0.47%), whereas caffeic acid was present in the smallest amount (on average 0.18%). Another research show that 10 phenolic acids were identified in liquid ethanol extracts of propolis, including 4 derivatives of benzoic acid, such as protocatechuic acid and gentisic acid, as well as 6 derivatives of cinnamic acid, including caffeic acid, ferulic acid, and p-coumaric acid [13–17].

The most important aromatic esters comprise ethyl esters of cinnamic acid and caffeic acid as well as phenylmethyl ones of benzoic acid. Among 52 aromatic esters the most numerous ones include: caffeic acid phenethyl ester – phenethyl caffeate (CAPE), benzyl caffeate, 3-methyl-3-butenyl caffeate, benzyl coumaran, 3,3-dimethylallyl caffeate, benzyl ferulate, cinnamyl caffeate, 3-methyl-2-butenyl ferulate, benzyl cinnamate, and 3-methyl-2-butenyl caffeate. Pentenyl ferulate and caffeate were detected as well. The content of caffeic acid phenethyl ester in 15 liquid ethanol extracts of propolis ranged within 0.31–1.78% calculated as the extracts dry mass (on average 0.81%), whereas that of caffeic acid 1,1-dimethylallyl ester ranged within 0.17–1.08% calculated as the extract dry mass (on average 0.60%). The average content of both mentioned esters in the analyzed propolis extracts amounted to 1.41% [11, 14, 15, 18].

In the case of flavonoids encountered in the poplar propolis in the number of 79, the most important ones include: chrysin, pinocembrin, galangin, pinobanksin, pinobanksin-3-acetate, pinostrobin, tectochrysin, kempherol, apigenin, pinobanksin 3-butylate, quercetin, naringenin and acacetin. Moreover, propolis also contains the following: volatile compounds (geraniol, nerol, pharnezol,  $\beta$ -eudesmol, caryophyllene, patchulene), other aromatic compounds (coumaran, vanilla), hydrocarbons (eicosene, tricosene, pentacosene, hexadecanol), triterpene alcohols (fucosterol, stigmasterol), enzymes (amylases, esterases) and microelements (among others manganese, iron, silicon, magnesium, zink, selenium) [8, 14, 15, 17, 19].

### 3. Medicinal properties of propolis

Apitherapy (from Lat. *apis* – bee) consists in the medical use of bee products such as honey, propolis, pollen, royal jelly and bee venom. In the past this term was applied only in the case of treating rheumatic ailments with bee venom, however at present most bee-keeping products are apitherapeutic agents, among which propolis enjoys higher and higher recognitions [20, 21]. Medicinal properties of propolis have long been known to mankind. Ancient Assyrians and Egyptians took advantage of antiputrid properties of bee glue for embalming dead bodies, and Dioskurides, a Greek physician, recommended it as a suitable

antiulcerous and anaesthetic medicament, Hippocrates used it for treatment of wounds and liver conditions. In turn the Incas applied propolis as a fever reducing medication, whereas in the Middle Ages propolis was used to disinfect dwellings. Propolis is also known as the oldest medicament of the Slavic peoples. Propolis was placed on the official list of medicaments only in the 7<sup>th</sup> century [22–24].

Propolis displays antimicrobial activity as well as anaesthetic, replenishing, immunostimulating and anti-atherogenic properties. It is applied, among others, to treat diseases related to skin, oral cavity and teeth, nose and throat, lungs, circulatory system, digestive system, bones and joints, or female illnesses. Additionally, it possesses very good oxidizing properties [23, 25, 26] thanks to the big amounts of phenolic compounds and flavonoids in its content.

### 3.1. Antimicrobial properties and pharmacological synergism

Propolis extracts, i.e. liquid or concentrated substances free from waxes and mechanical impurities display an extensive antimicrobial activity covering aerobic bacteria, anaerobic bacteria, yeast-like fungi and moulds, viruses and pathogenic protozoa [10, 11, 27]. Microbes demonstrating a high sensitivity to propolis effects include among others staphylococcal species, streptococcus pyogenes, pathogenic mycobacteria, dermatophytes, viruses and mould fungi. According to current research it is believed that the efficiency of propolis constitutes the sum of actions of all microbiologically active components. It is known that bacteria rapidly develop resistance to pharmaceutical antibiotics since they generate antibodies and the applied antibiotic will not be effective when applied to following generations of bacteria. Propolis, however, is a combination of chemical compounds that generate a synergistic effect. Bacteria are not able to generate so many antibodies within one generation. Thus not possessing an adequate defence they all die. Some researchers call propolis the antibiotic of the 21<sup>st</sup> century [13, 28].

Concentrations of propolis extracts that inhibit development depend on the kind of pathogenic factor, as well as on the preparation method of the extract. They usually range between 0.005 mg/ml in the case of protozoa causing trichomoniasis or toxoplasmosis, 0.1 mg/ml in the case of influenza viruses and herpes simplex as well as fungi causing skin, hair and nail diseases, and as much as 3 mg/ml for anaerobic bacteria causing pathological changes within the oral cavity [29, 30]. Propolis displays an average activity impact in the case of streptococcus faecalis and *Candida* fungi. The activity of these fungi responsible for skin and mucous membranes diseases in the oral cavity and respiratory system is inhibited in the case of propolis extract concentration ranging from a few to as much as 40 mg/ml. On the other hand, enterobacteriaceae are usually destroyed in the concentrations of 10–80 mg/ml, which indicates a weak effect of propolis on this kind of microbes [11, 27, 31, 32].

Moreover, it appears that propolis enhances the effect of commonly applied antibiotics. Propolis in combination with commonly applied antibiotics (e.g. penicillin, streptomycin, neomycin) yields considerably better therapeutic effects since it increases the bacteriostatic activity in relation to staphylococci and coccobacilli. Synergism between propolis and antibiotics such as penicillin and streptomycin was confirmed in many experiments all over the world. Apparently substances extracted from propolis in combination with antibiotic substances have a considerably more powerful impact on microbes than when acting as separate constituents [3, 11, 31].

### 3.2. Propolis in the treatment of respiratory system diseases

Propolis is used to treat diseases of the respiratory system as it lowers the sensitivity of the bronchial mucous membrane to acetylcholine, which improves lung ventilation. Research works conducted by Masterov on two groups of the sick (each of approximately 40 people) with a chronic inflammation of the bronchi revealed that applying propolis led to a more powerful healing effect, e.g. by increasing tolerance when taking other medicaments, reducing the number of *dyspnoea attacks*, and their moderate intensity. Bee glue is also frequently applied to eliminate influenza viruses and all sorts of infections accompanying colds, it is highly effective in the treatment of angina, pharyngitis and a sore throat, or even chronic tonsillitis. It is also an efficient enhancing addition which inhibits the development of *Mycobacterium tuberculosis* during complex treatments. The elimination of the foci with skin tuberculosis, which is one of extrapulmonary tuberculosis forms, by applying propolis ointment proved to be an interesting discovery – this painless therapy resulted in better effects than in the case of applying other medicaments [11, 33–35].

### 3.3. Propolis in the treatment of digestive system diseases

Stomach ulcer occupies a special place among digestive system diseases. In the course of the disease *Campylobacter pylori* bacteria appear in the body. These are treated with antibiotics, which results in numerous side effects. However, the pathogenic bacteria die when exposed to the influence of propolis, which is completely safe for the body. Propolis forms a protective layer on the ulceration and contributes to the epithelial regeneration and, additionally, chemical compounds present in propolis stimulate the immune system. Moreover, propolis cures chronic stomach and intestinal inflammation, the symptom of which is e.g. diarrhoea. To illustrate this, research conducted on calves demonstrated that the ethanol extract of propolis applied to the animals is a useful medicament improving health and reducing diarrhoea symptoms [36, 37]. Propolis eliminates a yeast infection of the digestive system, cures the state of gall bladder inflammation and detoxifies liver and all of the body by removing toxins and heavy metals. In turn the preparation which is a combination of propolis and pollen taken by the sick with metabolic disorders possesses properties replenishing cells [11, 21, 25].

### 3.4. Propolis in the treatment of dental and oral cavity diseases

Propolis is also used in stomatology to cure bothersome periodontium diseases and the inflammation of oral cavity mucous membrane. Propolis ointment or tampons moistened with a strong propolis extract helped to remove complications resulting from tooth extractions (the so-called dry socket, which is characterized by acute pain after tooth extraction). Propolis preparations proved to be an effective anaesthetic medicament which additionally exhibits anti-inflammatory properties and reduces swelling and enhances wound healing in the oral cavity. Clinical research extended over years has confirmed biological harmlessness and versatility of propolis preparations. Interestingly, in some cases even a single application resulted in regeneration of the damaged epithelium [2, 38, 39].

### 3.5. Propolis in the treatment of skin diseases

An exceptionally successful therapeutic effect can be observed when propolis is used in the treatment of skin diseases, such as phlegmonous inflammation of the skin of bacterial aetiology, fungal inflammation, ulcerations, third and fourth degree burns, frostbites and mild bedsores. In the case of skin diseases treatment with the application of propolis is very easy and does not require complicated tools or preparations. As an example, it is sufficient to wipe minor wounds with a propolis preparation swab or put on a dressing, which makes it possible to conduct the treatment at home [11, 40].

Propolis preparations can be divided into two categories, i.e. for internal and external use, depending on various applications of propolis-based preparations with respect to a type of ailment. Table 1 illustrates various propolis preparations taking into account this division.

Table 1

**Medical propolis preparations for external and internal uses [11, 40]**

Preparations for external use	Preparations for internal use
1. Propolis concentrate	1. Propolis tincture
2. Propolis tincture	2. Propolis butter
3. Propolis ointment	3. Propolis royal jelly
4. Paraffin, vaseline and propolis ointment	4. Propolis water extracts
5. Honey propolizata	5. Propolis alcohol extracts
6. Propolis water extract	
7. Raw propolis	
8. Plasters or compresses	

### 3.6. Other applications of propolis

Some propolis preparations demonstrate therapeutic activity also in the case of treating a number of gynaecological ailments [38, 41]. Propolis has also been successfully applied in the treatment of virus-induced corneal inflammation. Another important property of propolis preparations is their immunostimulating and regulating activity, as they help in generation of antibodies by the organism and enhance the activity of macrophages. The effect of propolis on the immune system is confirmed by research works in which water extracts were applied, which resulted in a slower absorption of antigens in inflammation of the liver's surface, which in turn beneficially influenced immunization against virus-induced liver inflammation. In another experiment propolis preparations helped to regulate generation of antibodies against influenza viruses in the experimental animals [4, 25, 42].

Propolis is also an ingredient of numerous cosmetic products – creams, lipsticks, haircare products, toothpastes. It imparts antiseptic and anti-inflammatory properties to cosmetics, and inhibits skin ageing processes thanks to the capacity to intercept free radicals [11, 26].

#### 4. Conclusions

Versatile healing properties as well as biological and pharmaceutical activity of propolis contribute to an increase in its popularity in the treatment of many ailments and in prophylaxis. The only contraindication regarding the application of propolis is an allergic reaction to it, hence it is necessary to conduct a test trial before the first application of propolis in humans or animals. Allergy to this beekeeping product is not a frequently encountered phenomenon – it merely occurs in 0.25–0.8% of all cases, and in particular it refers to people allergic to bee stings. Apart from the possibility of an allergic reaction, there has not been noted any case of a worsening health condition [20, 25].

It should be pointed out that not every bee glue demonstrates a healing value, as sometimes it appears to be completely useless. For medical purposes one should select the bee antibiotic only from renowned apiaries with a confirmed biological value. Products from unknown sources may contain impurities of various sorts. Propolis maintains its unique properties for approximately 4 years, but it displays the highest biological activity within the first 18 months. On the other hand, other research works on the extended storage of propolis extracts in an alcohol solution revealed an increased bacteriostatic and bactericidal activity even after 15 years of storage [3, 7, 43].

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