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Therapeutic Properties and Composition of Propolis

Smruti Nayak[1] , Lovleen Marwaha[2*] & Kumari Priya[3]
[1,2&3] Department of Zoology, School of Bioengineering and Biosciences,
Lovely Professional University, Punjab

*Corresponding Author**: Dr.Lovleen Marwaha**

Abstract: Propolis is a naturally occurring resin that honeybees gather from a variety of plant sources such as Baccharis dracunculifolia, Dalbergia ecastaphyllum, birch, poplar etc. Because of its unique chemical composition and remarkable medical properties, propolis has garnered a lot of interest. The bioactive components of propolis are the source of its antioxidative, anti-inflammatory, antibacterial, and immunomodulatory characteristics, making it a potential option for medicinal applications. All of these compounds work together to provide broad-spectrum antibacterial, anti-fungal, anti-viral and anti-cancer properties as well as wound treatment. With an emphasis on propolis's potential as a helpful natural medicine with possible impacts on human health, this brief paper aims to outline the chemical composition of propolis and its numerous therapeutic capabilities. Examining propolis's intricate chemistry, this paper highlights the polyphenols' existence, flavonoids, phenolic acids, and essential oils in propolis.

Keywords: Propolis, Honey bee, Antimicrobial, Anti-inflammatory, polyphenols.

Introduction

In the field of entomology, honey bees are among the most significant species, valued for their broad recognition, broad appeal, and substantial economic value. Honey bees are eusocial insects which involves altruistic acts, with sterile worker bees forgoing reproduction to support the queen, ensuring the colony's survival and success. This social insect builds huge colonies of between 20,000 and 80,000 individuals [1]. Queen, drones, and workers are the three different honeybee castes. Honeybees are efficient pollinators in addition to being one of the primary producers of honey. The honey bee is the most crucial pollinator for agricultural use. Honey bees are well known for producing large quantities of honey and storing it, as well as for their ability to construct durable wax colony nests [1]. Many animals, such as bears, honey badgers, and human hunter-gatherers, find honey bee hives to be very desirable feeding sites because of these characteristics. Honey bees can be maintained artificially in apiary and the process is called as apiculture. There are 20,000 distinct kinds of bees, but just eight species, including 43 subspecies, are classified as honey bees now, compared to seven to eleven species in the past. The black dwarf honey bee, Apis

andreniformis; the eastern honey bee, Apis cerana; the giant honey bee, Apis dorata; the red dwarf honey bee, Apis florea; the Koschevnikovi honey bee;The honey bee of the Himalayas, Apis laboriosa; Honey bee from west; and the honey bee from Philippine [2].

The different form or type of insect having a particular function live in the colony called the caste. There is a division of labour among the different type of castes. A good colony of honey consist of three castes queen, drone and worker.

The royal jelly is used by the worker bee to choose the queen. Because they continually grow to be larger than before, queens are separated into larger chambers. They can take up to 16 days to develop in terms of all morphological, physiological, and behavioural traits. Being able to hold onto sperm renders her the sole fertile female. The sting of a queen bee is not nearly as effective as that of a worker bee, and it lacks the glands that produce beeswax [2]. In "basic" social clusters, queen supremacy is maintained via aggressive physical interactions; in more complex insect communities, pheromones play a role. Worker bee is fertile but the drones are parthenogenetically produced [1].

Workers in bee colonies are infertile females, with the exception of a specific African subspecies (A. m. capensis) that can only lay haploid male eggs [3]. Ranging from 80 to 110 mg, they possess specialized morphological features, like wax glands, pollen basket etc for their survival [2]. These roles encompass tending to the brood, constructing the nest, and utilizing their lengthy proboscis for foraging nectar and pollen [2]. Although workers have ovaries, these are significantly smaller than the queen's, comprising a single pair with fewer than 20 ovarioles each. In the presence of the queen, workers often refrain from egg-laying [2]. Their lifespan is approximately 6 weeks, during which they dedicate their entire existence to maintaining the hive and caring for its inhabitants.

Drones are the colony's male members. That are created from unfertilized eggs and are haploid genetically [1]. They are larger than workers and queens. Drones are capable of producing five to ten million sperm. The development of a drone from an egg to an adult takes a day [4]. They are entirely dependent on the workers for nourishment because they lack a system for gathering food (pollen and nectar). The development of drones (24 days) is longer than that of queens and workers [5].Fertilization of the queen is the drone's primary job. They also aid in keeping the hive warm, which is essential for the egg to hatch.

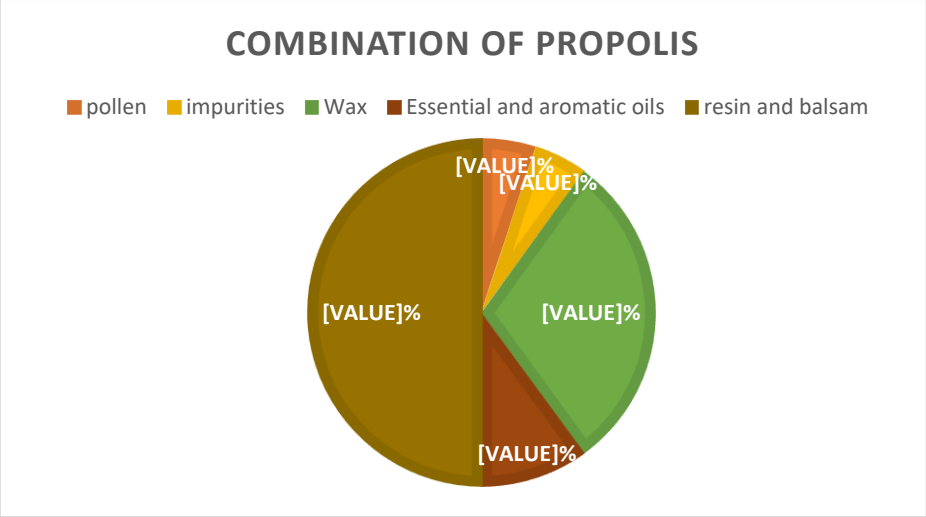
Propolis

The Greek word "propolis" suggest "in front," whereas "polis" means "city." This together evokes the feeling of being "in front of the city," that perfectly captures the defensive function of it in the hive [6]. Other names for propolis include propóleos, bee glue, bee propolis, hive dross, propolis balsam, propolis cera, propolis wax etc[6]. Apis mellifera gathers a sticky material called propolis from different tree buds, which they subsequently utilize to varnish hive components and fill hive gaps and fissures [7]. The hue might be light or dark brown, cream,

yellow, green, or brown. While some samples are pliable and gooey, others may be friable and rigid [8]. Bee glue, sometimes referred to as propolis, is gatheredfrom severalspecies of tree like Baccharis dracunculifolia, Dalbergia ecastaphyllum, palm, birch, pine, alder, poplar, willow.

Propolis is produced by combining components from various plant sections with salivary secretions from a bee collection. The dawn of time, man has utilised propolis for a variety of functions, including as an antibacterial, antioxidant, anti-inflammatory, and adhesive as well as to seal fissures and safeguard wooden and other surfaces. Propolis is used by the bees to repair damaged combs, reinforce the frail comb borders, and weatherproof or make simpler to defend the hive entrance. Another purpose for propolis is as an "embalming" material to conceal the remains of colony invaders that the bees have killed which are unable to remove from the hive.Investigations have shown that its effects may be due to its complex ingredients' synergistic activity [9]. Polyphenols, terpenes, esters, amino acids, vitamins, minerals, and sugars are among the organic substances that have been found in propolis.Brazilian propolis is widely utilized in food and drink products to preserve or enhance human health [10]. This resin has salivary enzymes, and the resulting partly digested substance is combined with beeswax and utilised in the hive [11].Honeybees gather resin from the leaf buds and crevices in tree bark [9].

Bees employ a strategy of covering the carcass of an intruder, unable to be removed from the hive after being killed, with a combination of wax and propolis [12]. This method serves as a means for the bees to prevent the spread of contamination brought about by a deceased animal. Propolis, a complex resinous substance, consists of five percent pollen, five percent impurities, thirty percent wax, ten percent essential and aromatic oils, and fifty percent resin and balsam [12]. The composition is shown in fig.1. Propolis chemical composition varies significantly according to factors such as the proximity of diverse plant species to the hive, seasonal variations, light exposure, altitude, type of collector, availability of food, and the activity involved in propolis harvesting. Propolis sourced from different locations has been found to contain over 300 chemical components. Various plant substances, including lattices, gums, mucilage, and lipophilic components emitted by plants, are utilized by bees to create propolis. The specific chemical composition is determined by the plant source applied, and its biological effectiveness is closely tied to the local flora in the collection area [7]. Climate change has the potential to directly impact honey bee behaviour and physiology, modify the quality of the floral environment, influence a colony's honey production capacity, and encourage the formation of new competitive relationships [13].



Fig;1 The above pie chart shows propolis composition.

Propolis Chemical Composition

A wide range of compounds have been reported to be present in propolis, encompassing sugars, hydrocarbons, phenolics and their esters, terpenes, flavonoids, and mineral elements. From the years 2000 to 2012, a total of 241 compounds were newly uncovered[14]. The primary compounds identified were phenolics and terpenoids, known for their effective anti-inflammatory properties [15].

Phenolics: Bee wax is abundant in phenolpropanoids, consisting cinnamic acid, p-coumaric acid, caffeic acid, and ferulic acid, along with their derivatives [14]. Prenylated cinnamic acids, present in propolis, exhibit antibacterial properties. Phenylpropanoids such as cinnamic acid, p-coumaric acid, caffeic acid, and ferulic acid and their derivatives are notably seen in green propolis of Brazil [16]. In propolis originating from Kenya, two geranyl stilbenes, Schweinfurthin A and Schweinfurthin B,have been recognized. These compounds are exclusive to the plant Macaranga schweinfurthin, although Solomon Islands' propolis has been confirmed to contain 5-farnesyl-3'-hydroxyresveratrol [14]. Propolis from Kangaroo Island in Australia is particularly rich in stilbenes, especially prenylated stilbenes, indicating that the origin of stilbenes is not restricted to a limited number of plants.

Flavonoid: Flavonoids constitute the primary components of propolis, playing a pivotal role in determining the extent of temperate propolis synthesis. These compounds possess diverse effect, such as antiviral, antibacterial, and anti-inflammatory effects. Flavonoids fall into several categories, such as neoflavanoids, chalcones, dihydrochalcones, isoflavones, isodihydroflavones, flavones, flavanols, flavanones [17]. Furthermore, propolis has been found to contain two exceptionally rare flavonoid glycosides: flavone C-glycoside and isorhamnetin-3-O-rutinoside [17].

Terpenoids: While comprising only 10% of propolis's overall chemical makeup, volatiles are responsible for imparting the distinct resinous fragrance and contributing to some of its therapeutic qualities. Terpenoids, which make up the majority of the volatile components, havebiological properties such as antioxidant and antibacterial properties that help identify good propolis from subpar or false propolis. Sesquiterpenes, acyclic, monocyclic, and dicyclic monoterpenes have all been identified from propolis [14]. Thujenes, caranes, pinanes, fenchones, and camphene are the five groups that make up the dicyclic monoterpenes. The most prevalent chemical elements in propolis are sesquiterpenes, which can be divided as 4 groups: acyclic, monocyclic, dicyclic, and tricyclic [17]. Propolis has five primary diterpenes: cembrane, labdane, abietane, pimarane, and totarane. Pentacyclic triterpenes include lupane, ursane, and oleanane; tetracyclic triterpenes include lanostanes and cycloartane[17].

Sugar: Glucose, fructose, and sucrose are believed to originate from nectar and honey [14]. Another perspective proposes that they result from the hydrolysis of flavonoid glycosides in propolis. Additionally, mucilage, having various sugars, sugar alcohols, and acids, could be a feasible source of sugar in propolis [14].

Hydrocarbons: Hydrocarbons are the primary constituents of propolis; however, studies have shown the presence of fatty acids, steroids, alkanes, alkenes, alkadienes, monoesters, diesters, aromatic esters, and propolis variations from various regions, including Brazil, Egypt, and Anatolia [14]. This discovery highlights the fact that, in contrast to plant sources, bee genetics controls the composition of both propolis and comb waxes, in addition to bees being the producers of these waxes.

Therapeutic Properties and Health Applications of Propolis

Anaesthetic Properties: Due to its surface anaesthetic properties with limited penetration, propolis extract finds application in dental procedures. In experiments conducted by Paintz and Metzner, a combination of caffeic acid esters, along with compounds like 5,7-dihydroxyflavanone (pinocembrin) and 5-hydroxy7-methoxyflavanone (pinostrobin), as well as the complete extract, was employed to achieve comprehensive anesthesia. In the research, an ethanol propolis extract and certain isolated components exhibited nearly three times greater potency compared to the entire extract [12].

Antimicrobial Activity: The strongest anti-microbial activity among bee products is propolis. Propolis functions as a bactericidal agent, inhibiting bacterial cell division, destroying bacterial cytoplasm and cell walls, and halting protein production [17]. Bacteria such as Staphylococcus aureus, Escherichia coli, and Enterococcus species are considerably inhibited in their proliferation by propolis. Propolis ethanolic extracts were also shown as being more effective

towards gram-positive bacteria and less effective against gram-negative bacteria [17].Propolis has been believed to be the most potent antibacterial agent; it is found in high-altitude regions of Bulgaria and the North Caucasus [18]. The antibacterial activity is brought about by its active ingredients, which include flavonoids and aromatic compounds like caffeic acid. Artepillin C is more concentrated in propolis ethanolic extracts than in hexane preparations. These extracts also shown substantial antibiotic activity against MRSA S. aureus [19]. Research is being done on propolis, a substance that has antimicrobial properties [10].

Antifungal Activity: Propolis has demonstrated effectiveness in inhibiting the growth of numerous fungi. It has been discovered that propolis inhibits the growth of conidia in Aspergillus flavus and the aflatoxigenic fungus [20]. The human fungal diseases Candida albicans, Candida glabrata, and Aspergillus fumigatus were successfully eradicated by French propolis [21]. Out of the 26 constituents, pinocembrin, p-coumaric acid, and caffeic acid all exhibit anti-fungal activity [22]. It has been demonstrated that caffeine exerts antifungal effects on Helminthosporium carbon. Propolis has also shown promising results against Mycobacteria, Candida, Trichophyton, and Fusarium, among fungal fungus that infects skin [21].

Antitumoral Activity: It also possesses anti-protozoal properties against a range of protozoans that sicken humans and other animals. It also has anti-inflammatory qualities because flavonoids are included, which control the action of hyaluronic acid, myeloperoxidase, NADPH oxidase, and ornithine decarboxylase [21].Fatty acids (C7-C18 acids) and other substances including artepillin C and caffeic acid phenethyl ester (CAPE) are found in propolis [17]. These compounds support anti-angiogenesis, matrix metalloproteinase inhibition, cell cycle arrest, and disease prevention. They also age tumour cells, prevent DNA synthesis in tumour cells, and restrict activity of many lymphoid cells [17]. Propolis' combined action of its polyphenolic ingredients is what causes it to have an anti-tumour effect. By promoting programmed cell death and delaying the development of leucine, thymidine, and uridine into cancerous cells, propolis shows anti-tumouractivity [21].

Anticancer Activity: Propolis as a possible cancer therapy and prevention tool has piqued the interest of the oncology community. As a result, propolis has been shown to include a sum of components having anticancer qualities, like propolin A—C, artepillin C, phenethyl caffeate (CAPE) [23]. The red propolis demonstrated specific cytotoxicity against the human pancreatic cancer cell line PANC-1 [23]. Propolis methanol extract has also been investigated for possible use in human pancreatic cancer cell lines.

Antiprotozoal Activity: Propolis has antiprotozoal properties that can affect a wide range of protozoans, including Leishmania donovani, Trypanosoma cruzi, Giardia lamblia, Trichomonas vaginalis, etc. Chemicals like apigenin, caffeic acid, chrysin, moronic acid, protocatechuic acid, p-coumaric acid, and others may show antimicrobial action [21].

Antiviral Activity: The reason propolis has antiviral qualities is that it stops the viral protein coat and making the virus latent by use of the body's enzymes [24]. Propolis exhibits antiviral properties against many viruses, including coronavirus strains, rotavirus, pseudorabies virus, feline calicivirus, canine adenovirus type 2, bovine respiratory syncytial virus, and bovine viral diarrhoea virus[6].

Applications of Propolis: Propolis is purported to possess a spectrum of advantageous attributes, including anesthetic, anticancer, antifungal, antiulcer, astringent, spasmolytic, anti-inflammatory, and immunomodulatory properties. Its applications vary, with formulations such as creams and ointments being utilized for treating burns, skin conditions, ulcers, and wound healing. Different propolis formulations have been employed in the management of various ailments, encompassing laryngological issues, diabetes, gynaecological disorders, and asthma [17]. It has been incorporated into toothpaste and mouthwash formulations to address stomatitis and gingivitis [17]. The long-recognized antiviral qualities of propolis contribute to its multifaceted applications. Moreover, propolis and its preparations have demonstrated benefits in tissue regeneration, promoting dental pulp regeneration, hastening the repair of damaged cartilage, and enhancing ossification in artificially induced bone defects [17].

Conclusions

Many of the major chemical components of propolis, including phenolic acids, phenolic acid esters, flavonoids, and terpenoids,are assumed to be in charge of the chemical's biological effects. Propolis from numerous nations has more than 500 chemicals that have been discovered. Future studies should concentrate on how species and behaviour affect propolis, as well as feeding tests to pinpoint the origin of the plant component. Propolisexhibit many pharmacological potentials which includes antibacterial, antioxidant, antiprotozoal, hepatoprotective, antifungalproperties and many other. Propolis plays an essential role for maintaining human health as well as for veterinary care and animal husbandry. To achieve accurate pharmacological effects and ecologically friendly production methods, modern and efficient extraction procedures, non-toxic ES, and additives that increase extraction chemo selectivity are required.

Authors' Contribution

Smruti Nayak: Data curation, Formal analysis, Investigation, Writing – original draft.

Dr. Lovleen Marwaha: Editing, Conceptualization, Supervision, Validation, Writing-review and editing

Kumari Priya: Data collection, Interpretation.

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