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Assemblage of bee propolis from distinct regions, their chemical configuration, and regional variations: A review

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Abstract

Propolis is a sticky compound produced by honey bees and it consists the mixture of bee saliva, bee wax and other constituents of plants. As India has diverse floral diversity so every region has its own chemical composition in their propolis. Different studies have been reviewed and concluded with diversified constituents in propolis from different states of India. Then due to regional variations they were grouped in four regions of India (North, South, East, and West). This regional variability shows the chemical composition of propolis of each region with some variations in it, the reason behind the increase concentration of chemicals in each region is explained in North because of the presence of balsam content. In South and west due to richness in phenolic content. In East the flora made considerable difference. The health benefits and medicinal uses of chemical compounds present in propolis are also discussed. It is well known that propolis have anti-inflammatory, antioxidant, anticancer and anti-allergic properties, also it has various health implications related to the treatment of cancer or uterine diseases. Propolis itself consist immune booster power which increases immunity of the individual. Propolis is now used worldwide in medical sciences to produce antibiotics and more often research is done by scientists to treat viral diseases by using propolis as it contains antiviral properties.

Keywords: Propolis, regional variation, flavonoids, terpenoids, phenols

Introduction

Honeybees collect propolis, sometimes known as "bee glue," collected from different plants and mix it with saliva to create a wonderful natural compound "galangin". (Choudhari *et al.*, 2012 and Janani *et al.*, 2022)^[2, 7]. This resinous material has attracted a lot of interest because it can be used in both conventional medicine and cutting-edge scientific inquiry due to abundance of nutraceuticals present in it. Kumar *et al.*, (2011)^[12] and Zuhendri *et al.*, (2021)^[36]. Antimicrobial, anti-inflammatory, antioxidant, immunomodulatory, and wound-healing actions are some of the therapeutic effects attributed to propolis. Kapare *et al.*, (2019)^[9] and Sankaran *et al.*, (2023)^[28]. Location, climate, flora, and the local plant species accessible to the bees which perform a role in determining propolis composition. Naiket *et al.*, (2021)^[17] and Nalbantsoy *et al.*, (2022)^[18]. Regional variations in propolis composition and their effects on human health have been the subject of fascinating review thanks to this intrinsic heterogeneity. Thirugnanasampandan *et al.*, (2012)^[34] and Pant *et al.*, (2021)^[21]. India is a country full of cultural traditions and flora diversity and these aspects are the topic of this review study. Jayanthi & Kothai, (2017)^[8]. This study seeks to give a complete exploration of the chemical variety and possible health advantages of propolis by inspecting into the propolis gathered from various locations of India. Farag *et al.*, (2021)^[4], Saccardi *et al.*, (2021)^[27]. The propolises of bee have the potential to substantially boost the revenue of tiny meliponiculturists and provide added value nutraceuticals and functional food items. Zuhendri *et al.*, (2022)^[37]. Basic composition of bee consists:- Bee wax, resin, pollen, some essential oils and other compounds as seen in (Figure 1). (Kapare *et al.*, 2019 and Sharaf *et al.*, 2013)^[9, 29].

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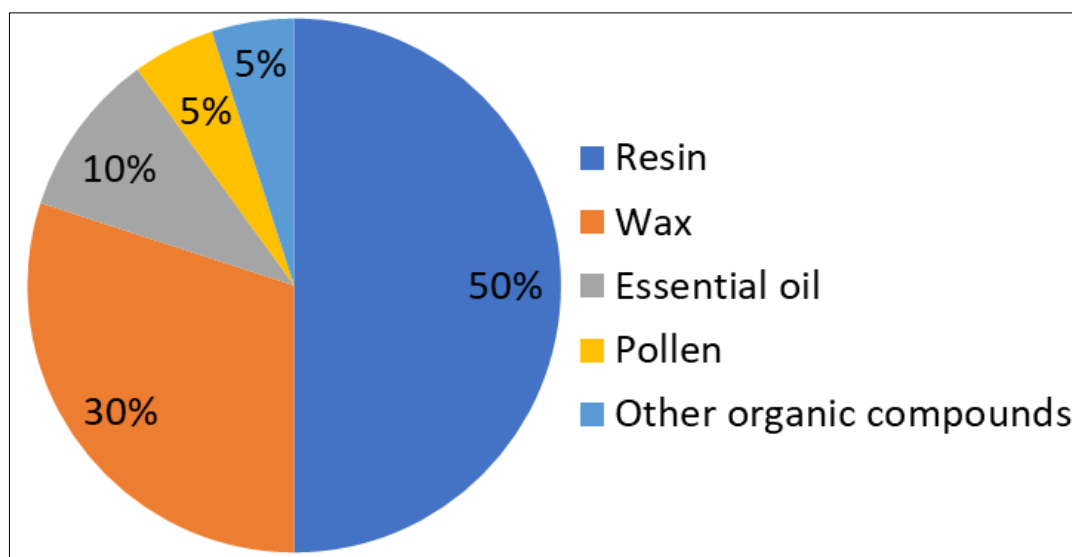


Fig 1: Chemical composition in bee propolis

Historical context

For millennia, India's traditional medical systems have included propolis for its presumed therapeutic benefits. Propolis, also known as "Dhamasa" or "Guggul," is used as a treatment for a number of conditions in Ayurveda as well as other indigenous medicinal practices Choudhari *et al.*, (2012) [2]. Traditional systems recognition of propolis cultural and therapeutic value is supported by its long history of use within them. Propolis is considered to be conducive as the beneficial effects on health have been mentioned in Ayurvedic texts, including its "Krimighna" (antiparasitic), "Vranaropana" (wound-healing), and "sandhanakaraka" (rejuvenating) qualities Kapare *et al.*, (2019) [9]. The widespread faith in its health-enhancing properties is reflected in the widespread use of its components in pharmaceutical preparations. Propolis has long been recognised as a remedy for a wide variety of health problems including skin, stomach, lungs, and teeth, according to conventional wisdom.

It is crucially important for contemporary research to be guided by an understanding of the historical background of propolis in Indian systems of traditional medicine Thirugnanasampandan *et al.*, (2012) [34]. The experiences and knowledge of ancient healers can shed light on the modern potential of propolis components. Researchers can find chemicals with therapeutic promise, verify traditional claims, and create evidence-based solutions to health and wellbeing by bridging the gap among traditional wisdom and modern scientific study. In addition to confirming conventional applications, historical context is crucial since it provides a basis for making educated choices in cutting-edge R&D. Propolis's chemical diversity and its significance to various health scenarios can both be better understood and better utilised if its use in different cultural contexts is investigated.

Current status and objectives

Propolis' wide variety of health benefits has led to a recent uptick in attention Kasote *et al.*, (2019) [11] and Zuhendri *et*

al., (2021) [37]. As a result of this renewed interest, scientists in India have begun conducting in-depth studies of the chemical components of propolis in an effort to determine its true therapeutic potential. Their inspection profound that the polyphenolic chemicals, flavonoids, and phenolic acids found in propolis are responsible for its powerful antioxidant activity (Kumar *et al.*, 2011) [12]. These bioactive ingredients helps to fight from free radicals, which can cause health problems due to oxidative stress.

Propolis anti-inflammatory properties releases some chemicals to suppress inflammatory enzymes and cytokines (Kapare *et al.*, 2019) [9]. This quality makes it a potentially useful tool in the treatment of inflammatory diseases. A variety of bacteria have been demonstrated to be resistant to Propolis by scientific investigation (Zuhendri *et al.*, 2021) [36]. This antibiotic resistance is important for the treatment and prevention of infectious diseases. Choudhari *et al.*, (2012) [2] found that propolis has immunomodulatory effects, means which stimulates and dampens the immune system in appropriate amounts. The possibility of using this special quality to treat immune-related diseases has attracted a lot of attention.

Overview of propolis collection practices

With regard to the chemical diversity seen in different propolis samples into context, it is important to understand the practices and procedures followed in collecting propolis from various parts of India. Propolis varies in its make-up based on the plant species and other ecological parameters in each region. Jayanthi & Kothai, (2017) [8]. For this study researchers scraped frames from *Apis mellifera* beehives in different locations across India: Haryana, Himachal Pradesh, Uttaranchal, Bihar, Arunachal Pradesh, Tamil Nadu, Karnataka and Kerala (Figure 2). Ramnath *et al.*, (2015) [25]. Unprocessed propolis samples were kept in the refrigerator until further testing could be done.

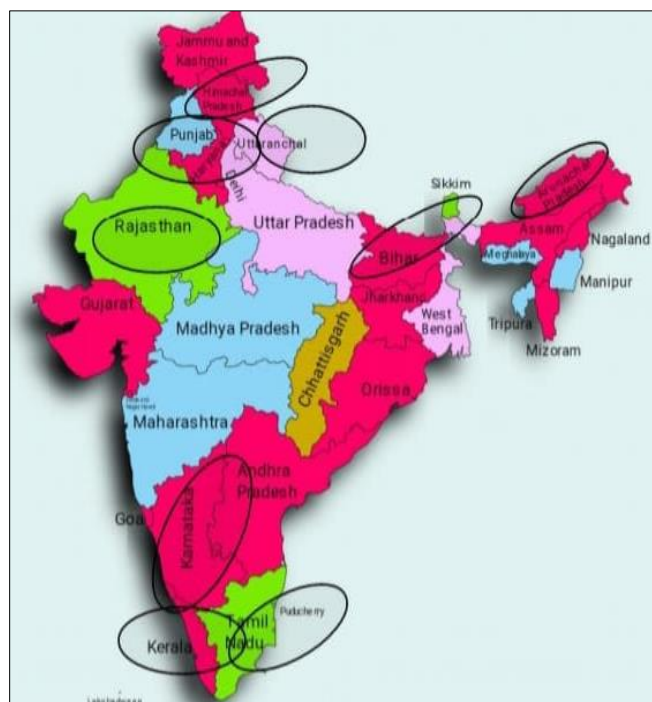


Fig 2: Samples from different regions

Collection and analysis of propolis sample

This study compiles and analyze information on chemical characteristics of Propolis samples gathered from various locations around India. For this reason, many chemical profiling techniques have been used in the past including GC-MS and HPTLC. Kasote *et al.*, (2019) ^[11] and Sankaran *et al.*, (2023) ^[28]. These studies reveal the complex matrix of chemicals responsible for propolis's wide range of uses. Samples are collected from different beehives and propolis trap of different states. Then extraction and grinding of propolis sample is done, further characterization is done on the basis of their fatty acid profile, amino acid profile, mineral profile, their thermal stability after that analysis is done. Identification of fatty acid profile is done with GC-FID method; Samples detected Linoleic acids presence in the sample. Pant *et al.*, (2022) ^[22]. Initial discovery of 17 amino

acids revealed that samples were predominately composed of tyrosine, glutamic acid, arginine, lysine, and aspartic acid. (Figure 2). The melting of fatty acids, particularly ceraalba and hexadecanoic acid, was demonstrated by large endothermic peaks in differential scanning calorimetry (DSC) at about 60 °C, while the vaporization of aromatic compounds was revealed by secondary peaks. Between 270 and 470 °C, thethermo gravimetric analyser (TGA) showed significant weight loss of propolis. The first three principal components showed 99.18% variation according to principal component analysis. Kumar *et al.*, (2021) ^[13]. All of the propolis samples were effectively categorized according to geographic locations using hierarchical cluster analysis. In the future, this study might help quality control organizations set nutritional and quality requirements for Indian propolis. Pant *et al.* (2022) ^[22].

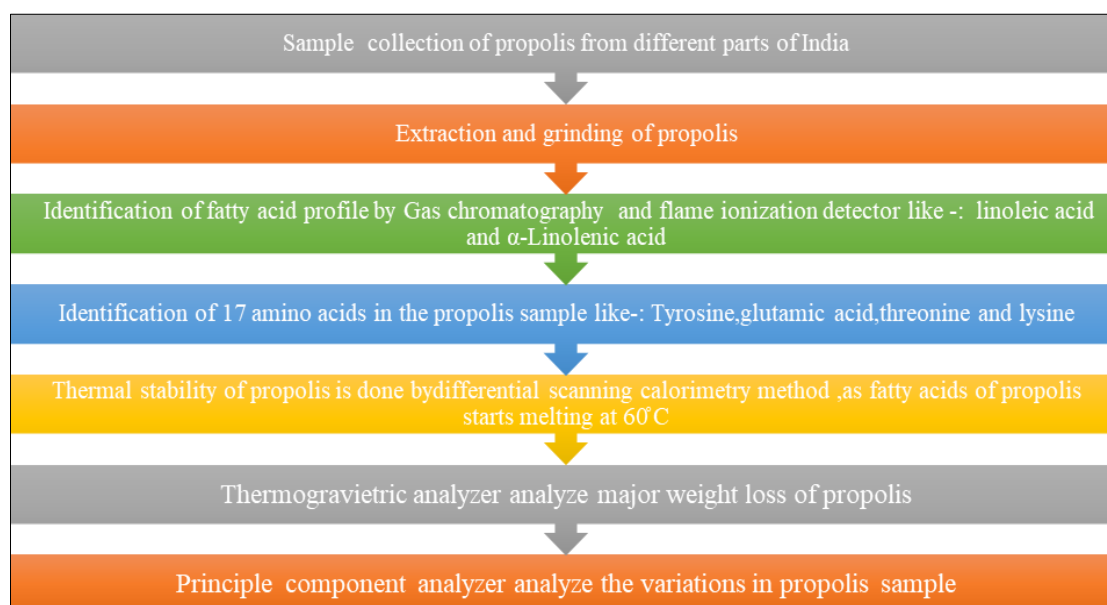


Fig 3: Whole process of sample analysis

Chemical composition of Indian propolis: We have emphasized propolis from different regions of India. This section examines the chemical substance of Propolis specimens from distinct parts of India. In order to better understand propolis complicated chemical composition, the goal is to uncover any regional variations in its chemical profile. Researchers have tabulated and emphasised the numerous phenolic acids, flavonoid compounds, and Terpenoids factors present for our convenience. Propolis of some temperate and tropical areas have different chemical constitution like Rajasthan, Some parts of Punjab and Haryana are high in phenol whereas J&K, H. P and Uttarakhand are rich in Flavonoids. Kumar *et al.*, (2021) [13]. Propolis from plants collects resins and exudates as a result of water availability, other environmental factors, and from different geographical regions exhibits diverse chemical compositions. The chemical makeup of propolis from temperate and tropical regions differs greatly (Kasote *et al.*, 2019) [11].

Regional variation in chemical profile

Northern India: Different states of northern India consist different compounds in their propolis. Himachal Pradesh, Haryana, Delhi, Uttar Pradesh have more amount of carboxylic acid and steroids present in their propolis. Himachal Pradesh and Haryana have highest amount of sugar in their Propolis sample. Jayanthi, & Kothai., (2017) [8]. The Propolis sample of Himachal, Haryana, Uttarakhand, Rajasthan lacked Lanosterol and ethyl oleate. Lanosterol is a fungal steroid used to treat cataracts (Prasad *et al.*, (2017) [23]. Northern India may account for the region's relatively high levels of particular phenolic acids and Flavonoids. (Figure 4). The amount of phenolic, p-coumaric acid derivatives, Terpenes, and lignin in tropical climates is particularly high Naik *et al.*, (2021) [17].

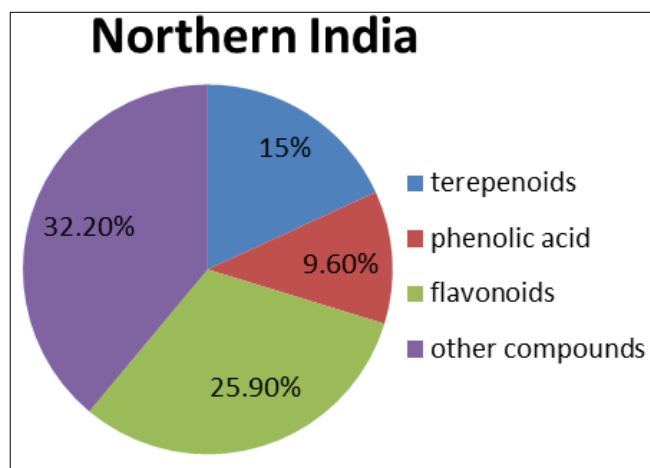


Fig 4: Graphical representation of chemical composition in North India

Southern India: Karnataka, Tamil Nadu have high amount of terpenoid and Polyphenolic content than other states and Karnataka and Uttaranchal have low amount of sugar in their propolis while Tamil Nadu and Kerala have low amount of sugar. D- Mannose is absent in propolis sample of Karnataka which is an important substrate to treat uterine diseases (Godhi *et al.*, 2022) [5]. Tamil Nadu, Kerala, Andhra Pradesh and Telangana found a new compound in their propolis papaveroline which is a source of papaver and withania

species papaveroline is present in opium, also used in medical science. Falcarinol is a compound present of Tamil Nadu which is known as carotoxin. Different southern states have different Terpenoids content (Teggar *et al.*, (2023) [33]. Lupeol is present in samples with a moderately high Flavonoids concentration. Samples with little Flavonoid content the Lupeol wasn't present at all. (Figure 5) (Kumar *et al.* 2011) [12].

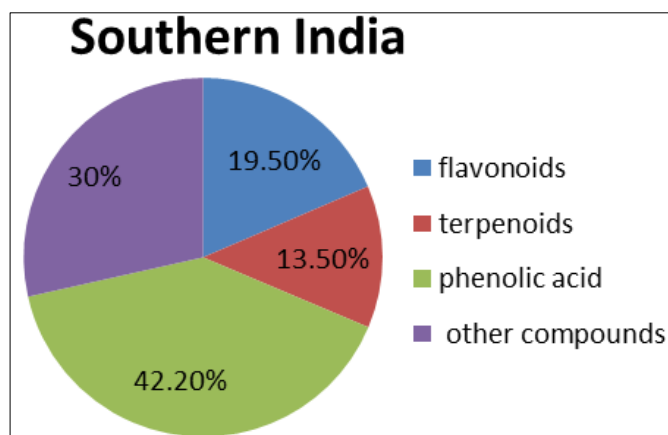


Fig 5: Graphical representation of chemical composition in South India

Eastern India: In eastern states like Assam, Arunchal Pradesh, Meghalaya, Mizoram and Tripura have moderate amount of Flavonoids in their propolis. Assam and Tripura have high amount of polyphenol present in their propolis. Meghalaya and Mizoram have low amount of sugar and Terpenoids in their propolis (Chanu *et al.*, 2018) [1]. As seen in the chart, Eastern states have more amounts of other compounds than these main constituents in a propolis. These states have low count of Terpenoids in their propolis. This is because of change in environmental conditions (Figure 6).

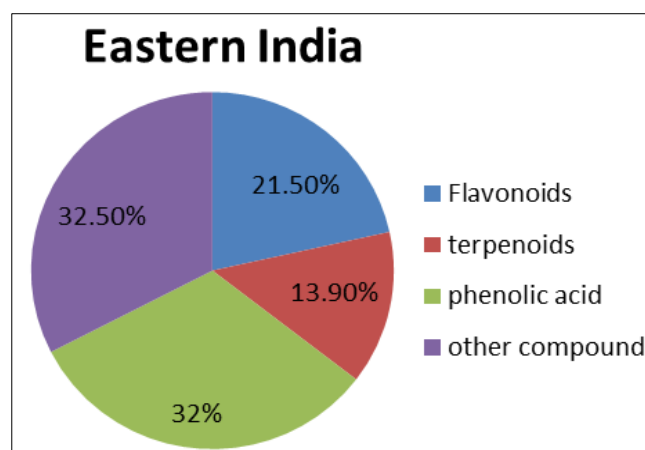


Fig 6: Graphical representation of chemical composition in East India

Western India: In western states, Goa, Gujarat, Maharashtra have highest amount of phenolic acid present in their propolis whereas Daman and Diu have low amount of phenolic acid present in their propolis. Gujarat and Maharashtra have moderate amount of Flavonoids and Terpenoids present in their propolis. The other compounds like carboxylic acid, Lupeol and Linoleic acid are highly present in their propolis (Riaz, 2019) [26]. In Western Region equilibrium can be seen in

other bioactive compounds. But the Western States of India have more count of phenols in their propolis (Figure 7).

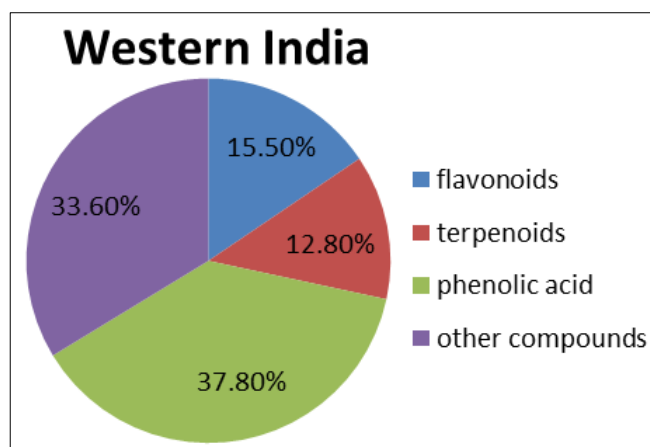


Fig 7: Graphical representation of chemical composition in West India

When we make an attempt of collecting propolis from different parts of India, we will find that the composition of its chemicals varies significantly. These differences are attributable to the diverse types of flora present in various areas Jayanthi & Kothai., (2017) [8]. Propolis contains a wide variety of bioactive chemicals due to the dynamic interplay between honeybee feeding patterns and area vegetation. Given the rich flora of the area, this may cause propolis to exhibit heightened antioxidant qualities that complement the local flora Nayak *et al.*, (2023) [19]. On the other hand, the particular plant species native to Southern India's propolis may yield a varied ratio of Terpenoids. It is possible that the regional plant kingdom is reflected in the propolis's antibacterial properties because to the presence of these Terpenoids (Kasote *et al.*, 2019) [11]. It's possible that the Eastern region has a unique chemical profile, with its own phenolic compound and Flavonoids blend standing out. Because of the wide variety of plants in this area, propolis from this location may have unique anti-inflammatory properties Shubharani *et al.*, (2019) [30]. The propolis of Western India may also have a complex makeup, with a nice equilibrium of phenolic acids and other bioactive components. These factors, along with the local flora, may explain the outstanding therapeutic potential of Western Indian propolis Choudhari *et al.*, (2012) [2]. Even traditional therapies and alternative therapies can be informed by the unique chemical profiles of propolis from different regions. If we have a clear grip on the chemical compositional distinctions between the propolis of different regions, we can learn more about the potential medicinal uses and benefits of each.

Health implications and applications

The complex chemical makeup of Indian propolis suggests it may have multiple beneficial effects on human health. Due to the great variety of therapeutic possibilities presented by its complex blend of bioactive compounds, propolis is enjoying rising popularity in conventional medicine and scientific investigation. The Flavonoids and phenolic found in Indian have been shown to have antibacterial effects (Kasote *et al.*, 2019) [11]. When it comes to treating bacterial infections, this antibacterial capability is invaluable. Because of its effectiveness against so many different types of bacteria,

propolis may serve as a safer alternative to synthetic antibiotics (Machado *et al.*, 2016) [15]. Propolis's complex make-up includes antiviral characteristics which perform inhibitory actions against viruses. These inhibitory actions have been observed in several propolis compounds, suggesting they may be useful in the treatment or prevention of viral infections (Zulhendri *et al.*, 2021) [36]. Due to widespread fear of virus epidemics, this quality is essential because of its high concentration of phenolic chemicals, which indicate propolis as a potent antioxidant (Ramnath *et al.*, 2015) [25]. These antioxidants are essential because they eliminate dangerous free radicals, which may reduce the severity of oxidative stress-related illnesses and chronic diseases. Propolis may be useful in the treatment of inflammatory illnesses due to the presence of anti-inflammatory chemicals including Flavonoids (Kapare *et al.*, 2019) [9]. Propolis may provide a natural way to treat a variety of inflammatory disorders by regulating the body's inflammatory response because of the presence of specific components of propolis which can modulate the immunological response (Choudhari *et al.*, 2012) [2]. These features have potential uses in boosting immunity and treating autoimmune diseases. Despite the compelling health implications of the chemicals in Indian propolis, its prospective applications are still being elucidated through continuing studies and clinical trials. Its potential as an adjunctive treatment for a variety of conditions is now being investigated; they include wound healing, oral health, and even cancer (Kapare *et al.*, 2019) [9] and (Thirugnanasampandan *et al.*, 2012) [34]. There is hope for propolis potential to be translated into practical therapies if it is incorporated into a variety of formulations such lotions, ointments, or nutritional supplements (Kasote *et al.*, 2019) [11]. Due to the delicate equilibrium of its bioactive ingredients, it may be able to improve several different aspects of health simultaneously. This review will focus on clarifying the potential health advantages of individual propolis components. Terpenoids are antibacterial, whereas Flavonoids are antioxidant and anti-inflammatory (Janani *et al.*, 2022) [7].

Chemical and biological makeup of propolis

Recent study has deepened our familiarity with the chemical and biological makeup of propolis from a variety of geographic contexts. Algerian propolis' antibacterial efficacy against food borne microorganisms was studied by Nedji and Loucif-Ayad (2014) [20]. Their research supported the widespread cultural belief that propolis can fight off microbial illnesses. Polish propolis was the subject who elucidated its chemical and biological properties (Woźniak *et al.*, (2022) [35]. Their study showed that propolis contains a wide range of compounds, including polyphenol, Flavonoids, and Terpenoids, all of which contribute to its usefulness. *In vitro* investigations on the cytotoxicity of Indian bee propolis on cancer cell lines were undertaken by Shubharani *et al.*, (2014) [31]. Their findings bolster the case for future study into propolis' apoptotic and anticancer properties and demonstrate its potential as an adjuvant therapy in cancer treatment. The importance of propolis to the Indian beekeeping industry was recently highlighted by Kasote (2017) [10]. The research highlighted the potential economic significance of propolis and the necessity for thorough examination of the substance to fully realise its health advantages and commercial potential.

The anti-inflammatory benefits of the essential oil of Indian

propolis have been investigated by Naik *et al.*, (2013) ^[16] and Naik *et al.*, (2021) ^[17]. Their results show that propolis' anti-inflammatory capabilities may be useful in treating inflammatory diseases and immune-related disorders. The antioxidant potential of Indian propolis was studied by Ramnath and Venkataramgowda in 2016 ^[24]. Their findings further demonstrated the promise of propolis in ameliorating the health effects of oxidative stress. The benefits of propolis as a nutritional element were examined by Irigoiti *et al.*, (2021) ^[6]. Because of its high bioactive content and possible health benefits, propolis is increasingly being used into food products. Incorporate findings from Shubharani *et al.*, (2014) ^[31] and Kasote 2017) ^[10] into the "Health Benefits and Therapeutic Potential" section to emphasise propolis's numerous applications, such as its potential as an adjuvant therapy in cancer treatment and its economic value in beekeeping. The anti-inflammatory activities of propolis and their possible implications in immune-related illnesses are discussed further in the section under "Immunomodulatory and Anti-Inflammatory Properties," where the research of Naik *et al.*, (2013) ^[16] and Naik *et al.*, (2021) ^[17] is incorporated. Include the research from Ramnath and Venkataramgowda (2016) ^[24] and Irigoiti *et al.*, (2021) ^[6] in the section under "Antioxidant Activity and Functional Food Applications" to further emphasise propolis' antioxidant potential and its rising reputation as a functional food ingredient.

Reason behind why the chemical compounds of propolis have increased concentration in different regions.

The other compounds like -: pinocembrin, galangin, caffeic

acid and its esters are more in northern India as recent studies shows that propolis of northern states consist highest balsam content (47.66%), protein and wax content (Pant *et al.*, 2021) ^[21]. Southern states have more phenolic compound in their propolis as they found that in comparison to ethanol extract, water produces higher levels of total phenolic components and antioxidant activity (Sulaeman *et al.*, 2019) ^[32].

Due to environmental factors, the extraction process, and the equilibrium of phenolic acids with other bioactive components, Western States of India have more phenolic compounds in their propolis (Woźniak *et al.*, 2022) ^[35]. India's eastern states contain higher levels of other chemicals like polyphenols. Eastern states' propolis may offer special anti-inflammatory qualities because of the region's diverse flora (Nayak *et al.*, 2023) ^[19].

Terpenoids present in propolis have medicinal and cosmetic use:- Terpenoids treat acne skin and also used produce Anti-fungal drugs, Anti-bacterial drugs and also used as disinfectant against many wounds (Pant *et al.*, 2021) ^[21] (Figure 8).

Flavonoids also plays a significant role in medicinal sciences and cosmetics. Due to the inclusion of phenolic acids (caffeic acid), Terpenes, and flavonoids (pinocembrin and pinobanksin), propolis-based skin care products are effective against skin fungus issues (Kurek *et al.*, 2020) ^[14].

Phenolic compounds found in propolis have antioxidant and free radical-scavenging properties, and when they enter the upper and lower layer of skin, they help to protect the skin from oxidative stress that can damage skin tissue and cause premature aging of the skin (Žilius *et al.*, 2013) ^[38].

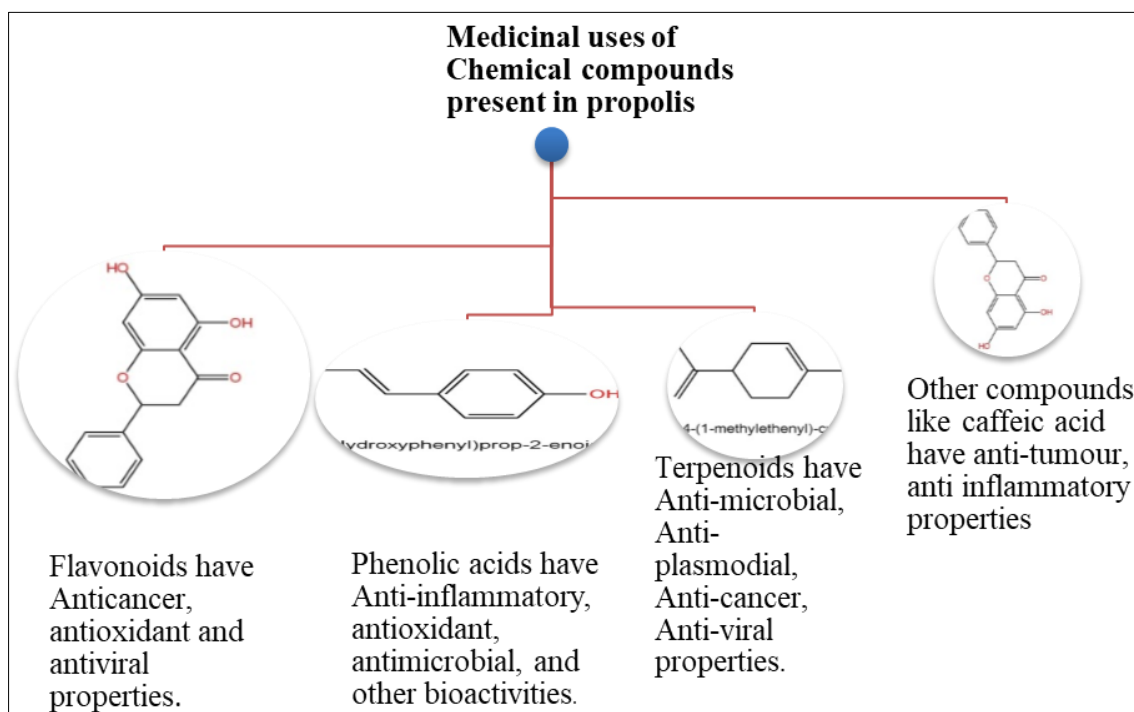


Fig 8: Medical uses of chemical components

Conclusion

Finally, the fascinating tale of chemical complexity and therapeutic potential in propolis collected from different parts of India is revealed. This in-depth analysis deftly connects the dots between the past, current studies, and the unique regional

variations that characterise Indian propolis. Propolis deep historical roots in Indian traditional systems of medicine have given modern studies a wealth of nuance. Since it has been discovered, propolis is being focused on both admiration and curiosity, inspiring new research that helps to bridge the gap

between traditional medicine and cutting-edge science. Propolis is currently in the limelight, and scientists are investigating its many uses. Researchers in India are dedicated to unlocking the secrets of this natural wonder by studying its antioxidant, antibacterial, anti-inflammatory, and immunomodulatory properties. Visiting several parts of India has revealed a colourful mosaic of regional variation in propolis composition, from the north to the south to the east to the west. These differences, which are inextricably related to the unique floral communities found in each area, are evidence of the honeybee's ability to coexist with its environment. There are several potential medicinal applications hidden within the complex structure of propolis components. Propolis appears as a multifunctional compound on the way to holistic health, with antibacterial and antiviral property. Propolis shines as a light of hope in contemporary medicine as on-going study closes the gap among laboratory findings and clinical applications. The final act of this review sets the stage for propolis to step out of the shadows and into the centre of scientific attention. Indian propolis has a rich cultural history, a wide range of chemical constituents, and significant health implications that point to a future where ancient and contemporary cultures meet to move us towards new frontiers in wellness and therapeutic innovation.

References

1. Chanu KV, Leishangthem GD, Srivastava SK, Thakuria D, Kataria M, Telang AG. Phytochemical analysis and evaluation of anticancer activity of Parkia javanica seeds. *The Pharma Innovation*. 2018;7(5, Part E):305.
2. Choudhari MK, Punekar SA, Ranade RV, Paknikar KM. Antimicrobial activity of stingless bee (*Trigona* sp.) propolis used in the folk medicine of Western Maharashtra, India. *Journal of ethno pharmacology*. 2012;141(1):363-367.
3. Daffalla KA, Mahmoud AS. Propolis as a natural remedy. *Journal of International Oral Health*. 2016;8(5):646.
4. Farag MR, Abdelnour SA, Patra AK, Dhama K, Dawood MA, Elnesr SS, *et al.* Propolis: Properties and composition, health benefits and applications in fish nutrition. *Fish & Shellfish Immunology*. 2021;115:179-188.
5. Godhi BS, Beeraka NM, Buddi JSHP, Mahadevaiah S., Madhunapantula SV. Updates in the Analytical Isolation of Indian Propolis Chemical Constituents and Their Role in Dental Pharmacology-A Review. *The Natural Products Journal*. 2022;12(7):77-88.
6. Irigoiti Y, Navarro A, Yamul D, Libonatti C, Tabera A, Basualdo M. The use of propolis as a functional food ingredient: A review. *Trends in Food Science & Technology*. 2021;115:297-306.
7. Janani D, Lad SS, Rawson A, Sivanandham V, Rajamani M. Effect of microwave and ultrasound-assisted extraction methods on phytochemical extraction of bee propolis of Indian origin and its antibacterial activity. *International Journal of Food Science & Technology*. 2022;57(11):7205-7213.
8. Jayanthi B, Kothai S. Chemical characterization of ethanolic extract of propolis of stingless bees collected from four different districts of Tamil Nadu in India. *J Chem. Chem. Sci*. 2017;7(12):1170-1178.
9. Kapare H, Lohidasan S, Sinnathambi A, Mahadik K. Standardization, anti-carcinogenic potential and biosafety of Indian propolis. *Journal of Ayurveda and integrative medicine*. 2019;10(2):81-87.
10. Kasote DM. Propolis: A neglected product of value in the Indian beekeeping sector. *Bee World*. 2017;94(3):80-83.
11. Kasote DM, Pawar MV, Gundu SS, Bhatia R, Nandre VS, Jagtap SD, *et al.* Chemical profiling, antioxidant, and antimicrobial activities of Indian stingless bees propolis samples Indian. *Journal of Apicultural Research*. 2019;58(4):617-625.
12. Kumar MR, Bose VSC, Sathyabama S, Priyadarisini VB. Antimicrobial and DPPH free radical-scavenging activities of the ethanol extract of propolis collected from Indian *Journal of Ecobiotechnology*. 2011;3(1).
13. Kumar M, Prakash S, Radha Kumari N, Pundir A, Punia S, Saurabh V, *et al.* Beneficial role of antioxidant secondary metabolites from medicinal plants in maintaining oral health. *Antioxidants*. 2021;10(7):1061.
14. Kurek-Górecka A, Górecki M, Rzepecka-Stojko A, Balwierz R, Stojko J. Bee products in dermatology and skin care. *Molecules*. 2020;25(3):556.
15. Machado BAS, Silva RPD, Barreto GDA, Costa SS, Silva DFD, Brandao HN, *et al.* Chemical composition and biological activity of extracts obtained by supercritical extraction and ethanolic extraction of brown, green and red propolis derived from different geographic regions in Brazil. *PloS one*. 2016;11(1):e0145954.
16. Naik DG, Mujumdar AM, Vaidya HS. Anti-inflammatory activity of propolis from Maharashtra, India. *Journal of Apicultural Research*. 2013;52(2):35-43.
17. Naik RR, Shakya AK, Oriquat GA, Katekhaye S, Paradkar A, Fearnley H, Fearnley J. Fatty acid analysis, chemical constituents, biological activity and pesticide residues screening in Jordanian propolis. *Molecules*. 2021;26(16):5076.
18. Nalbantsoy A, Sarıkahya NB, Özverel CS, Barlas AB, Kırıcı D, Akgün İH, *et al.* Chemical composition and biological activities of Cypriot propolis. *Journal of Apicultural Research*. 2022;61(2):233-245.
19. Nayak G, Sahu A, Bhuyan SK, Bhuyan R, Kar D, Kuanar A, *et al.* A comparative study on antioxidant activity of propolis ethanolic extract and oil from different agroclimatic regions of Eastern India. *Biocatalysis and Agricultural Biotechnology*. 2023;50:102685.
20. Nedji N, Loucif-Ayad W. Antimicrobial activity of Algerian propolis in foodborne pathogens and its quantitative chemical composition. *Asian Pacific Journal of Tropical Disease*. 2014;4(6):433-437.
21. Pant K, Thakur M, Chopra HK, Nanda V, Ansari MJ, Pietramellara G, *et al.* Characterization and discrimination of Indian propolis based on physico-chemical, techno-functional, thermal and textural properties: A multivariate approach. *Journal of King Saud University-Science*. 2021;33(4):101405.
22. Pant K, Thakur M, Chopra HK, Dar BN, Nanda V. Assessment of fatty acids, amino acids, minerals, and thermal properties of bee propolis from Northern India using a multivariate approach. *Journal of Food Composition and Analysis*. 2022;111:104624.
23. Prasad K, Haq RU, Bansal VASUDHA, Siddiqui MW, Ilahy R. Carrot: Secondary metabolites and their prospective health benefits. In *Plant Secondary Metabolites, Volume Two*. Apple Academic Press;

- c2017. p. 133-220.
24. Ramnath S, Venkataramgowda S. Antioxidant activity of Indian propolis-An *in vitro* evaluation. International Journal of Pharmacology, Phytochemistry and Ethnomedicine. 2016;5:79-85.
 25. Ramnath S, Venkataramgowda S, Singh C. Chemical composition of bee propolis collected from different regions in India by GCMS analysis. International Journal of Pharmacognosy and Phytochemistry. 2015;30(1):1319-1328.
 26. Riaz S. Antimicrobial Activity of Propolis Extract on Microorganisms (Doctoral dissertation, CAPITAL UNIVERSITY); c2019.
 27. Saccardi L, Schiebl J, Weber K, Schwarz O, Gorb S, Kovalev A. Adhesive behavior of propolis on different substrates. Frontiers in Mechanical Engineering. 2021;7:660517.
 28. Sankaran S, Dubey R, Lohidasan S. Optimization of Extraction Conditions using Response Surface Methodology and HPTLC Fingerprinting Analysis of Indian Propolis. Journal of Biologically Active Products from Nature, 2023;13(1):76-93.
 29. Sharaf S, Higazy A, Hebeish A. Propolis induced antibacterial activity and other technical properties of cotton textiles. International Journal of Biological Macromolecules. 2013;59:408-416.
 30. Shubharani R, Mahesh M, Yogananda Murthy V. Biosynthesis and characterization, antioxidant and antimicrobial activities of selenium nanoparticles from ethanol extract of Bee Propolis. J. Nanomed. Nanotechnol. 2019;10(2).
 31. Shubharani R, Sivaram V, Kishore BR. *In-vitro* cytotoxicity of Indian bee propolis on cancer cell lines. International Journal of Pharma and Bio Sciences. 2014;5(4):698-706.
 32. Sulaeman A, Marliyati SA, Fahrudin M. Antioxidant activity and total phenolic content of stingless bee propolis from Indonesia. Journal of Apicultural Science. 2019;63(1):139-147.
 33. Teggat N, Bakchiche B, Abdel-Aziz MES, Bardaweel SK, Ghareeb MA. Chemical Composition and Biological Evaluation of Algerian Propolis from Six Different Regions. Jordan Journal of Pharmaceutical Sciences, 2023, 184-197.
 34. Thirugnanasampandan R, Raveendran SB, Jayakumar R. Analysis of chemical composition and bioactive property evaluation of Indian propolis. Asian Pacific journal of tropical biomedicine. 2012;2(8):651-654.
 35. Woźniak M, Sip A, Mrówczyńska L, Broniarczyk J, Waśkiewicz A, Ratajczak I. Biological Activity and Chemical Composition of Propolis from Various Regions of Poland. Molecules. 2022;28(1):141.
 36. Zulhendri F, Chandrasekaran K, Kowacz M, Ravalia M, Kripal K, Fearnley J, Perera CO. Antiviral, antibacterial, antifungal, and antiparasitic properties of propolis: A review. Foods. 2021;10(6):1360.
 37. Zulhendri F, Perera CO, Chandrasekaran K, Ghosh A, Tandean S, Abdulah R, *et al.* Propolis of stingless bees for the development of novel functional food and nutraceutical ingredients: A systematic scoping review of the experimental evidence. Journal of Functional Foods. 2022;88:104902.
 38. Žilius M, Ramanauskienė K, Briedis V. Release of

propolis phenolic acids from semisolid formulations and their penetration into the human skin *in vitro*. Evidence-based complementary and alternative medicine; c2013.