

The 2nd
International Conference Of Pharmaceutical
Sciences Basra- Iraq

2022
May
18-19

نحت شعار
العلوم الصيدلانية ودورها في اسدامة صحة المجتمع



وقائع المؤتمر الدولي الثاني للعلوم الصيدلانية

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Biomaterial Products for Oral and Dental Tissue Health

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Abstract

Natural materials in their origin are the main components of medical preparations available since ancient civilizations and are used to treat several medical conditions, including some dental diseases and pain. Nowadays, more natural materials are available for dental applications. A single material may have several effects like caries prevention, antimicrobial, anti-inflammatory effect, etc. Also, it has other features such as its availability at low cost and fewer side effects that give the advantage to these materials replace the synthetic chemicals more in the future with the continuous research on them.

Keywords: natural products, medical uses, dental applications

Introduction

Phytotherapy is a branch of natural science that studies the uses of extracts from a natural origin as drugs or health-promoting agents. Materials with medicinal properties are important and valuable for treating various disease processes (1), including oral diseases.

Worldwide, oral diseases remain a significant health concern. Dental caries and periodontal diseases are among the most important global oral health issues; moreover, other diseases such as oral and pharyngeal cancers and lesions of the oral tissue are still serious concerns. Many natural products have been used, including herbal extracts, that interact with specific chemical receptors in the body. Natural medical products have fewer side effects compared to traditional medicinal products. However, natural products may vary in potency. (2)

Finding an alternative treatment became a global demand, for oral prevention and treatment, instead of synthetic chemicals due to their unfavorable side effects, such as altering the microflora of the oral cavity, vomiting, and diarrhea. Natural materials are essential as they are used in nearly every dental specialty and branch. (3) They have been used as an antimicrobial, anti-inflammatory, sedative, and anxiolytics. Phytotherapeutic materials can be classified into three sources (Figure 1). This article will shed light on the plant source.

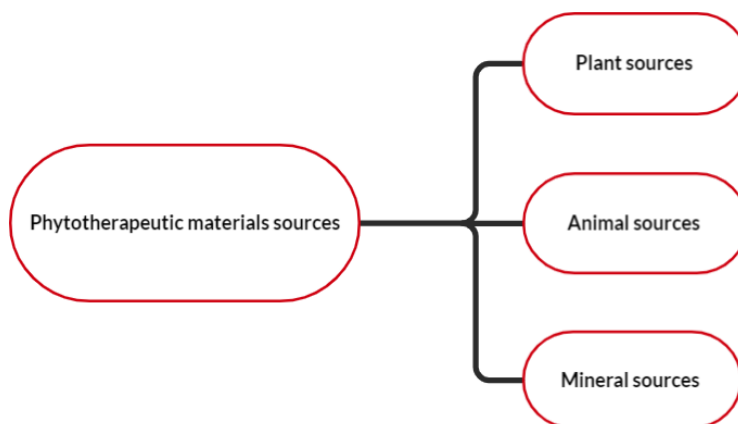


Figure 1: Phyto

Thousand years ago, natural extracts were used in traditional medicine (4), and the information on medicinal plants has been collected and based on several therapeutic systems, including Unani, Siddha, and Ayurveda. In India, around 2,500 plant species have been reported to use traditional healers as regular sources of medicine. (5) Also, the ancient Egyptians and Etruscans made bone and wire and repurposed them for animal and human teeth dentures. Typical denture products in Europe and the U.S. were used for human and animal teeth and ivory throughout the 18th century. Babylonians, Assyrians, and Egyptians (4500-4000 BC) were familiar with gold, and Etruscans and Phoenicians (2700 BC) practiced gold crowns (6).

Aloe vera derived its current name from "alloe," an Arabic word, and "vera," a Latin word to be *Aloe vera* which means bitter substance. (7) The plant is a member of the Lily family (Figure 2). It usually only grows in warm tropical areas and cannot survive at freezing temperatures. (8) The clear internal gel contains 99 percent water and about 75 active ingredients, including vitamins, sugars, minerals, lignin, saponins, and salicylic acids. (9)



Figure 2: Aloe vera fruit

The aloe vera juice has been used to relieve pain and burn (the oral lichen planus). Topical skin pruritus (skin lesions) can also be reduced by applying Aloe vera (10)

Aloe vera proved to be good obturation material for deciduous teeth. Aloe vera with sterile water had high antimicrobial activity against most microorganisms. (11)

Cellulose is one of the most sustainable materials in nature. It can be found in cotton, hemp, wood, and other plants, and it has a significant role in maintaining its structure. (12) Cellulose is a natural homopolymer with a high molecular weight, consisting of anhydro-D-glucose units linked to α -1,4. The sugar units are connected by combining the group H and -OH with water removal (Figure 3). (13)

Cellulosic fibers were added to glass ionomer cement to improve the mechanical resistance of this material. Studies have shown that the cellulosic fiber-modified glass ionomer cement can enhance the compressive strength and resistance to abrasion. The same trend is observed for the bond strength of dental structures. (14) In a recent test, glass ionomer cement has been documented to be completely interlaced with randomly distributed cellulose nanocrystals in the cement matrix, indicating union (15).

It also can be used as a passive hemostatic agent in surgical procedures. The passive hemostatic agents work by forming a lattice-like matrix that triggers the extrinsic coagulation pathway providing a base for the platelets to aggregate (16).

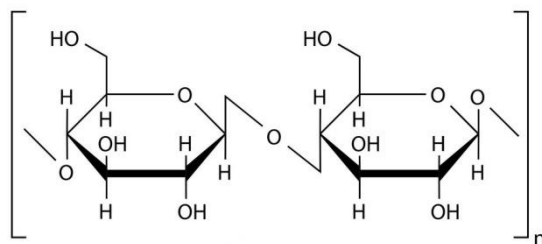


Figure 3: Chemical structure of cellulose

Eugenol is a natural product composed of phenylpropene (Figure 4) extracted from clove and basil that is widely used in dentistry. (17) Eugenol has analgesic effects, which may be related either to the inhibition of voltage-dependent Na⁺ channels or to the activation of TRPV1 receptors. (18) It is also added to cavities used in restorative procedures and rubbed on the gums before applying dentures. Eugenol is commonly used during acute pulpitis as an analgesic agent and is a significant component of root canal sealers (19).

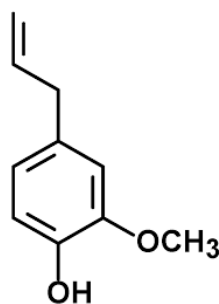


Figure 4: Chemical structure of eugenol

Calendula officinalis (*C. officinalis*) is a medicinal herb that exhibits outstanding antimicrobial, wound healing, and anti-inflammatory properties (Figure 5). Calendula mouthwash is effective in reducing dental plaque adjunctive to scaling. It is native to the region of the Mediterranean. Clinically Calendula is used to treat gingivitis, skin disorders, and pain. Ease healing after oral surgery and in inflammations of the oral cavity. It also possesses anti-edematous properties (20).



Figure 5: *Calendula officinalis*

Curcuma longa (Turmeric) is classified as one of the most important herbs used in medicine, cosmetics, and condiment (Figure 6). Curcuminoids and essential oils are the main active components of turmeric. (21) It has been reported that turmeric possesses antimutagenic, antibacterial, antioxidant, and anticarcinogenic. It has been used in planus of oral lichen, fissure, dental caries, pit, halitosis, and gingivitis in dentistry. (22) The effect of *Curcuma longa* extract in treating early infective inflammatory periodontal diseases was evaluated by Vikrant and colleagues. They reported that treating early infective-inflammatory periodontal diseases by *Curcuma longa* extract with or without scaling and root planing (SCRCP) was too active (23).



Figure 6: *Curcuma longa*

Miswak or siwak is one of the oldest oral hygiene tools that is taken from the *Salvadorapersica* tree (Figure 7). In India, it is quite popular to use miswak as a chewing stick, and people there consider it as "Nature's little toothbrush." It is also a natural toothpaste with antibacterial, anticaries, anti-peripatric disinfection, antifungal, and antiplaque properties. In 2012 Patel PV and colleagues reported that the use of Misiak as an adjunct to tooth brushing exhibited considerable improvement in gingival health and plaque score (24).



Figure 7: Miswak

Licorice is also known in Chinese as gancào, meaning "sweet herb," and popularly known as Jeshthamadh in India (Figure 8). The sweetness of Licorice comes from glycyrrhizin as it makes around 10-25 percent of Licorice. It is 50 times sweeter than refined sugar (glucose). Licorice possesses antimicrobial, anti-adhesive, and anti-inflammatory properties that make it widely used to treat oral diseases such as oral cancer, aphthous ulcers, periodontitis, gingivitis, and dental caries. (25, 26, 27) However, some studies reported some side effects of Licorice, such as high blood pressure, low blood potassium, and muscle pain. (28)



Figure 8: Licorice

Mentha Piperita Aromatic plant oils such as peppermint (*Mentha Piperita* L.), which generally contain high volatile oil, are widely used in dental care due to their biofilm-inhibiting, antibacterial, and antifungal properties (Figure 9). Peppermint oil is extracted from the leaves of *Mentha Piperita*, and it is quite common to find it in the ingredient of many oral care products. (29) Haghgo and colleagues researched to evaluate a peppermint mouth rinse for students who suffered from halitosis. This study involved two steps; in the first step, they examined 504 students to explore those who suffer from halitosis, and their number was 84. The second step was to divide them into two groups; the first group was given a peppermint mouth rinse, while the

second group received a placebo. The results concluded that the chi-square test demonstrated a significant difference and peppermint mouth rinse can actively reduce halitosis (30).



Figure 9: Menthapiperita

Agar is a polysaccharide that is derived from seaweed such as *Gelidium* sp. It is also known as a (reversible hydrocolloid) impression material. More specifically, agar is the sulphuric ester of galactose polymer. Agar hydrocolloids, introduced in 1925, were the first elastic impression of dentistry fabrics. They aren't widely used today, however. Nonetheless, this material has more reasonable use in crown and bridge procedures. Moreover, it's still preferred by practitioners. Impressions of agar have a good elastic recovery and excellent detailed reproduction. Unlike some elastomeric impression materials, the products are unique and easy to clean. After the initial investment in water-cooled trays and cooling baths. (31)

Coriander Satvium (Figure 10), also known as *C. Satvium*, while in the west, known as Cilantro, is a parsley family member. It is native to regions spanning South-Eastern Europe and is widely used to grow throughout Europe, Turkey, India, and China. Coriander extract possesses significant antibacterial, antiviral, antifungal, and antioxidant properties. Recently, Pillay and Geetha investigated the effect of *C. sativum* in reducing *Streptococcus mutans* count. The results showed that the coriander extract had a beneficial impact on influencing the *S. mutans*. They concluded that this extract could be added to toothpaste and mouthwash to reduce the count of *S. mutans* (32).



Figure 10: *Coriander Satvium*

Azadirachta Indica (Figure 11) is an evergreen plant called Neem. Indian people commonly use it to treat various diseases due to its medicinal benefits. It has been used in a wide range of anti-diabetic, antibacterial, anti-helminthic, anti-inflammatory, anti-cariogenic, and anti-helminthic effects. It has been reported that every part of the neem tree has potential medicinal use. The neemt看ws is renowned as oral deodorant and toothache reliever, while the bark for gum healing disease, the oil for soap, and the leaves for medicine. Neem holds great potential as an inhibitor for adhesion to hydroxyapatite in tooth surfaces, bacterial development, and insoluble glucan production as they can affect the in vitro plaque formation (33, 34).



Figure 11: *Azadirachta Indica*

Allium sativum (Garlic) is an herb that is grown around the world. It is related to onion (Figure 12), leeks, and chives. It is thought that garlic is native to central Asia, northeastern Iran, and Siberia. It has been reported that garlic possesses an effective antibacterial action against oral pathogens and showed promise for treating a wide range of oral cavity diseases, including

periodontal diseases and dental caries. Traditionally, garlic sterilizes the oral *Streptococcus pyogenes* by chopping it and leaving it in the mouth for 5 minutes (35, 36).



Figure 12: Garlic

Curcuma zedoaria, also known as (White turmeric) (Figure 13), is a medicinal plant that grows in East-Asian countries such as Bangladesh, Indonesia, China, Japan, India, Malaysia, and Vietnam. It is reported that the margin of safety of the *Curcuma zedoaria* for human consumption is high.

It has antibacterial, antifungal, antiinflammation, antiamebic, antimutagenic, antioxidant, and anticancer effects that act as the most important characteristics of *Curcuma* plants.(37) It has been found that the mouthwashes consisting of hydroalcoholic extracts of *Curcuma zedoaria* extract can be used as auxiliaries for the mechanical control of dental plaque and gingivitis due to their anti-inflammatory and antimicrobial properties in addition to their low toxicity in the form of mouthwashes. (38) It has been reported that the rhizomes of white turmeric can be used as an alternative for irrigation solutions. (39)



Figure 13: Curcuma zedoaria

Sanguinarine, or benzophenanthridine, is extracted from rhizomes of *Sanguinaria canadensis* L. (bloodroot) (Figure 14). The safety profile of Sanguinarine extract has been widely used in oral health products. This can be deduced due to its antimicrobial and anti-inflammatory properties. In vitro studies have previously shown the antiplaque action of sanguinaria, which could be explained depending on its ability to inhibit bacterial attachment to the newly formed pellicle. Reports mention that long-term use of sanguinaria-containing

oral hygiene products, including toothpaste and oral rinse products, did not cause shifts in oral flora (40, 41).

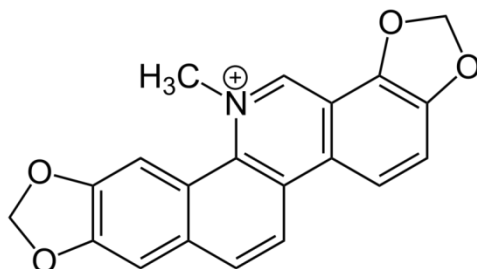


Figure 14: Chemical structure of Sanguinarine

Matricaria chamomilla, or German chamomile (Figure 15), is another well-known medicinal plant species belonging to the Asteraceae family. Recently, chamomile and linseed have been tested as saliva substitutes by Morales-Bozo and colleagues to relieve xerostomia in elderly participants. Morales-Bozo and colleagues concluded that the chamomile- and linseed new formula effectively reduced dryness symptoms. *Matricaria*'s effects on oral mucositis are sparse. However, these materials have been proven to be a promising alternative to preventing and treating oral mucositis. Its principal advantages are non-invasive treatment and its low cost. *M. Chamomilla* effectively reduces inflammatory activity, speeding up repair processes and promoting analgesia. (42)



Figure 15: *Matricaria chamomilla*

Marcocystis pyrifera (Alginate) (Figure 16) is a natural polymeric compound commonly collected from brown seaweed. Its properties, such as low toxicity, biocompatibility, and

affordable price of alginate, lead to widespread use in biomedical applications. Alginate gel is widely prepared by mixing alginate with divalent cations such as Ca^{+2} (43).

Traditionally alginate is used in dentistry to take an impression of oral structures. Alginate impression materials possess several advantages over the other compounds, including affordable price, rapid setting times, and easy use. The significant problems with alginate are its poor dimensional stability and inaccurate reproduction of elastomeric impression. It is possible to produce only one plaster model, which is another disadvantage of this type of material (44).

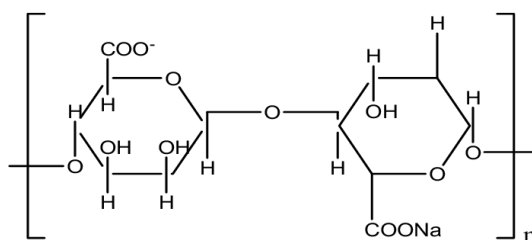


Figure 16: Chemical structure of alginate

Natural polyphenols can be divided into five classes based on chemical structures, including flavonoids, phenolic acids, lignans, stilbenes, and other polyphenols. The most common classes among these compounds are phenolic acids and flavonoids; phenolic acids account for 30 % of all natural polyphenols and flavonoids around 60%, respectively.

Generally speaking, natural polyphenols refer to a wide variety of aromatic compounds consisting of at least one aromatic ring attached to one hydroxyl group, ranging according to the molecule size from the simplest one (phenol) to highly polymerized polyphenols. Natural polyphenols are abundantly found in foods such as spices, vegetables, tea, fruits, and nuts. Stilbenes, lignans, flavonoids, and phenolic acids are the most common species of natural phenols (45, 46).

Polyphenols have been previously shown to enhance dentine remineralization, dentine strength, and bonding to restorative materials. Furthermore, researchers are reported that polyphenols possess antimicrobial activity and can be used as an alternative to common chemicals for caries prevention (47).

Orange oil, The food and Drug Administration agency (FDA) generally accepts the use of essential oils as additives in particular foods. The oil extracted from orange fruit was considered of scientific interest due to its great medical properties. It had been reported that orange oil could be used for gutta-percha softening instead of chloroform or xylene and dissolve endodontic sealer

(48, 49). Since orange essential oils appear to destroy bacteria effectively, they have been used to treat oral problems such as ulcers, gingivitis, and bad breath in your oral.

Echinacea (Figure 17), also known as the American con flower, is a flowering medicinal plant with important immunostimulatory and anti-inflammatory properties prescribed to treat malaria, syphilis, scarlet fever, and diphtheria. It is also valuable for mouth infections, sore throats, colds, cough, and snake bites treatments. In addition, echinacea is commonly accepted as a treatment for menstrual disorders in traditional Chinese medicine. Echinacea plant species are composed of caffeic acid derivatives, water-soluble polysaccharides, and chicoric acid (50). It has been reported that *echinacea purpurea* can be mixed with *Centella Asiatica* and *Sambucus nigra* to develop mouth wash to treat gingivitis (51). Recently, Khozeimeh and colleagues have investigated the effects of echinacea on the treatment of aphthous ulcers. In this study, 25 patients took *echinacea* as tablets, and the results were compared to 25 patients who didn't take any pills. They concluded that the positive effects of *echinacea* tablets on several lesions, the intensity of pain, and the recurrence rate in patients were observed (52).



Figure 17: Echinacea app

Psidium Guajava (Guava) (Figure 18) is a perennial tree belonging to the Myrtaceae family, growing in tropical and subtropical regions but preferably in dry climates. It originates from Mexico or Central America, and it grows abundantly in different countries due to its health benefits. (53)

It has an antiplaque effect by exhibiting bacteriostatic action on the bacteria in the early stage of plaque formation, preventing its progression and growth. (31) So, the therapeutic potential of guava is to be used as an adjunct in the treatment of periodontal disease as an excellent antiplaque, antimicrobial, anti-inflammatory, and antioxidant agent (54).



Figure 18: Psidiumguajava

Myrrh is an oleo-gum resin (Figure 19) from the *Commiphora molmol* tree and the shrub-like *Balsamodendron myrrh* that grows in the north and east of Africa and Arabia. (55, 56) Research has shown that myrrh contains around 2-8 percent essential oil (myrrhol), 23-40 percent resin (myrrhin), 40-60 percent gum, and 10-25 percent bitter principles.

In dentistry, Myrrh extracts may be an alternative remedy for commercially synthetically manufactured mouthwash such as chlorhexidine gluconate for oral health care since the latter will mostly produce teeth and tongue surface staining. Therefore there will be a loss of taste sensitivity and many other side effects. (57, 58)



Figure 19: Myrrh

Sage is plant, which has the common name sage and the scientific name *Salvia officinalis*, is found in dry, rocky places (Figure 20). It is native to the Balkans and the Mediterranean but has spread widely elsewhere as a herb garden and pot. In sunny areas, it prefers dry chalky soils but thrives in rich loamy soil with good drainage (59, 60).

Salvia officinalis include aromatic, carminative, spasmolytic, antiseptic, astringent, and antihidrotic. The thujone in the volatile oil has an antiseptic and antibiotic function, and *Salvia* successfully acts on throat infections, dental abscesses, infected gums, and oral ulcers when used as a mouthwash. In *Salvia*, phenolic acids are highly effective against *S. Aureus*. (61)



Figure 20: Sage

Ankaferd blood stopper (ABS) is an essential medicinal extract, historically used as a hemostatic agent in traditional Turkish medicine. Based on protection and efficacy studies suggesting its sterility and non-toxicity, ABS has been licensed to manage external hemorrhage and dental surgery bleedings in Turkey. The ABS consists of a uniform mix of the *Thymus vulgaris*, *Glycyrrhizaglabra*, *Vitisvinifera*, *Alpiniaofficinarum*, and *Urticadioica* species. (62) Induces very rapid protein network formation in plasma and serum. Blood cells, particularly erythrocytes, accumulate rapidly (< 1s) in the presence of ABS and participate in network formation. Throughout this antihemorrhagic cycle, individual coagulation factors are unaffected. ABS operates independently of the classical cascade of coagulation and leads to a wounding cure. (63) ABS as a hemostatic agent effectively manages dental-related bleeding. ABS may give the dental profession more time and confidence during the surgical intervention. It is helpful in periodontal surgeries and dental extractions for local hemostasis and wound healing, and infection prevention (64).

Triphala is a famous powder preparation that has been used since ancient times in India. Triphalais prepared by equal measures of the *EmblicaOfficinalis*, *Terminaliachebula*, and *Terminaliabelerica*. (65) *EmblicaOfficinalis* is also known as Amalaki where a fruit is used due to its incredible healing properties since it contains vitamin c, riboflavin, and tannins. *Terminaliachebulais* also used in traditional medicine since its fruit is very rich in tannin.

Terminaliabelerica is a deciduous tree that grows in many areas around the world, and its fruit has been used to relieve many symptoms because it contains gallic acid (66).

Triphala has many uses in the dental field due to the variety of valuable chemical components (Figure 21).

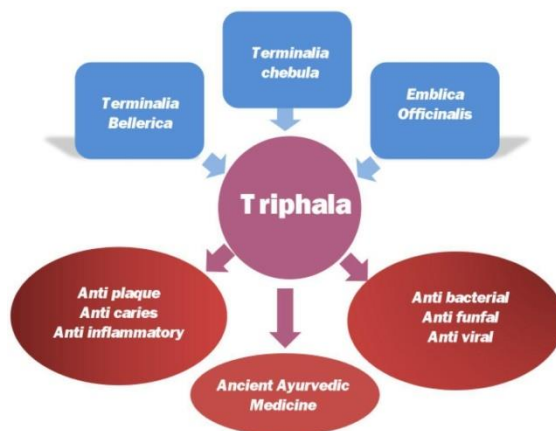


Figure 21: Triphals uses in the dental field

It has an anticaries effect and helps prevent caries and the treatment of gum inflammation. Its action is the prevention of adherence of dental plaque on the teeth and inhibits the impact of streptococcus bacteria on the dental tissue. (67). Effective as root canal irrigation solution in the elimination of bacteria in the canals and has the same effect as NaOCl but with fewer side effects (68). Anti collagenase effect, which profits from periodontal disease. work in the same manner as doxycycline with the advantage of less undesirable effects on long-term use. (69). Its ability to prevent dental caries and periodontal diseases; therefore, it is used in mouth rinse with an effect similar to chlorhexidine (66).

Propolis is resinous material is collected from the bee colonies, where the bees form it by the mixture of bees' saliva and other exudates with the wax. The bees are used to seal their hives to protect themselves from outside invaders. The component of this material has made it very beneficial to be used in medical and dental applications; some of these components are different types of vitamins, amino acids, minerals, pollens, and phenols (70).

There is a massive application in dentistry (Figure 22), and we will talk about the most clinically significant of them: it has a very promising capacity to be used as an anticaries agent and maybe in the future will be used as an adjunctive for traditional caries preventing methods

(71); It is used as a transport medium for the avulsed teeth due to trauma, and researches show that it is better than the milk and HBSS(72); its role in endodontics as an intracanal irrigant and medicament due to its powerful antimicrobial ability (70); pulp capping material for permanent teeth; it has been found that teeth capped with it have shown hard tissue formation (73).

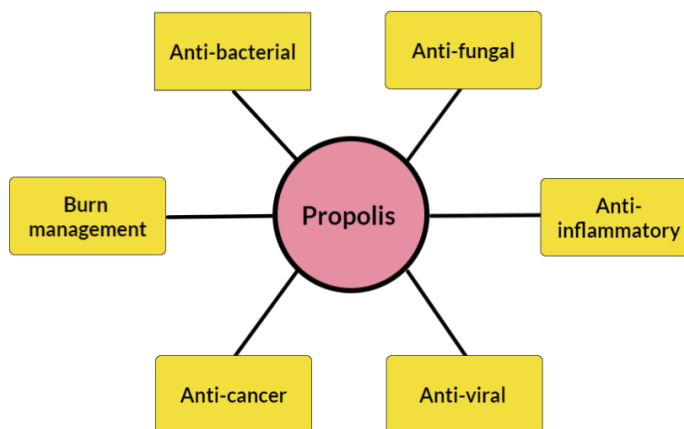


Figure 22: Propolis applications

GuttaPercha, a natural material with a chemical structure similar to the natural rubber obtained from trees of *Palaquium*sp that grows in Asia. (74) it was first used in dentistry as a temporary filling for the canals. However, it has become the primary obturation material in endodontics over the years, replacing the old silver points and providing excellent opportunities for clinical success in root canal treatment. Because of its success, many forms of gutta-percha were manufactured and introduced into the market, such as solid points, thermo-plasticized, and others. With continuous research to find other superior materials, the gutta-percha points remain the most commonly used core filling material in root canal treatment (75).

Conclusion

Many natural materials have an extensive range of dental applications in different branches. They all hold the main advantage of biocompatibility with the oral tissues and provide a good potency with fewer side effects. However, some materials have proven effective and efficient in daily dental practice. In contrast, others need more extensive studies and research to provide more information to utilize them in the dental field better.

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