

FLORAS FOR TREATING SINUSITIS – A REVIEW

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ABSTRACT

Sinusitis is inflammation of the sinuses, which are air-filled cavities in the skull. The inflammation leads to blockade of the normal sinus drainage pathways which in turn leads to mucus retention, hypoxia, decreased mucociliary clearance and predisposition to bacterial growth. It is characterized by headache, Postnasal drip, face and eye pain, pain over the bridge of the nose sometimes tinged with blood and stuffy or runny nose. Treatment for sinusitis includes antibiotics, antihistamines, analgesics, corticosteroids etc. Antibiotics are first line therapy for sinusitis. Antihistamines, analgesics and corticosteroids are used as adjuncts to reduce inflammation, pain and for decongestion, respectively. But about one in four people who take antibiotics have side effects, including stomach problems, dizziness or rashes. Infection and allergy (dust and smoke allergy) may be risk factors in sinusitis patients and need to be managed with simplified but effective treatment regimen. Herbal medicines are now in great demand in the developing world for primary health care not because they are inexpensive but also for better cultural acceptability, better compatibility with the human body and minimal or no side effects. The present review focusses on the various medicinal plants that can be successfully used to combat against sinusitis.

KEYWORDS: Papain, Eucalyptol, Allicin, Bromelain, Andrographolide, Sinusitis.

INTRODUCTION

Sinus is a sac or cavity in any organ or tissue, or an abnormal cavity or passage caused by the destruction of tissue. In common usage, "sinus" usually refers to the paranasal sinuses, which are air cavities in the cranial bones, especially those near the nose and connecting to it. Each individual has four paired cavities located in the cranial bone or skull. The largest sinus cavities are around an inch across; others are much smaller. The sinus cavities include, the maxillary sinuses (the largest) in the cheekbones; the frontal sinuses, in the low-center of the forehead; the ethmoid sinuses, between the eyes at the nasal bridge; the sphenoid sinuses, in bones behind the nasal cavity (Fig. 1). The sinuses are lined with soft, pink tissue called mucosa. Normally, the sinuses are empty except for a thin layer of mucus. The sinuses are the spaces between the bones in the face where air passes and where a fluid called mucus drains into the nose. The inside of the nose has ridges called turbinates. Normally these structures help humidify and filter air. The nose is divided in the center by a thin wall, called the septum. Most of the sinuses drain into the nose through a small channel or drainage pathway called the middle meatus. The purpose of the sinuses is that it helps to humidify the air we breathe in; another is that they enhance our voices. Sinusitis (more properly known as rhinosinusitis due to

the regular involvement of the nasal cavity) is a swelling of the inner lining of the sinuses. In sinusitis, the swelling blocks the openings in the sinuses through which mucus drains into the nose. When mucus cannot drain properly, the pressure of the blocked fluid inside the sinuses can be painful.

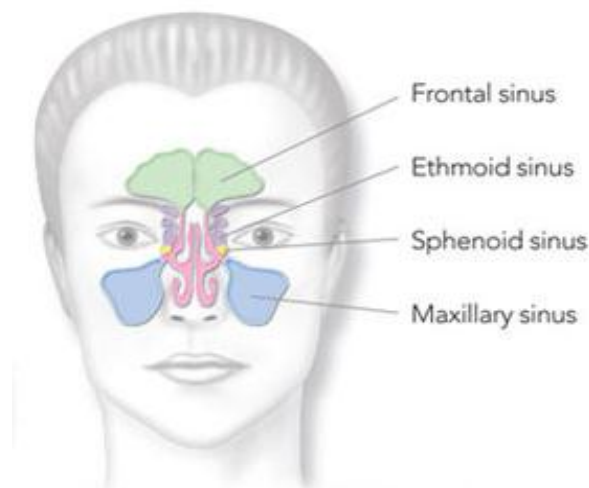


Fig. 1: Types of sinuses.

Sinus Conditions

- Acute sinusitis (sinus infection): Viruses or bacteria infect the sinus cavity, causing inflammation. Increased mucus production, nasal congestion, discomfort in the cheeks, forehead or around the eyes and headaches are common symptoms.
- Chronic sinusitis (or chronic rhinosinusitis): More than just a series of infections, chronic sinusitis is a persistent process of inflammation of the sinuses.
- Allergic rhinitis: Allergens like pollen, dust mites, or pet dander cause the defenses in the nose and sinuses to overreact. Mucus, nasal stuffiness, sneezing and itching result.
- Deviated septum: If the septum that divides the nose deviates too far to one side, airflow can be obstructed.
- Turbinate hypertrophy: The ridges on the nasal septum are enlarged, potentially obstructing airflow.
- Nasal polyps: Small growths called polyps sometimes grow in the nasal cavity, in response to inflammation. Asthma, chronic sinus infections, and allergic rhinitis can lead to nasal polyps.

Causal Organisms

Most sinus infections are viral and only a small proportion develops a secondary bacterial infection. Rhinoviruses, influenza viruses, and parainfluenza viruses are the most common causes of sinusitis. The most common bacteria causing sinusitis are *Streptococcus pneumoniae*, *Haemophilus influenzae*, *Moraxella catarrhalis* and *Streptococcus pyogenes*. *Staphylococcus aureus* and anaerobic bacteria (*Prevotella*, *Porphyromonas*, *Fusobacterium* and *Peptostreptococcus* spp.) are the main isolates in chronic sinusitis. *Pseudomonas aeruginosa* and other aerobic and facultative gram-negative rods are commonly found in nosocomial sinusitis, the immune-compromised host, those with HIV infection and in cystic fibrosis. Fungi and *Pseudomonas aeruginosa* are the most common isolates in neutropenic patients.^[1] Saprophytic fungi of the order Mucorales including *Rhizopus*, *Rhizomucor*, *Absidia*, *Mucor*, *Cunninghamella*, *Saksenaea*, *Apophysomyces* are usual etiological agents. Occasionally species of *Aspergillus*, *Fusarium* and *Pseudallescheria boydii* may cause chronic sinusitis.^[2]

Treatment

The following treatments are adopted which helps to relieve from sinusitis symptoms.^[3]

- **Saline nasal irrigation:** Which has to be sprayed into nose to rinse the nasal passages.
- **Nasal corticosteroids:** These nasal sprays help prevent and treat inflammation. Examples include fluticasone (Flonase), budesonide (Rhinocort Aqua), triamcinolone (Nasacort AQ), mometasone (Nasonex) and beclomethasone (Beconase AQ).
- **Oral or injected corticosteroids:** These medications are used to relieve inflammation from severe sinusitis, especially if there is nasal polyps. Examples include prednisone and

methylprednisolone. Oral corticosteroids can cause serious side effects when used long term, so they are used only to treat severe symptoms.

- **Decongestants:** These medications are available in over-the-counter (OTC) and prescription liquids, tablets and nasal sprays. Examples of OTC oral decongestants include Sudafed and Actifed. An example of an OTC nasal spray is oxymetazoline (Afrin). These medications are generally taken for a few days at most; otherwise they can cause the return of more severe congestion (rebound congestion).
- **Over-the-counter pain relievers:** Viz., aspirin, acetaminophen (Tylenol, others) or ibuprofen (Advil, Motrin IB, others). Aspirin is not generally recommended for anyone younger than age 18 owing to the risk of Reye's syndrome - a potentially life-threatening illness.
- **Aspirin desensitization treatment:** If there is reactions to aspirin that cause sinusitis. However, this treatment is usually available only in specialized clinics and medical centers.
- **Antibiotics:** Antibiotics are sometimes necessary for sinusitis if there is a bacterial infection. However, chronic sinusitis is often caused by something other than bacteria, so antibiotics don't always help.
- **Immunotherapy:** If allergies are contributing to sinusitis, allergy shots (immunotherapy) that help reduce the body's reaction to specific allergens may help treat the condition.
- **Surgery:** In cases that continue to resist treatment or medication, endoscopic sinus surgery may be an option. For this procedure, the doctor uses an endoscope, a thin, flexible tube with an attached light, to explore the sinus passages. Then, depending on the source of obstruction, the doctor may use various instruments to remove tissue or shave away a polyp that's causing nasal blockage. Enlarging a narrow sinus opening also may be an option to promote drainage.

But about one in four people who take antibiotics have side effects, including stomach problems, dizziness, or rashes. Those problems clear up soon after stopping the drugs, but in rare cases antibiotics can cause severe allergic reactions. Overuse of antibiotics also encourages the growth of bacteria that can't be controlled easily with drugs. That makes patients more vulnerable to antibiotic-resistant infections and undermines the benefits of antibiotics for others. In the present era of formulation and development we have seen a global interest in the non-synthetic or natural drugs derived from plant source.^[4] As an increase in demand for use of natural products WHO has taken a broader step of including Phytotherapy in the health care programs and they have given a basic guidelines and procedures for validation of drugs from plant source.^[5] Herbal medicines have been the main source of primary healthcare all over the world. From ancient times, plants have been catering as rich

source of effective and safe medicines. About 80% of world populations are still dependent on traditional medicines. Herbal medicines are finished, labeled medicinal products that contain as active ingredients, aerial or underground part of plants or other plant materials, or combination thereof, whether in the crude state or as plant preparations. The Indian subcontinent is a vast repository of medicinal plants that are used in traditional medical treatments.^[6] In India, around 15,000 medicinal plants have been recorded,^[7] however traditional communities are using only 7,000 - 7,500 plants for curing different diseases.^[8,9] The medicinal plants are listed in various indigenous systems such as Siddha (600), Ayurveda (700), Amchi (600), Unani (700) and Allopathy (30) for different ailments. The valuable medicinal properties of different plants are due to presence of several constituents i.e. saponins, tannins, alkaloids, alkenyl phenols, glycol-alkaloids, flavonoids, sesquiterpenes lactones, terpenoids and phorbol esters.^[10] Among them some are act as synergistic and enhance the bioactivity of other compounds. Thus the present review focusses on various medicinal plants that could be successfully used for treating sinusitis and which are powerful and safe.

Floras for Treating Sinusitis

Allium sativum L. (Garlic)

Garlic, *Allium sativum* L. belonging to the family Liliaceae has been widely recognized as a valuable spice and a popular remedy for various ailments and physiological disorders. It is one of those plants that were seriously investigated over several years and used for centuries to fight infectious diseases.^[11] Garlic is nicknamed as Russian penicillin for its widespread use as a topical and systemic antimicrobial agent; it is commonly used in many cultures as an excitement and

reputation of healing power.^[12] Garlic contains 33 sulfur compounds, several enzymes and the minerals germanium, calcium, copper, iron, potassium, magnesium, selenium and zinc; vitamins A, B₁ and C, amino acids, fiber and water.^[13] It has a higher concentration of sulfur compounds than any other *Allium* species which are responsible both for garlic's pungent odor and many of its medicinal effects. One of the most biologically active compounds in garlic is allicin (diallyl thiosulfinate or diallyldisulfide) (Fig. 2). The most abundant sulfur compound in garlic is alliin (S-allylcysteine sulfoxide), which is present at 10 and 30 mg/g in fresh and dry garlic, respectively.^[14] Typical garlic food preparation such as chopping, mincing and crushing disturbs S-allyl cysteine sulfoxide and expose it to the allinase enzymes, then quickly converts it to diallyl thiosulfinate, which give off garlic's characteristic aroma.^[15] Allicin exhibits antibacterial, antiviral and antifungal properties that help to clear sinus infection and its symptoms. It contains decongestant and expectorant properties that reduce the symptoms of sinus infection. It is enriched with vitamin C, enzymes, minerals (selenium, Sulphur), flu busting components, etc. will help to boost up the immunity and thereby clears the infection. The alliin, ajoene and other active components in garlic will exhibit curative properties and thereby clears bacteria or fungus causing sinusitis. Scordinin in garlic helps to boost the immunity and restrict the growth of abnormal cells to get rid of sinusitis and also to perform proper functioning. It also has anti-inflammatory and antioxidant properties that reduce the inflammatory symptoms and clears infection without any side effects. For Sinusitis, garlic can be taken raw or in the form of juice or infusion or it can be steamed and inhaled.^[16]

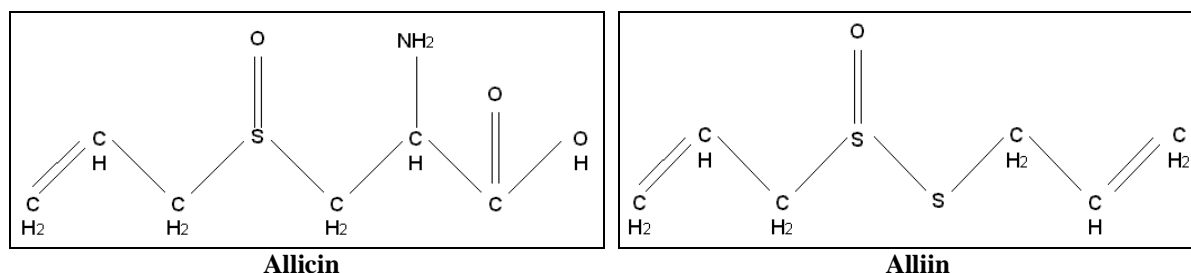


Fig. 2: Phytochemicals of *Allium sativum* L.

Andrographis paniculata (Burm.f.) Nees (King of Bitters)

Andrographis paniculata (Burm.f.) Wall. ex Nees., (Family-Acanthaceae) (English name-King of Bitters, Tamil name-Nilavempu) is an annual herbaceous plant. In traditional medicine, *A. paniculata* is widely used to get rid of body heat, dispel toxins from the body; prevent common cold, upper respiratory tract infections including sinusitis and fever and as an antidote against poisons of snakes and insects.^[17] The plant has been reported to exhibit various mode of biological activities *in vivo* as well as *in vitro* viz., antibacterial, antiviral,

anti-inflammatory, anti HIV (Human immunodeficiency virus), Immunomodulating / immunostimulatory and anticancer. In traditional medicine the plant has been used for centuries to successfully treat respiratory diseases, fever, cough with thick sputum, sore throat and to reduce inflammation.^[18] The major phytoconstituents are diterpenoids, flavonoids and polyphenols. Among the single compounds extracted from *A. paniculata*, andrographolide is the major one in terms of bioactive properties and abundance (Fig. 3). Among the andrographolide analogues, 14-deoxy-11, 12-didehydroandrographolide is immunostimulatory, anti-

infective and anti-atherosclerotic; neoandrographolide is anti-inflammatory, anti-infective and anti-hepatotoxic; 14-deoxyandrographolide is immunomodulatory and anti-atherosclerotic. Among the less abundant compounds from *A. paniculata*, andrograpanin is both anti-inflammatory and anti-infective; 14-deoxy-14, 15-dehydroandrographolide is anti-inflammatory; isoandrographolide, 3, 19-isopropylidene andrographolide and 14-acetylandrographolide are tumor suppressive; arabinogalactan proteins are anti-hepatotoxic. The four flavonoids from *A. paniculata*, namely 7-O-methylwogonin, apigenin, onysilin and 3, 4-

dicafeoylquinic acid are anti-atherosclerotic.^[19] Consuming extracts of the herb can help with an effective treatment of sinus by directly working on the symptoms associated with the condition. It treats headaches, inflammation, muscle aches, facial muscle aches and nasal congestion. Crude aqueous or alcohol extractions of *A. paniculata* and one principle, Andrographolide have been reported to be effective in the treatment of upper respiratory infections that includes any infection in nose, throat, sinuses and ears.^[20] The leaf juice of the plant is an effective cure for sinusitis.

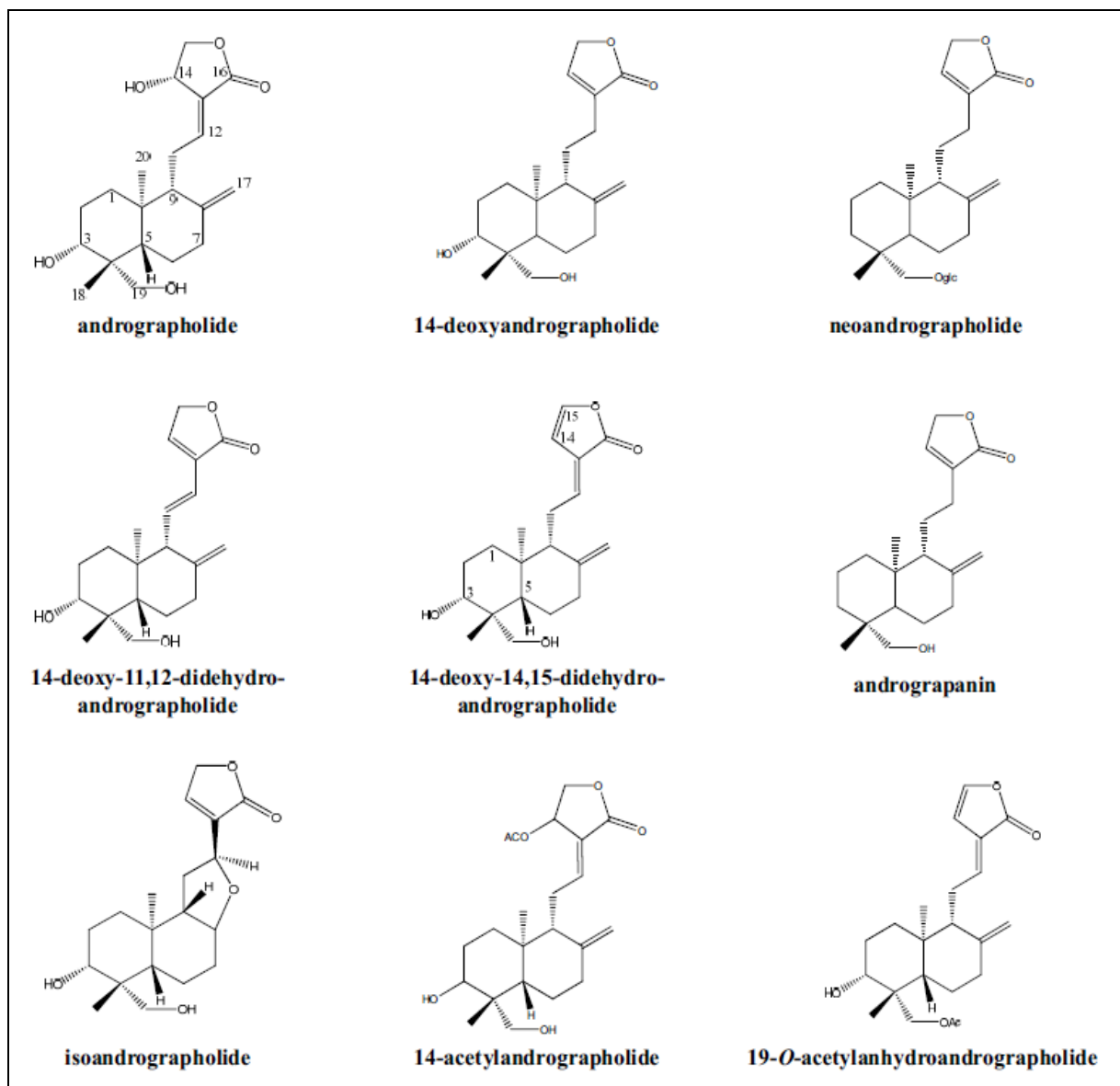


Fig. 3: Phytochemicals of *Andrographis paniculata* (Barm. f.) Nees.

Carica papaya L. (Pawpaw)

Carica papaya L. belonging to family Caricaceae is commonly known as papaya in English, the plant is native to tropical America and was introduced to India in 16th century. Traditionally leaves have been used for treatment of a wide range of ailments, like in treatment of malaria, dengue, jaundice, immunomodulatory and

antiviral activity. Young leaves are rich in flavonoids (kaempferol and myricetin), alkaloids (carpaine, pseudocarpaine, dehydrocarpaine I and II), phenolic compounds (ferulic acid, caffeic acid, chlorogenic acid) and the cyanogenic compounds (benzylglucosinolate) (Fig. 4).

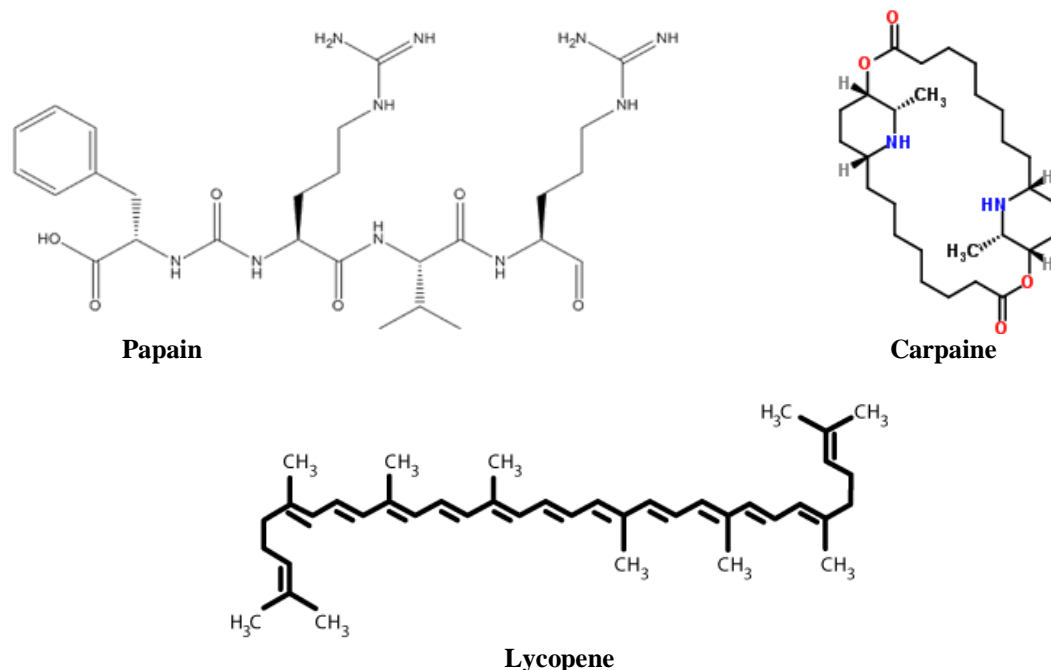


Fig. 4: Phytochemicals of *Carica papaya* L.

Both leaf and fruit of the plant possess carotenoids namely β -carotene, lycopene, anthraquinones glycoside, as compared to matured leaves and hence possess medicinal properties like anti-inflammatory, hypoglycemic, anti-fertility, abortifacient, hepatoprotective and wound healing. Recently its antihypertensive and antitumor activities have also been established.^[21] It is a rich source of three powerful antioxidants vitamin C, vitamin A and vitamin E; the minerals, magnesium and potassium; the B vitamin pantothenic acid and folate and fiber. In addition to all this, it contains a digestive enzyme-papain that effectively treats causes of trauma, allergies and sports injuries. All the nutrients of papaya as a whole improve cardiovascular system, protects against heart diseases, heart attacks, strokes and prevent colon cancer. The fruit is an excellent source of beta carotene that prevents damage caused by free radicals that may cause some forms of cancer. Papaya helps in the digestion of proteins as it is a rich source of proteolytic enzymes. Papain has previously been reported to have significant analgesic and anti-inflammatory activity against symptoms of acute allergic sinusitis like headache and toothache without side effects.^[22] The enzymes papain and chymopapain and antioxidant nutrients found in papaya have been found helpful in lowering inflammation and healing burns. That is why people with diseases (such as asthma, rheumatoid arthritis, and osteoarthritis) that are worsened by inflammation, find relief as the severity of the condition reduces after taking all these nutrients. Papaya contributes to a healthy immune system by increasing your resistance to coughs and colds because of its vitamin A and C contents. The constituents exhibit alkaline combination, as with borax or potassium carbonate and they have showed good results in treatment of warts, corns, sinuses, eczema, cutaneous

tubercles and other hardness of the skin. Papaya leaf and fruit juice are a very effective cure for sinusitis.

***Echinacea purpurea* L. (Purple cone flower)**

Echinacea purpurea L. is one of the most important and well-known medicinal plants in the world, belonging to the Asteraceae (Compositae) family. The plant is the most widely cultivated medicinal plant in this genus,^[23] which has been mainly used in chemo preventive and chemotherapy for infectious diseases in both upper and lower respiratory systems. This species has been traditionally employed for the treatment of toothache, bowel pain, snake bite, skin disorders, seizure, chronic arthritis, and cancer. *Echinacea* is widely used as an herbal remedy today. The most important finding so far is the discovery of immuno-stimulatory property.^[24] Stimulation of the immune system appears to be strongly influenced by dose level. Recent pharmacological studies indicate that a 10-mg/kg daily dose of the polysaccharide over a ten-day period is effective as an immuno-stimulant.^[24] *Echinacea* species contain a great variety of chemical components that contribute to their activity (Fig. 5). The most important components to which activity can be attributed include high molecular-weight polysaccharides, polyacetylenes, highly unsaturated alkamides, and caffeic acid derivatives.^[25] Caffeic acid derivatives reported from *Echinacea* species include echinacoside, des-rhamnosylverbascoside and 6-O-caffeoylechinacoside, cynarin, cichoric acid, caftaric, chlorogenic, isochlorogenic acids and others.^[25] Cichoric acid is the major active compound found in the roots and flowers of *E. purpurea* with a concentration range of 1.2-3.1% and 0.6-2.1% of dry weight, respectively. Rutoside is the major flavonoid found in the leaves and stems. In addition, the following flavonoids have been reported, and occur as both the aglycones and as conjugates with

various sugars: luteolin, kaempferol, quercetin, quercetagetin, apigenin, isorhamnetin. The flavonoid content of the leaves calculated as quercetin, has been estimated at 0.48%. Essential oil of *E. purpurea* contains borneol, bornyl acetate, pentadeca-8-(Z)-en-2-one, germacrene D, caryophyllene and caryophyllene epoxide.^[26] The pyrrolizidine alkaloids, isotussilagine and tussilagine, are found only in trace amounts (0.006% in dried materials). *Echinacea* acts as a natural antibiotic

which can enhance the immune system to help drain out sinus congestion associated with allergies and infections. It is used to relieve pain and reduce inflammation. Its antioxidant and antiviral effects help in improving the immune system and fight off infections like sinusitis. *Echinacea* is available as tinctures, ointments, capsules, extracts and as dried root. *Echinacea* herbal tea is used to improve sinus inflammation. It is the only herb that can fight against fungal sinus infections.

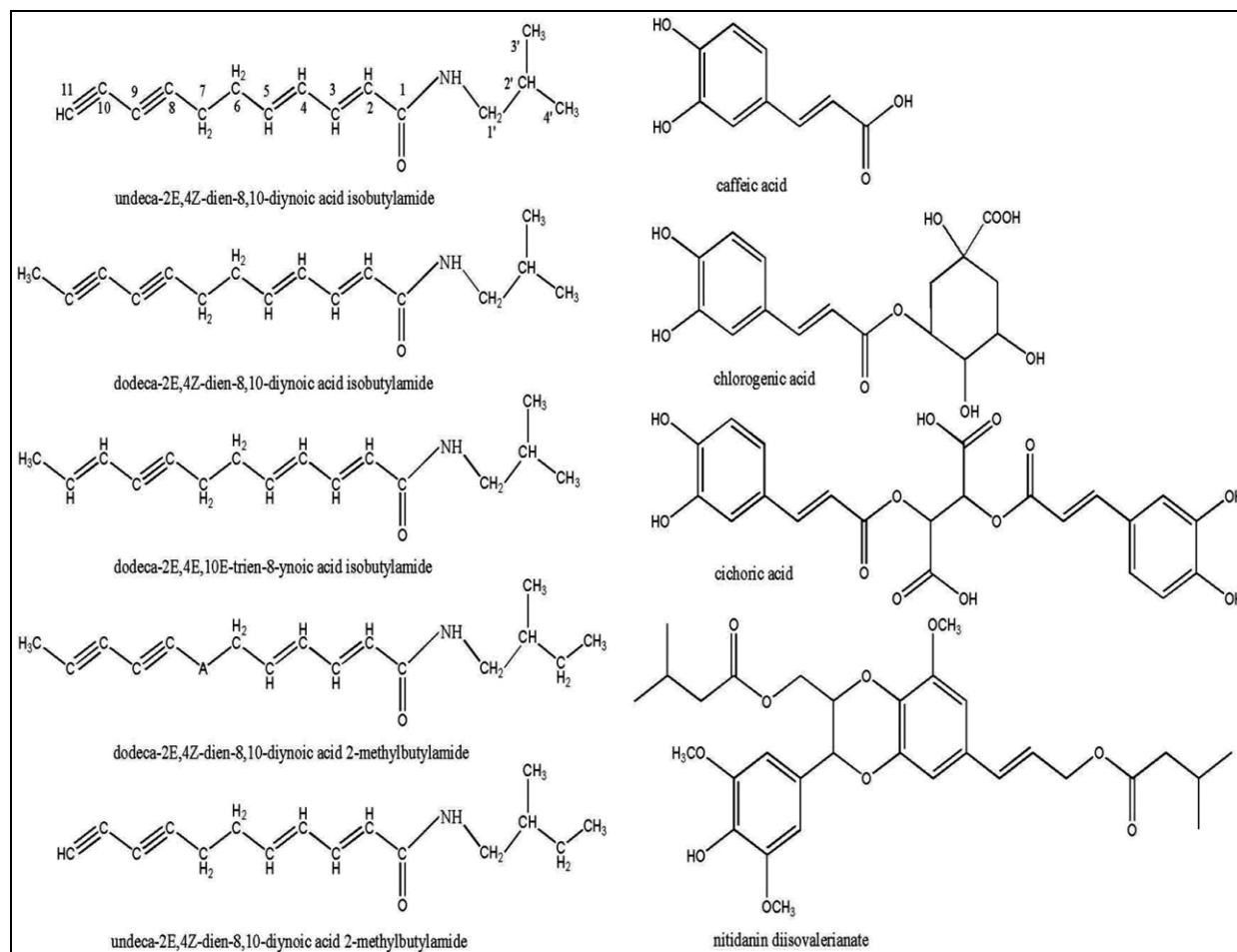


Fig. 5: Phytochemicals of *Echinacea purpurea* L.

Trigonella foenum-graecum L. (Fenugreek)

Fenugreek (*Trigonella foenum graecum*) is an annual plant belonging to the family Leguminosae. It is one of the famous spices in human food. The seeds and green leaves of fenugreek are used in food as well as in medicinal application. It has been used to increase the flavoring and color, and also modifies the texture of food materials. Seeds of fenugreek spice have medicinal properties such as hypocholesterolemic, lactation aid, antibacterial, gastric stimulant, for anorexia, antidiabetic agent, galactagogue, hepatoprotective effect and anticancer.^[27] Fenugreek contains a number of chemical constituents including steroidal sapogenins. Diosgenin component has been found in the oily embryo of fenugreek. Alkaloids such as trigocoumarin, nicotinic acid, trimethyl coumarins and trigonelline are present in stem. The mucilage is a standing out constituent of the

seeds (Fig. 6). There is about 28% mucilage; a volatile oil; 2 alkaloids such as trigonelline and Choline, 5% of a stronger-smelling, bitter fixed oil, 22% proteins and a yellow coloring substance are present in stem. The leaves contain seven saponins, known as graecunins. These compounds are glycosides of diosgenin. Leaves contain about 86.1% moisture, 4.4% protein, 0.9% fat, 1.5% minerals, 1.1% fiber, and 6% carbohydrates. The mineral and vitamins present in leaves include calcium, zinc iron, phosphorous, riboflavin, carotene, thiamine, niacin and vitamin C.^[28] Fresh leaves of fenugreek contain ascorbic acid of about 220.97 mg per 100 g of leaves and β -carotene is present about 19 mg/100 g. Even drinking the water that seeds have soaked in and been rinsed with, helps to soften and dissolve, accumulated and hardened masses of cellular debris. Fenugreek has been used for head colds, influenza, catarrh, constipation, bronchial

complaints, asthma, emphysema, pneumonia, pleurisy, tuberculosis, sore throat, laryngitis, hay fever and sinusitis.^[29] The herb is a powerful astringent that can loosen the air passage and relieve congestion. Fenugreek tea or infusions can be taken for relief from sinusitis. It is beneficial especially for reducing the condition that promotes mucus formation like stuffiness in nasal passage and building of pressure in the cavities. It relieves postnasal drip, cough and breaks down congestion in the chest. It drains the sinus cavity when there is excess secretion of mucus. It has anti-inflammatory effects and restores the normal blood circulation to nasal passages. It alleviates sinus pressure, pain and symptoms.

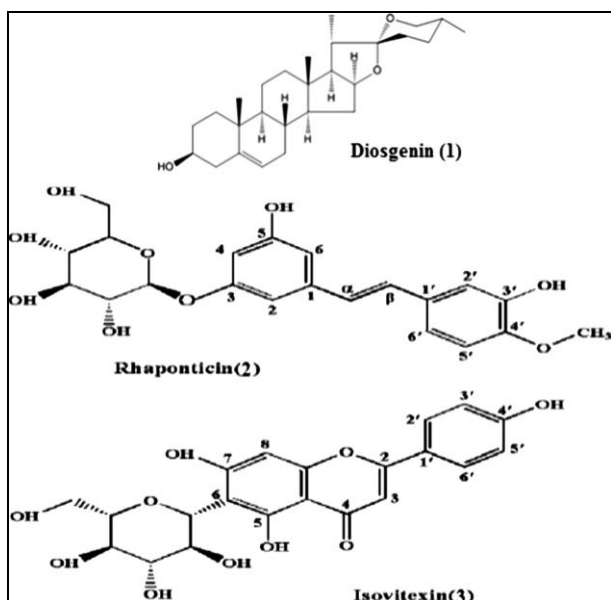


Fig. 6: Phytochemicals of *Trigonella foenum-graecum* L.

Eucalyptus globulus Labill. (Blue gum; Sugandh patra)

Eucalyptus globulus Labill. (Myrtaceae) was discovered on the island of Tasmania in 1792 by French explorers which grows upto a height of 101 m. About 500 species of *Eucalyptus* have been discovered.^[30] *Eucalyptus globulus*, commonly known as blue gum, was introduced into India as a fuel tree in 1843. The leaves and shoots of the plant have been reported to possess various volatile constituents like aromadendrene, γ -cadinene, 1,8-cineole, α -gurjunene, globulol, linalool oxide, eremophilene, β -pinene, pipertone, α -, β - and γ -terpinen-4-ol, and alloaromadendrene. Moreover, borneol, bornylacetate, camphene, caproic acid, citral, eudesmol, fenchone, isoamylalcohol, *p*-menthane, myrcene, myrtenol, trans-pinocarveol, sabinene, α -terpineol, α - and β -thujone, thymol, transverbinol, verbinone, asparagine, cysteine, glycine, glutamic acid, norvaline, ornithine, theonine have been found in fruits of the plant. In addition, the flowers and honey of the plant have been noted to yield dextrin and sucrose, whereas, eucalyptol is obtained from buds (Fig. 7). Further, leaves have been known to yield carvone, caryophyllene, cinnamic acid,

citral, citronellal, cuminaldehyde, eudesmyl acetate, γ -elemene, geranyl acetate, epi-globulol, S-guaiazulene, ledol, d-myrtanal, α -pinene, cis-pinocarveol, α -pinocarvone, β -selinene, viridifloral, homoserine, chrysanthemin, chrysin, cyanin, cynaidin, delphindin, keracyanin, lycoricyanin, malvidin, peonin, peonidin, 8-demethylsideroxylin, hyperoside, quercetol, quercetin, rutin, caffeic, ferulic, gallic, gentisic and protocatechic acids.^[31] Furthermore, cypellocarpin C; eucalyptone; and heteroxylan have been isolated from the fruits of the plant.^[32]

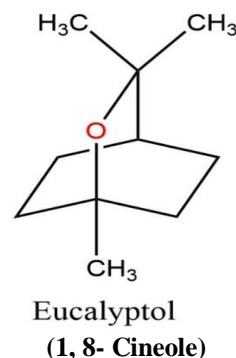


Fig. 7: Phytochemicals of *Eucalyptus globulus* Labill.

Eucalyptus is a folk remedy for abscess, arthritis, asthma, boils, bronchitis, burns, cancer, cold, cough, diabetes, diphtheria, dysentery, dyspepsia, fever, inflammation, malaria, sore throat, spasms, tuberculosis, tumors, vaginitis, wounds, and worms. *Eucalyptus* oil has been reported to possess potent expectorant and mucolytic properties, which stimulates the bronchial epithelium. The oil is believed to decongest the upper respiratory tract in case of common cold; the action being the stimulation of receptors normally stimulated by the incoming nasal air flow. The product is the chief ingredient of many proprietary drugs because of its potent antiseptic and decongestant activity. Hence, the dosage forms like syrups, lozenges, nasal drops and inhalations have been proposed to treat the symptoms of ordinary respiratory disorders. *Eucalyptus* leaves have been traditionally used to treat acute benign bronchial disease, and to relieve nasal congestion in the common cold.^[33] Furthermore, *Eucalyptus* has also been used for treating catarrh of upper respiratory system and bronchitis. In addition, the tannin isolated from the plant has been shown to exert potent astringent effect on the inflamed mucous membranes of the throat, that further account for its therapeutic potential.^[34] The essential oil formula is used to assist in cleansing the sinuses, in reducing the congestion, head stuffiness and to breathe easier.

Ananas comosus (L.) Merr. (Pineapple)

Pineapple (*Ananas comosus* (L.) Merr. Family: Bromeliaceae) is one of the most important commercial fruit crops in the world. It is known as the queen of fruits due to its excellent flavour and taste.^[35] Mature fruit contains 14% of sugar; a protein digesting enzyme, bromelain, and good amount of citric acid, malic acid, vitamin A and B.^[36] The U.S. National Library of

Medicine lists bromelain as a proteolytic digestive enzyme. When taken with meals, bromelain aids in the digestion of proteins, working to break proteins down into amino acids. Pineapple contains considerable amount of calcium, potassium, vitamin C, carbohydrates, crude fibre, water and different minerals that is good for the digestive system and helps in maintaining ideal weight and balanced nutrition. Pineapple contains 81.2 to 86.2% moisture, and 13-19% total solids, of which sucrose, glucose and fructose are the main components. Carbohydrates represent up to 85% of total solids whereas fibre makes up for 2-3%. From 25-30% of nitrogenous compounds are true proteins. Out of this proportion, Ca. 80% has proteolytic activity due to a protease known as Bromelin (Fig. 8). Ascorbic acid or vitamin C in the fruit fights against bacterial and viral infections, which is an effective antioxidant and helps the body absorb iron. Half a cup of pineapple juice provides 50 percent of an adult's daily recommended amount of vitamin C.^[37] Pineapples are rich in manganese, a trace mineral that is needed for body to build bone and connective tissues. One cup of pineapple provides 73% of the daily recommended amount of manganese. Pineapple juice's high manganese content means it is a good choice for boosting fertility through sperm quality.^[37] Bromelain has demonstrated significant anti-inflammatory effects, reducing swelling in inflammatory conditions such as acute sinusitis, sore throat, arthritis and gout and speeding recovery from injuries and surgery. Pineapples are used to help cure bronchitis and throat infections. Bromelain is a mixture of different thiol endopeptidases and other components like phosphatase, glucosidase, peroxidase, cellulase, escharase, and several protease inhibitors. Bromelain accounts for many therapeutic benefits like the treatment of angina pectoris, bronchitis, sinusitis, surgical trauma and thrombophlebitis, debridement of wounds, and enhanced absorption of drugs, particularly antibiotics. It also relieves osteoarthritis, diarrhea, and various cardiovascular disorders. Bromelain also possesses some anticancerous activities.^[38] Bromelain also decreases mucus production, allowing mucus to drain and relieve facial pressure and headache commonly experienced with sinusitis.

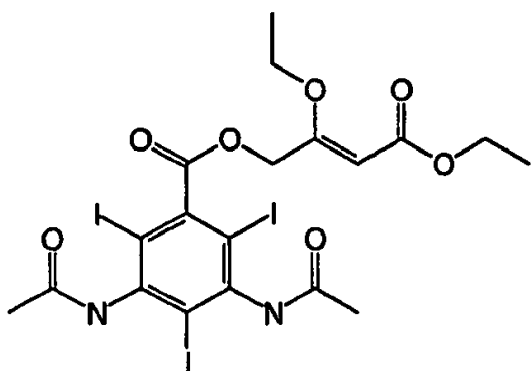


Fig. 8: Bromelain structure of *Ananas comosus* (L.) Merr. (Pineapple).

Urtica dioica L. (Stinging nettle)

Urtica dioica or stinging nettle is a member of Urticaceae family, herbaceous perennial plants which have many little hairs and contain histamine, acetylcholine, acetic acid, etc. (Fig. 9). For a long time, in folklore medicine, *U. dioica* has been used as a diuretic agent and to treat arthritis and rheumatism. A number of chemical constituents such as flavonoids, tannins and sterols have been isolated from different parts of the plant.^[39] The main chemical constituents of *Urtica dioica* are flavonoids, tannins, volatile compounds and fatty acids, polysaccharides, isolectins, sterols, terpenes, protein, vitamins and minerals.^[40] The compounds responsible for the burning sensation properties of leaves trichomes are acetylcholine, histamine, 5-hydroxytryptamine (serotonin), leukotrienes and formic acid. The main components of essential oil of *U. dioica* are carvacrol (38.2%), carvone (9.0%), naphthalene (8.9%), (E)-anethol (4.7%), hexahydrofarnesyl acetone (3.0%), (E)-geranyl acetone (2.9%), (E)- β -ionone (2.8%) and phytol (2.7%).^[40] The flavonoids are mainly kaempferol, isorhamnetin, quercetin, isoquercitrin, astragalin, rutin and their 3-rutinosides and 3-glycosides. The carotenoid such as β -carotene, hydroxy- β -carotene, luteoxanthin, lutein epoxide and violaxanthin are reported.^[41] Fresh nettle juice in doses forms one to two table spoonful's is a most useful remedy for all sorts of bleeding, whether from the nose, the lungs, or some internal organ. When dried, the leaves often relieve asthma and similar bronchial troubles by inhalation.^[42] Plant is also used for sciatica, for difficulty in breathing or some heart troubles, for some coughs, palsy and suppression of the menstrual flow in women, rheumatism and for lack of muscular energy.^[43] A dose of 300 mg/day of freeze-dried *Urtica dioica* is recommended for the treatment of allergic rhinitis.^[44]

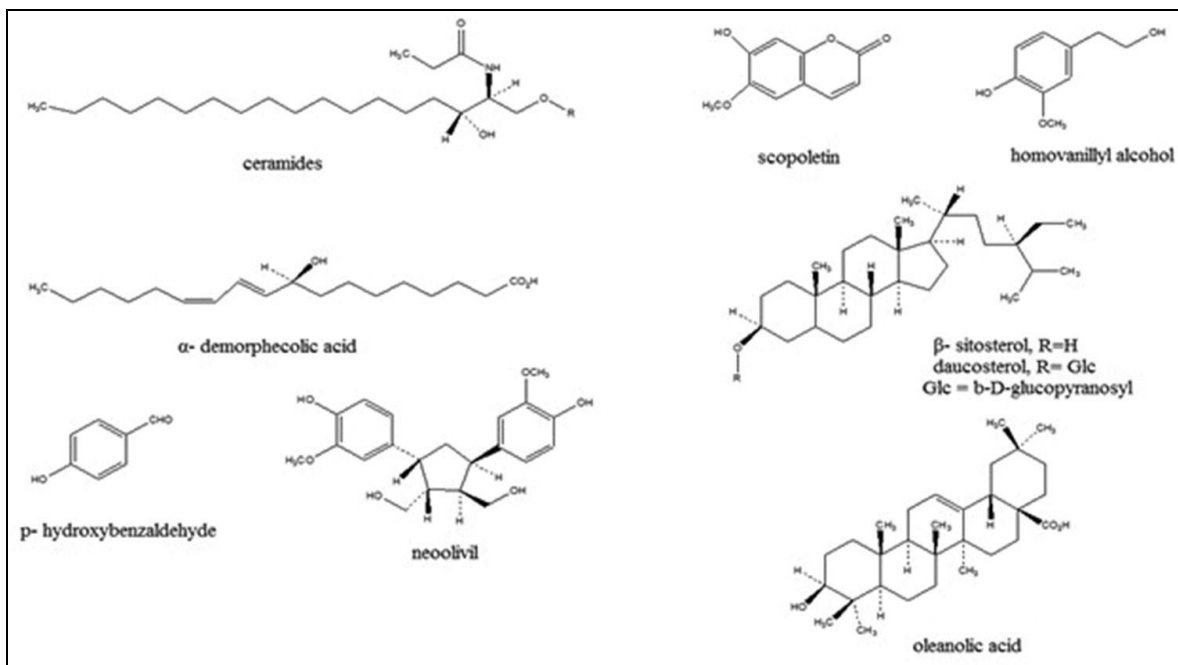


Fig. 9: Phytochemicals of *Urtica dioica* L. (Stinging Nettle).

Curcuma longa L. (Turmeric)

Turmeric (*Curcuma longa* L.) is a therapeutic plant that belongs to family Zingiberaceae. It is considered as native to the India and is well known for culinary use as a key constituent of curry powder. Turmeric is normally called haldi, manjal or haridra in India (Fig. 10). It is also known as “Indian saffron”, as it was broadly used as a substitute to the more costly saffron spice.^[45] Turmeric has healthy influence on digestive system and it also enhances the mucin secretion in the digestive tract.^[46] Turmeric is a prompt source of bioactive compounds like antioxidants, polyphenols and flavonoids, which may be the substitute of antibiotics used in food and food products. Turmeric contains 69.4% carbohydrates, 6.3% protein, 5.1% fat, 3.5% minerals and 13.1% moisture. The essential oil (5.8%) obtained by steam distillation possesses sesquiterpenes (53%), zingiberene (25%), α -phellandrene (1%), sabinene (0.6%), cineol (1%), and borneol (0.5%). Curcumin (3–4%) is responsible for the yellow colour, and comprises curcumin I (94%), curcumin II (6%) and curcumin III (0.3%).^[47] Demethoxy and bisdemethoxy derivatives of curcumin have also been isolated from turmeric. Presence of tumerone a, tumerone b, curzerenone, curdione, mono- and di-demethoxycurcumin have been reported in the rhizomes. The essential oils of leaves of *C. longa* contains linalool, caryophyllene, geraniol, α -pinene, β -pinene, sabinene, myrcene, α -phellandrene, 1,8-cineole, *p*-cymene, C8-aldehyde, and methyl heptanone. Turmeric has a long history of therapeutic uses as it is credited with a variety of important beneficial properties such as its antioxidant, antibacterial, anti-inflammatory, analgesic, and digestive properties.^[48] Turmeric has natural anti-inflammatory properties that can reduce swelling in the sinus cavities. Turmeric for medicinal purposes is usually taken in daily doses of 0.5 to 3 grams. The herbal supplement is also a stimulant that

will act as a natural decongestant, alleviating sinus pressure and pain. Steam inhalation of turmeric is an effective remedy for sinus headache. Consumption of warm milk with a pinch of turmeric added to it also reduces sinus inflammation. Gargling with turmeric can heal a sinus infection and reduce chronic sinus inflammation.

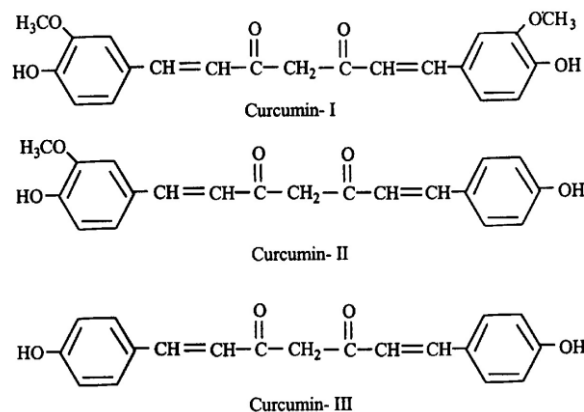


Fig. 10: Structure of Curcumins in *Curcuma longa* L. (Turmeric).

Ocimum sanctum L. (Holy basil; Tulasi)

Tulsi, the “Queen of Herbs”, (family: Lamiaceae) is the most sacred herb of India. There are three important varieties of Tulsi namely, Rama Tulsi (*Ocimum sanctum*), Krishna Tulsi (*Ocimum tenuiflorum*) and Vana Tulsi (*Ocimum gratissimum*). The presence of essential or volatile oil provides specific aromatic odour to *Ocimum Sanctum* which is mainly concentrated in the leaf (Fig. 11). The aromatic volatile oil present mainly contains phenols, terpenes and aldehydes. Apart from volatile oil, the plant also has been reported to contain alkaloids, glycosides, saponins and tannins.^[49]

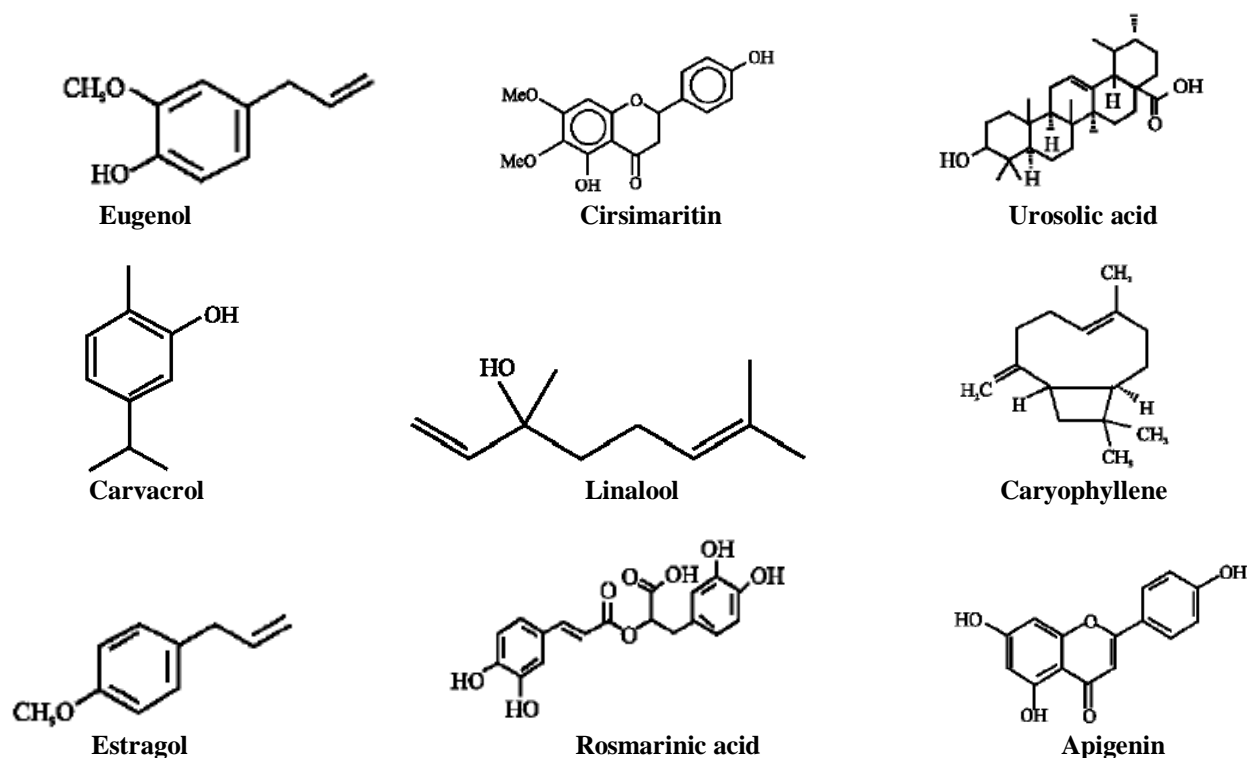


Fig. 11: Phytochemicals of *Ocimum sanctum* L. (Tulasi).

The essential oil from the leaves of *Ocimum Sanctum* has been found to possess α - Thujene, Octane, Nonane, α - pinene, β -pinene, Toluene, Camphene, Sabinene, Dimethyl benzene, Myrecene, Ethyl benzene, Limocene, p-cymene, Terpinolene, Allo-oc-imene, Butyl-benzene, α -cubebene, Linalool, Eugenol, Methyl eugenol, β - elemene, Lactate, β -caryophyllene, Iso-eugenol, α - guaiene, α -amorphene, α -humulene, γ -humulene, α - terpeneol, Isoborneol, Carvacrol, Borneol, α -selinene, β - selinene, α -murolene, Cadinene, Calamene, Geraneol, Nerolidol, Iedol and Elemol.^[50] Also, the alcoholic extract of the aerial parts of the plant have been found to contain Urosolic acid, Apigenin, Luteolin, Isorientin, Orientin, Molludistin, Stigmasterol, Triacantanol ferulate, Vitexin, Isovitexin, Aesculetin, Aesculin, Chlorogenic acid, Galuteolin, Circineol, Gallic acid, Procatechuic acid, Caffeic acid and Chlorogenic acid.^[51] The traditional medical practitioners have used *Ocimum Sanctum* as expectorant, analgesic, anticancer, antiasthmatic, antiemetic, diaphoretic, antidiabetic, antifertility, hepatoprotective, hypotensive, hypolipidemic and anti-stress agents. Moreover, tulsi has also been used in treatment of fever, bronchitis, arthritis, convulsions etc. The leaf juice along with Triphala is used in Ayurvedic eye drop preparations recommended for glaucoma, cataract, chronic conjunctivitis and other painful eye diseases. A decoction of the root of Tulsi plant is given as a diaphoretic in malarial fever.^[52] The plant has also been used in treatment of fever, bronchitis, arthritis, convulsions etc.^[53] Tulsi is a great antitussive (helps in reducing the amount of cough) and expectorant (helps to expel phlegm from chest). Drinking Tulsi tea or Kashaya will help in combating sinusitis.

CONCLUSION

Men have been using herbal medicines for thousands of years. The advantages of this type of therapeutics include good availability, local cultural aspects, individual preferences, the increasing demand for natural and organic products, and the already validated synergistic effects of herbal medicines. Medicinal herbs as potential source of therapeutic aid has attained a significant role in health care system all over the world for human beings not only in the diseased condition but also as potential material for maintaining proper health. The above discussed plants can be successfully used for treating sinusitis with no side effects. But scientific validation of the drugs is essential because “evidence-based herbal medicine,” is the need of the hour for making people’s health care better and safer. Maybe then we will see “health for all” as reality.

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