3

Terpenoids

Compounds with basic skeletons derived from mevalonic acid, or a closely related precursor, are termed terpenoids. They are considered to be built up of isopentane or isoprene units linked together in various ways, with different modes of ring closure, unsaturation and different functional groups. The isoprene residues are usually linked in a ‘head to tail’ fashion. However, head-to-head and tail-to-tail linkages as also irregular linkages do occur.

Not all terpenoids comprise carbon atoms in multiples of five, as can be expected of them, considering that they are composed of isopentane units. Some compounds have additional or missing carbon atoms, the modifications (probably) being wrought in the course of the long biosynthetic pathways. Sometimes isoprenoid side chains occur attached to non-terpenoid central skeletons.

The classification of terpenoids is present in Table 3.1.

<table>
<thead>
<tr>
<th>Class</th>
<th>Number of carbon atoms</th>
<th>Number of isoprenes</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemiterpenoids (C_5H_8)</td>
<td>5</td>
<td>1</td>
<td>Volatile oils, esters</td>
</tr>
<tr>
<td>Monoterpenoids (C_10H_16)</td>
<td>10</td>
<td>2</td>
<td>Volatile oils, glycosides, mixed terpenoids</td>
</tr>
<tr>
<td>Sesquiterpenoids (C_15H_24)</td>
<td>15</td>
<td>3</td>
<td>Volatile oils, bitter principles</td>
</tr>
<tr>
<td>Diterpenoids (C_20H_32)</td>
<td>20</td>
<td>4</td>
<td>Resins, chlorophyll</td>
</tr>
<tr>
<td>Sesterpenoids (C_25H_40)</td>
<td>25</td>
<td>5</td>
<td>Rare (mostly in animals)</td>
</tr>
<tr>
<td>Triterpenoids (C_30H_48)</td>
<td>30</td>
<td>6</td>
<td>Resins, waxes, steroids, saponins, cardiac glycosides</td>
</tr>
<tr>
<td>Tetraterpenoids (C_40H_64)</td>
<td>40</td>
<td>8</td>
<td>Carotenoids</td>
</tr>
<tr>
<td>Polyterpenoids (C_5H_8)_η</td>
<td>α</td>
<td>η</td>
<td>Rubber and gutta</td>
</tr>
</tbody>
</table>

3.1 Monoterpenes

Monoterpenes are colourless, steam distillable, water insoluble liquids with a characteristic aroma, with boiling points ranging from 140°C to 180°C. These C_{10} compounds are formed by the head-to-tail, head-to-head or tail-to-tail condensation of two isoprene residues, and exhibit every possible
mode of ring closure, various degrees of unsaturation, and substitution of
different functional groups.

In all, 450 monoterpenes have been discovered (Sticher, 1977), and these
can be classified as derivatives of 15 common types of basic skeletons and
15 less common types of basic skeletons (Devon and Scott, 1972).

Based on their chemical structures, monoterpenoids are classified into
the following three groups:
(a) Normal monoterpenes
(b) Cyclopentanoid monoterpenes
(c) Tropolones.

**Normal Monoterpenes**

These monoterpenes include all aliphatic and cyclic (having basically a
6-membered ring), steam-distillable monoterpenes. These occur usually in
their free state in steam-distillable oils, and possess a distinct aroma.
Recently, non-steam distillable monoterpene glycosides, e.g. β-D-glucosides
of geraniol, neral, citronellol, thymol and carvacrol, have been found to
exist naturally (Skopp and Horster, 1976).

Based on their ring closures, normal monoterpenes are classified as:
(i) Acyclic, (ii) Monocyclic, and (iii) Bicyclic. Functionally, these may be
hydrocarbons, aldehydes, alcohols, ketones or oxides.

(i) Acyclic Normal Monoterpenes

Majority of the acyclic compounds are aldehydes. The alcohols occur either
freely, or as esters.

(ii) Monocyclic Normal Monoterpenes

The ρ-menthane skeleton appears to be the basis of a majority of monocyclic
monoterpenes. The members differ in the number and positions of double
bonds and functional groups. Geometrical isomerism is common, resulting
from the formation of asymmetrical carbon atoms due to attachment of
various functional groups.

(iii) Bicyclic Normal Terpenoids

The bicyclic forms can be visualized as derived from the monocyclic forms
by additional ring closures. These are of 7 main structural types.

Normal monoterpenes are employed pharmacologically as skin stimulants,
sedatives, expectorants, antiseptics, etc., and as a flavouring for foods and
medicines with disagreeable tastes. A few are insecticidal, and hence used
as pesticides.
Iridoids (Cyclopentanoid monoterpenes)

This recently recognized group of monoterpenes, is characterized by a cyclopentanopyran ring nucleus. Most of them occur as β-D glucosides (loganin, asperuloside, etc.), but those of the nepetalactone type are without a sugar moiety and are volatile, occurring in essential oils. Secoiridoids are compounds arising from loganin by the cleavage of the cyclopentane ring (gentiopicroside, oleuropin and swertiamarin).

Both iridoids and secoiridoids are bitter in nature and contribute much to the bitter taste of many medicines. Both these groups of compounds are found to exhibit a wide range of medicinal properties. For example, all of them are antimicrobial in nature; allamandin from Allamanda cathartica is antileukemic; oleuropin from olive as well as valeopicrates (a group of non-glycosidic compounds) from Valeriana spp. are found to be hypotensive and sedative; herpagide from Herpagophytum procumbens is analgesic and geniposide from Gardenia jasminoides is found to be a laxative. Amarogentin and amaroswerin, two secoiridoid glycosides from gentian root, are among the most bitter substances.

Tropolones

These compounds do not contribute to the flavor, but have been included here owing to their terpenoid nature. Tropolones have a seven-membered ring with a double bond system conjugated with a keto group and a hydroxyl group, as their basic structure. They are restricted in distribution, identified as yet only in certain fungi and conifers, e.g. γ-thujaplicene in Thuja. Tropolones resemble phenols structurally and in being strong fungicides. They occur freely or are linked with other compounds. Tropolones are reviewed by Erdtmann (1955) and Pauson (1955).

The C₁₀ monoterpenes are also present in combination with a large number of compounds. These compounds, sometimes named as mixed terpenoids, are alkaloids (many of the indole alkaloids such as iboga, aspidosperma and corynanthe types); phenols (cannabinoids); ketoalcohols (pyrethrins); flavonoids (rotenone, calophyllolide, etc.) or coumarins (marmelosin).

3.2 Sesquiterpenes

More than 1,200 sesquiterpenes are known today. Their structures are based on 30 main skeletal structures, of which there are around 700 compounds; and 70 less common skeletal structures, of which there are around 500 compounds.

Sesquiterpenes are composed of three isoprene units, i.e. are C₁₅ compounds; and occur in steam-distillable volatile oils, and in the bitter principles of many plants. Sesquiterpenes contribute to the flavour, and are classified into the following three groups: (a) Acyclic, (b) Monocyclic, and (c) Bicyclic.
Farnesol is the most important acyclic sesquiterpene widely distributed amongst plants. Its pyrophosphate is a key intermediate in terpenoid biosynthesis (Robinson, 1975). Abscissic acid, a growth regulator, is a sesquiterpene carboxylic acid, related structurally to the carotenoid violaxanthin.

Bicyclic sesquiterpenes are based structurally on either the naphthalenic or the azulenic (one cyclopentane and one cycloheptane rings) type of basic skeleton.

Sesquiterpenes are known to exhibit a number of biological and pharmaceutical properties. Guaiazulene and chamazulenes are antiinflammatory. Bisabolol is antiphlogistic and spasmylytic as also petasin and isopetasin (from Petasites hybridus). Illudin M. and S., tumigillin, etc., are antibiotics. Many of the sesquiterpenes are bitter to taste and are the constituents of many bitter medicines. Asteraceae are particularly rich in these compounds. A large number of sesquiterpenes are found to exhibit antitumour activities. They are germacranolides, guaianolides and pseudoguaianolides, elemanolides and related compounds. Germacronolides form the largest group here. The important members of this group are the following.

1. Elephantin, elephantopin, molephantin, molephantin and deoxyelephantopin from various species of Elephantopus
2. Onopordopicrin from Onopordon acanthium
3. Vernomygdin from Vernonía amygdalina
4. Eupatoropicrin, eupacunin, eupacunoxin, eupatocunin, eupatocunoxin, eupatolide (from various species of Eupatorium)
5. Liatrin from Liatris
6. Ovatifolin, erioflorin from Podanthus
7. Alatolide from Jurinea
8. Ursiniolide from Ursinia
9. Cnicin from Cnicus
10. Tagitin from Tithonia
11. Costunolide, epitulipinolide and lipiferolide (Liriodendron)

Guaianolides and pseudoguaianolides are also equally large groups containing the following members.

1. Gaillardin from Gaillardia
2. Eupatorin, eupachlorin, eupatoroxin from Eupatorium
3. Damsin, damsinic acid from Ambrosia
4. Cyanaropicrin, grosheimin from Cynara
5. Zaluzanin C from Zaluzania
6. Angustibalbin, helenalin from Balduina
7. Autumnolide, microelen, microelenenin A from Halenium
8. Multiradiatin, radatin, pleniradin, fastigelin from Baileya
9. Trilobolide (Laser)

Elemanolides and related compounds are vernolepin, vernomenin, vernodalin (Vernonia), arnicolide (Arnica) and eremantholide A (Eremanthus). Expect for Liriodendron (Magnoliaceae) and Laser (Apiaceae), all other plants containing sesquiterpene lactones belong to the Asteraceae.
3.3 Volatile Oils

Both monoterpenes and sesquiterpenes are the components of volatile oils. Volatile oils are volatile aromatic liquids present in special ducts or oil glands. The aroma is due to a principal component or a group of components often modified by the other compounds present. Monoterpenes form the major components of a large number of oils; though sesquiterpenes are present in many oils in varying amounts, they predominate.

Various essential oils and their constituents are generally used against infections, particularly those of the bronchial and urinary tracts and in preventing sepsis of burns and wounds. The antiseptic activity of certain monoterpenes like thymol is about 20 times more than phenol. Thymol and carvacrol are used in mouthwashes and other monoterpenes like eugenol, menthol are employed in toothpastes for their antiseptic and rubefacient actions that are beneficial to gums. Some, like ascaridol, are important anthelmintics. Due to the irritant properties, some are used as counter irritants and as rubefacients in the form of embrocations and liniments. They produce an initial feeling of warmth and smarting, which is often followed by a mild local anesthesia making them useful in antipruritic preparations. Such preparations alleviate rheumatic pain and neuralgia and can be administered in common colds and bronchitis. Due to their mild irritation of the bronchial glands, they are also used as inhalants with expectorant and cough stimulant properties. Volatile fractions of poppy seeds, sacred basil and cumin seeds, on interacting with glutathione-S-transferase, transform into anti cancer agents and inhibit cancer development (Aruna and Sivaramakrishnan, 1996).

Certain essential oils contain monoterpenes, which act on the central nervous system and thus can exhibit central stimulating, central sedative and narcotic effects. Oils of valerian, calamus, melissa and lavender exhibit a sedative effect. The sedative property is attributed to citronellal, geraniol, citronellol and citral, the first showing the greatest activity. Camphor is said to have a central stimulating effect. The carminative property exhibited by certain oils is due to local irritation (by which the enzymes are released) and due to the spasmolytic effect.

Sulphur-containing oils, containing sulphides and isothiocyanates, being volatile, are included here.

3.4 Aromatherapy

Aromatherapy is a relatively new term for an ancient practice of using fragrant essential oils to treat a wide range of physical and emotional ailments. A French chemist Rene-Maurice Gattefose coined the term aromatherapy to describe the medicinal uses of essential oils. The oils are directly applied to the affected parts like wounds and burns or massaged into the skin so that the oil reaches the bloodstream or is inhaled into the lungs and the effect of the aroma reaches the mind.
Since the monoterpenes are small molecules and are lipidic, they are rapidly absorbed by the skin. This property is used for chest rubs or abdominal rubs. The antimicrobial, expectorant and local irritant properties of these compounds are fairly known and, therefore, they are often used thus by many people.

Today, aromatherapy is more concerned with the physiological and emotional effects of the fragrance of essential oils than with their antimicrobial and healing qualities. How scents can affect moods, one’s state of mind and health by sending messages directly to the brain are subject to an increasing number of research studies.

The part of the brain that receives and processes smells is known as the **limbic system**. This is the oldest part of the brain, the core around which higher brain functions are located. It includes the primary control systems for most of our body functions, including hormone secretion and the autonomic nervous system. Thus, inhaling a fragrance can stimulate the release of hormones, which cause euphoria, pain relief, sexual response, stimulation, control anger or fear, induce sleep or reduce stress.

It is found out that fragrance can affect both mood and behaviour both at home and workplace. People are found to cooperate more when placed in a room with a pleasant smell. The aroma of oils of rosemary, cinnamon, basil, jasmine, basil, black pepper, etc., are found to cause brain-wave patterns much like those caused by caffeine. Researchers in Japan measured the brain waves of women who were receiving facials scented with orange, tangerine and peach designed to lift their spirits. They found that these patterns are similar to those achieved during deep relaxation or meditation. It is also found that the women’s blood pressure also lowered. The oils of valerian, neroli, nutmeg and mace cause a lowering of blood pressure. The fragrances of chamomile, marjoram, sandalwood and bergamot are found to sedate the mind and body. International Fragrance and Flavour, a large perfume company, has acquired a patent to produce a product to ease stress in the workplace by using a blend of neroli, valerian and nutmeg. Adding a few drops of these oils to a warm bath also produce similar effects. In an article in the *British Journal of Occupational Therapy*, aromatherapy is described as a way to promote health and well being through massage, inhalation, baths, compresses, creams and lotions. Using fragrance in hospitals is advocated to reduce stress and depression, sedate or invigorate, stimulate sensory awareness and provide pain relief. Memorial Sloan-Kettering Cancer Centre in New York is already using aromatherapy to lower the stress levels not only of patients, but also their families and staff. (Keville and Green, 1995).

**Angelica sinensis** Diels (*Apiaceae*)

**Dong quai, Female Ginseng**

Dong quai is an aromatic perennial herb with a striate stem, tripinnate leaves, small white flowers in a terminal umbel and a compressed cremocarp. It is a native of China.
The roots yield an essential oil containing ligustilide, safrole, \( p \)-cymene, butylidene dinaphthide and sesquiterpenes. Also present are coumarin bergapten and fatty alcohols.

This drug (roots) is useful in relieving menopausal symptoms and for other menstrual disorders and dysmenorrhoea. It is also a restorative in nature and used in general debility and anaemia.

**Melissa officinalis** Linn. (Lamiaceae)

*M. officinalis* is a lemon-scented perennial herb reaching a height of 1-1.5 m, with simple opposite ovate serrately toothed, deeply veined leaves and small white flowers. Native of southern Europe and W. Asia, this plant is now widely cultivated.

The whole plant yields a volatile oil, flavonoids, and triterpenes. The volatile oil is about 0.1%, consisting of more than 50 compounds of which the major ones, citronellal, \( \beta \)-caryophyllene, neral, geranial, citronellol and geraniol amount to 70%. Also present in the leaves are caffeic, rosemarinic and ferulic acids.

This herb can calm nerves and is a folk medicine for insomnia. It is also used in fevers, colds and spasms. Recently, this plant was found to possess antiviral and anti herpes properties (Dimitrova et al. 1993; Wohlbling and Leonhardt, 1994).

**Hyssopus officinalis** Linn. (Lamiaceae)

*Hyssopus officinalis* is an aromatic herb with opposite lanceolate leaves, irregular lilac flowers in axillary clusters on long narrow spikes and four nutlets. This is a native of the Mediterranean region.

All parts yield a volatile oil (upto 1%) consisting of cineole, \( \beta \)-pinene and a variety of bicyclic monoterpene derivatives (L-pinocamphene, isopinocamphone, pinocarvone, etc.), diterpenoid phenols such as carnosol and carnosolic acid, depsides of caffeic acid, triterpenoid acids (marrubin, ursolic and oleanolic acids), tannins and flavonoids (diosmin and hesperidin). Also present are hyssopin (a glycoside) and resin.

Hyssop (all parts) is an excellent nerve tonic and helps recovery after an illness. It is useful in colic, colds, flu, coughs and flatulence. Hyssop is an emmenagogue and abortifacient too (to be avoided during pregnancy). The polysaccharide fraction and tannins of hyssop are found to inhibit SF-strain of HIV-I virus.
Tanacetum vulgare Linn. (Asteraceae)

Syn. Chrysanthemum vulgare Bernh.

Tansy

Tansy is an aromatic perennial (upto 2 m tall) with pinnate leaves (leaflets lanceolate, pinnately divided), yellow disc florets in heads borne on dense terminal corymbs and small 5-angled achenes. This is a native of Eurasia. Flowers yield a volatile oil rich in thujone and camphor. Sesquiterpenes are also present in the oil. The flowers yield flavonoids and resin.

Tansy is a toxic plant, carefully used for killing intestinal worms. It is also useful in reducing menopausal problems, and must be avoided during pregnancy.

Acorus calamus Linn. (Araceae)

Vacha, Sweet Flag

Calamus is the sweet and aromatic rhizome of sweet flag, growing in marshy places of Europe, Asia and America. The rhizomes are furrowed longitudinally on the upper surface, jointed and spongy. The leaves are long and linear. Flowers are small yellow green, borne in a spadix enclosed by a spathe, and the berries are green, 1-3 seeded with oblong seeds.

All parts of the plant contain an essential oil having asarone (80%), asaraldehyde, acoradin, phenylindane, a phenyl propene [1-(p-hydroxy phenol)-1-(O-acetyl) prop-2-ene], calamenol, calamene and sesquiterpene ketones like acorone, calarene and calacone and monoterpenes 1,8-cineole, linalool, α-terpeneol and eugenol methyl ether. The yield of oil is maximum in dried rhizomes (3.5%). In addition, roots yield choline and acoric acid. Acorin, a bitter principle, luteolin glycoside, tannins, mucilage, β-sitosterol, and calcium oxalates are the other constituents reported from the plant.

Vacha is well known for its role in improving memory power (especially for loss of memory) and intellect and is used in treating epilepsy and other mental disorders. It is also employed in chronic diarrhoea, dysentery, abdominal tumours, bronchial catarrh, rheumatism and eczema. The rhizome powder is a well-known insecticide against fleas, bedbugs and used to prevent insect pests in rice and other grains and silverfish in libraries. β-Asarone, a derivative of asarone, is suspected to be carcinogenic.

Alpinia galanga Willd (Zingiberaceae)

Barakulanjar, Greater Galangal

A. galanga is a tall herb with tuberous aromatic reddish brown rootstock, oblong-lanceolate leaves, greenish-white flowers streaked with red, borne on dense-flowered long panicles and orange globose capsules. A native of Indonesia, this plant is cultivated throughout India for its aromatic rhizomes.
Rhizomes contain a volatile oil of a strong and spicy odour, consisting of methylcinnamate (48%), cineole (30%), camphor and pinene. Leaves also yield a volatile oil rich in methyl cinnamate. Seeds are found to contain a volatile oil consisting of l’-acetoxychavicol acetate, l’-acetoxyeugenol acetate, caryophyllene oxide and caryophyllenol and fatty acids.

The dried rhizome is the drug Greater Galangal, a reputed medicine for rheumatism and catarrh. It is also considered to be a tonic, carminative and stimulant and used as an expectorant helping in clearing the voice. The rhizome is effectively used as an insecticide against houseflies. The leaves and flowers are reported to have anti-tubercular properties. L’-Acetoxychavicol acetate and l’-acetoxyeugenol acetate possess anti-ulcer properties.

**Alpinia officinarum** Hance

**Lesser Galangal**

A native of China, *A. officinarum* is a perennial herb with thick, creeping reddish-brown rhizomes, lanceolate acuminate ornamental leaves and showy white flowers in racemes.

The constituents of the rhizome, the drug, are a volatile oil and flavonoids. The volatile oil, amounting to 1%, consists of 1,8-cineole, α-pinene, β-pinene, methyl cinnamate, etc. Flavonoids reported are about 14, including quercetin, kaempferol, isorhamnetin, galangin and 3-OMe galangin.

Lesser galangal is used as a spice and carminative.

**Amomum subulatum** Roxb. (Zingiberaceae)

**Bari Elachi, Large Cardamom**

*A. subulatum* is a tall perennial herb reaching up to 2.5 m in height with creeping rhizomes, several erect leafy shoots bearing oblong-lanceolate large leaves and short penduncled glabrous spikes. The capsules are up to 2.5 cm long, obcordate, brownish, containing many flattened seeds. A native of Himalayas, this plant is now cultivated widely in northeast India.

The seeds of this plant yield up to 3% of a volatile oil consisting of cineole (65%), terpeneol, terpenene and pinenes. Other constituents of the seed are protein (6%), starch (43%), anthocyanins such as petunidin; an aurone, subulaureone; chalcone, cardamonin and a flavone, alpinetin. The seeds are used as a substitute for cardamom. They are stimulants and stomachics and are also used in indigestion, abdominal pains and rectal diseases.

**Anethum graveolens** Linn. (Apiaceae)

Syn. *Peucedanum graveolens* Linn.

**European Dill**

*A. graveolens* is an aromatic annual/biennial, up to 1 m in height with
glabrous branching stems bearing tripinnatipartite finely dissected leaves. The yellow flowers are borne in compound umbels and the mericarps are oblong, dorsally compressed, having two winged lateral ribs. This is a native of Eurasia.

The fruits of the European dill contain 2.5-4% of volatile oil, 16-20% of fatty oil, and 15% proteins. The major constituents of the volatile oil are carvone (30-60%) and \( d \)-limonene. Dihydrocarvone, \( d \)-phellandrene, \( \alpha \)-terpenene, carveol and dill-apiole are the remaining components of vol. oil. The fixed oil is rich in petroselinic acid triglycerides. Other compounds isolated from the fruits are myristicin, coumarins (bergaptene, umbelliprenin, umbelliferone, scopoletin and aesculetin), flavonoids (kaempferol, glycoflavone), phenolic acids (caffeic, ferulic, chlorogenic) and steroids (\( \beta \)-sitosterol and \( \gamma \)-sitosterol. The leaves also are found to contain a volatile oil consisting of \( d \)-phellandrene, \( \alpha \)-terpenene, limonene, carvone, dihydrocarvone and eugenol. When the plants age, the oil becomes richer in carvone and limonene content decreases. Vitamin C, vanadium and uranium are the other constituents of the leaves. The inflorescences also yield a volatile oil, phytofluene, \( \beta \)-sitosterol, stigmasterol, scopoletin and umbelliferone.

The volatile oil and its emulsion in water are stomachic, diuretic, anthelmintic and antiflatulent and form an important ingredient in gripe water preparations for children. It has been found that the limonene fraction is active against paramecia and helminthes. The oil is also used in beverages, gargles and toothpastes. Apiole as well as dill are powerful emmenagogues (to be avoided by pregnant women). Dill leaves are used for flavouring curries, beverages and pickles and possess carminative and preservative properties.

**Anethum sowa** Roxb.

Syn. *A. graveolens* DC,

*Peucedanum sowa* Roxb.

**Sowa, Indian Dill**

*A. sowa* is similar to *A. graveolens* Linn, but the fruits are subelliptical with three longitudinal ridges and vittae having marginal walls appearing irregular.

The fruits yield a volatile oil (1.5 to 3.5%), proteins (20%), carbohydrates (31%), \( \beta \)-sitosterol, piperine and flavonoids (kaempferol and quercetin). The major constituent of oil is carvone (20-70%), with dihydrocarvone, \( d \)-limonene, \( d \)-phellandrene, myristicin, apiole and dill-apiole. The tender plant also yields a volatile oil rich in \( d \)-phellandrene.

Sowa is used as a carminative, antipyretic and anthelmintic and is a component of gripe water. It is also used as a condiment and in confectionery. The seed oil is useful in preventing flatulence in children.
Angelica archangelica Linn. (Apiaceae)

_A. archangelica_, a native of Syria, is a stout aromatic perennial herb, glabrous except for the inflorescence, with bi/tripinnate leaves bearing toothed leaflets, small greenish white flowers in compound umbels and ellipsoid winged mericarps. This herb is cultivated in Europe and W. Asia.

All parts of the plant yield volatile oils. The oil from roots, amounting to 1% dry basis, consists mainly of α-phellandrene. Other constituents of roots are furanocoumarins such as archangelin, prangolarin, oxypeucedanin, ostruthol and osthol, an isocoumarin angelicain and a chromone glycoside. The volatile oil from the fruit (upto 3.8%) contains α-phellandrene, p-cymene, azulene and sesquiterpenes. Umbelliprenin, isoimperatorin, bergaptene, prongolarin and ostruthol are the coumarins present in fruits.

The roots of Angelica are aromatic and used as diaphoretics, expectorants, and diuretics and in flatulent colic.

_A. glauca_ Edgew, an allied species, and a native of western Himalayas, yields a volatile oil (from roots) containing sesquiterpenes, α-pinene, α-phellandrene and α-cadinene. The root is used as a spice and in medicine in bilious complaints, infantile atrophy, and menorrhagia as also for treating rinderpest.

Apium graveolens Linn. (Apiaceae)

_Celery_

This strongly aromatic perennial is a native of temperate Europe. It has an erect grooved jointed stem, pinnate (leaflets ovate, 3-lobed) leaves, white small flowers in short-pedicelled/sessile compound umbels and small suborbicular, slightly bitter schizocarps.

The fruits yield a volatile oil (2-3%), a fatty oil (17%), resin, flavonoids, coumarins and alkaloids. The principal component of the volatile oil is limonene (50%), along with selinene (15%), sedanolide and sedanonic anhydride. The last two compounds are responsible for the characteristic odour of the oil. A number of phthalides are also present in the oil. The fatty oil is rich in petroselinic and oleic acids and contains upto 7% resin acids. The flavonoids present are apigenin, luteolin and chrysoeriol. Rutaretin, apiometin, bergaptene, psoralen and isopimpinellin are the coumarins located. Glutamine, asparagine, caffeic acid and chlorogenic acid are the other compounds isolated from the fruit. From the water extract of seeds, 5 sesquiterpenoid glycosides (celeriosides A-E) and three phthalide glycosides (celephthalides A-C) along with nor-carotenoid glycosides and a lignan glucoside are isolated (Kitajima et al. 2003). Celery leaves yield protein (6.3%), and an essential oil besides the furcoumarins, bergaptene, xanthotoxin and isopimpinellin.
Celery seeds (fruits) are extensively used as spices and possess stimulative and carminative properties. They are used as nerve sedatives and tonics. A decoction of seeds is effectively used against rheumatism and for problems of the liver and spleen. The fatty oil is also used as an antispasmodic and nerve stimulant. The volatile oil is shown to exhibit tranquilizing and anticonvulsant properties. The leaves are used as salad and used in the cure of vitiligo and psoriasis.

*Calendula officinalis* Linn. (Asteraceae)

Calendula is an erect aromatic herb with angular glandular hairy stems, lower leaves spatulate and upper lanceolate having cordate amplexicaul base, light yellow heterogamous flower heads and boat shaped (upto 1 cm long) achenes. This is a native of southern Europe but cultivated throughout India.

The flower heads yield 0.1 to 0.4% volatile oil, consisting of pedunculatine, \(\alpha\)-, and \(\beta\)-ionones, *trans*-caryophyllene oxide, carvone, geranyl lactone, \(n\)-tricosane, terpene alcohols and lactones. The flowers contain a large number of triterpenes such as calenduline, oleanolic acid-based saponins, \(\alpha\)-amyrin, \(\beta\)-amyrin, taraxasterol, \(\gamma\)-taraxasterol, lupeol, brein, faradiol, arnidiol, erythrodial, calenduladiol, coflodiol (ursadiol), manilladiol, olean-12-ene-3(\(\beta\), 16\(\beta\), 28-triol, lup-20 (29)-ene-3(\(\beta\), 16\(\beta\), 28-triol, tarax-20-ene-3(\(\beta\), 16\(\beta\), 22\(\alpha\)-triol, tarax-20-ene-3(\(\beta\), 16\(\beta\)-30-triol, ursa-12-ene-3\(\beta\), 16\(\beta\), 21-triol and loliotide acetate. In addition, heliantriol C, oleanolic aldehyde, oleanolic acid, \(\beta\)-sitosterol, stigmasterol, 28-isofucosterol, campesterol, 24-methylene cholesterol, cholesterol, 4\(\beta\)-methyl stigmasta-7, 24 (28) dien-\(\beta\)-ol and 4\(\beta\)-methyl ergosta-7, 24 (28)-dien-3(\(\beta\)-ol are also present. The phenolics present are \(p\)-hydroxybenzoic, \(p\)-coumaric, gentisic, vanillic, caffeic, gentisic, vanillic, caffeic, \(o\)-hydroxyphenylacetic, salicylic, ferulic and protocatechuic acids, scopoletin, umbelliferone and aesculetin. The carotenoids of the petals are phytoene, phytofluene, \(\alpha\)-, \(\beta\)-, \(\lambda\)-, and \(\zeta\)-carotenes, prolycopene and lycopene. Also present in the flowers are a bitter principle, loliolide and water-soluble polysaccharides.

The roots contain 8 saponins, calandulosides A-H, all based on oleanolic acid, while the seeds yield protein (33%), oil (44%), [consisting of calendic (53%) and linoleic (34%) acids as major constituents as well as \(\beta\)-carotene], phytin and haemagglutinins (Varljen et al. 1989).

The ray florets form the drug *Calendula*, which is said to possess tonic, sudorific, febrifuge, carminative, antiemetic and anthelmintic properties. Externally, the paste of flowers is used against malignant ulcers, skin diseases, and frost bite. In the USSR, the florets have been used for abdominal cancer. The extracts (aqueous/alcoholic) are sedative and hypotensive in nature and also used against amenorrhoea and leucorrhoea. The leaves, which are used as pot herbs, are useful for treating varicose veins (externally), suppu-

**Syzygium aromaticum** Merr. & Perry (Myrtaceae)

*E. aromatica* Bail

**Laving, Clove**

Clove are the unopened flowers of a small, evergreen tree, native of the Molucca islands. Cultivated in many tropical countries, the trees have oblong-ovate leaves. In wild state they produce purplish or crimson flowers in terminal branching racemes, but never reach the flowering state when cultivated. The flower buds are greenish or reddish when fresh and have slightly cylindrical receptacles surrounded at the top by 4 calyx teeth enclosing the plump globular unopened corolla. When dried, the buds are brown and brittle.

Clove contain 14-20% volatile oil, 10-13% tannins, oleanolic acid, vanillin, and a chromene-eugenin. 70-90% of volatile oil is eugenol. Also present in the oil are minor quantities of eugenol acetate, caryophyllene, methyl-n-amyl ketone and some esters.

Clove are used for flavouring foods and as a stomachic and carminative in medicine. It is also found to heal stomach ulcers and inhibit carcinogens by inducing the production of detoxifying agents such as glutathione S-transferase (Zheng et al. 1992). Clove oil is antiseptic and antispasmodic and is often an ingredient of toothpastes and mouthwashes. It is a toothache remedy. It also finds great use in medicines, perfumery, and histological work and for commercial production of vanillin.

Clove stems, a commercial product, contain only 4-7% of volatile oil and are less aromatic. They are used to adulterate cloves. The dried fruit or ‘mother cloves’ contain starch and are only slightly aromatic. They also are a common adulterant to cloves.

**Marrubium vulgare** Linn. (Lamiaceae)

**Hoarhound**

The white wooly stems of this perennial herb are up to 1 m in height and bear ovate leaves and white flowers in axillary whorls. Hoarhound is a native of Europe and C. Asia.

The leaves and flower tops contain about 0.4% of marrubin, a cyclic diterpenoid bitter principle, an alkaloid l-betonicine and an essential oil.

Hoarhound is used as a flavouring agent, and as an antiseptic and expectorant.
**Lavandula officinalis** Choix (Lamiaceae)**

Lavender

This is an evergreen shrub of about 1 m height, with linear lanceolate leaves and blue flowers in terminal spikes. This plant is indigenous to S. Europe.

Fresh flower spikes and leaves yield 0.8-2% volatile oil, comprising of 30-40% esters, chiefly l-linalylacetate; geraniol, linalool, limonene, cineole, esters of butyric and valeric acids, and a sesquiterpene.

Lavender is a flavoring agent and used in perfumery as well as an expectorant.

**Rosemarinus officinalis** Linn. (Lamiaceae)**

Rosemary

Rosemary is a native of the Mediterranean region, cultivated in Europe and the USA. These evergreen shrubs are 1-2m in height with slender ash-coloured branches. The leaves are linear and sessile with grey wooly lower surfaces. The mauve flowers are borne in verticillasters.

Leaves and flower tops yield 1-2% volatile oil consisting of bornyl acetate, borneol (the chief constituents), cineole and minor quantities of camphene and α-pinene. Also present in the leaves are rosemarinic acid and triterpene alcohols like α-, and β-amyrrins, betulins and β-sitosterol.

Rosemary is known as the "herb of remembrance" and is used to enhance memory and, therefore, recommended for patients suffering from Alzheimer’s disease in aromatherapy. It contains a couple of dozen antioxidants and half-dozen compounds that are reported to prevent breakdown of acetylcholine. This plant is a well-known flavouring agent and widely used in perfumery.

**Mentha piperita** Linn. (Lamiaceae)**

Pudina, Peppermint

Peppermint is a small perennial aromatic herb (with an aroma of pepper) having a running rootstock, opposite oblong lanceolate serrate glabrous leaves and purple flowers in thick terminal spikes. It is a native of Europe now cultivated everywhere.

The whole plant yields a volatile oil (1-3%), flavonoids, phenolics and steroids. The main constituents of volatile oil are menthol (30-35%) and menthone (15-30%). Other components are menthyl acetate, menthofuran, cineole, limonene, neomenthol, isomenthol and a sesquiterpene (viridofloral). The flavonoids present are apigenin and luteolin along with highly oxygenated flavones. Caffeic, chlorogenic and rosemarinic acids are the phenolic acids present, whereas the triterpenes located are α-amyrrin, ursolic acid and sitosterol.
Peppermint is a carminative and flavouring agent. It is a spasmyolytic, smooth muscle relaxant and anti-inflammatory. It helps in the production of bile and is a diuretic as well as a mild sedative.

The yield and composition of volatile oil are influenced by environmental factors, harvesting time and planting time.

Japanese peppermint *Mentha arvensis* Linn. yields a similar volatile oil rich in menthol and is used likewise.

*Mentha spicata* Linn. (Lamiaceae)

**Spearmint**

This native of temperate Europe and Asia has now spread all over the world. The plant is a glabrous annual with leafy stolons. Stems are 30-60 cm in height, erect with ascending branches bearing green sessile lanceolate leaves and flowers in interrupted cylindrical spikes.

The yield of volatile oil from the leaves and flowering tops is about 0.5%. The oil contains 55% $l$-carvone (caraway and dill contain $d$-carvone), limonene, phellandrene and some esters. The leaves also contain resins and tannins.

Spearmint is a flavouring agent used in stews, sauces, beverages, chewing gum, dentifrices, etc.

The oil of *Mentha pulegium* Linn. (European penny royal), an allied plant, contains pulegone as its principal constituent.

*Thymus vulgaris* Linn. (Lamiaceae)

**Thyme**

This native of the Mediterranean region is a suberect herb, with sessile, linear to ovate leaves borne on slender woody pubescent branches. The lilac flowers are borne in dense head-like resinous clusters.

Dried leaves and flower tops yield 1-2.5% of a volatile oil, 25-40% of which is constituted by thymol. Minor quantities of carvacrol, $p$-cymene, $l$-borneol, linalool, etc., occur in the oil along with thymol. The leaves also contain gums, resins and tannins.

Thyme is a flavouring agent used in soaps, salads, etc. The oil is an antiseptic and is used in perfumery, toothpastes, as fungicides and in internal medicines.

*Gaultheria procumbens* Linn. (Ericaceae)

**Wintergreen**

The plant is an evergreen shrub, with a creeping stem and erect leafy branches. The oval leaves are 3-6 cm long, apiculate, glabrous and shining. These are the source of wintergreen. The white flowers are solitary and the fruits are scarlet in colour. This is a native of North America.
The leaves contain gaultherin, a phenolic glycoside that, in the presence
of water, is acted upon by an enzyme gaultherase to produce a volatile oil
consisting of methyl salicylate (98%), and a sugar, primeverose. The other
constituent of the oil is an ester of enanthic alcohol.

Wintergreen oil is used in medicine and flavoring. However, the chief
source of the oil of wintergreen today is the sweet birch, *Betula lenta* Linn.
that contains gaultherin in the bark.

*Caesulia axillaris* Roxb. (Asteraceae)

Bagra, Caesulia

A glabrous decumbent/semierect herb with sessile, semi-amplexicaul, ob-
long-lanceolate leaves, white/pale blue disc florets clustered in the axils of
leaves and dark brown ribbed achenes. Bagra a common weed in rice
fields throughout India.

The whole plant from Ujjain (Madhya Pradesh) yielded a volatile oil
consisting of $\gamma$-asarone (48%), limonene (34%), cineole (4%) and pinene (3%).
Another sample from northwest Himalayas is found to contain volatile oil
consisting of dilapiole (50%) and methyl heptanol (42%). Catechol, 2,4,5-
trimethoxy cinnamaldehyde, 2,4,5-trimethoxy benzaldehyde and asarone are
reported from aerial parts. Seeds are found to yield fat (15%) consisting of
stearic (32%), linoleic (46%), palmitic (15%) and oleic (6%) acids and protein
(5%).

The plant is used for treating baldness and goiter and as a diuretic. The
young leaves are used as a pot herb. The volatile oil, when isolated, exhibited
anti-fungal and anti-bacterial activities as well as anti-feedant activities
against insects such as *Spodoptera litura* and *Achoea janata*.

*Carum carvi* Linn. (Apiaceae)

Kala Zira, Caraway

Caraway is an aromatic glabrous annual/biennial herb reaching a height of
1m, with thick fusiform roots, grooved hollow branches, pinnately dissected
leaves having laciniately cleft leaflets, white flowers in compound umbels
and oblong-oval yellowish fruits, mericarp curved, brownish with five
prominent ribs. This plant is found wild in north Indian hills, and cultivated
in a large scale for its aromatic seeds.

The mericarps (‘seeds’) contain protein (40%), fixed oil and resin (10%) and
a volatile oil (3-8%). The principal constituents of the volatile oil are
carvone (55-60%) and limonene. Other monoterpenes present are $\alpha$-pinene,
$\beta$-pinene, and $\eta$-cymene. The fixed oil is rich in oleic (60%), linoleic (20%)
and petroselinic (17%) acids. The phenolics reported from the seeds are
glycosides of kaempferol, quercetin and isorhamnetin and coumarins such
as 5- and 8-methoxy psoralens, umbelliferone, herniarin, and scopoletin.
The whole plant also yields a volatile oil consisting of cadinene (37%), carvone (31%) and dihydrocarveol (10%). The roots contain polyenes, falcarnindione, falcarninolone, phytofluene, β-sitosterol, umbelliferone and scopoletin. Leaves contain glycosides of kaempferol and quercetin.

Caraway is a popular spice and condiment. It is prescribed in flatulent colic and stomach problems. Its alcoholic extract is antispasmodic. Caraway roots are edible and leaves are eaten as salads.

*Chenopodium ambrosioides* Linn. (Chenopodiaceae)

**Kshetravastuka, Indian Wormseed**

Indian wormseed, a much-branched woody herb with a smell of camphor, having angular-ridged purple-tinged fleshy stems, oblong-ovate leaves, green flowers in axillary/terminal spikes and small reddish brown seeds. A native of tropical America, is now found as a weed in waste places.

The flowering and fruiting shoots yield a volatile oil (0.25-0.45%) containing ascaridole (50%), xylene, p-cymene, tetradecanol, caproic and caprylic acids. The leaves contain kaempferol and organic acids and the fruits yield glycosides of kaempferol as well asisorhamnetin, quercetin and 4’-O-demethylarborictorin (Jain et al. 1990).

The entire plant is a tonic, emmenagogue, antispasmodic and useful in treating nervous affections. The dry plant is anthelmintic against hookworms and roundworms. The tender leaves and shoots are used as a vegetable. The powdered seed or its decoction is used as an insecticide.

*Chenopodium anthelminticum* Linn.

**American Wormseed**

This plant also yields a volatile oil containing 60-80% ascaridole and the amount of oil also is higher (upto 2%). It is used in a similar capacity to the Indian wormseed.

*Cinnamomum aromaticum* Nees. (Lauraceae)

**Syn. C. cassia Blue.**

**Chinese Cassia**

*C. aromaticum* is an aromatic evergreen tree with a smooth grey bark; oblong, elliptic large leaves (3-nerved from base), small flowers in terminal or axillary panicles and black aromatic fruits containing single seeds. This is a native of China.

The bark of Chinese Cassia is rich in diterpenes such as cinnzeylanin, anhydrocinzeylanin. cinnzeylanol, anhydrocinzeylanol, cinnacassiols A,
B, C, D₁, D₄ and E and their glycosides. Other compounds in the bark are cassioside, cinnamoside, lyoniresinol glucoside, syiringaresinol, cinnamic aldehyde, epicatechin, cinnamtannins A₁-A₄, procyandins and a volatile oil (0.3%). The constituents of volatile oil are cinnamaldehyde (82%), eugenol, cinnamic acid, cinnamyl acetate etc. The leaves yield an essential oil (0.4%) containing 71% cinnamaldehyde and 10% eugenol. The flowers and unripe fruits also yield similar volatile oils.

Chinese cassia is used as diaphoretic, antipyretic, analgesic, purgative, cardiac stimulant, diuretic and sedative. The diterpenes are found to be anti-ulcerogenic. The oil is used as a flavouring agent, and in perfumes.

**Cinnamomum camphora** Presl.

*Kapoor, Camphor*

All the parts of this tree contain a volatile oil rich in camphor. Camphor separates out on cooling the steam-distilled oil. Other compounds in the mother liquor are safrole, cineole, borneole, camphene, dipentene and terpeneol. A number of varieties of *C. camphora*, produce a volatile oil rich in compounds like safrole, linalool, cineole, etc.

Camphor is used as an anodyne, rubefacient, in rheumatism, as external application on sprains or as a liniment. When taken internally, it is a carminative, expectorant, reflex stimulant of heart and as a nervous depressant in hysteria, epilepsy, etc.

**Cinnamomum tamala** Nees. & Eberm.

*Tamalpathra, Indian Cassia Lignea*

This is a moderate-sized tree with dark brown bark, elliptic/oblong 3-nerved leaves, pale yellow flowers in panicles and ovoid black fruits. Two chemotypes of *C. tamala* occur in India. The eugenol-type is found in north India and cinnamic aldehyde-type in eastern India.

The leaves yield an essential oil (0.3-0.6%). The eugenol type contains eugenol (13%), eugenol acetate (12.5%), cinnamic aldehyde (41%), linalool (15%), β-caryophyllene, benzaldehyde, camphor and cadinene. The cinnamic aldehyde type contains linalool (50%), cinnamic aldehyde (12%), α- and β-pinenes, p-cymene, geraniol etc. A sample from Assam showed 80-85% eugenol. The leaves contain 3'-methoxy kaempferol, quercetin, free as well as glycosides. The volatile oil from bark contains cinnamic aldehyde in large amounts (80%).

The leaves are used as spice and in colic, diarrhoea and rheumatism. Leaf powder is said to be hypoglycemic. The bark is carminative and used to cure gonorrhoea.
**Coleus ambonicus** Lour. (Lamiaceae)

**Syn.** *C. aromaticus* Benth

**Karpurvalli/Patjarchur, Indian Borage**

This highly aromatic succulent herb is much branched and bears broadly ovate, crenate-serrate fleshy leaves, small zygomorphic purple flowers in dense whorls at intervals in a racemose axis, and a utricle of 4 orbicular nutlets. A native of Malaya, it is now widely cultivated everywhere.

The leaves of this plant contain a volatile oil, large amounts of exalacetic acid along with cirsimaritin, β-sitosterol and other triterpenoid acids. Flavonoids such as salvigenin, 6-OMe genkwanin, chrysoeriol, luteolin, apigenin, quercetin, eriodictyol and taxifolin are reported from South American varieties. The volatile oil consists of thymol (40%) and carvacrol.

This is a common home remedy for cough, cold and fever in children. It also used for kidney and bladder stones, bone fractures, headache, asthma, bronchitis, indigestion, diarrhoea, dysentery and cholera. It is a good carminative, diuretic and stimulates the function of the liver.

**Coriandrum sativum** Linn. (Apiaceae)

**Dhanya/Kottmir, Coriander**

Coriander is a glabrous aromatic annual with a slender branching stem. Basal leaves are entire with crenate margin whereas the leaves from stem are pinnate (leaflets branched dichotomously to linear segments but outline of leaflet remains ovate), leaf base almost sheathing. White flowers are borne in umbels in which the outer flowers have enlarged ray-like petals. The spherical cremocarp contains two hemispherical mericarps united by their margins. Each mericarp has five wavy inconspicuous primary ridges alternating with four prominent secondary ridges. Coriander is a native of the Mediterranean region, now widely cultivated everywhere.

The leaves yield isocoumarins like coriandrones A & B, coriandrin and dihydrocoriandrin and are good sources of vitamin C and carotenoids. Fruits contain fixed oil (15%), volatile oil (upto 1%), tannins and calcium oxalate. 65-70% of the volatile oil is linalool. Other components are α- and β-pinenes, limonene, γ-terpenene, p-cymene, borneol, citronellol, camphor, geraniol and geranyl acetate. Heterocyclic components such as pyrazine, pyridine, thiazole, furan and tetrahydrofuran derivatives, isocoumarins, viz., coriandrin, dihydrocoriandrin and coriandrones A-E, flavonoids like 6-methoxyquercetin, sterols, phthalides such as neochochilide and 2-digustilide are the other constituents reported from coriander (Gijibels et al., 1982; Tanaguchi et al., 1996; Lamparsky and Linies, 1988).

Coriander is a well-known spice with stomachic, spasmolytic and carminative properties. The essential oil is antifungal in nature.
**Cymbopogon citratus** Stapf. (Poaceae)

*Lilichai, Lemongrass*

This is a tall aromatic grass with linear, distichous leaves, elongate panicles and many sessile spikelets. Lemongrass is found wild or cultivated.

The leaves yield a volatile oil rich (78-82%) in citral, waxes, flavonoids (luteolin, isoorientin and orientin), phenolic acids (chlorogenic, caffeic and p-coumaric acids), triterpenoids such as cymbopogonol and cymbopogone. Other constituents of volatile oil are \( d \)-limonene, citronellol, geraniol and myrcene.

Lemongrass is used in elephantiasis, as CNS depressant, analgesic, antirheumatic, antipyretic and expectorant. Lemongrass oil is anticarcinogenic in the sense that \( d \)-limonene and geraniol induce activity of glutathione transferase, an enzyme that inhibits cancer development. The oil is also used as a remedy for ringworm. Citral is an insect repellant.

**Cymbopogon martinii** Wats.

There are two varieties of this plant, *sofia* and *motia*, the former yielding ‘ginger grass oil’ and the latter ‘palmerosa oil’. These oils are used in rheumatism.

**Eucalyptus globulus** Labill. (Myrtaceae)

*Nilgiri, Eucalyptus*

*E. globulus* is a tall aromatic tree with grayish white smooth bark exfoliating occasionally and elliptic lanceolate leaves and greenish yellow flowers. Eucalyptus cultivated in many parts as a social forestry tree.

The leaves yield a volatile oil (up to 1.5%) consisting of cineole (65-75%), caryophyllene, \( \alpha \)-pinene, limonene, etc. The bark and wood contain polyphenols. Euglobals (acyl-phloroglucinol-monoterpene/sesquiterpene, 11 in number, such as euglobal 1\(_{a1},1_{b2},1_{1b},1_{1c},11_{a1},11_{b1},11_{b2}\) 11-X) form another group of compounds isolated from this plant. Also present in the leaves are acetogenin mevalonates, eucalyptin, quercetin, rutin, chrysin, phloroglucinol, oleanolic acid, ursolic acid and phenolic acids such as caffeic, ferulic, gallic, gentisic and protocatechuic acids (Dayal, 1988).

The essential oil is used as an expectorant and antiseptic. A gum resin from plant is used in diarrhoea. Euglobal III is a granulation-inhibiting agent.

**Foeniculum vulgare** Mill. (Apiaceae)

*Madhurika/Saunf, Fennel*

Fennel is an aromatic, glabrous erect perennial reaching a height of 1m with finely dissected leaves and yellow flowers in large umbels. The glabrous
fruits bear a stylus pod at the apex and each mericarp is linear oblong, slightly curved and possesses five prominent primary ridges. The plant is a native of Mediterranean region, now cultivated all over the world.

The fruits contain fixed oil (12%), proteins, a volatile oil (1-4%) and phenolics. The principal component of volatile oil is a phenolic ether, anethole (60%) followed by the ketone, fenchone (10-30%). Other components of oil are methyl chavicol, limonene, α-pinene etc. The phenolics include furanocoumarins (imperatorin, bergapten, and xanthotoxin), stilbene trimers (miyabenol C and cis-miyabenol C and the glycosides of the latter such as foeniculosides 1-4) and flavonoids. Also present are monoterpene glycosides, viz., foeniculosides V-IX, and other compounds such as zizybeoside I, icavisd A, syringin, sinapyl alcohol, adenosine and anethole glycol.

Fennel is used as a spice and carminative. The fruits are anabolic, estrogenic, analgesic, antipyretic, and antimicrobial agents. It reduces flatulence in infants.

**Myrrista fragrans** Houtt. (Myristicaceae)

**Jatiphala, Nutmeg**

Nutmeg is the seed of an evergreen dioecious tree, a native of Molucca islands. The leaves are simple, ovate, the yellow flowers are fleshy and aromatic. The golden yellow fruits contain a single seed, covered by a brilliant red branching aril, the ‘mace’ (*Javantri*) of commerce. The seed has an outer dark brown perisperm and an inner light brown endosperm. The perisperm is infolded and penetrates the endosperm, giving it a marbled appearance.

Nutmeg contains fat (24-40%), occurring as prismatic crystals-nutmeg butter; volatile oil (5-15%), phytostearin, large amounts of starch, protein and amylodextrin. The volatile oil consists of 80% terpenes like pinene, camphene and sabinene, 8% dipentene, 4% myristicin, 2% elemicin and isoelemicin; upto 1% safrole and 1% other constituents like eugenol, methyl eugenol, isoeugenol, etc.

Nutmeg, in doses larger than 10-15 gm (one teaspoonful), is found to produce intoxications and hallucinations-similar to LSD-after a delay of 3-5 hrs in many individuals. This intoxication is often accompanied/followed by certain side effects like headache, absence of salivation, dizziness, etc. The active principles responsible for this are not clearly pinpointed, but are found to be present in the volatile oil fraction of nutmeg. It is believed that both myristicin and elemicin—two major ingredients of aromatic fraction of volatile oil—are involved in this process. The myristicin content varies from 3.9-13% and that of elemicin from 0.02-2.4% and their relative amounts account for the variations in the psychotomimetic properties of different samples.

Nutmeg is a carminative efficiently used against indigestion and other stomach problems of children.
Ocimum tenuiflorum Linn. (Lamiaceae)

Syn. O. sanctum Linn.

Tulsi, Basil

This is a perennial herb with a brownish pink stem, elliptic-oblong pubescent (minutely gland-dotted) leaves on a hairy slender petiole, whitish pink flowers on terminal racemes and a carcerule fruit enclosing 4 nutlets. Basil is a native of India, cultivated as a sacred plant.

The leaves yield a volatile oil (upto 0.8%), triterpenes, flavonoids and fatty acid esters. Eugenol (content of which is maximum in spring, upto 20%) and caryophyllene (38%) are the principal components of vol. oil. Other constituents are bornyl acetate, β-elemene, methyleugenol, neral, β-pinene, camphene and α-pinene. Ursolic acid, campestrol, cholesterol and stigmasterol are the triterpenoids present.

Tulsi is known to possess hypoglycaemic, immunomodulatory, antistress, analgesic, antipyretic, antiinflammatory, antiulcerogenic, antihypertensive, CNS depressant, radioprotective and antitumour properties.

Curcuma zedoaria Roscoe. (Zingiberaceae)

Syn. Amomum zedoria Christm.
Curcuma zerumbet Roxb.

Kacurah, Zedoary

Zedoary is a large perennial with rootstock having palmately branched sessile cylindric oblong annulate yellowish white tubers and a camphoraceous odour, a pseudostem of sheathing leaf bases, long-petioled oblong leaves clouded with purple down the middle, yellow flowers in axils of pouched bracts in dense strobiliform spikes, (stamen one, staminodes petaloid) and trigonous globose capsule containing ellipsoid seeds having a white lacerate aril. This plant is cultivated and also grows in the wild in most parts of India.

Rhizomes are found to contain sesquiterpenes such as curcumol, curcolene, procurcumenol, isocurcumenol, furanodiene, curcumadiol, dehydrocurdione, zederone, etc. Other compounds present are ethyl-β-methyl cinnamate and curcuminoids. Also present is a volatile oil containing sesquiterpenes zedoarone and curzerenone.

The rhizomes are used mainly for cough, bronchitis, asthma, skin diseases, wounds and splenic disorders. It is also a carminative.

Piper betel Linn. (Piperaceae)

Tambulah/Pan, Betel

This plant, a native of Malaysia, is a perennial dioecious vine with semi woody stems climbing by means of adventitious roots, broadly ovate-cordate leaves, dense cylindrical male spikes and long pendulous female spikes.
The leaves, used for chewing, contain up to 2.6% of bright yellow aromatic oil which is extracted by steam distillation. Chavibetol (an isomer of eugenol) forms the characteristic component of betel oil. But some of the Indian samples contain eugenol in larger quantities (25-40%). Other constituents of oil are chavicol, eugenol methyl ether, cineole, caryophyllene and cadinene.

Betel is a carminative, stimulant, anthelmintic, expectorant and antiseptic and cures dyspepsia, fever, flatulence and filariasis. Oil of betel is used in the treatment of respiratory troubles, as an antispasmodic and a carminative. It is antibacterial in nature and is an effective antioxidant. Roots cause sterility in women.

**Ruta graveolens** Linn. (Rutaceae)

Garden Rue

A strongly odoriferous glabrous herb reaching a height of about 1m with 2-3 pinnate leaves having oblong/spathulate strongly aromatic leaflets covered with a bloom, small yellow flowers in corymbs and small capsules. A native of Mediterranean region, it is now cultivated widely.

The herb contains a volatile oil, alkaloids, flavonoids and coumarins. The volatile oil, rue oil, is strongly odoriferous, pungent and contains methylnonyl ketone (80-90%), methyl heptyl ketone, \( \alpha \)-pinene, limonene, cineole, etc. Rutin amounts to 2% of the plant. Imperatorin, isoimperatorin, xanthotoxin, bergaptene and psoralen are the coumarins present. The alkaloids obtained from the stem and leaves are skimmianine, graveolinine and kokusaginine, whereas the roots yield dictamine and \( \gamma \)-fragarine.

Rue oil is anthelmintic, antispasmodic, antiepileptic, rubefacient and emmenagogue. The herb is diuretic, emmenagogue and antispasmodic. As a poultice, the herb is applied to rheumatic joints. Coumarins are responsible for the antispasmyotic activity.

**Hyptis suaveolens** Poit. (Lamiaceae)

Gangatulsi, Hyptis

This is a rigid erect aromatic annual with petiolate ovate (lower cordate) serrate leaves and blue flowers in axillary cymes and a carcerule containing 4 elongate black nuts. A native of tropical america, Hyptis is grown in gardens or found as an escape.

Leaves, twigs and flowers contain a volatile oil consisting of sabinene, \( \alpha \)-pinene, limonene, \( \beta \)-caryophyllene, 1,8-cineole, spathulenol, caryophyllene and bicyclogermacrene. Aerial parts contain a triterpenoid, hyptadienic acid.

This plant is a stimulant, carminative, antiseptic, sudorific and galactogogue. Infusion of the plant is used in catarrhal conditions, affections of the uterus, diabetes and cancer.
Iridoids

*Barleria prionitis* Linn. (Acanthaceae)

This is a spiny much-branched shrub with sharp long axillary spines, elliptic/ovate long-petioled leaves, yellow flowers (solitary in lower axils, spicate above) having spiny tipped bracts, and ovoid beaked capsules containing 2 compressed hairy seeds. *B. prionitis* is very common in India and also grown as a hedge plant.

The leaves and stems are found to contain five iridoid glucosides, barlerin, acetyl barlerin, shanzhiside methylester, 5,6-β-epoxy, 7β-hydroxy, 8β-methyl-1β-rhamnosidal iridoid, gentioside, 4-carbomethoxy, 5,6-dehydro, 7,8-dihydroxy, 8-methyl-1β-D-glucopyranosidal iridoid (Taneja & Tiwari, 1975) as well as β-sitosterol. The leaves yield a 6-hydroxy flavone, scutellarein and phenolic acids, p-hydroxy benzoic, vanillic, syringic, and melilotic acids (Daniel & Sabnis, 1987). Flowers contain scutellarein glycoside.

Sahacharah is widely used against neurological disorders like paraplegia, sciatica, etc. The plant is antiseptic, diuretic and applied over boils and glandular swellings. The bark is used against whooping cough and as a diaphoretic and expectorant.

*Barleria cristata* Linn.

*Raktajhinti, Sahacharah*

*B. cristata* is an erect hirsute undershrub with long-petioled lanceolate leaves, purple blue/pink flowers having serrate spiny bracts/bracteoles, and 4-seeded oblong capsules. This plant is found throughout India.

The roots of *B. cristata* contain iridoids and anthraquinones barlacristone and cristabarline. Leaves yield flavones, luteolin and 7-OMe luteolin and phenolic acids, p-hydroxy benzoic, vanillic, syringic and p-coumaric acids. Flowers are found to contain β-sitosterol, quercetin, apigenin, naringenin and malvidin.

This plant is used as sahacharah in many places in India.

*Barleria strigosa* Willd.

*Sahacharah*

This is another plant used as sahacharah. *B. strigosa* is a tall shrub with ovate decurrent leaves and blue flowers in dense spikes. The whole plant is found to contain β- and λ-sitosterol. Leaves yield apigenin, vanilllic acid, p-hydroxy benzoic acid and p-coumaric acid (Daniel & Sabnis, 1987).

*B. courtallica* Nees is another plant used in Kerala as a substitute of *B. prionitis*. 
**Vitex negundo** Linn. (Verbenaceae)

**Nirgundi, Vitex**

Nirgundi is a small tree with grey pubescent branches, 3-5 foliolate leaves (leaflets lanceolate, white tomentose beneath, petioled, lateral leaflets small, lanceolate and terminal leaflets larger), small blue bilabiate flowers (stamens 4-didynamous) and ovoid black drupes containing 4 obovate seeds. This tree is common in India, Afghanistan, Philippines and Ceylon.

The leaves contain, aucubin agnuside, alkaloids nishindine (C₁₅H₂₁ON), hydrocotylene (C₂₂H₃₃O₈N), glycoflavonoids orientin and isoorientin and 5-hydroxy, 3,6,7,3',4'-penta methoxy flavone.

The leaves, in the form of a paste, are used for inflammatory swellings of the joints formed due to rheumatism, hydrocele and spleenic enlargement. They are also used in skin diseases, nervous disorders, leprosy and as a vermifuge. Oil prepared with leaves is useful for growth of hair and increases the functions of brain. Roots also are useful in rheumatism, dyspepsia, piles and as anthelmintics.

**Vitex trifolia** Linn, a related species with 3-foliolate, sessile, obovate leaflets and blue flowers are used as a substitute for *V. negundo*.

**Picrorhiza kurroa** Linn. (Scrophulariaceae)

**Katuka, Picrorhiza**

Katuka is a hairy shrub, native to the Himalayas, with perennial bitter woody rootstock clothed with persistent leaf bases. The subradical leaves are ovate with winged leaf bases and the white/blue flowers are borne on a stout leafy scape. The ovoid capsule contains a number of seeds, each enclosed in a large bladdery, loose and hyaline reticulate testa.

The major constituents are two iridoid glycosides, picroside 1 and kutkoside. Also present are other iridoids picroside III, veronicoside, minecoside; phenol glycosides picein and androsin, a number of cucurbitacin glycosides and 4-hydroxy-3-methoxy acetophenone (Stuppner and Wagner, 1989).

Kutkin as well as the whole extract show hepatoprotective activity. It is also an immunostimulant of both cell-mediated and humoral immunity (Ansari et al. 1988b).

**Gentiana lutea** Linn. (Gentianaceae)

**Gentian**

The fermented rhizomes and roots of *G. lutea* constitute this drug. It is a perennial herb, a native of America and Europe, with very long roots (often more than 1m long), big oval rosette leaves, 3-10 yellow long-pedicelled flowers in axillary clusters and capsular fruits.
The rhizome and roots yield more than 2% of a bitter iridoid principle known as gentiopicrin (gentiopicroside, gentiamarin) which, on hydrolysis, yields a lactone gentiogenin and glucose, along with related glycosides amaropanin, amarogentin and amaroswerin. The other components of the drug are 0.6-1% of monoterpenoid alkaloids gentianine and gentialutine, swertiamarin and sweroside, flavones, glycoflavones isoorientin and isovitexin, β-amyrrenol, xanthones, tannins, gentianose (a trisaccharide) and gentiobiose (a disaccharide). In addition, roots contain xanthenes mangiferin, genistein, isogenistin, gentioside, 1-hydroxy-3, 7-dimethoxy xanthone, 7-hydroxy, 3-methoxy xanthone and 1-hydroxy, 3-methoxy xanthone glycosides (Hayashi and Yamagishi 1988).

Gentian is extensively used as a bitter tonic. The root infusion is used for lack of appetite and stomach disorders and as a weak febrifuge.

**Sesquiterpenes**

*Chrysanthemum parthenium* Pers. (Asteraceae)

Syn. *Pyrethrum parthenium* Sm.

*Tanacetum parthenium* Pers.

**Featherfew, Feverfew**

Feverfew is a small herb with furrowed hairy stem, bipinnatifid leaves having serrated margins and numerous small yellow heads with outer white rays. It is a native of Europe and America.

The principal component of feverfew is a sesquiterpene lactone, parthenolide. Other sesquiterpenes present are santamarine and esters of parthenolide such as reynosin, artemorin, hydroxy costunolide, 8-hydroxyestatitatin, etc. Other constituents of feverfew are volatile oil containing pinene and its derivatives along with bornylacetate, costic acid, etc., acetylenes and flavonoid glycosides.

The entire plant is used as a carminative tonic, emmenagogue and employed in hysterical complaints, nervousness and lowness of spirits. It is also recommended for the prevention of migraine and as an antiinflammatory in rheumatoid arthritis. Feverfew is reported to inhibit synthesis of leucotrienes, prostaglandins and thromboxanes, the compounds causing inflammations. In many places, this is a primary remedy in the treatment of migraine.

*Nardostachys jatamansi* DC. (Valerianaceae)

**Jatamansi**

A native of alpine Himalayas, jatamansi is an erect, perennial herb with a long woody stout rootstock, often covered by a dense mat of reddish brown fibres formed from the petiole of withered leaves. The stem is up to 50 cm long and bears radical leaves, red flowers in cymose heads and one-seeded white tomentose indehiscent fruits.
A sesquiterpene, jatamansone (valeranone), forms the major chemical component (up to 0.1%) of the rhizome, the drug. Other sesquiterpenoids present are spirojatamol, patchouli alcohol, norseychelanone and \( \alpha-, \beta- \) patchoulenenes. Also present are jatamol, jatamanshic acid, terpenoid coumarins oroselol and jatamansin and neolignans such as 1-hydroxy pinoresinol and virolin. (Bagchi, 1991a, 1991b; Rucker et al. 1993).

Jatamansi is used as a bitter tonic, antiseptic and for treatment of epilepsy and hysteria. It is also used for insomnia and exhibit negative inotropic and chronotropic effects (Sajid et al. 1996.)

**Anthemis nobilis** Linn. (Asteraceae)

**True Chamomile**

This is a low-growing aromatic (apple-scented) herb with creeping/trailing hairy highly branched stem, perennial fibrous jointed roots, leaves which are divided to five threadlike segments, daisy like white heads (about eighteen white ray flowers around a conical center bearing yellow tubular florets) borne on erect stalks and small dry achenes. This plant is a native of Europe.

Flowers yield a volatile oil, a bitter principle (anthemic acid) and tannins. The essential oil contains \( \alpha- \) bisabolol and chamazulene. Also present are anthesterol and apigenin.

The whole plant, especially the flower head, is used as a tonic, anodyne and antispasmodic. It is also a good emmenagogue and is an efficacious remedy for hysterical and nervous affections in women during menopause. Chamomile tea is employed as a nerve tonic and for fever and insomnia.

German chamomile is *Matricaria recutita* Rausch. containing essential oil (consists of azulene), flavones, tannins and coumarins. Aromatherapists recommend inhaling the vapourized oil of chamomile to relieve nervous disorders such as depression and anxiety associated with menopause.

**Ageratum conyzoides** Linn. (Asteraceae)

**Sahadevi, Goatweed**

Goatweed is an aromatic annual with decumbent stem, broadly ovate leaves, pale blue/white flowers (disc florets) in homogenous heads, which are borne in corymbs and glabrous achenes having awn-tipped serrate pappus scales. *A. conyzoides* is a native of tropical America, now occurs as a weed throughout.

The leaves yield an essential oil containing ageratochromene (75%), 7-methoxy-2, 2-dimethyl chromene, monoterpenes such as sabinene, \( \beta- \) pinene, 1,8-cineole, \( \beta- \) phellandrene and limonene and sesquiterpenes sesquiphellandrene, caryophyllene and caryophyllene oxide. Other constituents of the leaves are coumarin, friedelin, \( \beta \)-sitosterol, stigmasterol and
pyrrolizidine alkaloids, lycopsamine and echinatin as well as tertiary and quaternary alkaloids. Precocenes 1 & 2 (antigonadotropic hormones), quercetin, kaempferol, 5’OMe nobiletin, sesamin, caffeic and fumaric acids and conyzorugum are the other compounds reported from leaves. The flower heads also yield a volatile oil similar to the one obtained from the leaves. The seeds contain fatty oil (25%) rich in linoleic (57%) acid (Wiedenfeld & Roder, 1991; Horiff et al. 1993).

*A. conyzoides* is used internally as a stimulating tonic and is useful in diarrhoea, dysentery, colic, rheumatism and fever. The juice is said to be a good remedy in *prolapse ani*. The leaf juice is useful in boils, leprosy and skin diseases and also as an eye lotion. The essential oil is anthelmintic against tapeworm.

**Artemisia cina** Berg. (Asteraceae)

*Kirmala, Wormseed*

*A. cina* is a herbaceous white silky aromatic annual with lobed leaves, yellow florets in discoid heads arranged in panicles and pappus-less achenes. It is a native of South Asia.

Wormseed, the dried unexpanded flower head, contains two crystalline sesquiterpene lactones, santonin and artemisin and a volatile oil.

The wormseed or santonin is a good anthelmintic specific for roundworms and threadworms.

A number of other species of *Artemisia* are used as wormwood or sources of santonin and used likewise. They are the following:

**Artemisia absinthium** Linn.

*Damar, Absinthe*

Absinthe is an aromatic and bitter shrub with pinnatifid leaves and yellow heterogamous heads and elliptic-oblong achenes. This species is common in Kashmir. *A. absinthium* yields a volatile oil called wormwood oil or absinthe, from the leaves. This oil contains thujyl alcohol, phellandrene, pinene, s-guaiazulene and chamazulene. Also present in the plant 24-zeta-ethyl cholesta-7, 22-dien-α-ol, flavonoids artemisetin, homoditerpenes peroxides 1-(E)-8-isopropyl-1,5-dimethyl-nona-4,8-dienyl-4-methyl-2,3-dioxabicyclooct-5-ene and its diasteriomerich absinthin, anabasin, anabasin and thujone. Methanol extract contains α-santonin and ketopelenolid A. The powdered plant material, which forms the drug ‘Afsanteen’, is used in India in chronic fever, swellings, inflammation of liver and as a tonic and stimulant. The wormwood oil is applied externally to swellings and is antimicrobial in nature. Fresh wormwood is a good source of azulenes. Artemisetin exhibited marked antitumour activity against melanoma-B 16. Homoditerpenes are antimalarial substances (Rücker et al. 1992).
**Artemisia maritima** Linn.

*Kirmala, Wormseed*

This is a deciduous perennial shrub common in western Himalayas, possessing bipinnatisect leaves having many small linear segments and homogamous heads. Santonin content is maximum in unexpanded flower heads of 2-year-old plants, up to 2.2%. The essential oil (up to 0.32%) contains α-thujone (63%), sabinene, 1,8-cineole, α- and β-pinenes, camphene, bornyl acetate and citral. Aerial parts contain sesquiterpene lactones 1-oxo-6β, 7α, 11βH, 14β-methyl germacra-4(5)-ene-12, 6-olide and 1-oxo-6β, 7α-11βH-germacra-4(5), 10(14)-dien-12, 6-olide besides vulgarin, santonin and gallicin. Kirmala is used for flavouring liquors and pharmaceutical preparations (Pathak & Khanna, 1987).

**Achillea millefolium** Linn. (Asteraceae)

*Swetadurva, Millfoil*

*A. millefolium* is a pubescent erect aromatic annual with stoloniferous roots, oblong, tripinnatisect leaves, pink/white flowered heads in corymbose clusters and oblong shining flattened achenes. Millfoil is found commonly in the foothills of the Himalayas.

The aerial parts of this plant are found to contain desacetylmatricarin and two sesquiterpene lactones of 3-oxyguaianolide type, 8-acetyl egelolide and 8-angeloloyl egelolide alongwith achilleine, choline, betaine, trigonelline, stachydrine, β-sitosterol, and a volatile oil. The oil, maximum in heads, contains three antitumour sesquiterpenoids, achimillic acids A,B&C, isoapressin, 10-isovaleryl desacetylisoapressin, 8-tigloyldesacetylisoapressin, 8-tigloyldesacetylezomantin, α-peroxyachifolid, β-peroxyachifolid, guaianolide, azulene lactones such as millefin, de-Ac-matricarine, chamazulene, α-pinene and other minor constituents. Leaves yield luteolin, apigenin, folic acid, rutin and ascorbic acid (Rükker et al. 1991).

Milfoil is astringent, tonic, diaphoretic and anti-spasmodic and is useful in treating cold, colic, hysteria, epilepsy and rheumatism. Infusion of the plant is useful in preventing premature ageing of the skin. Achilleine is reported to be haemostatic and reduce blood clot time in rabbits.

**Santalum album** Linn. (Santalaceae)

*Safed Chandan, Sandalwood*

Sandalwood is the heartwood of a small tree native to peninsular India. This is a root parasite with glabrous elliptic ovate leaves, small purple/violet flowers in terminal or axillary paniculate cymes and purple black globose drupes.

The oil, amounting to 4-5% of the wood, is extracted by water distillation, which is further purified by a subsequent distillation. The roots are richer in
oils, yielding up to 10% dry weight. The refined oil is a pale yellow clear liquid consisting principally of a sesquiterpene alcohol, santalol (90%). Santalol exists both in \( \alpha \)- and \( \beta \)-forms, the former being predominant. Also present in the oil are santene (C\(_9\)H\(_{14}\)), \( \alpha \)- and \( \beta \)-santalenes and santalone.

Sandalwood oil is one of the very important raw materials in perfumery, soaps, face creams, powders, etc. It has a very high fixative value due to its high boiling point. The wood is a sedative, diuretic, and tonic and useful in bronchitis, biliiousness, thirst, cystitis, gonorrhoea, etc. The wood paste is applied externally for ulcers, headache, inflammation and pruritus. This wood is ideal for carving.

*Cichorium intybus* Linn. (Asteraceae)

**Kasani, Chicory**

This is an erect perennial with a fleshy cylindrical long (up to 75cm) tap root, broadly oblong/oblanceolate lower leaves crowded at the base forming a rosette, cordate upper leaves, blue flowers in homogenous heads and 5-angled achenes. A native of Europe, chicory is now cultivated everywhere.

The fresh roots contain inulin, gum and sesquiterpene lactones such as lactucin, 8-deoxylactucin, lactucopicrin, crepidiaside, sonchusides, cichoriolides and cichoriosides. Also present are ribosylzeatin, chlorogenic, neochlorogenic, isochlorogenic, caffeic and chicoric acids. Inulin, on storage, gets converted to fructose.

Chicory is used mixed with coffee. The root is a carminative, diuretic and tonic and is effective in jaundice, liver enlargement, gout and rheumatism. The whole plant is used in fevers, diarrhoea and as emmenagogue and alexiferic.

Applied externally as a poultice, roots and leaves cure inflammatory swellings. The whole plant is a good antiseptic. Seeds yield 'Ben oil' which is a valuable lubricant.

*Pogostemon cablin* Benth. (Lamiaceae)


**Patchouli**

Patchouli is an erect much-branched aromatic herb (upto 1.2m high) with ovate crenate-serrate tomentose leaves, white flowers with purple streaks in whorls on terminal and/or axillary spikes. This plant is a native of Philippines.

Leaves yield the volatile patchouli oil (upto 5.8% dry wt basis) and a resin. The oil consists of sesquiterpenes, patchouli alcohol (major compound), \( \beta \)-patchoulen, \( \alpha \)-guaiaene, \( \alpha \)-bulnesene and benzaldehyde.

The leaves and tops of Patchouli are antirheumatic and said to be good for menstrual problems.
**Saussurea lappa C.B. Clarke (Asteraceae)**

*Kushta, Costus*

This is a woody erect perennial reaching a height of 2m, with stout robust pungent roots (up to 60cm long), fibrous thick stem, large (up to 1m) radical leaves having long lobately winged stalks, large flower heads (3-5cm in diam.) containing dark blue-purple or black flowers and small curved compressed achenes. Costus is endemic to Kashmir valley at altitudes of 2500-3000m.

The roots, which form the drug, yield a resin (6%), volatile oil (1.5%), inulin (18%) and alkaloids. The oil consists of costunolide (a sesquiterpene lactone-principal component), dehydrocostuslactone, dihydrocostuslactone, 12-methoxy dihydrocostunolide, costol and β-ionone. β-Sitosterol, stigmasterol and betulin are the components of resin. The alkaloids reported are saussurine and kushin.

*Kushta* is a well-known incense, insecticide and used in asthma and chronic bronchitis.

**Anamirta cocculus W. & A. (Menispermaceae)**

*Kakamari, Fish Berries*

*A. cocculus*, a native shrub of India, yields the ‘fish berries’. The plant is a climber with glabrous corky shoots, ovate leaves, unisexual flowers in panicles and a drupe containing globose seeds.

The seeds contain approximately 1.5% of a bitter principle picrotoxin (cocculin) consisting of equimolecular proportions of highly oxygenated sesquiterpenes picroxinin (C_{15}H_{16}O_{6}), picrotin (C_{15}H_{16}O_{6}) and about 50% fat.

*Kakamari* seeds are highly toxic to fish. Picrotoxin is a potent long-acting respiratory stimulant and used to treat overdoses of CNS depressants such as barbiturates and narcotics.

**Elephantopus scaber Linn. (Asteraceae)**

*Gojiva, Elephantopus*

Elephantopus is a rigid perennial herb with short rootstock with numerous stout fibrous roots and a dichotomously branched short stem covered by appressed white hairs. Leaves are mostly radical, ob lanceolate-spathulate forming a spreading rosette on the ground; cauline leaves smaller and sessile. The flowers are violet in homogamous heads of 2-5 flowers, the heads collected into a closely packed terminal inflorescence, the achenes are truncate, 10-ribbed. This is a common weed forming undergrowth in the Western Ghats.
The plant contains hydroxylated germacrolides, molephantin, molephantinin, phantomolin and its cis-epoxide, elephantin, elephantopin, deoxyelephantopin, iso-deoxyelephantopin, 11,13, dihydrodeoxyelephantopin, along with \( \alpha \)-curcumene, \( \beta \)-amyrin. lupeol, epifriedelinol and stigmasterol. Also present are 4,5- dicaffeoyl quinic and 3,5-dicafeoyl quinic acids. Roots contain deacylcyanopicrin, glucozaluzanin-C and stigmasterol (Hisham et al. 1992).

The roots, which form the drug, are useful in fever, cardiac problems and liver trouble. This plant is also used in insomnia, diabetes, and urethral discharges, rheumatism and for filariasis. Molephantin and molephantinin possess cytotoxic and antitumour properties, the latter also shows antileukemic properties. Phantomolin and its cis-epoxide exhibit potent inhibitory action on Ehlich ascitis carcinoma and Walker 256 carcinosarcoma cells.

**Inula racemosa Hook.f. (Asteraceae)**

**Puskarmula, Inula**

*I. racemosa* is a tall stout herb with a grooved stem, many radical broad elliptic-lanceolate leaves (tomentose beneath) heterogamous yellow/white heads and achenes having red pappus. Inula is common in Jammu and Kashmir and Himachal Pradesh.

The roots yield an essential oil, a germacranolide, i.e. inunolide, alantolactones such as alantolactone and isoalantolactone and \( \beta \)-sitosterol.

Roots are used as a general tonic, aphrodisiac, diuretic and febrifuge. The drug is also used for cough, anaemia, cardiac disorders, etc. Root extract is found to be anti-inflammatory, antipyretic, anthelmintic, and hypolipidic.

**Inula helenium Linn.**

The roots of this plant is used for the same purposes as *I. racemosa* in Europe. They yield alantolactones, whereas the aerial parts contain scopoletin and umbelliferone.

**Cyperus rotundus** Linn. (Cyperaceae)

**Musta/Nagar Moth**

This is a perennial herb with stoloniferous rhizome bearing hard, ovoid, tunicate, black fragrant tubers (up to 3 cm in dia.) triquetrous stem, flat 1-nerved narrowly linear finely acuminate leaves, spikes in umbels or contracted into a head, and trigonous black nuts. Musta is a very troublesome weed in most tropical countries.

The tubers yield an essential oil and steroids like oleanolic acid, its glycoside and \( \beta \)-sitosterol. The volatile oil is rich in sesquiterpenes such as
patchoulenone, cypernone, α- and β-retunol, cyperotundone and nor-sesquiterpenes, kobusone and isokobusone.

Musta is used for indigestion, diarrhoea, sprue and other stomach problems. It is diuretic, carminative, anthelmintic, galactogogue, emmenagogue and nerve tonic. It is also useful for epilepsy, increasing memory power and a tonic.

Glucosinolates and Sulphides

*Lepidium sativum* Linn. (Brassicaceae)

Halim, Garden Cress

This is a small herbaceous glabrous annual with variable leaves (sessile linear/pinnatifid cauline leaves, long-petioled bipinnate radical leaves) small white flowers in racemes and small orbicular, ovate notched pods containing two winged seeds. A native of Ethiopia, garden cress is cultivated as a salad plant everywhere.

The leaves contain protein (5.8%), carbohydrates (8.7%) and a glucosinolate glucotropaeolin which on steam distillation produces a pungent volatile oil (cress oil, 0.115%) consisting of benzyl isothiocyanate and benzyl cyanide. Seeds contain protein (24%), fat (16%), glucotropaeolin, sinapin (choline ester of sinapic acid), sinapic acid, mucilage and an alkaloid. The fixed oil is rich in oleic (62%), and linolenic (28%) acids and contains β-sitosterol and α-tocopherol. Mucilage is an acidic polysaccharide consisting of galacturonic acid, L-arabinose, galactose, rhamnose and glucose.

Garden cress is consumed raw in salads. It is used for treating asthma, cough and bleeding piles. Leaves are also used as a diuretic, for scurvy diseases and liver complaints. Seeds are rubefacient, galactogogue, emmenagogue, laxative, tonic, aphrodisiac and diuretic. Roots are used in syphilis and tenesmus.

*Tropaeolum majus* Linn. (Tropaeolaceae)

Garden Nasturtium

This is a small spreading succulent herb having peltate, orbicular zig-zagged long-petioled leaves, large zygomorphic spurred red/scarlet (or variously colored) flowers and 3-seeded schizocarp. A native of South America, this plant is now grown everywhere for the colourful flowers and beautiful foliage.

The herb yields a water-soluble essential oil (on steam distillation) consisting mostly of benzyl isothiocyanate. The glucosinolate present in the plant is glucotropaeolin which is acted upon by myrosinase to give benzyl isothiocyanate. Also present in the leaves are vitamin C and glycosides of quercetin and phenolic acids. Seeds yield protein (27%), fixed oil (10%-containing 72% erucic acid and 21% eicosenoic acid) and a volatile oil
consisting entirely of benzyl isothiocyanate. Flowers contain carotenoids, kaempferol and pelargonidin.

The herb is employed in cystitis and for inflammation of kidneys. The extracts are strongly antibiotic and used for urinary and respiratory diseases and eye diseases. Leaves and petioles are used in salads and the pungent fruits are edible.

**Armoracia rusticana** Gaertn. (Brassicaceae)


**Horse radish**

This tall hardy glabrous plant possesses a conical woody/fleshy root, large stems, large oblong lower leaves, small lanceolate upper leaves, white flowers in racemes and globose pods containing many small seeds. It is a native of S. E. Europe, now cultivated in hilly areas of India.

The thick roots, used as a condiment, possess a bitter taste and a characteristic pungent odour due to allyl isothiocyanate, occurring free or as the glucoside, sinigrin. Horse radish contains a volatile oil, protein (2%), sugars (3%) and vitamin C. The oil, when isolated, consists of allyl and/or 2-phenethyl isothiocyanate as major constituents along with methyl, isopropyl, 2-butyl or 4-pentenyl isothiocyanate. The minor components are considered to be produced as artifacts during extraction.

**Capsella bursa-pastoris** Medic. (Brassicaceae)

**Mumiri, Shepherd’s Purse**

This is a pubescent erect annual with radical pinnately divided leaves, small cauline leaves having hastate base, white small flowers in racemes and glabrous obcordate, laterally compressed capsules enclosing numerous ellipsoid reddish brown seeds. Occurs as a weed throughout the temperate regions.

The plant is found to contain flavonoids, glucosinolates, volatile oil and saponins besides choline. Choline amounts to 0.2%. The flavonoids reported are hesperidin, rutin, robinetin, derivatives and glycosides of luteolin, quercetin, kaempferol, fisetin, gossypetin and related compounds. The sulphur containing compounds present are sinigrin and α-methylsulfinylnonyl and 10-methylosulfinyl decylglucosinolates, thiocyanic acid and s-methyl-L-cysteine sulphoxide. The volatile oil is rich in camphor. Other compounds isolated are coumarins, ascorbic acid, histamine, two crystalline alkaloids, tyramine, inostiol, a proteolytic enzyme, β-sitosterol and stigmasterol.

Seeds yield oil (26%), protein (32%), mucilage, sulphur containing volatile oil and quercetin. The oil consists of linolenic (35%), linoleic (18%), gadoleic (13%), oleic (11%) and palmitic (9%) acids.
The herb possesses bitter, pungent, astringent, antiscorbutic, febrifugal and emmenagogue properties and is substituted for *Hydrastis*. This plant is a remedy for atrophy of limbs by rubbing the affected parts with an alcoholic solution of *Capsella* and *Alchemilla vulgaris*. The juice of the plant checks menorrhagia and other haemorrhage of renal and urino-genital tracts. The leaves are used as salads and its seeds are used for bread making. The seeds possess rubefacient and vesicant properties.

*Moringa oleifera* Lam. (Moringaceae)

*Syn. M. pterygosperma* Gaertn

**Sigru, Drumstick**

Drumstick tree is a soft-wooded medium-sized tree with pungent roots, large 3-pinnate leaves having articulated rachis, small elliptical (terminal leaflet obovate) leaflets, white flowers (with reflexed sepals and spathulate petals) in axillary or terminal panicles and a long-pendulous cylindrical 9-ribbed capsule constricted between seeds and enclosing trigonous seeds broadly winged at the angles. This is found wild in western Himalayas and grown all over India and tropics for its edible leaves, flowers and fruits.

The root bark contains three alkaloids moringine (benzylamine), moringinine and spirochin and glucosinolate pterygospermin yielding benzyl isothiocyanate. Leaves contain kaempferol, 3'-OMe quercetin, acacetin, vitexin, vanillic acid, syringic acid and melilotic acid. Fruits contain proanthocyanidins (Daniel, 1989).

All parts of the plant are useful. Roots and root bark are used in fever, asthma, rheumatism, inflammation, epilepsy and hysteria. Leaves are galactogogue, useful in eye diseases, fainting fits and spasmodic problems of bowels and hysteria. Roots, leaves, fruits and seeds are attributed with a number of medicinal properties such as aphrodisiac, cardiotonic, anthelmintic and good for eye diseases, enlargement of spleen and joints. Applied externally as a poultice, the roots and leaves cure inflammatory swellings. The whole plant is a good antiseptic. Seeds yield 'Ben oil' which is a valuable lubricant.

*Allium sativum* Linn. (Liliaceae)

*Laahsuna, Garlic*

*A. sativum* is a hardy perennial with an underground bulb consisting of a disc-shaped stem, swollen axillary buds (clove) encircled by 2-3 layers of tunica and long flat leaves. Flowers are small, white, borne on scapes. A native of Central Asia, garlic is now cultivated everywhere.

Garlic bulbs contain carbohydrates (30%), protein (6%) and an essential oil (0.1%) besides minerals and vitamins. Also present are peptides such as $\gamma$-glutamyl phenylalanine, $\gamma$-glutamyl-S-methyl cysteine, $\gamma$-glutamyl-S-$\beta$-carboxy-$\beta$-methyl ethyl cysteinyll glycine, S-allyl mercaptato-L-cysteine, $\gamma$-
glutamyl-S-allyl mercapto-L-cysteine and γ-glutamyl-S-propyl cysteine. In addition garlic contains sulphur containing amino acids such as S-propyl-L-cysteine, S-propenyl-L-cysteine, S-methyl cysteine, S-allyl cysteine, S-allyl cysteine sulphoxide (alliin, which is acted upon by an accompanying enzyme allinase produces allicin, i.e. thio-2-propene-1-sulphinic acid-S-allyl ester) and S-butyl L-cysteine sulphoxide. Other compounds reported from garlic are a thioglucoside, scordine, scordinines A, A2 and B and cyanidin. The volatile oil of garlic consists of allyl alcohol, allyl propyl disulphide, methylallyl disulphide, diallyl disulphide, dimethyl trisulphide, methyl allyl trisulphide and diallyl trisulphide. Garlic skin is rich in pectin.

Garlic is a stimulant, diaphoretic, expectorant, diuretic, and tonic. It exhibits anthelmintic, emmenagogue and antidysenteric properties. It is also used as anti-tubercular, anticholeric, anti-fertility, hypocholesteremic and hypoglycemic drug. Almost all the compounds from garlic exhibit anti-microbial activity. Allicin exhibits anticancerous properties and is used in treatment of rheumatoid arthritis. The volatile oil is used externally in paralytic pain. It is found to increase fibrinolytic activity in patients with coronary artery disease. Ajoene, a derivative of allicin, is antileukaemic in nature.

Other species of Allium used in medicine are the following.

**Allium cepa** Linn.

**Piyaz, Onion**

*A. cepa* is used as a vegetable and contains an essential oil (rich in allylpropyl disulphide), soluble carbohydrates, vitamins, γ-glutamyl peptides, phenolic acids, flavonols, anthocyanins, and oleanolic acid. The anthocyanins are 4-substituted, carboxypyranocyanidins such as 5-carboxy-2-(3,4-dihydroxy phenyl)-3,8-dihydro pyrano-(4,3,2-de)-1-benzopyrillium (Fossen and Andersen 2003). The juice of onion is used for treatment of ophthalmia, earache and jaundice. Onion is also said to possess aphrodisiac, antimalarial and anti-rheumatic properties. It is also a hypoglycemic agent.

**Allium porrum** Linn.

**Vilayati piaz, Leek**

Leek is used as a substitute of garlic and contains more (up to 17%) carbohydrates.  

**Allium schoenoprasum** Linn.

**Chives**

The young leaves and bulbs of this plant, which are eaten as salad, are found to exert hypotensive and cardiac depressant properties. The leaves yield a volatile oil (consisting of sulphides) and a number of peptides.
**Ferula asafoetida** Bios (Apiaceae)

**Hing, Asafoetida**

*F. asafoetida* and related plants, natives of Iran, India and Afghanistan, yield the oleo-gum-resin asafoetida. *F. asafoetida* is a stout perennial herb 2-3 m in height with 2-4 pinnate pubescent leaves having cauline sheaths, yellow flowers in large terminal compound umbels and dorsally compressed cremocarps. Cutting off successive horizontal slices collects the gum resin, occurring in the cortex of thick fleshy rootstock, after removal of the crown.

The fresh resin oozing out and collected at the cut surface is yellowish white and translucent, but becomes a reddish brown opaque solid on standing.

Asafoetida possesses a powerful alliaceous odour and a bitter acrid taste. It contains a volatile oil (4-20%), resin (40-60%), gums (20%) and some impurities. The oil consists chiefly of isobutyl propanyl disulphide and related compounds, which are responsible for the characteristic smell of the gum resin. The resin is composed of coumarins such as umbelliferone, 5-hydroxyumbelliprenin, 8-hydroxyumbelliprenin, 9-hydroxyumbelliprenin, 8-acetoxy, 5-hydroxy umbelliprenin, asafoetidin, ferocolicin and asacoumarins A&B; phenols such as asaresinol ferulate and free ferulic acid and a group of sesquiterpenes, farnesiferol A, B, & C characteristically containing coumarin groups (Appendino et al. 1994).

Asafoetida is extensively used in the east for flavouring foodstuffs and in the west as an ingredient of perfumes in dilute concentration. Medicinally, it is used as a carminative, expectorant, antispasmodic, laxative and against asthma, whooping cough, chronic bronchitis, hysteria, epilepsy and cholera.

### 3.5 Diterpenes

Diterpenes are C20 compounds formed by the condensation of four isoprene residues. The known 1000 or more diterpenes fit into 20 major common skeletons and four less common skeletons. Similar to the other terpenes, hydrocarbons, alcohols, aldehydes, ketones, and acids are all known in this group. Phytol, which constitutes the tail of the chlorophyll molecule, is the only acyclic diterpene known and most of the diterpenoids are regarded to be derived from it by ring closures, oxidation and substitutions. Artemisone, wormwood diterpene and camphorene represent a few monocyclic derivatives known. The rest of diterpenes have larger ring structures. The important skeletons found in this category are: (1) labdane (bicyclic), (2) abietane, (3) pimarane, (4) casane (tricyclic), (5) kaurene, (6) gibbane, (7) bayerene (tetracyclic), and trachylobane (pentacyclic). Some of the physiologically active diterpenes are: (1) gibberellins (growth regulators), (2) ryanodine (insecticide) and (3) phorbol (purgative).

Diterpenes exhibit some very interesting properties. Stevioside, a diterpenoid glycoside isolated from leaves of *Stevia rebaudiana* Bert. (Asteraceae), is at least 300 times sweeter than sugar and used as a sweet-
ener for diabetic patients and dieters. Bitterness is a phenomenon of certain
diterpenoids such as marrubin and columbin. A number of other diterpenes
are isolated from plants showing a variety of properties. One of the most
acclaimed antileukemic principle, taxol, isolated from *Taxus brevifolia* Nutt.
is a diterpene. Other diterpenes exhibiting antitumour activity are the
following:

1. Taxodone and taxodione from *Taxodium distichum* (Taxodiaceae)
2. Nagilactones B - E from *Podocarpus* sp. (Taxaceae)
3. Podolide from *P. gracilior*
4. Triptolide and tripdiolide from *Tripterygium wilfordii* (Celastraceae)
5. Gnidin, gniditrin, gnicdcin from *Gnidia lamprantha* (Thymeliaceae)
6. Mezerein from *Daphne mezereum* (Thymeliaceae)
7. Jatrophone from *Jatropha gossypifolia* (Euphorbiaceae)
8. Jatrophatrione from *J. macrorhiza*
9. Ingenol-3, 20-dibenzoate from *Euphorbia esula* (Euphorbiaceae)
10. Phorbol, 12-tiglate, 13-decanoate from *Croton tiglium* (Euphorbiaceae)
   (Sticher, 1977)

**Ginkgo biloba** Linn. (Ginkgoaceae)

*Ginkgo, Maidenhair Tree*

*G. biloba* is a tall dioecious tree with fan-shaped long-petioled obconical
bilobed leaves having dichotomous venation, borne in whorls in short shoots
(spurs). Staminate trees have stamens in pairs borne in catkin-like bractless
cones, present in leaf axils. Ovulate trees bear ovules in pedunculate pairs
(one of each pair often aborting) on short shoots. The so-called ‘fruit’ is
actually a seed, plum like and drupaceous, having a fleshy outer layer and a
horny inner layer (‘seed’). A native of China, *G. biloba* is occasionally culti-
vated in gardens in many places.

Leaves contain terpene lactones (6%) and flavonols (24%) as the major
constituents. The terpene lactones include diterpenoids ginkgolides A, B
and C and a sesquiterpene, bilobalide A. The flavonols present are
kaempferol, quercetin and isorhamnetin as mono-, bi- and triglycosides and/or
or as esters with coumaric acids. Biflavones seen are 1,5-di-methoxy bilobetin,
amentoflavone, lobstein, ginkgetin, isoginkgetin and sciadopitysin.
Procyanidin, catechins, shikimic acid, sequoyitol and pinitol are the other
compounds reported. Seeds contain bilobalide, ginnol, bilobals, cardenols
and phenolic lipids, 4-hydroxy anacardic acids like 6-(pentadec-9-enyl)
resorcylic acid and 6-tridecyl resorcylic acids (Joly et al. 1999).

In traditional Chinese medicine, seeds are considered more important
whereas in western countries, leaves are held in high esteem. Ginkgo is
used generally for diseases appearing due to advanced age. Leaves are
effective in improving memory, removing depression and used in cardio-
vascular disorders, Alzheimer’s and Parkinson’s diseases, cerebral ischemia
and liver fibrosis. It is vasodilatory, aphrodisiac and modulate cerebral en-
ergy metabolism due to antioxidant properties of flavonoids. The flavonoids and ginkgolide B act as a platelet-activating factor (PAF) antagonists, strengthen blood capillaries in brain and ensure that all parts of the brain get proper oxygen through blood. This and the antioxidant, free-radical scavenger properties of flavonoids maintain proper cerebral functioning. Since PAF is linked with many cardiovascular, renal, respiratory and CNS disorders, all these diseases are prevented by this drug. It is also useful in premenstrual syndrome, in acute allergic inflammations and increases the blood flow to the retina and reduces retinal deterioration and hearing loss.

The seeds are used as an expectorant, for bladder ailments, spermatorrhoea, menorrhoea, uterine fluxes and cardiovascular ailments.

**Taxus brevifolia** Nutt. (Taxaceae)

Syn. *T. baccata* subsp. *brevifolia* Pilger

**Pacific Yew**

This is a small dioecious tree, with scaly, purplish bark, drooping branches, small, linear, acute, mucronate leaves having a decurrent leaf base, arranged in two rows, staminate flowers solitary or in small axillary cone-like clusters of 3-14 stamens (anthers 3-9 celled) borne on peltate or apically thickened microsporophylls and female cone of a solitary terminal ovule borne on a fleshy fertile sporophyll. The seed is dark blue, ovoid, 2-4 angled, surrounded by a red fleshy cup-shaped cupule. Pacific yew is a native of America.

The bark yields a group of diterpenes (taxanes), alkaloids (taxine and taxagitine), lignans (isotaxiresinol), flavonoids (quercetin, rhamnetin and sciadopitysin) and glycosides. Taxanes isolated include taxol (an amide), baccatin, brevifoliol, cephalomanine and many derivatives of taxol.

Taxol (also known as paclitaxel) is one of the most potent anticancer compounds today. It disrupts microtubule formation by binding to the tubulin to form abnormal mitotic spindles and, thus, stops cell division. It is also used in chronic fatigue syndrome, herpes, lupus and candida. Nearly 1000 kg of bark are needed to produce 1 kg of taxol.

*Taxus baccata* Wall., the Himalayan yew, provides diterpenoids like 10-deacetylbaccatin, from needles and twigs, which can be semi-synthetically converted to taxol. Taxol is obtained from *Taxus chinensis* also, which is a richer source (upto 0.02%). It is also found that *Taxomyces andreanae*, an endophytic fungus occurring in *Taxus brevifolia* also produces taxol. Recently, it has been found that the hazelnut tree (*Corylus avellana*) also contains taxol.

**Swertia chirata** Buch.-Ham. (Gentianaceae)

**Kairata**

This is a small stout herb branching towards the tip, with a green stem, opposite sessile elliptic 7-nerved leaves, greenish-yellow flowers (petal lobes
with two glands on either side) in axillary/terminal corymbose cymes and sessile oblong capsule enclosing numerous minute ovoid bitter seeds. Kairata is found in temperate Himalayas.

The entire plant, used as a drug, contains bitter principles amarogentin (0.04%) and amaroswerin (0.03%) as major components. Other compounds present are xanthes such as chiratol, methyl bellidifolin, decussatin, 7-OMe swertianin, mangiferin, swertianin, swertenin and chiratanin; triterpenoids like masilinic acids (and its glycoside swericinctoside), chiratenol, gammacer-16-en-3β-ol, 2α-H-hop-22(29)-en-3β-ol, swertenol, episwertenol, pichierenol and kairatenol; secoiridoid glycosides, viz., swertiamarin and gentiopicroside and alkaloids, such as gentianine, gentiocrucine and enicoflavine (Sharma, 1982; Mandal and Chatterjee, 1987; Astham et al. 1991; Chakravarty et al. 1992).

Kairata is a bitter tonic and febrifuge. It is also used as antihepatotoxic, antiinflammatory, antiulcerogenic, anticholinergic, CNS depressant, antimalarial and hypoglycemic.

Andrographis paniculata Wall. (Acanthaceae)

Kalmegh, Creat

A. paniculata is a small erect annual with winged quadrangular stem, glabrous lanceolate leaves, small white purple flowers borne on horizontal axillary racemes and linear-oblong capsules containing numerous sub quadrangular brown seeds. Kalmegh is a native of tropical Asia.

The whole plant is intensely bitter due to the presence of diterpenoid lactones such as andrographolide (0.6%), 1, 4-deoxy-11-oxoandrographolide, 14-deoxy-11,12-didehydroandrographolide, 14-deoxy andrographolide and a non-bitter neoandrographolide. Also present are flavones such as 5-OH,7,2′,6′-triOMe flavone, 5-OH,2′,7,8 triOMe flavone, 2,5-diOH,7,8-diOMe flavone, mono-O-methyl wightin, 5-OH-7,8-diOMe flavone and 5-OH-7,8,2′-tetraOMe flavone; a C23 terpene, 14-deoxy-15-isopropylidene-11,12-didehydroandrographolide and an iridoid glucoside-procumboside. The leaves contain up to 1% andrographolide. The roots, in addition to andrographolide, contain flavones such as 7,4′-diOMe apigenin, echidiolin, andrographin and panicolin, as also α-sitosterol (Abeyasekara et al. 1990; Reddy et al. 2003).

This herb is extensively used as a bitter tonic and febrifuge. It is also used in dysentery, cholera, diabetes, influenza, piles and gonorrhea. It is also considered a tonic, blood purifier and a cure for liver dysfunction.

Aleurites fordii Hemsl. (Euphorbiaceae)

Tung Oil tree

A small, much-branched milky tree, A. fordii possesses simple trifid leaves, unisexual flowers in clusters in which one or more pistillate flowers are
surrounded by a number of staminate flowers, spheroid/top-shaped fruits containing 3-5 one-seeded segments. It is a native of China but currently cultivated widely in India.

The leaves yield three ellagitannins, aleurinins A,B&C along with corilagin, geraniin and chebulagic acid. This wood is found to contain a coumarinolignoid and 5,6,7-trimethoxy coumarin. Seeds yield 30-35% oil containing $\alpha$-elaeostearic (75-85%) and linoleic acids (10%) as the principal fatty acids, about 10% proteins, starch and 2 diterpene esters 13-O-acetyl-16-hydroxy phorbol and 12-O-palmitoyl-13-O-acetyl-16-hydroxy phorbol and a non-protein amino acid, L-3-carboxyl-1, 2, 3, 4-tetrahydro-\beta-carboline. The bark and fruit husk contain 12 and 4.5% tannins, respectively (Fozdar et al. 1989).

The seed oil is used for treating boils, ulcers, swellings and burns. Phorbol derivatives are anticancerous.

**Baliospermum solanifolium** Suresh (Euphorbiaceae)

*Syn. B. montanum* Muell. Arg

* B. axillare Blume

A stout undershrub of about 2m, with many shoots arising from the base of stem carrying large (lower) and small (upper) palmately lobed leaves, small green monoecious flowers in axillary racemes (male flowers more common, towards the top; female flowers few at the base), and 3-lobed obovoid capsules containing oblong, mottled, shiny seeds. *B. solanifolium* is common in all parts of India.

Roots contain phorbol derivatives such as montanan, baliospermin, 12-deoxyphorbol palmitate, 12-deoxy-16-hydroxy phorbol palmitate and 12-deoxy-5\beta-hydroxy phorbol myristate. The seeds yield an oil with a hydroxy fatty acid, i.e. 11,13-dihydroxy-tetracos-trans-9-enoic acid.

The roots are considered pungent, anthelmintic, diuretic and useful for piles, enlarged spleen and skin diseases. It is also cathartic and used in dropsy and jaundice. Ethanol extract of roots are active against P-388 lymphocytic leukaemia. Whole plant is used for treating cancer and abdominal tumours. The leaves also exhibit purgative and expectorant properties and useful in dropsy, while the seeds are drastic purgatives. Seed oil is a powerful hydragogue and used externally in rheumatism. Seeds are substituted for those of *Croton tiglium* (Jamalgota).

**Jatropha gossypifolia** Linn. (Euphorbiaceae)

*Dravanti, Bellyache bush*

This is a tall shrub with branches and petioles clothed with numerous fascicled and branched gland-tipped bristles. The leaves are simple, brown
when young, turning green on maturing, lamina deeply 3-5 lobed and margin glandular hairy. Flowers are unisexual, and red in terminal cymes, capsule is 3-lobed. A native of Brazil but now dravanti has become naturalized in India and is seen in all parts of India.

The roots contain macrocyclic diterpenes, jatrophone and jatropholones A & B, and the bark yields β-sitosterol. The leaf contains flavones and lignan.

Seeds are used as drastic purgatives, aphrodisiac, anthelmintic and are useful in piles, enlarged spleen and skin diseases. Seed oil is used in rheumatism and is a remedy for itch, herpes and eczema. Leaves are galactogogue, insecticidal and used for wounds and ulcers. Roots and leaves are also used in dysentery, anaemia, biliousness, fistula and ulcer.

**Jatropha glandulifera** Roxb.

*Dravanti*

A plant similar to *J.gossypifolia* with smaller leaves having serrate margins, this is a native of Sri Lanka, now common as a wild plant in many localities. It is used in place of Dravanti in many places.

The latex and leaves are used in warts and tumours. The plant yields pigments such as 3,3-dimethyl acrylylshikonin and isohexenylnaphthazarin.

**Boswellia serrata** Roxb. (Burseraceae)

*Shallaki/Salai, Frankincense*

*B. serrata* is a medium-sized deciduous aromatic tree with smooth greenish resinous bark exfoliating in thin papery scales, moderately large imparipinnate leaves having ovate-lanceolate serrate leaflets, small white flowers in axillary racemes, trigonous drupes splitting along 3 valves and compressed winged seeds. A native of India, shallaki is very common in central parts of India.

On injury from the bark, an oleo-gum-resin oozes out, which on exposure to air hardens to brownish yellow tears or crusts known as frankincense (salai guggul). The resin is also extracted by tapping the bark. It contains 8-9% volatile oil, 40-45% resin and 30-35% gum. The oleo-gum-resin is treated with pure ethanol with vigorous shaking when the gum gets precipitated which is then filtered off. The ethanol solubles are concentrated and steam distilled to remove the volatile oil. The resin remaining in the flask is taken out by dissolving in ether or alcohol.

The volatile oil consists of α-thujene (50%), and p-cymene (14%) as major components and β-pinene, d-limonene, linalool, terpeneol, terpenyl acetate, methyl chavicol, cadinene, geranil and elemol as minor components. Also present in the oil are three terpenoic acids, viz., α-campholenic acid, α-campholytic acid and 2,2,4-trimethylcyclopent-3-en-1-yl- acetic acid. The resin
consists of a diterpene alcohol, serratol and eight triterpene acids such as derivatives of tirucallenoic acids (four in number, viz., 3-α-acetoxy tirucall-8, 24, dien-21-oic acid, 3-ketotirucall-8, 24-dien-21-oic acid, 3-α-hydroxy tirucall-8, 24-dien-21-oic acid and 3-b-hydroxytirucall-8, 24-dien-21-oic acids) and four boswellic acids (β-boswellic acid, acetyl β-boswellic acid, acetyl-11-keto-β-boswellic acid and 11-keto-β-boswellic acid) besides α- and β-amyrrins. The gum is an acidic polysaccharide consisting of uronic acid (30%), galactose (46%), D-arabinose, xylose and mannose (Pardhy and Bhattacharya, 1978).

The bark is found to contain tannins (9%) and β-sitosterol. Seeds contain protein (9%) and carbohydrates (30%). The leaves contain methoxy quercetins, myricetin, proanthocyanidins, gallotannins and phenolic acids (syringic, gentisic, and gallic acids).

Frankincense is very effective in osteoarthritis, juvenile rheumatoid arthritis and spondylitis and is used as astringent, stimulant, expectorant, diuretic, diaphoretic, emmenagogue, and ecbolic and also exhibits antispetic properties. It is also useful in ulcers, tumours, rheumatism, inflammations, piles and skin diseases.

*Caesalpinia bonduc* Roxb. (Caesalpiniaceae)

*Kuberakshi, Bonduc nut/Fever nut*

A heavily armed woody climber, *C. bonduc* possesses branches and rachis of leaves armed with stout recurved prickles, bipinnate leaves with 6-11 pairs of ovate leaflets and foliaceous stipules, yellow fragrant flowers in the racemes and swollen flattened spiny beaked pods containing 1-2 large orbicular shiny polished seeds. A native of India and Persia, it is found wild in many parts of India.

The seeds contain proteins (25%), oil (20-24% rich in linoleic and oleic acids) and α-, β-, γ-, δ- and ε-caesalpins, caesalpin F and a homoisoflavone, bonducellin. The leaves contain protein (25%), a bitter principle (C_{24}H_{32}O_{8}), wax and pinitol.

Bonduc nuts are known for their antiperiodic efficacy. They are used as diuretic, antipyretics, and tonic, in malaria, diarrhoea and for treating hydrocele. The seed oil is antirheumatic in nature. Leaves are used in skin diseases and rheumatism. Roots are used to cure leucorrhoea, in intermittent fevers and diabetes.

*Caesalpinia crista* Linn.

Syn. *C. nuga* Ait

*C. crista* is considered same as *C. bonduc* by many, but differs from the latter in having simple stipules and smooth pods (Sivarajan and Balachandran, 1994). Since the identity of the plants studied is controversial, the compounds
reported from *C. bonduc* would have been from the material of *C. crista* and vice versa. Therefore, the chemistry and properties of both the plants, for the present, are considered to be the same.

**Calophyllum inophyllum** Linn. (Clusiaceae)

*C. inophyllum* is a moderate-sized evergreen tree with milky latex, black bark, large, broadly elliptic oblong leaves, fragrant polygamous white flowers in axillary racemes and light yellow drupes containing a single large globular seed. This plant is a native of S.E. Asia, common in the coastal regions of India.

The seeds contain large amounts of oil (60%) of a disagreeable odour, protein (6%) and carbohydrates (4%). The oil consists of oleic (60%), palmitic (20%) and stearic acids (13%). Other constituents of oil are calophyllolide, calucustralin, inophyllolide, apetalolide and calophylllic, inophyllic, inophenic, calophynic and pseudobasinic acids. Cinnamic acid, an essential oil and leucocyanidin are the other constituents of the seed. The root bark contains xanthones, caloxanthones A, B & C, 4-OH xanthone, 1-OH, 2OMe xanthone, 1,2-diOMe xanthone, macluraxanthone, and 1,5 diOH xanthone, besides 6-deoxyjacareubin and (-)epicatechin. Other compounds extracted are inophyllums A, B, C, E, P, G₁ and G₂. The heartwood contains xanthones like calophyllin B and 1, 5, 6-trihydroxy xanthone, jacareubin, 6-deoxyjacareubin, 1,3,5,6-tetrahydroxy xanthone, 2-(3-methyl but-2-enyl)-1,2,5,6-tetrahydroxy xanthone, 2-(3-methyl but-2-enyl)-1,3,5-trihydroxy xanthone and 2-(3-hydroxy-3-methyl butyl)-1,3,5,6-tetrahydroxy xanthone. Sapwood contains erythrodiol acetate, γ-sitosterol, friedelin and friedelan-3-ol in addition to the xanthones reported from heartwood. Stem bark contains tannins (9%), inophyllic acid, inophyllodic acid, friedelin, β-sitosterol and β-amyrin. The leaves are found to yield biflavones (amentoflavone), friedelin, canophyllal, canophyllol, canophyllic acid and piscicidal inophyllum A, B & D and cis- and trans-inophyllolides. Petals yield procyanidin and stamens, quercetin and myricetin (Goh & Jantan, 1991).

The oil and seed paste are useful in painful joints, rheumatism and gout. Calophyllolide, inophyllolide and calophylllic acid are reputed remedies of leprosy and, therefore, the oil is intramuscularly injected in leprosy patients. The other uses of oil include its application against venereal diseases, scabies, cutaneous diseases and ringworms. Calophyllolide, isolated from defatted seed meal, possesses anti-coagulant, antiarrhythmic, coronary dilator and CNS depressant activity. Leaves are inhaled for migrane and vertigo. Stem bark is purgative. The gum exudate from bark is emetic, purgative and is used for ulcers. Flower decoction is used for syphilis and eczema. Flowers and stamens are substituted for the Ayurvedic drug *Nagkesar* (*Mesua ferrea* Linn.).
3.6 Triterpenoids

The term triterpenoid refers to a heterogeneous collection of biochemical substances, which are believed to be derived from the C-30 acyclic compound squalene by ring closures and substitutions. Apart from a few acyclic members, the majority is represented by tetra or pentacyclic compounds. One may frequently encounter alcohols, aldehydes, ketones or carboxylic acids in them. Many are colourless crystalline compounds with high melting points. Optical isomerism is a common phenomenon exhibited by these natural products. **Tetracyclic triterpenes** are recognized by a cyclopentanoperhydrophenanthrene nucleus and an 8-carbon side chain at C₁₇. The resemblance with the steroids is apparent and erroneously prompted some authors to group them as sterols and name them accordingly, e.g., lanosterol. They are abundant in laticiferous plants. Cucurbitacins, a group of bitter principles (12 have been identified occurring free or as glycosides), represent a physiologically active set of compounds in this series.

**Pentacyclic triterpenes** are widely distributed in higher plants, occurring free or as glycosides (saponins). The aglycones, found in the excretions and cuticle, have a protective as well as water-proofing function, e.g. β-amyrin. Invariably all the members are oxygenated at the C₃ position. The bitterness exhibited by some of these members are notable, e.g. limonoids and quassinoids. Gymnemic acids, which can destroy the ability to taste sweet substance form another interesting group.

**Steroids**

Steroids also possess the cyclopentanoperhydrophenanthrene nucleus and 8-carbon side chain at C₁₇. But they differ from the tetracyclic triterpenes by the reduction of methyl groups to 2, i.e. only at positions 10 and 13. These compounds, once believed to be of animal origin, are extensively located in higher plants now, where they occur free, as esters or as other derivatives. The typical “animal sterols” like cholesterol and hormones like estrones and ecdysones are reported recently from many plants, but their role in plants is still very ambiguous. Ergosterol is confined to fungi whereas sitosterol, stigmasterol and campesterol are widely distributed in the plant kingdom. More than 100 plant sterols have been identified.

**Sterolins and Saponins**

Sterolins are sterol glycosides which occur along with free sterols in waxes and unsaponifiable lipid fractions. Unlike saponins, they are non-toxic to fish and do not haemolyse RBC. But the lesser number of sugar moieties—normally only one—make them insoluble in water. They possess high m.p. like sterols but are less soluble in lipid solvents. β-Sitosterol glycoside is the commonest sterolin.
Saponins, on the other hand, are soluble in water and like soaps, produce stable froth when shaken with water. Toxicity to fish and haemolysis of RBC are two distinct properties of this group. The sugar component, usually an oligosaccharide consisting of 2-5 sugar units and one glucuronic acid molecule, is linked to C3 position of the aglycones. Sapogenins, the aglycones, may be a triterpene like oleanolic acid or a steroid possessing a spiroketal side chain like digitogenin. A series of saponins may have different sugar components but same sapogenin.

Saponins are widespread in higher plants, having been detected in well over 70 plant families. Steroid saponins are frequent in monocot families like Liliaceae, Amaryllidaceae, and Dioscoreaceae, whereas triterpene saponins are predominant in dicots.

3.6a Triterpenes and Steroids

*Allamanda cathartica* Linn. (Apocynaceae)

Campanilla

A native of S. America, *A. cathartica* is a tall shrub with whorled, obovate to lanceolate leaves, large yellow flowers in cymes and prickly capsules containing many obovate flat, winged seeds. Campanilla is generally grown in gardens for its beautiful flowers.

The leaves contain triterpene esters, plumericin, isoplumericin, plumieride, ursolic acid, β-amyrin and β-sitosterol. The stem also contains most of these compounds. The roots contain an iridoid lactone allamandin, allamandicin, allamdin and triterpene lactones such as fluvoplumeirin, plumericin, isoplumericin and plumieride as well as lupeol and fatty alcohols and fatty acids. The petals yield flavonoids, quercetin and kaempferol.

The leaves are used as cathartics. The extracts of roots and leaves cause hypotension in male cats. The bark is useful as a hydragogue in ascitis. Allamandin exhibits anti-leukemic properties.

*Achyranthes aspera* Linn. (Amaranthaceae)

Apamargah, Prickly-Chaff Flower

*A. aspera* is an erect pubescent herb, with opposite, short-petioled, obovate, softly tomentose leaves and terminal spikes containing small greenish-white sessile deflexed flowers. Bracts and bracteoles of the flower are spinescent. Seeds are subcylindric, reddish brown and truncate at the apex. A native of S.E. Asia, this plant is found throughout India as a weed.

All the parts of the plant are found to contain ecdysterone, an insect-moulting hormone. The whole plant yields two alkaloids achyranthine and betaine; leaves contain phenolic acids such as vanillic, syringic and *p*-coumaric acids, roots contain oleanolic acid besides ecdysterone, and the
seeds yield protein (22%), carbohydrates (56%) and two saponins, saponin A and B, based on oleanolic acid.

The entire plant is medicinally useful. Young leaves are consumed as a vegetable. The whole plant is much valued for its pungent, diuretic and emmanagogue properties. The decoction is useful in pneumonia, cough and kidney stone. Leaf extract is used to treat eczema, dropsy, for treating cataracts and tetanus. Leaves are also used as a cure for gonorrhoea and leprosy. Root paste is applied to remove opacity of cornea and as a haemostatic and is used in abdominal tumours and as an antifertility agent. Seeds are used against bronchial affections. Achyranthine is reported to dilate blood vessels, lower blood pressure and increase the rate and amplitude of respiration.

Siddha physicians use apamargah as an effective remedy for bronchial asthma (Suresh et al. 1985). Wadhwa et al. (1986) found the plant to be an effective contraceptive in rats and hamsters.

_Trianthema portulacastrum_ Linn. (Aizoaceae)

_Syn._ T. monogyna Linn.

**Punarnava**

A prostrate succulent mucilaginous herb with fleshy, obliquely opposite leaves. The leaves are in unequal pairs, the larger orbicular-ovate and smaller oblong apiculate. Flowers are axillary, solitary and enclosed and sunken in the membranous enlargement of the petiole of the smaller leaves, forming a pouch. Flowers are apetalous, sepals pinkish white and ovary unicellular. The fruit is in the form of a capsule with two spreading teeth. Concealed by the pouch, it opens by circumscissile dehiscence. Seeds are many, black, reniform. A common weed throughout India, this plant is found in moist places.

The roots contain ecdysterone and an alkaloid, trianthemine (C_{32}H_{46}O_{6}N_{2}). Leaves are found to possess sesuvin (6,7-diOMe, 3,5,4’-triOH flavone), vanillic acid and _p_-hydroxy benzoic acid (Daniel and Sabnis, 1986).

Roots are considered punarnava (in place of _Boerhavia diffusa_), a rejuvenative drug specific to general weakness, jaundice, oedema, etc. The drug is a laxative, diuretic, expectorant, antipyretic and cardiotonic. _T. monogyna_ is found to be analgesic and antiinflammatory. The whole plant is used as a vegetable.

_Vernonia cinerea_ Less. (Asteraceae)

_Syn._ Conyza cinerea Linn.

**Sahadevi**

Sahadevi is an erect hispid annual with leaves variable from broadly elliptic to spathulate, margin wavy/crenate, pinkish violet homogamous heads in
lax terminal corymbose panicles, flowers are in the form of disc florets, pappus of 2 whorls of white hairs and 5-angled achenes bearing appressed white hairs. This plant is found as a weed throughout India and Africa.

The herb contains β-amyrin, lupeol, β-sitosterol, stigmasterol, α-spinasterol and phenols.

Sahadevi is a reputed drug for all types of fevers. The entire plant is febrifuge, diaphoretic and can calm the mind. It is also useful in leucorrhoea, excessive bleeding, skin diseases, and conjunctivitis. Flowers are used in conjunctivitis and rheumatism. Seeds are anthelmintic and alexipharmic and for skin diseases like leucoderma and psoriasis.

**Gossypium arboreum** Linn. (Malvaceae)

Karpasa, Cotton Tree

G. *arboreum* is an erect arborescent shrub with purple hairy branches, palmately 5-7 lobed (with an extra tooth in the sinus) lower surface punctate with black dots, long-petioled bristle-tipped leaves, large purple (or yellow with purple base) flowers having 3 large, foliaceous, ovate-cordate bracteoles (flowers with monadelphous stamens and reniform anthers) and a loculicidal capsule containing many seeds covered by cotton fibres. A native of India and Africa, Karpasa is cultivated in gardens and temples and not as a field crop or seen wild.

The seed is considered an aphrodisiac, galactogogue and an effective medicine for anaemia and genito-urinary diseases. The leaves are diuretic, used in mental disorders and skin diseases. Flowers are blood purifiers and heal ulcers due to leprosy. Roots are used to bring down fever.

**Gossypium herbaceum** Linn.

Kapas, Cotton Plant

G. *herbaceum* is an erect shrub differing from *G. arboreum* in having yellow flowers or yellow with purple base, becoming reddish after maturity. This is the cultivated cotton plant.

Cottonseed is known for the oil (30%), protein and the dimeric naphthalene derivative, gossypol. Gossypol is present in root bark along with β-sitosterol and α-amyrin.

G. *herbaceum* is used in place of *G. arboreum* and possesses most of the medicinal properties of the latter. Root bark is emmenagogue and useful in dysmenorrhea. Flowers are useful in uterine discharges. Gossypol is used in treating endometriosis and uterine bleeding. Gossypol is considered a safe antifertility drug for males.
**Helicteres isora** Linn. (Sterculiaceae)

**Mrigashinga/Maraphali, East Indian Screw Tree**

*H. isora* is a small stellately pubescent tree with oblong-obovate cordate acuminate stellately hairy leaves, red fading to lead-colored flowers in axillary clusters of 2-6 (flowers with 2-lipped calyx, unequal reflexed petals and a deflexed staminal column fused with gynophore) and follicles (5) spirally twisted in the form of a screw containing many small tubercled seeds. This medicinal plant is common all over India and nearby countries.

The plant contains a 4-quinolone alkaloid malatyamine. Root and stem yield \(\beta\)-sitosterol, betulic acid, oleanolic acid and daucosterol. Roots also contain a triterpenoid, isorin and \(3\beta\)-27-acetoxy-lup-20(29)-en-28-oic methyl ester. Fruits contain \(\alpha\)- and \(\beta\)-amyrins, lupeol and its acetate, friedelin, epifriedelinol, baueranol acetate and taraxeron.

The roots of this plant are used in cough and asthma. The leaf paste is effective against eczema and skin ailments. Pods are antidysenteric and used for colic, flatulence and stomach ache.

**Hemidesmus indicus** R.Br. (Asclepiadaceae)

Syn. *Periploca indica* Linn.

**Anantamool/Sariva, Indian Sarasaparilla**

This is a twining undershrub with a woody rootstock, many slender laticiferous branches thickened at the nodes, leaves varying from elliptic-oblong to linear-lanceolate, and often variegated with white above, small greenish yellow/purple flowers crowded in subsessile axillary cymes in the opposite axils and a pair of divaricate long slender follicles containing flattened oblong comose seeds. A native of India, this plant is common throughout.

The roots, which are used as the drug, contain an essential oil consisting of \(p\)-methoxy salicylic aldehyde; coumarino-lignoids, hemidesminine (C\(_{25}\)H\(_{22}\)O\(_8\)) and hemidesmin 1 & 2 and steroids such as hemidesmol, hemidosterol, lupeol octacosanate and \(\beta\)-amyrin acetate and coumarin. Stem contains pregnane glycosides hemidine, hemidescine, emidine, indicine, a triterpene lactone (3-keto-lup-12-ene 21(28)-olide), a lupanone, \(\Delta^{12}\) dehydrolupanyl-3\(\beta\)-acetate, besides \(\Delta^{12}\) dehydrolupeol acetate, lupeol acetate, sitosterol and several hydroxymethoxy benzaldehydes (Mandal et al. 1991; Gupta et al. 1992; Chandra et al. 1994).

Sariva is one of the rejuvenating drugs used for its cooling and blood purifying qualities. It is an alterative, aphrodisiac, refrigerant, diuretic and tonic. It is also useful in chronic rheumatism, anaemia, dyspepsia, leucorrhoea, uterine haemorrhage and skin diseases as well as abdominal tumours and as an antilithic.
**Ichnocarpus frutescens** R.Br. (Apocynaceae)

*Sariva, Ichnocarpus*

*I. frutescens* is an extensively branched woody laticiferous twiner with rusty pubescent young branches, elliptic-oblong leaves, small greenish white flowers in axillary or terminal rusty pubescent trichotomous pedunculate cymes and a pair of cylindrical follicles enclosing black linear seeds crowned by a tuft of white hairs. This plant is distributed throughout India, Malaya and Australia.

Leaves contain flavones apigenin and luteolin, glycoflavones, vitexin and isovitexin, proanthocyanidins and phenolic acids, vanillic, syringic and sinapic acids (Daniel and Sabnis, 1978). Stem contains friedelin, friedelinol, lupeol acetate, $\Delta^{12}$ dehydrolupeol, $\Delta^{12}$ dehydro lupanyl, oleanolic acid, $\beta$-sitosterol and $\alpha$-amyrin glycoside (Verma and Gupta, 1988).

This plant is used as Sariva (in place of *Hemidesmus*). Various plant parts are used in night blindness, bleeding of gums, enlargement of spleen, atrophy, smallpox, ulcer, dysentery, cough and asthma. It is also used in abdominal and glandular tumours.

**Gymnema sylvestre** R.Br. (Asclepiadaceae)

*Madhunashi, Gymnema*

*G. sylvestre* is a large, much-branched woody twiner, with opposite pubescent ovate-lanceolate leaves, small yellow flowers in sessile or pedunculate cymes (flowers with staminal corona and a gynostemium) and an etaerio of lanceolate beaked follicles (one follicle often suppressed) enclosing flat ovoid-oblong seeds having a thin broad marginal wing. Common in Western ghats, Gymnema is a native of tropical Africa.

The leaves contain gymnemic acids (with gymnemic acid being the main component), 3$\beta$-glucuronides of acylated gymnemagenins (hexa hydroxy olean-12-one), gymnestrogenin, conduritol A, nonacosane, choline, betaine and an alkaloid gymnamine, and tritriacontane. Also present are dammerane type saponins gymnamasides I-VIII and gypenosides XXVII, XXXVII, LV and LXIII. The phenolics present are flavonols (quercetin and 3’OMe quercetin) and phenolic acids (vanillic, syringic, $p$-hydroxy benzoic, protocatechuic, ferulic and sinapic acids) (Daniel and Sabnis, 1982).

The leaves and stems of this climber are hypoglycemic and, therefore, used in treating diabetes. They are diuretic and stimulate cardiovascular system. The drug is useful in skeletal fractures and exerts a purgative action.

**Holoptelia integrifolia** Planch (Ulmaceae)

*Putikaranjah, Holoptelia*

*H. integrifolia* is a large glabrous deciduous monoecious tree with elliptic glabrous leaves, male and female flowers mixed in short racemes from the
scars of fallen leaves and an orbicular samaroid fruit 2-3 cm in dia. having reticulately veined wings. A native of China, Holoptelia can be seen in all deciduous forests.

The bark yields \( \beta \)-sitosterol, friedelin, friedelan-3\( \beta \)-ol and triterpenoidal fatty acid esters, holoptelin A (epi-friedelinol palmitate) and B(epi-friedelinol stearate). Heartwood contains dihydroxy olean-12-en-28-oic acid, and the leaves contain \( \beta \)-sitosterol, \( \beta \)-amyrin and hexa- and octacosanols.

Both the bark and leaves are used (normally in combination with Karanjah; Pongamia pinnata) as laxative and anthelmintic. They are also used for oedema, leprosy, skin diseases and diabetes. Branches are used as fish poison, stem bark and seeds applied to cure ringworm. Stem bark is also used in scabies and rheumatism. The drug exhibits lipolytic action and, therefore, helps reduce obesity.

**Commiphora spp. (Burseraceae)**

**Myrrh**

Myrrh is an oleo-gum-resin obtained from various species of *Commiphora*; growing in Africa, Arabia and Abyssinia. Apart from *C. myrrha* Engl., which forms the principal source, *C. abyssinica* Engl., *C. schimperi* Engl. And *C. erythraea* Arn. also yield this valuable resin.

The resin, occurring in the schizolysigenous cavities of phloem, exudes naturally from the spontaneous cracks or crevices developed in the bark or can be obtained by making incisions. The yellowish white liquid oozing out gradually solidifies to form reddish brown irregular masses, which is then collected.

Myrrh contains 5-10% volatile oil, 25-40% resin, 55-60% gum and some bitter principles as impurities. The yellow-green volatile oil consists of eugenol, cuminaldehyde, mono- and some sesquiterpenes. The resin—the components of which are not fully characterized—contains \( \alpha \), \( \beta \) and \( \gamma \)-commiphoric acids; \( \alpha \) and \( \beta \)-heerabomyrrholic acids and some phenolic compounds such as protocatechuic acid and pyrocatechin. The gum portion is composed of about 20% protein and 60% carbohydrates, which on hydrolysis yield galactose, arabinose and glucuronic acid as principal components.

The oldest and most valuable gum-resin, myrrh is used as an incense, in perfumes and embalming. In medicine it is employed as a tonic, stimulant and antiseptic.

**Commiphora wightii** Arnott — (Burseraceae)

**Guggul**

Guggul is the oleo-gum-resin obtained from *C. wightii*, a native of India. The plant is a small tree, branched from the base with knotty divaricate glandular pubescent branches ending in sharp spines. Leaves are 1-3 foliolate with
shining rhomboid ovate leaflets. The red-coloured drupe contains two woody pyrenes.

The resin, which is exuded naturally or by incisions, forms pale yellow or reddish brown vermiform crystals and possesses a bitter aromatic taste. It contains about 0.37% essential oil, consisting chiefly of myrcene, dimyrcene and polymyrcene; sterols like guggulusterol I, II, & III, cholesterol, guggulusterones Z & E, diterpenes such as α-camphorene, cembrene and mukulol and long chain aliphatic tetrals and sesamin. Muscanone, 3-O- (1″, 8″, 14″ trimethyl hexadecanyl) naringenin is an antifungal flavone isolated from this plant along with naringenin (Fatope et al. 2003).

Guggul is used in treating rheumatism, obesity, and neurological and urinary disorders. Guggulsterols are found to be anti-inflammatory and hypocholesteremic.

*Aerva lanata* Juss. (Amaranthaceae)

*Aerva lanata* is a much-branched woody herb with simple alternate ovate/orbicular leaves, minute sessile white flowers in axillary spicate clusters and reniform seeds enclosed in greenish compressed utricles. *Aerva* is a common weed throughout India.

The plant is found to contain six alkaloids, canthin-6-one, 10-OMe canthin-6-one, 10-OH canthin-6-one, β-carboline-1-propionic acid and its 6-OMe deriv. and glucooxycanthin-6-one. Also present are β-sitosterol, α-amyrin, betulin, four coumaroyl glycosides, phenolic acids such as vanillic and syringic acids and saponins. Roots yield aervin, methylaervin and aervoside (Zepesochnaya, et al. 1991).

The plant is anthelmintic, demulcent and used against kidney and urinary stones and diabetes. It is also used in malaria and skin diseases and as an expectorant and for indigestion and wounds. The roots are often preferred, though the whole plant is medicinal. *A lanata* is one of the 10 auspicious herbs that constitute the group *Dasapushpam* (`ten flowers`).

*Drypetes roxburghii* Hurus. (Euphorbiaceae)

Syn. *Putranjiva roxburghii* Wall.

*Putranjiva*

This is an evergreen/dioecious tree (upto 20m ht.) with pendent branches, dark green, shining elliptic-oblong serrulate pinninerved leaves, shortly pedicellate male flowers crowded in globose axillary clusters, female flowers 1-3 in axils and ellipsoid white tomentose drupes containing a single hard seed enclosed in a hard endocarp. *Putranjiva* is common in tropical India.

The stem bark yields triterpenoids friedlin, friedelanol, roxburgholone, putranjivadione, putranjivanol, putranjijc acid and putrolic acid. Leaves con-
terpeneoids 107

Tain β-amyrin, putrone, putrol, putranjivic acid, methyl putranjivate, stigmasterol, roxburghonic acid, saponins A-D and biflavones. Seeds yield fatty oil and an essential oil containing isothiocyanate produced from glucosinolates glucopatranjivin, glucocochlearin, glucojiaputin and glucolemin. Seed coat yields triterpenoid saponin putrainjivoside (1.3%), β-sitosterol and its glycosides and saponins such as putranosides A-D. The fruit pulp contains mannotol, a saponin and an alkaloid.

Leaves and stones of the fruits are used in rheumatism. Leaves are also used externally to swollen joints and inflamed areas. All parts of the plant are used for colds and fevers.

Euphorbia hirta Linn. (Euphorbiaceae)

Syn. E. pilulifera Linn.

Dugdhika

E. hirta is a laticiferous erect herb with long yellowish crisped hairs, opposite obliquely oblong-lanceolate (base unequal sided) leaves, pedunculate umbellate clusters of cyathia and pubescent capsules containing 3 reddish brown trigonous seeds. Dugdhika is a very common weed found all over India.

The whole plant yields cycloartenol, friedlin, taraxerol, aphyldienol, ingenol triacetate, euphorbol hexacosanate, β-amyrin acetate, tinytoxin, β-sitosterol, cycloartenol, choline, shikimic acid and inositol. Also present are quercetin, rutin, an alkaloid xanthorhamnine and dimeric tannins euphorbins A, B & C (composed of geraniin and pentagalloyl glucose). The latex contains diesters of 12-deoxy-4β-phorbol (Okuda et al. 1993).

This plant is used as a diuretic, aphrodisiac, and galactogogue, for skin diseases, asthma and other respiratory diseases. It is also used as an antisyndenteric, vermifuge and in diseases of the urinogenitory tract. It also exhibited anticancer properties in the sense that the aqueous extract reduced release of prostaglandins L₂, E₂ and D₂ and had an inhibitory effect on platelet aggregation and carrageenan-induced rat paw oedema.

Euphorbia thymifolia Linn.

Syn. E. prostrata Ait.

Dugdhika

This plant is also used as Dugdhika, but it is further administered in ophthalmia and other eye troubles, atrophy, dysentery and breast pain. This is considered as an insecticide, a blood purifier and cures spermatorrhoea.

The entire plant yields deoxyphorbol acetate derivatives, epitaraxerol hexacosanol, euphorbol, 24-methylene cycloartenol, taraxasterol, tirucallol and quercetin.
Euphorbia nivulia Buch. - Ham. (Euphorbiaceae)

Syn. E. neriifolia Linn.

E. nivulia is a large fleshy, armed erect shrub with pairs of sharp stipular spines arising from conical truncate spirally arranged tubercles. Leaves, seen towards the end of branches, are fleshy, alternate, obovate-oblong or spathulate and tapering towards the base. Cyathia are in twin cymes from above the leaf sears. The capsule contains 4-angular smooth seeds. This plant is common in wastelands.

The latex contains euphol and nerifloiol, while the bark yields deoxyphorbol acetate, euphol, euphorbol hexacosanate, 24-methylene cycloartenol and glycosides of pelargonimid and tulipanin. Leaves and stem are found to possess friedelan-3α-ol, taraxerol and glut-5 (10)-en-1-one, whereas the roots contain 24Me-25-ene cycloartenol, cycloartenol, ingenol triacetate, euphorbol and deoxyphorbol acetate.

The stem, with a milky latex, is used as a purgative, expectorant and digestive and cures liver and spleen enlargement, asthma, fever, leprosy and rheumatism. The juice is applied externally to remove warts and similar structures, ulcers, scabies, etc.

Clerodendrum indicum Kuntze (Verbenaceae)

Syn. C. siphonanthus C.B. Clarke

Bharangi

C. indicum is a woody shrub with an obtusely 4-angled stem, simple lanceolate serrate thick leaves in whorls of three white flowers in a terminal panicle and purple drupe containing 4 seeds, partly enclosed in calyx. Bharangi is a common plant throughout India.

The stem contains β-sitosterol and cholesta-5,22,25-triene-3β-ol. Leaves contain scutellarein and hispidulin, whereas the flowers yield β-sitosterol.

Root, which is the official drug, is antispasmodic, expectorant, febrifuge and used for epilepsy and dropsy. The leaves are suppurative, while the fruit decoction is said to have antifertility factors.

C. serratum Moon. is used as bharangi in some plants of India.

Ficus benghalensis Linn. (Moraceae)

Nyagrodhah/Vad, Banyan Tree

F. benghalensis is a very large laticiferous tree with numerous aerial roots from the branches which take root on the ground and thus extend the growth of the tree infinitely. Leaves are large, broadly elliptic, glabrous above and minutely pubescent beneath. Figs are monoecious, axillary depressed globose 2 cm in diam, brick red when ripe with 3 broad rounded basal bracts. Male flowers are numerous near the mouth, female flowers at the base of
receptacle and neuter flowers in the middle. Achenes are globose, ellipsoid. A native of India, banyan tree is cultivated or found wild throughout India. The stem bark contains bengalenoside, procyanidin, \( \beta \)-sitosterol, meso-inositol and ketones. Leaves yield friedelin and \( \beta \)-sitosterol, quercetin and rutin. Heartwood contains \( \gamma \)-taraxasterol.

All the parts of the tree are used in medicine, especially for skin diseases. The bark is useful in menorrhagia, leucorrhoea and other vaginal disorders and is found to cure diarrhoea and dysentery. Bengalenoside is found to be hypoglycemic. Latex and young buds are used in urinogenital diseases. The roots are also useful in haemoptysis, menorrhagia and ulcers. Young roots are found to cure pimples.

**Ficus carica** Linn.  
**Anjir, Fig**

This is a middle-sized laticiferous deciduous tree with cordate, 3-5 nerved, dentate and deeply palmately lobed leaves. Figs are large and edible.

The plant yields umbelliferone and scopoletin. The leaves contain psoralens, bergaptene, xanthotoxin, xanthotoxol and marmesin. Flavones, terpenoids and ficusogenin are the other compounds reported. Latex contains ficin and peptides. Roots yield guaiazulene.

The fruit is useful in anaemia. Latex is anthelmintic. Latex exhibited significant inhibition of the binding of 3H-benzo \( \alpha \)-pyrene, a known chemical carcinogen. Three peptides are also reported from latex which exhibited inhibitory action against Angiotensin-1-converting enzyme (ACE). The fruit extract contains an anticancer compound effective against Ehrlich sarcoma.

**Ficus racemosa** Linn.  
**Syn. F. glomerata** Roxb.  
**Udumber**

This is an evergreen laticifer with elliptic lanceolate leaves tapering to a blunt pointed apex, ovate-lanceolate pubescent stipules and red dense tomentose figs borne on short leafless warty short branches of a few inches long, subglobose or pyriform with 3 basal bracts and monoecious. Udumber is found throughout India.

Bark contains ceryl behenate, lupeol, \( \alpha \)-amyrin and \( \beta \)-sitosterol and gluanol acetate. Leaves yield \( \beta \)-amyrin, \( \beta \)-sitosterol and gluanol acetate. The fruit also contains gluanol acetate along with lupeol acetate, \( \beta \)-sitosterol and taraxasterol.

The bark of this tree is very useful in healing ulcers, skin diseases and vaginal diseases. It is highly effective in threatened abortions, gonorrhoea, menorrhagia and leucorrhoea. Leaves are hypotensive and cardiac depressant. The fruits are used to treat diarrhoea, dysentery, dyspepsia, hemorrhage and menorrhagia.
Ficus religiosa Linn.

Aswattah

F. religiosa is a large glabrous laticiferous tree with long-petioled, broadly ovate rotund leaf having a long lanceolate cuspidate tip and monoecious paired dark purple figs. Aswattah is a highly venerated tree found throughout India.

The bark contains bergenin, lupin-3-one, methyl oleanolate, lanosterol, n-octacosanol, \( \beta \)-sitosterol, stigmasterol and caffeic acid (Swami et al. 1989).

The bark is alterative, haemostatic, laxative and is used in diabetes, diarrhoea, leucorrhoea, menorrhagia, nervous disorders and vaginal diseases. It is also an excellent remedy for skin diseases and is anthelmintic. Leaves are also used in skin diseases. Seeds have the power to sterilize women.

Cissus quadrangula Linn. (Vitaceae)

Syn. Vitis quadrangula Wall.

Asthisandana/Vajravalli, Bonesetter

C. quadrangula is a succulent perennial climber with quadrangular jointed cactus-like stems having 4 wings, leaf-opposed tendrils, aerial roots from nodes, cordate fleshy 3-7 lobed/entire leaves (leaves fall off in older stems), small greenish-white flowers in short umbellate cymes and globose, peasized berries enclosing solitary seeds. This is a native of S.E. Asia.

The stem contains protein (12%), carbohydrates (35%), carbonates of sodium, potassium, magnesium and calcium, potassium tartarate and triterpenoids. The triterpenoids present are onocer-7-ene-3\( \alpha \), 21\( \beta \) diol, onocer-7-ene-3\( \beta \), 21\( \alpha \)-diol, 7-oxo-onocer-8-ene-3\( \beta \)-diol, alkanes and two steroids designated I and II besides taraxasterol, friedelan-3-one, \( \beta \)-sitosterol, \( \delta \)-amyrin and \( \delta \)-amyrone (Gupta & Varma, 1991).

The stem is useful in piles, asthma, irregular menstrual periods and muscular pains. But the entire plant is excellent in healing bone fracture because of the two unidentified anabolic steroids I and II, which facilitate early regeneration of all connective tissues involved in healing and quicker mineralization of the callus. The aqueous extract of the plant is administered topically or as intramuscularly injection.

Withania somnifera Dunal (Solanaceae)

Ashwagandha, Indian Ginseng

W. somnifera is a green herbaceous perennial with long hard tuberous roots, dichotomously branched stem, ovate leaves and small sessile greenish-yellow flowers crowded in the axils of leaves. The small berry is enclosed in a green persistent inflated calyx. This medicinal plant is widely distributed in north western India.
The roots, which form the drug, exhibit a great chemical diversity. The majority of constituents are a group of steroidal lactones possessing an ergostane skeleton, the withanolides. The known withanolides are more than 20 and are withanone, withaferin A, withanolides I, II, III, A, B, C, D, E F, G, H, I, J, K, L, M, WS-1, P and S, withasomnidienone and withanolide C. About a dozen biochemically heterogeneous alkaloids are reported from this drug. The major compounds are tropane, pseudotropane (tropanes), hygrine (pyrrolidine), isopelletierine (piperidine), anaferine (two piperidine moieties), withasomnine (pyrazole) and anahygrine (having one pyrrolidine and one piperidine moiety). Also present is a large amount of starch (Bakuni and Sudha, 1995; Bessale and Lavic, 1992).

Ashwagandha is a rejuvenating drug used for rheumatism, hypertension, and as a tonic. It shows antitumour, bradycardic, respiratory stimulant and antispasmodic properties. Withanolides also show antitumour, antiarthritic and immunosuppressive properties (Sudhir et al. 1986).

*Citrus colocynthis* Schard. (Cucurbitaceae)

Syn. *Colocynthis vulgaris* Schard.

**Indravaruni, Colocynth**

*C. colocynthis* is a monoecious perennial with scabrid angular stems, bifid tendrils, triangular deeply 3-lobed (lobes pinnately divided) leaves, yellow unisexual flowers solitary in the axils of leaves and green fruits (pepo) mottled with yellow blotches containing spongy bitter pulp and numerous white seeds. Colocynth is abundant in northwestern plains of India on sand dunes.

The fruit contains a number of bitter principles generally known as cucurbitacins consisting of α-elaterin (cucurbitacin E), elatericin B (cucurbitacin I), dihydroelatericin B (cucurbitacin L), citrullin, citrullene, citrullic acid and citrullol. Also present are sugars (glucose), pectin, hydrocarbons such as hentriacontane, a volatile oil consisting of citronellal, methyl eugenol and methyl heptenone, choline, alkaloids, lanosterol and β-sitosterol. Seeds yield a bitter oil consisting of linoleic (60%), oleic (20%) and palmitic (10%) acids and a triterpene, citrullonol (Hatam et al., 1989).

The dried pulp, containing seeds (62%) and rind (23%) is the drug *colocynthis*. It is a hydragogue, cathartic and drastic purgative and therefore used along with carminatives. It is also useful in treating constipation, dropsy, and fevers and useful as a vermifuge and emmenagogue. The purgative property is attributed to α-elaterin glucoside.

### 3.6b Limonoids and Quassinoids

Limonoids and Quassinoids are the compounds formed by the loss of a few carbon atoms from triterpenoids and thus known as nortriterpenoids. All these compounds are unique to the order Rutales *sensu lato*. Limonoids are
tetranortriterpenoids formed by the conversion of the 8-carbon side chain at C-17 to a furan ring. But some of the members of this group, like turreanthin, retain an intact C_{30} triterpenoid skeleton. Azadirone, nimbin, trichilin, etc., are C_{26} limonoids. Almost all these compounds are bitter principles. Azadirachtin is a complex member of this group showing marked antifeedant activity. Limonoids are subdivided based on the cleavage of D ring (gedunin), C ring (nimbin), B ring (androbin), A ring (tricoccin S_{22}), both A & B rings (dregianin), both A and D rings (limonin) or with all 4 rings intact (azadirone). All these limonoids are restricted to the Meliaceae and Rutaceae. The Cneoraceae, a related small family, is found to contain C_{25}, pentanortriterpenoids (cneorin B). About 300 limonoids are known (Conolly, 1983; Dreyer, 1983).

Quassinoids are the characteristic bitter principles of the Simaroubaceae. They are highly degraded triterpenoids, which lost the 8-carbon side chain together. They possess C_{30} skeleton (glaucarubolone), C_{19} (samaderine C), C_{18} (laurycolactone A) or rarely C_{25} (simarinolide). About 100 quassinoids are known today (Polonsky, 1983).

Some of the quassinoids, like isobruceine A possess marked antileukaemic activity. Other biological activities include: (1) antiviral activity (castelanone), (2) antimalarial (glaucarubinone), and (3) antifeedant and insecticidal properties (most of limonoids and quassinoids).

**Picrasma excelsa** Planch. (Simaroubaceae)

**Quassia**

A native of West Indies, this plant is a tall polygamous shrub with very large compound leaves having numerous ovate unequally sided leaflets. The fine shavings of the wood, the Quassia of commerce, contain a mixture of bitter terpenoids like the lactone quassin (which form the chief constituent), neo-quassin (the hemiacetal of quassin) and picrasmin (iso-quassin). Quassia is a bitter tonic, an insecticide and anthelmintic. *Quassia amara* L., a native of Brazil, contains similar principles and is used in place of *Picrasma*. Recently, it has been observed that quassinoids possess antileukaemic properties. One such compound under study is Bruceantin isolated from *Brucea antidysenterica* Lam. (Simaroubaceae).

**Ailanthus excelsa** Roxb. (Simaroubaceae)

**Ardusa, Tree of heaven**

*A. excelsa* is a large majestic, deciduous tree with a tall cylindrical bole, pinnate leaves (upto 90cm long, having 8-14 pairs of unequal sided leaflets), small yellowish flowers in panicles and one-seeded samaroid fruits. This tree is very fast growing and is introduced all over India.
The stem bark contains quassinoids such as glaucarubin and excelsin, ailanthic acid, 2,6-dimethoxybenzoquinone, β-sitosterol, malanthin, triacontane and hexatriacontane. The root bark contains quassinoids such as ailanthione, glaucarubinone, glaucarubol-15-isovalerate and 13,18-dehydroglaucarubol-isovalerate. Glaucarbonone is anthelmintic and possesses anti-spasmodic and expectorant properties. It is used for asthma, bronchitis, dysentery, dyspepsia and earache. The bark is a substitute of kurchi (*Holarrhena antidysenterica*). All the quassinoids of root bark are found to possess substantial anti-tumour and cytotoxic activities against the P-388 lymphocytic leukaemia and KB test systems, respectively. The leaves are used as an adulterant for *Adhatoda zeylanica*.

### Azadirachta indica A. Juss. (Meliaceae)

**Nimba, Neem**

Neem is a large evergreen tree with imparipinnate leaves having ovate lanceolate, serrate unequal-sided leaflets, small white scented flowers in axillary panicles and green drupes containing a large seed. Neem is found all over India, cultivated or naturally grown.

All the parts of the plant contain limonoid bitter principles. The stem bark yields nimbin, nimbidin, β-sitosterol, tannins (12%) and a gum; the root bark also contains nimbin and nimbidin; the leaves contain nimbin, nimbinene, 6-desacetyl Nimbinene, nimbandiol, nimbolide, quercetin and β-sitosterol; and the flowers yield β-sitosterol (along with its glucoside), quercetin, kaempferol, thioamylalcohol and benzyl alcohol and a volatile oil containing sesquiterpenes margosene and azadirachtene. The fruits are found to contain gedunin, azadirachtin, 7-deacetoxy-7α-hydroxy gedunin, azadiradione, azadiradone, 17-β-hydroxy azadiradione, 17-epi azadiradione and nimbiol. Neem seeds yield oil and a number of bitter principles both in oil and outside. The oil consists of oleic (56%), palmitic (16%), stearic (14%) and linoleic (9%) acids and 0.8% unsaponifiable matter containing nimbidin, nimbin, nimbinin, meliantriol as major components along with gedunin, meldenin, desacetylgedunin, salannin, azadirone, epoxyazadirodione, veprin, nimbinene, 6-O-acetyl nimbandiol, etc.

The extracts of neem are found to be antimicrobial, anthelmintic and useful against fever especially of malaria. Since all parts are bitter, they are used as anti-diabetic drugs also. The leaves are useful in skin diseases. The fruits also are used as tonics, antiperiodic, purgative, in treating urinary diseases and piles. The oil is a remedy for some chronic skin diseases and ulcers. It is applied externally for rheumatism and leprosy. The flowers are used in cases of atonic dyspepsia and general debility. Nimbidin is an effective drug in acute and chronic inflammation as well as psoriasis.

All the bitter principles of neem are insecticidal and, therefore, the leaves, seed oil, etc., are used thus.
Brucea javanica Merril (Simaroubaceae)

Syn. B. amarissima Desv.,
B. antidysenterica Merril

Ya-Danzi, Brucea

Brucea, a native of Ethiopia, is a thickly pubescent dioecious evergreen shrub with imparipinnate leaves (leaflets six pairs + one), small purplish flowers borne in interrupted glomerate spikes and small oval black drupes.

The stem bark contains quassinoids such as bruceantin, bruceantinol, dihydrobruceantinol, bruceine B, bruceanols D, E, F, G & H, yadanzigan, yadanziolide A. and brucianthinoside C (a glycoside), apotirucallane type triterpenoids bruceajavanin A, dihydrobruceajavanin A and bruceajavanin B and an alkaloidal glycoside of β-carboline, brucianthoinode. Also present are β-carboline alkaloids like canthin-6-one, 11-OH canthin-6-one, 11-OH, 1-OMe canthin-6-one and canthin-6-one-3-N-oxide beside brusatol, emodin, chrysophanin, chrysophanol, ethyl gallate and β-sitosterol. The leaves yield a volatile oil of dillapiole (22%), thymol (17%), apiole, α-cedrene, carvone, etc. The fruits of Ya-Danzi contain an alkaloid 4-ethoxycarbonyl-2-quinolone, quassinoid bruceoside C, quercetin, luteolin and vanillic acid. Seeds yield a fatty oil.

The plant, especially the fruit, is traditionally used in China and Indonesia in the treatment of malaria, amoebic dysentery, cancer and parasitic diseases. Bruceajavanin A, dihydrobruceajavanin A and brucianthinoside inhibited the growth of cultured Plasmodium falciparum K1, a chloroquine-resistant strain). Bruceantin is active against B16 melanoma, colon 38 and L1210 and P388 leukaemia. It favoured apoptosis and exerted no toxic side effects (Cuendet and Pezzuto, 2004). Bruceanols are also found to be cytotoxic against many human tumour cell lines (Imamura et al. 1993).

3.6c Saponins

The crude drugs containing saponins are generally used for their detergent properties and some of them, which result in lesser degree of irritation on oral administration, are employed as expectorant and antitussive agents. Saponins are characteristically found to be antimicrobial in nature.

Saponins are widely distributed in the plant kingdom. About 70% of plant families contain them but they are much more common in Araliaceae, Rhamnaceae, Apiaceae, Fabaceae, Caryophyllaceae, Hippocastanaceae, Liliaceae and Dioscoreaceae. Guvanov et al. (1970) found that, of the 1730 plants belonging to 104 families of Central Asia, triterpenoid saponins are seen in 627 spp. and steroidal saponins in 127.

Steroidal saponins are also important as the starting materials for the syntheses of steroid hormones and related medicines.
**Polygala senega** Linn. (Polygalaceae)

*Milkwort or Snakeroot*

This herb of 5-20 cm height possesses a thick long taproot, simple estipulate leaves, blue bracteate flowers in racemes and a capsule containing arillate hairy seeds. Milkwort is a native of N.E. America, cultivated extensively in Canada and Japan.

The dry rootstock and roots contain a number of triterpenoid saponins that, on hydrolysis, yield the sapogenins, senegenin (a chlorinated sapogenin), presenegenin, senegenic acid, polygalic acid (hydroxy senegenin) and glucose. 1, 5-Anhydrofuranobitol (polygalitol) and sucrose impart a sweet taste to the drug and methyl salicylate the aromaticity. The root also contains a good amount of fats.

Senega is used as a cure for snake bite. It is a known expectorant, emetic and stimulant. The plants are given to cattle to increase the production of milk.

Indian senega consists of the roots of *Glinus oppositifolius* DC which contains oleanolic acid saponins.

**Smilax spp. (Liliaceae)**

*Sarasaparilla*

The long thin roots arising from the rootstock of *S. aristolochiaefolia* Miller, *S. regelii* K.& M. or *S. febrifuga* Kunth, constitute the drug Sarasaparilla. All these plants are straggling shrubs native to America and Spain.

The drug contains a number of saponins based on smilagenin and its isomer, sarasapogenin. Sarasaponin, one of the principal saponins, yields sarasapogenin, two molecules of glucose and one molecule of rhamnose on hydrolysis. Smilinon, another saponin, yields smilagenin and as many as five molecules of sugars. The roots contain certain other phytosterols, like β-sitosterol and stigmasterol, resins and a volatile oil.

Sarasaparilla is used in skin diseases, rheumatism and as a flavouring agent. The sapogenins are used as the starting material for the synthesis of cortisone and other steroid hormones.

**Panax spp. (Araliaceae)**

*Ginseng*

The sources of ginseng are *P. ginseng* A. Mey (Korean ginseng) in China and *P. quinquefolius* Linn. (American ginseng) in America. *P. ginseng* is a low perennial glabrous herb about 15-45 cm in height with a deep spindle-shaped root and whorls of 3-5 palmate leaves at nodes. Green flowers, numbering 6-20, are borne in an umbel on an elongated peduncle. The fruit is a bright red berry.
The dry roots of 3 to 6-year-old plants form the ginseng of commerce. Korean ginseng contains a number of saponins, ginsenosides R\textsubscript{x} (x = o, a, b\textsubscript{1}, b\textsubscript{2}, b\textsubscript{3}, c, d, e, f, 20-gluco-f, g\textsubscript{1} and g\textsubscript{2} - approximately 30). Ginsenoside R\textsubscript{g-1} is the panaxoside reported earlier. All these glycosides (except R\textsubscript{o}) are based on sapogenins 20-S-protopanaxadiol and 20-S-protopanaxotriol, dammarane tetracyclic triterpenes. Ginsenoside R\textsubscript{o} possesses oleanolic acid as the sapogenin. In American ginseng, ginsenoside R\textsubscript{g-1} is absent and R\textsubscript{b-1} is dominant. Other constituents of ginseng are: (1) essential oil containing polyacetylenes and sesquiterpenes; (2) polysaccharides; (3) peptidoglycans such as panacene as also peptides; (4) steroids like panaxatriol, panaxadiol and protopanaxadiol; and (4) choline, vitamins of B-group, C & E, fatty acids, carbohydrates, amino acids (of which a majority are essential amino acids, and a strong proportion of arginine), minerals like germanium and phenolic compounds such as salicylic and vanillic acids.

Widely used (especially in the Chinese system) as a tonic, stimulant, diuretic and carminative, ginseng is employed in anaemia, insomnia and as an aphrodisiac. The pharmacological actions of individual ginsenosides are sometimes found to work in opposition. For example, of the two main ginsenosides R\textsubscript{b-1} and R\textsubscript{g-1}, the former suppresses the central nervous system while the latter stimulates the same. These opposing actions may contribute to the adaptogenic properties of ginseng and its proposed ability to balance body functions. Panacene is hypoglycemic and another peptide present is found to be insulinomimetic. Other properties of ginseng include anti-fatigue, vaso-dilation, anxiolytic, anti-depressant, enhancing energy metabolism, stimulating learning, memory and physical capabilities, supporting radioprotection and providing resistance to infection.

*Panax pseudoginseng* var. *notoginseng* is the San-chi ginseng that originated in China. In this ginsenosides R\textsubscript{g-1}, R\textsubscript{e} and R\textsubscript{b-1} are dominant. Japanese Chikusetizu-Ginseng is *P. japonicum* C.D. Meyer containing chikusetsusaponins I, 1a, 1b, 111, IV and V based on oleanolic acid sapogenin.

**Eleutherococcus senticosus** Maxim. (Araliaceae)

**Siberian Ginseng**

Siberian ginseng, which is mainly used in Russia, contains saponins (eleutheroside I, K, L & M), steroid glycosides such as eleutheroside A (a glycoside of daucosterol), lignans such as sesamin and eleutheroside D (di-beta-D-glycoside of syringaresinol), polysaccharides (eleutherane A-G and eleutheroside C), hydroxy coumarins (isofraxidin), phenyalcrylic acid derivatives (eleutheroside B- a glycoside of syringin) and minerals.

In addition to the various species of ginseng, *Rumex hymenosepalus* (Polygonaceae—Wild red desert ginseng), *Pfaffia paniculata* (Amaranthaceae—Brazilian ginseng), *Pseudostellaria heterophylla* (Caryophyllaceae—a substi-
terpeneoids, *Caulophyllum thalictroides* (Berberidaceae—yellow/blue ginseng), *Triosetum perfoliatum* (Caprifoliaceae—ginseng) and *Codonopsis tangshen* (Campanulaceae) are the other plants used as ginseng in various parts of the world.

*Bupleurum falcatum* Linn. (Apiaceae)

A native of Europe and Himalayas, *Bupleurum* is a perennial, much-branched herb, 1 m in height with simple long linear leaves, yellow bracteate flowers in compound umbels and a cremocarp consisting of 2-ridged mericarps.

The roots are found to yield a number of saponins—saikosaponins A, C, & D being the principal ones. The sapogenins are of oleanane type, e.g. Saikogenin F. (Kubota et al. 1969).

The roots of Bupleurum are used as anti-inflammatory, diaphoretic and often prescribed for liver troubles.

*Platycodon grandiflorum* DC. (Campanulaceae)

*Platycodon* This erect perennial, 1 m in height, bears small, ovate-lanceolate leaves (glaucous blue on the lower surface), solitary blue/white flowers on long peduncles and 5-lobed capsules. The plant is a native of E. Asia.

Of the 8 or more saponins—platicodins A-H—known from the roots, platicodin-D forms the major one. The crude saponin extract on hydrolysis yields platicodigenin as the main sapogenin and polygalacic acid (Akiyama et al. 1972) as well as platycodigenic acids as minor sapogenins (Kubota et al. 1969).

The entire saponin extract is employed as an expectorant and an antitussive agent.

*Some of the other important Chinese medicinal plants* containing saponins are the following:

*Polygala tenuifolia* Willd. (Polygalaceae)

The roots of *P. tenuifolia*, known as *Yiian-chi* and *Onji* in Chinese and Japanese systems, are used as a sedative and to strengthen the nervous system. This drug contains onjisaponins A-F (onjisaponin A and B are found to be identical with senegin IV and III, respectively, of *P. Senega*).

*Akebia quinata* DC (Lardizabalaceae)

The stem bark of this plant, known as *Mu-T’ung* (Chinese) and *Mokutsu* (Japanese), is used as an anti-inflammatory agent, diuretic and menses stimu-
lant. The saponins isolated are akeboside St-e, St-b, St-c, St-d, St-f, St-h, St-j and St-k based on hederagenin and oleanolic acid sapogenins. The seeds of this plant also yield saponins based on hederagenin.

**Ziziphus jujuba var. spinosa** Hu. (Rhamnaceae)

This native of S. Europe and S. E. Asia is a glabrous spiny tree having fascicled branchlets, simple oblong leaves with stipular spines, small yellow flowers in short axillary cymes and a fleshy sub-globose drupe.

The seeds, which form the drug, contain two saponins jujubosides A & B. Both these saponins, on hydrolysis, yield ebelin lactone (Kawai et al. 1974).

In Chinese medicine, the seeds of Ziziphus are recommended for strengthening the nervous system and for insomnia.

**Abrus precatorius** Linn. (Fabaceae)

*Gunja, Crab’s eye, Indian Liquorice*

* A. precatorius is a greenish twiner with imparipinnate leaves having 16-40 oblong leaflets, pale purple flowers in axillary inflorescences, rectangular bulky pods containing ovoid glossy scarlet seeds with a black spot (or black with white spot or uniformly black/white). This plant is a native of India and Malaya.

The leaves, which are sweet in taste, contain up to 10% glycyrrhizin, triterpene glycosides, pinitol and alkaloids such as abrine, hypaphorine, choline and precatorine. The triterpene glycosides are abusosides A, B, and C (which are highly sweet) and three glycosides based on cycloartane-type aglycone, abrutogenin. Other compounds of leaves are triterpenes abrusgenic acid, abruslactone A and methyl abrusgenate and flavonoids vitexin, liquirtigenin-7-mono- and diglycosides and taxifolin-3-glucoside. The roots also contain glycyrrhizin and alkaloids like abrinose and precasein besides abrine and related bases. The seeds yield alkaloids, a fixed oil, steroids, lectins, flavonoids and anthocyanins. The alkaloids of the seeds are the same as those reported from leaves. The oil content of seed is only 2.5%, which is rich in oleic and linoleic acids, \(\beta\)-sitosterol, stigmasterol, \(5\beta\)-cholanic acid, abricin, abridin and cholesterol are the steroids present. The colour of the seeds is due to glycosides of abranin, pelargonidin, cyanidin and delphinidin. A sapogenol, abrisapogenol J, sophoradiol, its 22-O-acetate, hederagenin methyl ether, kaikasaponin III methyl ester, abrusin (8-C-glucosyl scutellarein 6,7-dimethyl ether), its 2"'-O-apioside, flavones such as abrectorin and aknone (Markham et al. 1989; Choi et al. 1989) are the other constituents of seeds. Lectins are the chief constituents of seeds, the principal ones being abrins (unto 0.15% of seed). Lectins are both toxic (abrin) and
non-toxic (*Abrus* agglutinin). Abrins are denoted by abrin a, b, c & d and consist of one large β-polypeptide chain (MW. 35,000) and a short α-polypeptide chain (MW. 32,000) joined by a disulphide bond. Agglutinin consists of 4 polypeptide chains; the chains are similar to those of abrins.

The roots, leaves and seeds of this plant are used medicinally. The roots and leaves are used as a substitute of liquorice in coughs and catarrhal affections. The roots possess diuretic, tonic and emetic properties and are also used in gonorrhoea, jaundice and other infections. The plant extract is one of the constituents of oral contraceptives. The seed extract is used externally in the treatment of ulcers and skin affections. Administered internally, the seeds are useful in affections of the nervous system, diarrhoea and dysentery. Abrin is extensively studied for its antitumour activity, where it was found to suppress tumour growth in rats and mice. Abrin is found to inhibit protein synthesis by inactivating ribosome dependant GTPase and exhibit no bone marrow suppressing affects as other cytostatic agents.

*Agave americana* Linn. (Agavaceae)

*Kantala, American Aloe*

*A. americana* is a short-stemmed plant bearing a rosette of long, erect, pointed, fleshy leaves with marginal spines and longitudinal white yellow streaks or bands. The plant flowers only once during its life and the flowering stem arises from the centre of the plant as a thick pole. The flowers are funnel shaped and capsules oblong clavate and beaked. A native of America, it was introduced in India for its leaf fibre.

The leaves yield saponins such as agavasaponins A-I (10 in number) based on hecogenin (aglycone), and chlorogenin, rockegenin, tigogenin, dehydrohecogenin and piscidic acid. The flowers contain chlorogenin and kaempferol and the seeds neotigogenin, hecogenin and kammagenin.

The leaves are used as laxatives and emmenagogue and in scurvy. Leaf juice is used for warts, cancerous ulcers and tumours. Roots are diuretic, diaphoretic and antisyphilitic. Hecogenin extracted from Agaves are used in the manufacture of corticosteroids β-methasone and dexamethasone.

*Asparagus racemosus* Willd (Liliaceae)

*Shataveri, Asparagus*

*A. racemosus* is a scandant much-branched spiny undershrub with tuberous short rootstock bearing a number of tuberous roots, stems armed with numerous recurved spines, sickle-shaped cladodes, leaves reduced to scale leaves, small white flowers in racemes and globose berries. Asparagus occurs wild and is cultivated throughout India.

The tubers contain saponins, named shatavarins 1,11,111,IV, glycoside AR-4 (C₄₅H₇₄O₁₆), tridecaacetyl shatavarin-I (C₇₇H₁₁₂O₃₆) and tetradeca-O-
methyl shatavarin-I (C_{65}H_{114}O_{23}). Shatavarin-IV is based on sarasapogenin. Also present are sarasapogenin, β-sitosterol, 4,6-dihydroxy-2-O-(2'-hydroxy isobutyl) benzaldehyde and undecanyl cetoate. Carbohydrates (53%) inclusive of mucilage, polyfructosans, free sugars and insoluble polysaccharides as well as proteins (3%) form the other components of the tubers. A polycyclic alkaloid, asparagine-A is reported from plants of Thailand. The cladodes are said to contain diosgenin and quercetin. Flowers yield a volatile oil, rutin, hyperoside and quercetin. The fruits also yield quercetin, rutin and hyperoside along with cyanidin glycosides (Joshi and Dev, 1988).

Asparagus is a tonic, demulcent and aphrodisiac and used for hyperacidity, diarrhoea and dysentery. It is a well-known galactogogue and beneficial to menstrual troubles and nervous breakdown.

**Chlorophytum borivilianum** Sant. & Fernandes (Liliaceae)

*Sweta musali/Safed musali*

*C. borivilianum* is a small perennial herb with 1-8 sessile, cylindrical brown to black-skinned (white after peeling) fleshy root tubers, 6-13 sessile linear radical spreading leaves, solitary terminal scape containing white flowers in clusters of 3 and a 3-angled loculicidal capsule enclosing many small black angular seeds. This is a native of western India, now widely cultivated.

The tubers contain saponins (2-3%) based on hecogenin, protein (8%) and carbohydrates (40%) mainly as mucilage.

Safed musali, the tuber, is much valued for its aphrodisiac properties. It is a valuable nervine and general tonic. The powder is useful for aphthae of mouth and throat and also in rheumatism.

Tubers of *Chlorophytum arundinaceum* Baker, *C. tuberosum* Baker, *Asparagus adscendens* Roxb. and *A. racemosus* Wild also are used as safed musali or its substitutes. *C. arundinaceum* tubers are found to contain a bibenzylxyloside, 2',4,4'-trihydroxy-2-xylopyranosyl bibenzyl, and steroidal sapogenins such as sarasapogenin, tigogenin, neotigogenin and tokorogenin, a disubstituted tetrahydrofuran, stigmasterol and its glucoside (Tandon and Shukla,1993).

**Fagonia cretica** Linn. (Zygophyllaceae)

*Syn. Fagonia arabica* Linn.

*Dasparsha/Duralabha (Fagonia)*

A small, much-branched spiny undershrub covered with glandular hairs, 1-3 foliolate leaves (opposite) having 2 pairs of sharp stipular spines (often longer than leaves), leaflets linear sessile, the middle longest and small rose-coloured flowers (petals double the number of sepals). The fruits are glandular, pubescent pyramidal 5-partite schizocarps enclosing flat compressed ovoid seeds. Dasparsha is common in dry areas of northwestern India, Afghanastan and Iran.
The aerial parts of this plant contain at least six saponins. Saponin A&B are based on nahagenin; saponin C, based on 21α, 22β-dihydroxy nahagenin; two saponins on hederagenin and the last on oleanolic acid. Also present are diterpenes fagonone, 16-O-acetyl fagonone and 7β-fagonone, chinovic acid, ceryl alcohol, β-sitosterol, fagonin, fagogenin, betulin, oleanolic acid, compesterol, 7β-sitosterol stigmasterol and an alkaloid harmine. Flavonoids present are ternatin, herbacetin, gossypetin, 5,7,4′- trihydroxy, 3,8,3′- trimethoxy flavone, kaempferol, 4′-OMe kaempferol and isorhamnetin. Also present are phenolic acids such as p-hydroxybenzoic, vanillic, syringic, p-coumaric and ferulic acids and alkaloids (Ansari et al. 1988; Umadevi and Daniel, 1991; Abdel-Kadar et al. 1994).

Duralabha is a blood purifier and cures fevers, asthma, diarrhoea, phantom tumour and dermatitis. It also possesses stimulant, laxative and alterative properties.

*Aesculus hippocastanum* Linn. (*Hippocastanaceae*)

**Horse Chestnut**

This is a tall deciduous tree with a palmately compound leaf bearing 5-7 oval to spindle-shaped leaflets, white/pink flowers borne on large terminal racemes and a spiny green fruit containing 3 rounded shiny brown seeds. This is a native of western Asia, now cultivated around the world as an ornamental.

The seeds yield saponins, flavonoids and lipids. There are over 30 pentacyclic saponins reported from this plant of which “aescin” is considered the principal saponin. But aescin is a group of saponins, based on the sapogenins proaescigenin and baringtenol, combined with angelic, tiglic or acetic acids.

Seeds are useful in varicose veins and to prevent thrombosis, thrombophlebitis, calf cramping, edema and hemorrhoids. The extract of the seeds is antiinflammatory and used as an expectorant in asthma and bronchitis, in prostrate enlargement, dysmenorrhoea and oedema. *Aesculus* is a well-known homeopathic remedy.

*Trigonella foenum-graecum* Linn. (*Fabaceae*)

**Methika, Fenugreek**

Fenugreek is a herbaceous annual with pinnately trifoliolate leaves having long ob lanceolate dentate leaflets, white/yellow flowers singly or in pairs from axils and long (upto 15cm) cylindrical pods containing 10-20 yellow grooved trapezoid seeds. A native of Mediterranean, fenugreek is now grown for seeds and as pot herb.

The seeds contain protein (26%), fat (6%), carbohydrates (44%), flavonoids such as quercetin and luteolin (free and as glycosides) saponins based on
diosgenin, tigogenin and gitogenin, trigonelline and minerals. A galactomannan is the main component of carbohydrates. Leaves yield proteins (41%) , carbohydrates (6%) and free amino acids. Also present in the leaves are saponins (similar to those of seeds), flavonoids such as kaempferol and 7,3’-diOMe quercetin (Daniel, 1989).

The seeds of fenugreek are mainly used as a galactogogue. They are carminative, a tonic and as a poultice, are useful in ulcers, and abscesses. They are used as emollient for inflammations in the intestinal tract. The mucilage is used as a tablet binder. The leaves are a pot herb, much in demand.

**Glycyrrhiza glabra** Linn. (Fabaceae)

*Yahtimadhuh, Liquorice*

This glandular hairy herbaceous perennial, 1 m in height, bears pinnate leaves having 9-17 ovate leaflets, pale blue flowers in spikes and a 3-4 seeded red-brown glabrous pod.

Liquorice, a native of southern Europe and western and central Asia, is cultivated on a mass scale in Spain, Turkey and the USSR.

The roots contain saponin glycyrrhizin (2-9%) and a mixture of potassium and calcium salts of glycyrrhizinic acid as the major constituents. Also present are some other triterpenoid saponins such as glabranin A&B, glycyrrhetol, glabrolide and isoglabrolide; flavonoids such as glucoliquiritin apioside, prenyllicosflavone A, shinlavone, shinpterocarpin and 1-methoxy phaseollin, isoflavones like formononetin, glabrone, neoliquiritin and hispaglabridin A & B; coumarins, viz., herniarin, umbelliferone and sterols, onocerin, β-amyrin and stigmasterol (Hikino, 1985; Bradley, 1992; Bisset, 1995).

The drug exhibits demulcent, expectorant, antimicrobial, antitumor and anti-inflammatory properties due to glycyrrhizin. It is also useful in treating peptic ulcer. Oral doses of liquorice are given for gastric, duodenal and oesophageal ulceration or inflammation, heartburn and mouth ulcers. It prevents infections of the urinary tract and is used in Chinese medicine as an emmenagogue. Glycyrrhizin extract is used for chronic hepatitis. Glycyrrhetinic acid exhibits a specific antitumour activity and is a cytostatic. It also induces phenotypic reversion, i.e. the cancer cells get converted into normal cells.

**Balanites roxburghii** Planch. (Simaroubaceae)

*Syn. B. aegyptiaca* Delile

*Hingoli, Desert Date*

*B. roxburghii* is a spiny evergreen tree attaining a height of 9 m with bifoliolate leaves having elliptic leaflets, small greenish flowers in axillary few-flowered clusters and ovoid woody 5-grooved fruits containing an oily seed. This plant is common in the drier parts of India and is a native of Africa.
The fruit pulp contains several steroidal saponins balanitisins A-E, based on the sapogenin diosgenin, yamogenin and cryptogenin. A furostanol saponin, balanitoside along with balanitin-3 and 6-methyl diosgenin is also reported from mesocarp. The amount of total saponins comes up to 4%. The seed kernels yield balanitins 4, 5, 6 & 7 and balanitisin F. Yamogenin is the major component of certain samples of fruit epicarp. Seeds contain a fixed oil (40%), rich in oleic (50%), palmitic (24%) and linoleic (20%) acids besides protein (54%). Stem bark contains steroidal saponins deltonin, prodelonin; furanocoumarins bergapten and marmesin as well as two sesquiterpenes balanitol and its isomer. The root wood yields balanitisin H and stem wood, balanitisin I. Leaves also contain a saponin of diosgenin, stigmasterol and a small amount of free diosgenin (Jain, 1987; Hosny et al. 1992b).

Almost all parts of the plant are found to be anthelmintic and purgative. The fruit is useful in whooping cough, skin diseases, and for pneumonia (in the form of an application to the chest). Seeds are also used as expectorants and oxytocics.

Bacopa monnieri Wettst. (Scrophulariaceae)

Syn. Herpestris monnieri H.B. & K.

Brahmi, Bacopa

B. monnieri is a small creeping succulent herb, rooting at nodes with simple opposite obovate-oblong leaves, white solitary axillary flowers and ovoid capsules. Brahmi is found in marshy places throughout India.

The entire plant contains alkaloids, saponins and flavonoids. Alkaloids found are brahmine, herpestine, nicotine and other bases. The saponins located are monnierin, hersaponin, bacoside A, A3 and bacoside B. Bacoside A is based on jujubogenin, whereas bacoside B is based on bacogenin. Betulic acid, stigmasterol and β-sitosterol are the steroids present. Luteolin and mannitol are the other compounds present (Rastogi et al. 1994).

The whole plant, known as Brahmi, is a very well-known brain tonic and is found to be effective in anxiety neurosis and to revitalize intellectual facility (Sharma et al. 1987). The plant is used against asthma, epilepsy, and insanity and as a potent nerve tonic, cardiotonic and diuretic. Other uses are against bronchitis, diarrhoea and rheumatism. Fifty percent of the alcoholic extract is found to the anticancerous.

Serenoa repens Small (Areaceae)

Syn. Sabal serrulata Linn.

Saw Palmetto

Saw palmetto is a small prostrate palm tree, up to 4m in length, and a native of southeastern United States. Roots are located on the ventral side of the
stem and are concentrated near the growing end. This palm bears palmately divided (upto 20 lobes or more) leaves (upto 1m wide) having a petiole toothed with sharp spines. The flowers are small, white, borne on the spadix and the fruit is a single-seeded bluish-black fleshy drupe.

Fruits yield volatile oil, fixed oil, steroidal saponins, tannins and polysaccharides. The fixed oil consists of 25% free fatty acids such as caproic, lauric and palmitic acids and 75% glycerides.

A concentrated extract of berries is useful in maintaining a healthy prostate function. The extract is found to prevent testosterone from converting to dihydrotestosterone, a hormone thought to cause prostate cells to multiply leading to an enlarged prostate.

*Taraxacum officinale* Weber (Asteraceae)

*Kanphul, Dandelion*

*T. officinale* is a laticiferous perennial having a thick taproot, radical, sessile irregularly pinnatifid leaves with triangular toothed lobes, yellow flowers in ligulate heads and flattened spiny (upper half) achenes bearing white pappus hairs. Dandelion is a native of Central Asia.

The roots contain inulin, steroids such as taraxasterol, taraxacerin, taraxacin, gum and rubber.

Roots and leaves are alterative, cholagogue, diuretic, lithotropic, tonic and used for a variety of ailments connected with menopause, like mood swings. They are also used to alleviate nausea during pregnancy. In Chinese medicine, this plant is used for breast problems, including breast cancer.

*Guaiacum officinale* Linn. (Zygophyllaceae)

*Lignum vittae, Guaiacum*

*G. officinale* is a small evergreen tree with paripinnate compound leaves (leaflet 3 pairs, ovate trapezoidal), deep blue flowers in axillary clusters and heart-shaped capsules. This plant is a native of South America.

A number of saponins are reported from various parts. Leaves contain guaicins A to F (guaicins C, D and E based on 30-nor-Olean-12, 20/29)-dien-28-oic acid while guaicin F, based on oleanolic acid). Stem bark yields guaicins D & E, while the fruits contain guaicins F & G. Heartwood contains lignans such as furoguaiaaciden and furoguaiadoin.

The wood and extracts are hepatotonic, antiinflammatory, diuretic and laxative and useful in treating gout, arthritis and other rheumatic conditions.
**Catunaregam spinosa** Tirveng. (Rubiaceae)

*R. dumetorum* Poir.
*Xeromphis spinosa* Keay.

**Madana, Emetic Nut**

*C. spinosa* is a thorny tree with dark brown bark, obtuse deciduous leaves narrowed into a short petiole, axillary thorns, solitary fragrant white flowers turning yellow and globose yellow berries enclosing flat angular seeds. This plant is common as undergrowth in sal forests.

The bark contains saponins based on randialic acid A & B, mannitol (upto 6%), 10-methyl lixoside (an iridoid) and scopoletin. Stems yield iridoids such as randinoside, galioside, deacetylasperulosidic acid methyl ester, scandoside methyl ester, geniposide and gardenoside. Roots also contain mannitol, scopoletin and a yellow dye. The leaves yield flavonoids, kaempferol, 4-OMe kaempferol and quercetin and phenolic acids p-hydroxy benzoic, gentisic, melilotic, vanillic and syringic acids (Thomas, 1989; Hamerski et al. 2003).

The fresh fruits contain 2-3% saponins (10% dry wt.) which are mostly concentrated in the pulp. They are dumetorins A, B, C, D, E and F (based on oleanolic acid), randioside A (on oleanolic acid), ursosaponin (on ursolic acid), two triterpenoid glycosides based on oleanolic acid and 10-methyl lixoside. Seeds contain protein (14%) and saponins based on oleanolic acid.

The bark is used in diarrhoea, dysentery and is an abortifacient, anthelminitic, antipyretic and emetic. It is also considered to be sedative and hypoglycemic. The roots are used for treating gonorrhoea and for poisoning fish. The fruit pulp, dried and powdered, is emetic and substituted for ipecac. It is also a nerveine calmative, antispasmodic, anthelmintic and abortifacient.

**Centella asiatica** Urban. (Apiaceae)

Syn. *Hydrocotyle asiatica* Linn.

**Manduk parni /Brahmi, Gotu Kola**

*C. asiatica* is a creeping stoloniferous annual/perennial with a prostrate stem rooting at the nodes, reniform long-petioled leaves, minute reddish flowers in umbels of three and a laterally compressed fruit. It is a common weed in crop fields and moist places.

A number of triterpenoid glycosides are isolated from this plant. They are asiaticoside, indecentelloside, brahmoside, brahminoside, thankuniside and isothankuniside. These saponins are based on asiatic, indecentolic, brahmic, thankunic and isothankunic acids as aglycones. Samples from Europe are found to contain madecassocide (aglycone madecassic acid). Asiatic, indecentolic and brahmic acids along with isobrahmic and betulic acids occur in free form. *meso*-Inositol, kaempferol, quercetin, sitosterol, campesterol and stigmasterol are some other components of this drug. Also
present is a volatile oil (containing β-caryophyllene, trans β-farnesene and
germacrene - D), a fatty oil, an alkaloid hydrocotylin (C_{22}H_{33}NO_8) and
polyacetylenes.

Gotu kola is used as Brahmi (Bacopa monnieri) at many places. This is one
plant recommended for improving memory, reducing anxiety neurosis and
hypertension and for treatment of leprosy and skin diseases. Externally, the
paste of the fresh herb is applied for rheumatism, elephantiasis and hydrocele.
It is valued as a tonic and used in asthma, catarrah, leucorrhoea, kidney
problems and tuberculosis.

Costus speciosus Smith. (Zingiberaceae)

Canda, Costus

C. speciosus is a succulent herb with tuberous rhizomes, spirally twisted
stem, oblong acuminate leaves pubescent below, large white flowers having
reddish brown bracts in dense terminal spikes and an ovoid 3-valved cap-
sule enclosing black seeds with a white aril. Canda can be seen in dense
evergreen forests of India.

Rhizomes contain saponins dioscin and gracilin based on diosgenin
(2.12%), tigogenin and β-sitosterol and a volatile oil. Roots yield aliphatic
hydroxy ketones and 5α-stigmast-9 (11)-en-β-ol. The seeds also contain
diosgenin.

The rhizome is bitter, astringent and used for dyspepsia, fever, cough
and other respiratory diseases, diabetes, oedema, blood diseases and skin
ailments and also improves the complexion. Saponins and genins cause
spasmodic uterine contraction and are estrogenic. They are antiflammatory,
hypotensive and bradycardic in nature.

Curculigo orchioides Gaertn. (Amaryllidaceae)

Musali

C. orchioides is a small perennial herb having a long cylindric rootstock
bearing a large number of root tubers. Leaves are basal, long, sessile linear/
lanceolate with the tips often bearing bulbils. Flowers are small yellow,
bore on a short scape hidden in the leaf sheath and the fruit is a 1-4 seeded
capsule. This plant is common in forests of central and western India.

Tubers contain a glycoside yuccagenin, an alkaloid lycorine, flavones and
3-MeO, 5-Ac, 31-tritriacontane.

The tubers (musali) are a well-known rejuvenative (rasayana) drug and
an aphrodisiac. It is slightly bitter, viriligenic, diuretic and is useful in general
debility, cough, piles, skin diseases, impotence, jaundice, urinary diseases,
leucorrhoea and menorrhagia.
**Tribulus terrestris** Linn. (Zygophyllaceae)

Goksura/Gokhru, Tribulus

*T. terrestris* is a prostrate wooly perennial with paripinnate leaves (leaflets ovate/elliptic), yellow flowers, and a pentagonal spiny fruit. This medicinal plant is a common weed throughout India.

The fruits, which form the drug, contain steroidal saponins, alkaloids and steroids. The saponins, terrestrosins A-E, desgalactotigonin, F-gitonin, desglucolanatigonin and gitonin are based on sapogenins diosgenin, hecogenin and neotigogenin. β-Sitosterol, stigmasterol, terrestiamide (a cin- namic acid amide) and 7-methyl hydroindanone are the other compounds reported. Leaves contain kaempferol, isorhamnetin, vanillic acid, syringic acid, melilotic acid and *p*-coumaric acid. (Ren et al. 1995; Yan et al. 1996).

Gokhru is a well known diuretic and antiurolithiatic. It is also nephroprotective and a cardiac stimulant.

**Actaea racemosa** Linn. (Ranunculaceae)

Syn. *Cimigifuga racemosa* Nutt.

Black Snakeroot, Black Cohosh

Black cohosh is an erect herb with a stout blackish hard and knotty rhizome bearing many stout ascending branches, tripinnate leaves (leaflets ovate serrate/dentate), cream-coloured flowers on tall racemes and an etaerio of follicles. *A. racemosa* is a native of N. America.

Roots and rhizomes contain triterpene glycosides actein, acetylactal, 27-deoxyactein, cimigenol and cimifugoside, quinazoline alkaloids, isoflavone (formonetin,) tannins and gallic, isoferulic and salicylic acids.

Roots and rhizomes are widely used in many gynecologic disorders, especially menopausal and menstrual dysfunction. The terpene glycosidal fraction is found effective in gonadotropin release in menopausal women and thus reduces premenstrual discomfort, dysmenorrhoea or other menopausal ailments.

### 3.6d Cardiac Glycosides

Cardiac glycosides also are triterpenoid glycosides but differ from saponins in having an unsaturated lactone ring at C-17 of the nucleus, a cis juncture of the rings C & D, an additional hydroxyl group at C-14 and the unique sugars they possess. They are also soluble in water and are surface-active agents, with soap-like properties. Cardenolides, being C₂₅ compounds, possess a 5-membered lactone ring (e.g. sarmentocymarin) and bufadienolides (scilladienolides) are C₂₄ compounds with a doubly saturated 6-membered lactone ring (e.g. Scilliroside). Both cardenolides and bufadienolides are mutually exclusive.
As the name suggests, cardiac glycosides elicit specific and powerful action on the cardiac muscle, the prime reason why natives used them as arrow poisons. This activity increases with the increase in hydroxyl groups. Their genins also exhibit these properties.

All the sugars, linked at C₃ position, possess methyl and/or methoxy groups (e.g. digitalose) and the number of sugar units present in a glycoside ranges from 1 to 4.

**Digitalis purpurea** Linn. (Scrophulariaceae)

A perennial, but biennial in cultivation, *Digitalis* reaches a height of 1 m and bears both long-petioled, radical leaves and sessile stem leaves. The large pendulous purple flowers are borne on a one-sided raceme. The bilocular capsule encloses numerous seeds. This plant, a native of southern and central Europe, is now extensively cultivated in all temperate parts of the world.

The rapidly dried leaves, which form the drug *Digitalis*, contain more than 40 cardiac glycosides based on 4 genins, digitoxigenin, gitoxigenin, gitaloxigenin, and gitaligenin along with their formyl or acetyl derivatives. The glycosides may be: (1) monoglycosides like verodoxin (gitaloxigenin digitaloside) and odoroside H (digitoxigenin digitaloside); (2) diglycosides like gitalin (gitaligenin + 2 x D-digitoxose) and digitalinum verum (gitoxigenin + digitalose + glucose); (3) triglycosides like gitoxin (gitoxigenin + 3 x digitoxose) and gitaloxin (16-formyl gitoxin; or (4) primary or tetruglycosides like purpurea glycoside A. (digitoxigenin + 3 x digitoxose + glucose).

The two primary glycosides—purpurea glycosides A & B—form the chief constituents of fresh leaves. But in dried leaves, triglycosides such as digitoxin and gitoxin are predominant. The triglycosides are probably derived from primary glycosides by an enzymatic splitting taking place during the process of drying. The glycosides of digitoxigenin and gitaloxigenin possess more activity than those of gitoxigenin. It is often observed that in the leaves, gitaloxigenin readily gets hydrolyzed to produce gitoxigenin and formic acid.

In addition to these compounds, leaves contain a group of glycosides, numbering a dozen, which resemble the cardenolides but for the lactone ring, named digitenolides. The known aglycones are diginigenin, digacetigenin, purprigenin and purprogenin and they occur as monoglycosides (diginin = diginigenin D-diginoside) or tri-glycosides (purpronin = purprogenin-digitoxosides). These compounds do not possess the cardiac activity.

Also present in the leaves are saponins, gitoxin- (gitogenin + 4 x galactose + xylose) and digitonin (digitogenin + 2 x glucose + 2 x galactose + xylose) exhibiting some of the properties of cardenolides and a few
anthraquinone derivatives like 3-methyl alizarin and 3-methoxy, 2-methyl anthraquinone.

Digitoxin is a cardiotonic increasing the tone of the cardiac muscle. Gitalin either alone or with other glycosides, are often used in treatment of congestive heart failure. All these glycosides improve the rhythm of heartbeats, making the contraction of the heart more powerful and help the heart to pump the blood at the time of cardiac failure.

Along with some of the active principles of leaf, Digitalis seeds contain some other cardenolides like digifucocellobiosides (digitoxigenin + fucose + glucose), gitosin and neogitosin; and saponins like gitonin and digitonin. Seeds are used as a substitute for the leaf occasionally.

Digitalis lanata Ehrh. yields more than 70 glycosides based on the four genins reported from D. purpurea and two new ones digoxigenin and diginatigenin. Digoxin, a triglycoside and the primary glycosides, lanatosides A, B, C, D and E are major ones. It is observed that in all the glycosides showing cardiac activity, the first three sugar residues are always digitoxose. Though some genins are similar to those of D. purpurea, their primary and triglycosides differ in having an acetyl group attached to the third digitoxose residue. Lanatosides and digoxin are valuable cardiotonics.

Convallaria majalis Linn. (Liliaceae)

Convallaria

A native of Europe, E. Asia and N. America, this low-scrapose rhizomatous plant produces only 2 oblong-oval leaves (15-20 cm long) situated one above the other. The flowers are white, borne on racemes. The fruit is a red berry containing a few seeds. The aerial parts, collected before the opening of the flowers, and the rhizome with roots form the commercial drug.

Of the 25 or more glycosides isolated from the drug, the important ones are convallatoxin (strophanthidin + rhamnose), convalloside (convallatoxin + glucose) and convallatoxol (strophanthid-19-ol + rhamnose). Also present in the drug are various flavones. Roots contain a saponin-convallamaroside also. The flowers are the source of ‘Lily-of-the-valley’ flower oil.

The drug is a cardiotonic but has lesser action than Digitalis. Convallatoxin is an effective diuretic. Flower glycosides are found to strengthen and regulate heart action and in dropsy, they assist urine secretion.

Strophanthus kombe Oliv., S. hispidus DC. (Apocynaceae)

Strophanthus

The seeds of these tall shrubs, native to Africa, provide the drug Strophanthus.

The dry seeds yield about 8-10% strophanthin or K-strophanthin, a mixture of more than 10 glycosides. The chief constituent is
K-strophanthoside (strophoside), a triglycoside consisting of the genin, strophanthidin, cymarose and 2 molecules of glucose. Two other major glycosides are cymarin and K-strophanthoside B. The genins present are strophanthidin, alloperiplogenin, strophanthid-19-ol, strophanthidic acid and periplogenin. The other constituents of the seed are about 30% fixed oil, nitrogenous bases like trigonelline and choline, resin and mucilage.

Strophanthus is the cardiotonic drug preferred to Digitalis in Europe.

The seeds of Strophanthus gratus Oliv., a native of Africa, provide another cardiotonic drug Ouabain (g-strophanthin), a rhamnoside of ouabagenin. One of the most rapidly acting cardenolide, ouabain is also obtained from the wood of Acokanthera sp.

**Asclepias curassavica** Linn. (Asclepiadaceae)

Kakatundi, Blood Flower

This is an erect much-branched perennial with a woody rootstock, lanceolate leaves, orange-red flowers in cymes and a pair of follicles containing comose seeds. It is a native of tropical America, now cultivated as an ornamental plant.

The leaves of Brazilian plants yield cardenolides such as clepogenin, curassavogenin, ascuragenin, carotoxigenin, uzarigenin, coroglaucigenin and a glycoside uzarin. But the leaves from Indian plants are devoid of the first four compounds but are found to contain 22 cardenolides of which calactin, calotropin, calotropagenin and asclepin are the major compounds. The Mexican samples also yielded a cytotoxic compound, calotropain. The roots are found to contain vincentoxin (asclepiadacin).

All parts of the plant are used in medicine. Root is considered emetic, cathartic, astringent and a remedy for gonorrhoea and piles. Roots are used as substitute of ipecac. The whole plant is used as emetic, styptic and purgative and the extract is found to inhibit carcinomatous cells of human nasopharynx. The plant, in the form of powder, balm or enema, is used to destroy abdominal tumours. The latex is used against warts and corns.

**Carissa carandas** Linn. (Apocynaceae)

Karaunda, Christ's Thorn

*C. carandas* is a small laticiferous tree with dichotomous branches armed with a simple or forked pair of thorns at the origin of branches. The leaves are elliptic and flowers are white/pink, faintly scented in terminal corymbose cymes. The fruits are pink ellipsoid berries containing eight seeds. A native of south Asia, this plant is grown for edible fruits.

The roots contain cardiac glycosides based on odoroside H and terpenoids such as carissone, carindone, carinol and related compounds. The leaves contain lupeol, β-sitosterol and ursolic acid. Flowers yield a volatile oil rich in phenyl ethyl acetate (60%), benzyl acetate (22%) and linalool (8%). The
fruits are rich sources of Vit.C and yield carisol (an epimer of β-amyrin), lupeol, β-sitosterol and organic acids like oxalic, tartaric and citric acids. The seeds yield a fixed oil rich in palmitic (66%), arachidic (21%) and stearic (10%) acids.

All parts of the plant are attributed with medicinal properties. Roots are cardiotonic, anthelmintic and effect a prolonged blood pressure lowering effect. The leaves are recommended in intermittent fevers. Ripe fruits are antiscorbutic, useful in bilious complaints and revealed cytotoxic activity in their fat-soluble fraction.

*Cerbera manghas* Linn. (Apocynaceae)

*Syn.* *C. odollum* Gaertn

**Odollum, Cerbera**

*C. manghas* is a small laticiferous tree with coriaceous linear-lanceolate leaves, white yellow/red throated fragrant flowers in terminal cymes and subglobose green drupes containing a single seed. A native of tropical Asia, this is found in coastal areas.

All parts of the plant contain cardiac glycosides. The stem contains nerifolin, seven glycosides based on digitoxigenin, two glycosides based on tanghminigenin and one based on oleagenin and free tanghminigenin. Also present are lignans, (-)-olivil, (+)-cyclo olivil, 5,5''-bis-olivil and similar dimers. Iridoids such as 10- and 11-carboxy carbinal also are isolated from the stem bark. The leaves are found to contain cerelaside A and B as the major cardenolides, and 5 glycosides of digitoxigenin, 5 of tanghminigenin, nerifolin, thevetin B, thevoside and thevirioside as minor components. Lignans present here are glucosides of olivil. Also present are quercetin, rutin, clitorin, nicotiflorin, bornesitol, and three normonoterpenoids, cerberidol, epoxy cerberidol, cyclocerberidol and their four β-allopyranosides and two iridoids, 10-O-benzyl thevoside and 10-dehydrogeniposide. Seeds yield cerelaside A, 2′-O-acetyl cerelaside A, 17α-nerifolin, 17β-nerifolin, cerberin, nerifolin, thevoside, thevirioside, odollin, odollotoxin etc besides a pale yellow oil having palmitic (32%), oleic (38%), linoleic (18%) and stearic (11%) acids (Abe et al., 1988, 1989; Laphookhieo et al., 2004).

The bark and leaves are cathartic and emetic. Seeds are fish poisons. Seed oil is used as hair oil and as a rubefacient to cure cold.

*Calotropis gigantea* Ait.f. (Asclepiadaceae)

**Arkah, Milkweed**

*C. gigantea* is an erect tomentose laticiferous shrub reaching a height of 2 m with large ovate subsessile leaves, white/purple-tainted flowers in umbel-late cymes and a pair of subglobose inflated follicles enclosing broadly ovate
comose seeds. This is a very common weed occurring in the dry regions of India.

The root bark, which constitutes the drug, yields cardiac glycosides such as gigantin, giganteol, isogiganteol, calotroposides A-G, steroids like \( \alpha \)- and \( \beta \)-amyrins, taraxasterol and its derivatives, \( \beta \)-sitosterol and a wax. The latex, found in all parts of the plant, contains caoutchouc (rubber), resin, cardiac glycosides gigantin, calotropin, uscharin, calotoxin, calactin and uscharin (all based on the genin calotropagenin), proteases like calotropain, calotropin \( D_1 \) and \( D_2 \), calotropain \( F_1 \) and \( F_2 \) and enzymes like invertase. Flowers yield a resin containing resinols, \( \alpha \)- and \( \beta \)-calotropeol, giganteol, calotropin, \( \beta \)-amyrin, flavonoids and fatty acids. Seeds contain a fatty oil (30%; rich in oleic acid and linoleic acid), stigmasterol, melissyl alcohol and laurane. Leaves contain free sapogenins, \( \beta \)-amyrin, \( \beta \)-sitosterol, taraxasterol, \( \psi \)-taraxasterol, tannins and resin. The flowering tops contain holarrhene and cyanidin glycoside.

Root bark is a substitute for ipecac and in small doses, it acts as a diaphoretic and expectorant. It is used in cures for leprosy and eczema. A 50% ethanolic extract is found to be anticancerous and low doses of crude methanolic extract act as a hypertensive and cardiotonic. The latex is a drastic purgative and emetic and induces abortion. The flowers are useful in cough, cold, catarrh and asthma. The fibre is used for ropes, clothes and as a filling fibre. The whole plant is used as an insecticide (against white ants and larvae of *Culex* and *Anopheles*), fish poison and possesses both antifungal and antibacterial properties.

In Indian systems of medicine, the tender fresh leaves are used to cure migraine and fits and convulsions in children.

*Calotropis procera* Ait.f.

**Alkarka, Dead Sea Apple**

*C. procera* is similar to *C. gigantea* in overall appearance but differs in having a broad, but short corona which is equal to or longer than the staminal column and not having the two auricles below the apex of corona. The height of the entire staminal column is about 0.5 to 0.8, i.e. less than a centimeter and the stigma is almost sunken in the corona lobes. [In *C. gigantea*, the corona is narrower and longer, much curved back to the staminal column towards halfway down, more than 1cm in height, but always lower than the gynostemium (stigma always elevated up) and possesses two obtuse structures (auricles) at the apex of each lobe.]

The root bark, which constitutes the drug, contains \( \alpha \)- and \( \beta \)-amyrins, taraxasterol and its isomers, isovalerates and acetates, giganteol, \( \beta \)-sitosterol and a wax. The latex, present all over the plant, consists of caoutchouc, resin and cardiac glycosides, proteases and steroids. The cardiac glycosides are calotropin, uscharin, calotoxin, calactin, uscharadin (all based on the genin calotropagenin), voruscharin, proceroside and two genins, uzarigenin and
syriogenin. The proteases encountered are calotropain $F_1$, $F_2$, calotropin $D_1$ and $D_2$. $\alpha$-Amyrin, $\beta$-amyrin and $\beta$-sitosterol are the steroids present. Flowers contain $\alpha$-, $\beta$-amyrins, stigmasterol, $\beta$-sitosterol, multiflorgenol, cyclosadol, procerasterol and calotropenyl acetate (Khan & Malik, 1989).

*C. procera* is found to possess almost all medicinal properties of *C. gigantea* and used likewise.

**Corchorus olitorius** Linn. (Tiliaceae)

Jew’s mallow

*C. olitorius*, a source of jute fibre, is a much-branched annual of 1m, with elliptic lanceolate serrate (lower serratures on both the sides prolonged to a filiform appendage) leaves, small pale yellow flowers and cylindric, 10-ribbed beaked capsules containing many small trigonous seeds. A common weed, this plant is often cultivated for the fibre from its stem.

Seeds contain cardenolides such as olitoriside A, erysimoside, coroloside, helveticoside, corchoroside A, evonoside, strophanthidol and strophanthidin. Roots yield a triterpene, corosin and $\beta$-sitosterol. Leaves contain kaempferol, quercetin, $p$-hydroxy benzoic acid, vanillic acid, syringic acid and melilotic acid.

Seeds are ecbolic in nature and are used as a cardiotonic. The cardenolides are very effective in acute and chronic cardiac insufficiency, peroxystic tachycardia and tachyarythmia.

**Pergularia daemia** Choiv. (Asclepiadaceae)


*Kurutakah, Pergularia*

P. daemia is a perennial twiner with a milky latex, stem clothed by spreading hairs, broadly ovate (base cordate) pubescent leaves in pairs, small greenish white flowers (with gynostemium and double corona) in lateral cymes, and a pair of echinate lanceolate follicles containing ovate seeds velvety pubescent on both sides. This common weed is found all over India, S.E. Asia and Africa.

The stem and seeds of Pergularia contain cardenolides such as calactin, calotropin, calotropagenin (from seeds) uzarigenin and coroglaucigenin (from stems). Leaves contain kaempferol, vanillic acid, syringic acid, $p$-hydroxybenzoic acid, gentisic acid, ferulic acid, sinapic acid and $o$-coumaric acid (Daniel & Sabnis, 1982).

The plant is used for vesical calculus, dysurea and anurea. Leaf juice is emetic and expectorant and used in asthma, rheumatism, menstrual disorders and diarrhoea. Leaves are also used externally for rheumatic swellings.
Nerium oleander Linn. (Apocynaceae)

Syn. Nerium indicum Miller, N. odorum Soland.

Karvirah, Oleander

This is an evergreen laticiferous shrub with linear-lanceolate coriaceous leaves in whorls of three, large showy scented flowers (colours vary from red/yellow/white; with corolline corona, twisted petals and sagittate anthers) in terminal cymes and a pair of cylindrical follicles containing linear, ribbed comose seeds. A native of western Himalayas, oleander is cultivated in Asia, Europe and Africa.

The bark yields a number of cardiac glycosides designated as odoroside A, B, D, F, G, H, K-M and odorobioside K based on digitoxigenin (odoroside A, D, F, G & H), uzarigenin (odoroside B, K and odorobioside K) and 16-anhydrodigitoxigenin (odoroside L & M). Also present are scoptelin, scopolin, tannins, fatty oil and wax. Leaves contain oleandrin (a cardenolide based on acetyl gitoxigenin), nerium E (16-deacetyl anhydro-oleandrin), nerium F (16-anhydrodigitoxigenin), ursolic acid, oleanolic acid, neriodin, rutin, vanillic acid, syringic and salicylic acid.

The root, the official drug, is considered to be highly toxic, but in controlled doses, it is a cardiotonic. It is anthelmintic, diaphoretic, carminative and used for ulcers, leprosy and skin diseases. Leaves and roots, as an external paste, is useful in leprosy and snake bites. Leaf juice is useful in ophthalmia and improving eyesight.

Leptadenia reticulata W & A. (Asclepiadaceae)

Jivanti, Leptadenia

Jivanti is a laticiferous shrubby twiner with small elliptic-oblong leaves, small greenish yellow flowers in axillary many-flowered globose cymes (flowers with a gynostemium and pollinia) and a pair of subwoody cylindric, shortly curved beaked follicles containing ovate-oblong comose seeds. Jivanti is common in Western Ghats and N.E.Asia.

Stems and roots yield wax consisting of long-chain alcohols (C_{28}-C_{34}) and acids (C_{28}-C_{34}), sterols such as stigmasterol, \( \gamma \)-sitosterol and a fructosan of 7-8 units. Leaves yield apigenin, luteolin, vitexin, isovitexin and phenolic acids like vanillic, syringic, \( p \)-hydroxybenzoic, gentisic, ferulic, \( p \)-coumaric and \( o \)-coumaric acids (Daniel and Sabnis, 1982).

Roots are considered a rasayana (tonic) drug, useful for vitalizing the body. L. reticulata is an aphrodisiac, rejuvenative, galactogogue and cures weakness, cough, dysentery, night-blindness and tuberculosis. Leaves are useful in treating skin diseases.
Thevetia peruviana Merril (Apocynaceae)

This is a large evergreen laticiferous shrub reaching a height of 6m, with linear acute leaves (10-15cm long), bright yellow flowers in terminal cymes and fleshy triangular fruits containing 4 seeds. A native of tropical America, it is now widely cultivated everywhere for the foliage and flowers.

All parts of the plant contain cardiac glycosides; seeds being the richest source of these compounds (containing up to 7 times) than the other parts.

The various compounds isolated are cereberoside (thevetin B), 2'-O-acetyl cerberoside and neriifolin, 2'-O-neriifolin (cerberin) all based on the genin, digitoxigenin; thevetin A (19-oxocerberoside) and peruvoside (19-oxonerifolin), both based on cannogenin; thevenerrin (19-oxyneriifolin-based on cannogenol) and peruvosidic acid (based on cannogenic acid). All of them are triosides or monosides. Also present in the seed are a fatty oil (67%) rich in oleic (64%) and palmitic (17%) acids. Bark is found to contain neriifolin and peruvoside along with lupeol acetate. Roots yield thevetin and neriifolin. Leaves contain α- and β-amyrins and flavonoids. Latex contains caoutchouc (rubber) and a resin.

All the glycosides are used as cardiotonics, the most preferred ones being peruvoside and thevetin. Bark is a bitter cathartic and emetic. Leaves are also purgative and emetic. Seeds are used as an abortifacient and as a purgative in rheumatism and dropsy.

Helleborus niger Linn. (Ranunculaceae)

Black Hellebore

This perennial herb, with unbranched underground stem and roots of thick fibres, is a native of central Europe. The scape-like flowering stem is 15-20 cm long with small deeply divided leaves and pale purple solitary flowers. The papery follicles are many seeded.

Rhizomes and parts of the aerial stem constitute the drug. Of the few glycosides it contains, hellebrin (hellebrigenin + rhamnose + glucose) shows the maximum cardiotonic activity:

Hellebrin is supposed to have approximately twenty times powerful action compared to Digitalis, and so is extensively used in veterinary practices.

Drimia indica Jessop (Liliaceae)

Jungly Piaz, Indian Squill

This is a herb with tunicate bulbs (5-10cm in diam.), flat, radical, linear subbifarious leaves, brown flowers (appearing before the leaves) in a raceme,
borne on an erect brittle scape (upto 50cm long) and ellipsoid, trigonous capsules containing many flattened black elliptic seeds. *D. indica* is common in Western Ghats, Himalayas and tropical Africa.

Bulbs contain bufadienolides (maximum in dormant stage of the bulb) such as proscillaridin A, scillipheoside and anhydroscilliphaosidin, sterols like sitosterol and mucilage (50%, consisting of mannose, glucose and xylose).

This is used as an expectorant, cardiac stimulant and diuretic. It is also useful as an anticancer and hypoglycaemic drug and for skin diseases. This is used as a substitute to *Digitalis* when the patients show hypersensitivity to the former drug.

### 3.7 Carotenoids

Carotenoids, the C\textsubscript{40} tetraterpenoid polyenes, are formed by tail-to-tail condensation of two diterpene molecules. They are extremely widely distributed, present in all plants and in a few animals through dietary intake. The hydrocarbon pigments are known as carotenes and their oxygenated derivatives, xanthophylls. All the carotenoids are coloured yellow or red, though a few, like phytoene and phytofluene, possessing lesser double bonds, are colourless. In most of the carotenoids, double bonds are all *trans*. Higher ring systems are absent in carotenoids and all of them are either acyclic monocyclic or bicyclic. Lycopene is the acyclic basic molecule from which all the other carotenoids are derived. Cyclization of lycopene at one end gives \(\gamma\)-carotene while cyclisation at both ends produces bicyclic \(\beta\)-carotene.

Xanthophylls may contain substituents like alcohol (monohydroxy-lutein; dihydroxy- zeaxanthin), epoxy (lutein) or, in rare cases, keto (rhodoxanthin) or carboxyl (crocein). A phenolic carotenoid, 3,3'-dihydroxy isorenieratene, is reported from *Streptomyces* sp. Generally cyclization in carotenoids produces a cyclohexane ring, but capsanthin is peculiar in having a cyclopentane ring at one end. Most of the xanthophylls occur as esters of fatty acids (palmitic, oleic or linoleic acids). Glycosides of carotenoids with rhamnose or glucose are reported from various algae (Herzberg and Liaan-Jensen, 1971). In higher plants, crocin is the only glycoside known.

\(\beta\)-carotene is an essential dietary requirement as provitamin A. One molecule of \(\beta\)-carotene is found to give rise to only one molecule of C\textsubscript{20} retinol (Vit. A). \(\alpha\)-, and \(\gamma\)-carotenes as well as cryptoxanthin containing a \(\beta\)-ionone residue also can give rise to vitamin A. All the carotenoids are excellent antioxidants. Lycopene is known for its role in treating prostrate cancer. Crocin and bixin are other two carotenoids (or derived carotenoids due to the lesser number of carbon atoms) having marked medicinal properties.
**Lycopersicon esculentum** Mill. (Solanaceae)

**Rakthamachi, Tomato**

This is a pubescent spreading annual with pubescent unevenly pinnate curled leaves, yellow flowers in extra axillary cymes, large orange/red globose berries containing many flat kidney-shaped seeds on a fleshy placentum. It is a native of Peru-Ecuador, now widely cultivated throughout the world.

The fruits contain protein (2%), carbohydrates (4.5%) minerals, pectin, citric, oxalic and malic acids, carotenoids and glycoalkaloids tomatine and solanine (in traces). The carotenoids present include lycopene, β-carotene, lutein and related compounds.

Tomato is a carminative, blood purifier and general tonic. Lycopene is highly recommended for prostrate cancer and an antioxidant of great demand.

**Carica papaya** Linn. (Caricaceae)

**Papeeta, Papaya**

Papaya is a quick-growing, tall, soft-stemmed laticiferous tree having a hollow trunk bearing leaf scars, a crown of large long-petioled, deeply palmatifid leaves and unisexual dioecious flowers. The male flowers are small yellowish-white, borne in many-flowered densely pubescent cymes, while the female flowers are large, solitary or in few-flowered racemes. The fruit is a large berry mostly obovate with a hollow centre and enclosing many black reticulate seeds enveloped by a transparent aril. Papaya is a native of southern Mexico, now cultivated everywhere.

The ripe fruits are a good source of pectin, carotenoids like β-carotene, cryptoflavin and violaxanthin. Other carotenoids present are phytoene, γ-carotene, chrysanthenaxanthin and neoxanthin. Vitamin C, sugars, citric, malic and butanoic acids, volatile oil consisting of methyl butanoate, linalool, benzyl isothiocyanate and benzyl glucosinolate, alkaloid like carpaine are the other constituents. Raw papaya is a good source of pectin and proteolytic enzymes papain and chymopapain. The latex, generally collected from fruits, is the main commercial source of papain. Besides papain and chymopapain A, B & C, the latex contains sulfhydryl compounds, glutamine cyclotransferase, peptidase and lysozyme. Seeds yield protein (8%), fatty oil (9.5%, rich in oleic acid), phospholipids, carpaine, and glucosinolates like carcin, benzylglucosinolate, and glucotropaolin and benzyl isothiocyanate. Roots contain carposide and myrosin and the leaves yield carpaine, pseudocarpaine, dehydrocarpezine, choline, vitamin C and vitamin E.

All parts of the plant are of medicinal value. The unripe fruit is a laxative and diuretic, while the ripe fruit is stomachic, galactogogue, diuretic and is effective in dysentery, chronic diarrhoea, bleeding piles, dyspepsia and as an emmenagogue. Seeds are emmenagogue, carminative and vermifuge. Carpaine shows antitumour and antitubercular activity.
**Crocus sativus** Linn. (Iridaceae)

**Kesar, Saffron**

The dried stigmas and tops of styles of this perennial herb constitute the saffron of commerce. The plant has small globose corms bearing numerous, radical, linear, ciliate leaves. The lilac/purple flowers are borne in 2-valved spathes. The styles of flowers are branched and blood red in colour.

The colour of saffron is due to a diterpene crocin, which is the gentiobiose ester of crocetin—a diterpene acid having a structure resembling carotenoids. The bitter taste of saffron is attributed to picrocrocin, a glycoside yielding glucose and safranal on hydrolysis. Safranal is dihydro β-cyclocitrinal and is the main odoriferous constituent. The bulbs contain four isolecins. Tepals yield myricetin, quercetin, kaempferol, delphinidin, petunidin, astragalin and helichrysoside. Pollen is found to contain crosatosides A and B and kaempferol glycoside.

Saffron is a colouring and flavouring agent. Saffron extract shows cytotoxic and antimutagenic activities and anti-tumour activities against ascites tumours in mice. It is also used for its mild hypotensive properties, as an emmenagogue, in amenorrhoea, dismenorrhagia, hysteria and to prevent premature ejaculation. Crocin is used to stabilise light-sensitive drugs.

**Nyctanthes arbor-tristis** Linn. (Oleaceae)

**Harsinghar, Nyctanthes**

The dried corolla tube of this plant, native to India, is used to adulterate saffron. The pigment here too is crocin. The flowers contain a volatile oil resembling peppermint.

**Bixa orellana** Linn. (Bixaceae)

**Shonapushpe, Annato**

Annato is a small tree with cordate acuminate long-petioled leaves, moderately large pink/white flowers in terminal panicles and red/green prickly capsules containing many trigonous seeds having a red pulpy testa. A native of tropical America, Annato is commonly found cultivated.

The red pulpy seed coat contains a group of pigments, with bixin, a sesterpene (having a carotenoïd skeleton) amounting to 70-80%. Other pigments present are orellin, methyl bixin, β-carotene, cryptoxanthin, lutein and zeaxanthin. Isobixin is the trans-form of the unstable naturally occurring cis-bixin. The seeds yield protein (17%), carbohydrates (14%), mucilage (4.5%), a fixed oil, an essential oil, oleoresin, phytosterols and alkaloids. The oleoresin which amounts to 1% of the seed contain all-E-geranyl geraniol (57%), farnasyl acetone, geranyl octadecanoate and volatile oil contains ishwarone (30%), α-pinene, β-pinene, etc. The dried leaves yield a gum and an essential oil (similar to that of seeds) consisting of a sesquiterpene, bixaghanane,
ellagic acid, flavones such as apigenin, luteolin along with their bisulphates and glucosides, isoscutellarien, bixorellin and a steroidal sapogenin. The roots contain a triterpene acid, tomentosic acid (Jondiko & Pattenden, 1989).

Annato dye is a widely used food colour. The pulp surrounding the seed is used as a haemostatic, antidysenteric, diuretic and febrifuge. It is also recommended for epilepsy and skin diseases. The seed oil is used for treating leprosy. The leaves are used for bronchial infections (as a gargle), jaundice, dysentery, tumours and as a febrifuge. The gum from leaves is used for gonorrhea and liver complaints. Roots are antiperiodic and antispasmodic.