# 5

# Under-utilized herbs and spices

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## 5.1 Introduction

In ancient times spices and herbs were valued as basic ingredients of incense, embalming preservatives, ointments, perfumes, antidotes against poisons, cosmetics and medicines, and were used less in culinary preparations. A notable use of spices and herbs in ancient and medieval times was for the treatment of a variety of illnesses. Subsequently, spices and herbs came to be used to flavour food and beverages. In the course of time, spices and herbs were shown to be useful not only for making food palatable, but also in retarding or preventing rancidity and spoilage. This knowledge acted as a catalyst for the use of spices in a variety of processed foods. Based on use, herbs and spices are classified as culinary, cosmetic and pharmaceutical. In the modern world spices have wide affiliation in the culinary art of people around the world, and are used in the food industry for flavouring and seasoning, as well as in pharmaceutical preparations in the traditional systems of medicine and in beauty care. Spices and herbs are useful because of the chemical constituents contained in the form of essential oil, oleoresin, oleogum and resins, which impart flavour, pungency and colour to prepared dishes.

The International Organization for Standardization (ISO) lists 112 plant species that are used as spices and herbs. Among these, a few are very widely used and grown commercially in many countries, a few are less widely used but are well-known, while others are less known and are under-utilized. Such under-utilized herbs and spices are indeed valuable, not only as spices for flavouring dishes, but also as medicinal plants of great importance. A list of such under-utilized herbs and spices is given in Table 5.1. This chapter deals briefly with some of the more important under-utilized herbs and spices. A few have already been dealt with in this volume as well as in Volume 1.

## 5.2 Sweet flag

Sweet flag is the rhizome of *Acorus calamus* Linn. of the family Acoraceae and is highly valued as herbal medicine in India and other European countries. It is used as an ingredient

**Table 5.1** List of some of the under-utilized herbs and spices

| SI No. | Botanical name | Common name | Family | Part used |
|---|---|---|---|---|
| 1. | *Acorus calamus* L. | Sweet flag | Acoraceae | Rhizome |
| 2. | *Alpinia galanga* Willd. | Greater galangal | Zingiberaceae | Rhizome |
| 3. | *Angelica archangelica* L. | Garden angelica | Apiaceae | Root |
| 4. | *Armoracia rusticana* Gart. | Horseradish | Brassicaceae | Root |
| 5. | *Bunium persicum* (Bosis) B Fedtsh. | Black caraway | Apiaceae | Seed, tuber |
| 6. | *Capparis spinosa* L. | Caper | Capparidaceae | Unopened flower buds |
| 7. | *Carum bulbocastanum* L | Black caraway | Apiaceae | Fruit, Bulb |
| 8. | *Ferula asafoetida* L. | Asafoetida | Apiaceae | Oleogum |
| 9. | *Garcinia gummi-gutta* (L.) N. Robson | Malabar tamarind | Clusiaceae | Pericarp lobes (fruit rind) |
| 10. | *G. indica* Choisy | Kokum | Clusiaceae | Pericarp lobes (fruit rind) |
| 11. | *Hyssopus communis* L. syn *H. officianalis* | Hyssop | Lamiaceae | Leaf |
| 12. | *Kaempferia galanga* L. | Galangal | Zingiberaceae | Rhizome, tubers |
| 13. | *Levisticum officianale* | Lovage | Apiaceae | Fruit, leaf |
| 14. | *Marjorana hortensis* (*Origanum marjorana*) | Sweet marjoram | Lamiaceae | Leaf and flowering top |
| 15. | *Murraya koenigii* L. | Curry leaf | Rutaceae | leaf |
| 16. | *Nigella sativa* L. | Black cumin | Ranunculaceae | Seed |
| 17. | *Pandanus amaryllifolius* | Pandan wangi | Pandanaceae | Leaf |
| 18. | *Papaver somniferum* L. | Poppy seed | Papaveraceae | Seed |
| 19. | *Piper betle* L. | Betel leaf | Piperaceae | Leaf |
| 20. | *Punica granatum* L. | Pomegranate | Punicaceae | Seed dried with flesh |
| 21. | *Rosmarinus officinalis* | Rosemary | Lamiaceae | Terminal shoot, leaf |
| 22. | *Salvia officinalis* | Garden sage | Lamiaceae | Terminal shoot, leaf |
| 23. | *Satureja hortensis* L. | Summer savory | Lamiaceae | Leaf, flowering top |
| 24. | *Satureja montana* | Winter savory | Lamiaceae | Leaf, flowering top |
| 25. | *Schinus terebenthifolius* | Brazilian pepper (Pink pepper) | Anacardiaceae | Fruit |
| 24. | *Sinapis alba* | White mustard | Brassicaceae | Seed |
| 25. | *Tamarindus indica* L. | Tamarind | Caesalpineaceae | Fruit pulp |
| 26. | *Thymus vulgaris* | Thyme | Lamiaceae | Terminal shoot, leaf |
| 27. | *Trachyspermum ammi.* (L) Sprague ex Tussil | Ajowan | Apiaceae | Fruit |
| 28. | *Trigonella foenum-graecum* | Fenugreek | Fabaceae | Seed, leaf |
| 29. | *Xylopia aethiopica* | Guinean pepper | Annonaceae | Fruit |
| 30. | *Zanthoxylum piperitum* | Japanese pepper | Rutaceae | Fruit and rind |

of several drugs of the *Unani, Ayurvedic* and modern systems of medicine. It is also well known for its insecticidal properties. The word *Acorus* is derived from *kore*, meaning pupil, and refers to the alleged ophthalmic virtues of the plant.

### 5.2.1 Origin and distribution

*Acorus* is native to most northern latitude countries around the world and may have been widely dispersed around the USA by Native Americans who planted the roots along their migratory paths to be harvested as needed. The species *A. calamus* is native to the southeastern USA, growing wild in wet areas in marshes and ditches.

*Acorus* is found wild or cultivated throughout India and Ceylon at up to 1800 m (6000 feet) height in the Himalayan region. It is a promising crop, especially for marshy land. In India, *A. calamus* is grown abundantly in the marshy tracts of Kashmir, in certain areas of Manipur, the Naga Hills and Sikkim.



### 5.2.2 Botany and description

*Acorus* is an attractive, perennial, herbaceous, aquatic, marshy plant. This species inhabits perpetually wet areas such as the edges of streams and around ponds and lakes, in ditches and seeps. It is a grass-like, rhizome-forming, semi-aquatic perennial herb that can grow up to 2 m high. The plant has a creeping and much branched aromatic rhizome. The rhizome is cylindrical; light brown or white and spongy in colour.

The leaves are thick, erect and sword-shaped with crimped edges. The leaves, when bruised, emit a strong scent. *Acorus* produces small, yellow flowers arranged on a spike. Plants rarely flower or set seed.

*Acorus* is a rather remarkable plant in a number of respects. Until recently, it was just another member of the family Araceae, one of the larger and more complicated monocot families. Upon investigation of its morphology, anatomy and DNA sequences, it now appears that *Acorus* is the most primitive monocot and may represent an early stage in the evolution of the monocots (Albertazzi *et al.*, 1998, Duvall *et al.*, 1993; Duvall, 2001). Acorus is now included in a separate family, Acoraceae.

The rhizome is light brown with long internodes, root and leaf scars and a soothing aromatic odour. The transverse section shows narrow cortical and large stellar regions. The cortex consists of thin-walled parenchymatous cells arranged in chains, leaving large intercellular spaces, sheathed collateral vascular bundles and bundles of fibres. Endodermal cells are barrel shaped and possess abundant starch grains. Large oil cells with yellowish contents and cells containing dark brown oleoresin and starch grains are scattered in the ground tissue of both cortex and stele. Solitary polygonal crystals of calcium oxalate are present in each cell of the storied row of cells running parallel to the fibres (Sharma *et al.*, 2000). Calquist and Schneider (1997) demonstrated the vessels in the metaxylem of both roots and rhizomes by scanning electron microscopy (SEM), and the end walls of the vessel elements are characterized by perforations that retain porose pit membranes and are interpreted as a primitive character.

On microscopic examination the powder appears yellowish-white and consists of masses of whole or broken, oval-shaped parenchymatous cells. Some of these cells contain yellow-brown oleoresin, packed with small spherical starch grains. A few xylem elements in groups of vessels with annular thickening are also seen (Karnick, 1994a).

### 5.2.3 Cultivation and production

*Acorus* is propagated vegetatively. Sprouted rhizomes collected from the vigorously growing mother plants are used as planting material. About 80 000 propagules are required for one hectare of land. The planting time is June–July. The rhizome bits are planted in about 6 cm deep furrows with a spacing of 30 cm between the rows and 35 cm between the plants. Application of farmyard manure or compost, 8–10 tonnes/hectare supplemented with organic fertilizer is needed for good growth. For satisfactory cultivation and yield application of 100 kg/ha nitrogen is recommended (Tiwari *et al.*, 2000; Kumar *et al.*, 2000).

Propagation of sweet flag through tissue culture was reported by Hettiarachchi *et al.* (1997); Harikrishnan *et al.* (1999); Kulkarni and Rao (1999) and Rani *et al.* (2000). All the authors used Murashigue and Skoog basal medium supplemented with varying levels of BA (benzyl adenine) and NAA (α-naphthalene acetic acid). The cultures initiated from rhizome

buds were multiplied, rooted and successfully established in soil. This method can be exploited for large-scale multiplication of quality planting material in this crop.

### 5.2.4 Chemistry

The root essential oil contains monoterpene hydrocarbons, sesquiterpine ketones (*trans* or α) asarone (2,4,5-trimethoxy-1-propenylbenzene) and β-asarone (*cis*-isomer). The American variety is consistently tested free of the carcinogenic β-asarone, whereas the Asian varieties contain varying amounts of β-asarone, and cause a more sedative feeling when ingested. European varieties of sweet flag have yielded various sesquiterpenoids with psychoactive or medicinal properties.

The volatile oil obtained by steam distillation of the rhizome was purified and subjected to liquid–gas chromatography. A total of 93 volatile components were detected from the Indian variety, of which β-asarone was found to be the major component. European calamus yielded 184 volatile components, including 67 hydrocarbons, 35 carbonyl compounds, 56 alcohols, 8 phenols, 2 furans and 4 oxido compounds. Its oil yield varies with temperature and method of storage. Sweet flag leaves, rhizome and roots contain 0.22–0.89, 3.58–7.80 and 1.77–3.15 ml/l00 g dry matter, of essential oil, respectively. Tannic substances are in the rangeof 1.22–1.85, 0.63–1.05 and 0% respectively in leaves, rhizome and roots. Leaves contain vitamin C (Kumar *et al.*, 2000).

The variation of essential oils and their major constituents in *Acorus,* with respect to season and geographical areas, was analysed. The major components of volatile oil obtained from the same part of the plants from different geographical areas exhibited no change in chemical structure and the best season for cropping was found to be June (Kumar *et al.*, 2000). The calamus root oil obtained from the plants grown in various geographical areas such as China, Japan (wild and cultivated types), Asian regions, Canada, Bangladesh and also the commercial sample from Germany were subjected to analysis by various researchers. It was found that there is variation in the presence and quantity of the components in those samples (Lawrence, 2002). The comparative percentage composition of the major components of various collections of Japanese and Asian calamus root oil is given in Tables 5.2 and 5.3.

Petrikova *et al.* (2000) studied the essential oil concentration in *Acorus* collected from 13 locations in the Czech Republic and found that the oil contents were higher in spring crops (0.8–2.6%) than in autumn crops (1–1.8%). The concentration of β-asarone ranged from 0.07 to 0.41%.

The volatile oil of accessions collected from Jammu and Kashmir had some common constituents, such as palmitic acid, isoeugenol, butyric ester, asarone and hydrocarbons. Both the oils differed in some components: eugenol, calamol and azulene are present in Jammu collections, whereas Kashmir collections have heptylic acid, 2-pinene, camphor, calamene and azulene. The presence of 124 mg% of choline per 100 g was reported in the *Acorus* plants (Chaudhary *et al.*, 1957). Sikkim collections of *Acorus* are reported to have a higher oil content and a higher percentage of other major constituents (Agarwal, 1987). Chowdhury *et al.* (1993) identified 1-(1-acetoxy-2-propenyl)-4-hydroxybenzene in Indian calamus roots. Essential oil isolated from calamus roots grown in India, in alkaline soil rich in exchangeable sodium, was analysed by GC–MS (gas chromatography–mass spectroscopy) for its constituents and more than 25 compounds were detected. The major components detected were (*E*)-asarone (58%), (Z)-asarone (2%), asaronaldehyde (8%), α-terpineol (2%), calamol (2%), etc. (Chowdhary *et al.*, 1997). The accuracy of this study is doubtful as the authors have reported presence of high amount of (*E*)-asarone, but Indian calamus is rich



**Table 5.2** Comparative percentage composition of the major components of Japanese calamus root oils

| Compound | Chemotype 1 (6)* | Chemotype 2 (12)* | Chemotype 3 (2)* |
|---|---|---|---|
| (Z)-methyl isoeuginol | 0–2.9 | 0–11.3 | 1.6–7.6 |
| Epi-shyobunone | 0.6–5.1 | 4.1–10.3 | 10.7–12.1 |
| Shyobunone | 1.0–4.8 | 7.1–15.2 | 14.3–22.1 |
| Elemicin | 1.4–1.7 | 0–3.7 | 0.7–2.2 |
| Preisocalaminidiol | 1.2–6.2 | 9.4–28.9 | 22.8–34.9 |
| (Z)-asarone | 64.7–92.1 | 23.5–48.7 | 6.0–8.1 |
| (E)-asarone | 1.8–10.0 | 1.4–13.8 | 2.6–4.1 |
| Other constituents | 0.4–10.9 | 7.7–34.4 | 24.1–26.1 |

*Number of samples.
*Source*: Sugimoto *et al.* (1997a).

**Table 5.3** Comparative percentage composition of the major components calamus root oils of Asian origin

| | Source* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Compound | 1 (1)† | 2 (1)† | 3 (1)† | 4 (8)† | 5 (3)† | 6 (2)† | 7 (1)† | 8 (2)† |
| Methyl euginol | – | – | – | – | – | – | – | 0–1.6 |
| (Z)-methyl isoeuginol | 1.2 | 1.6 | 0 | 0.3–9 | 0–0.7 | 0–2.9 | 87.3 | 0–1.3 |
| Epi-shyobunone | 1.8 | 0.7 | 3.4 | 0–1.1 | 0–3..5 | 2.2 – 3.0 | – | – |
| (E)-methyl isoeuginol | – | – | – | – | – | – | – | 0–1.6 |
| Shyobunone | 2.2 | 14.3 | 4.5 | 0–1.3 | 0–5.3 | 2.8 – 4.0 | – | – |
| Elemicin | 1.7 | 2.2 | 0.6 | 0–1.6 | 0–0. 7 | 0.5 – 2.3 | – | 42.7–72.7 |
| Preisocalaminidiol | 3.0 | 34.9 | 1.4 | 0–4.5 | 5.0–12.0 | 4.4 – 7.7 | – | – |
| (Z)-asarone | 85.7 | 8.1 | 20.9 | 73.8 – 96.3 | 10.2 – 17.9 | 43.6–53.7 | 12.7 | 25.7–37.3 |
| (E)-asarone | 2.6 | 4.1 | 3.5 | 1.8–15.0 | 0–6.0 | 3.9–4.5 | – | 1.6–2.4 |
| Other constituents | 1.8 | 24.1 | 65.7 | 0–13.6 | 55.9–85.1 | 29.0–35.5 | – | 0–13.0 |

*1. Cultivated Osaka, Japan 2. Cultivated Hokkldo, Japan. 3. Cultivated Chongging, China. 4. Various Asian sources. 5. Three areas in China. 6. Henen, China. 7. Jllin, China. 8. Hubei, China.
† Number of samples.
*Source*: Sugimoto *et al.* (1997b).

in β-asarone (=Z-asarone). Wu *et al.* (1993) characterized a new compound from *Acorus* roots of Chinese origin using X-ray diffraction analysis and named it as calamensesquiterpinol. The same group of workers (Wu *et al.*, 1994) identified calamenidiol, isocalamenidiol and calamenene in *A. calamus* roots.

Sweet flag oil also contains acoradin, 2,4,5-trimethoxy-benzaldehyde; 2,5-dimethoxybenzoquinone; galangin; sitosterol; the phenylpropane derivatives isoeugenol methyl ether, γ-asarone, *cis*-asarone, *trans*-asarone and acoramone (Patra and Mitra, 1981). The compounds Z-3-(2,4,5-trimethoxyphenyl)-2-propenal and 2,3-dihydro-4,5,7-trimethoxy-1-ethyl-2-methyl-3-(2,4,5-trimethoxyphenyl) indene were also isolated from *Acorus* plants. A phenyl propane derivative 1-(*p*-hydroxyphenol)-*l*-(*o*-acetyl)prop-2-ene, was isolated from the rhizome of *Acorus.*

The *Acorus* oil of Dutch origin was subjected to fractionation after separation of acidic and phenolic substances. The lower boiling fraction contains terpenes. The sesquiterpenes diol-isocalamenidiol and three monocyclic sesquiterpenes were isolated from essential oil of Japanese plant rhizomes. Two new selinane-type sesquiterpenes, two new sesquiterpenic ketones and a new tropane were isolated from sweet flag oil, and their structures were also elucidated. The structure of the sesquiterpenic hydrocarbon, (–)cadala-1,4,9-triene, was

determined from chemical and spectral data. Kumar *et al.* (2000) have made a detailed review on the chemistry of *Acorus*.

Various compounds such as calacone, telekin, isotelekin, calarene, monocyclic ketones – shyobunone, epishyobunone and isoshyobunone – were also isolated and their structure elucidated during the period from 1966 to 1968 (Rastogi and Mehrotra, 1990). (Z,Z)4,7-dicadienal was isolated from oil and synthesized; two new compounds: (Z)3-(2,4,5-trimethoxyphenyl)-2-propenal and 2,3-dihydro-4,5,7-trimethoxy-1-ethyl-2-methyl-3-(2,4,5-trimethoxyphenyl) indene, were isolated from rhizomes and their structures elucidated and confirmed by synthesis (Rastogi and Mehrotra, 1995).

Sugimoto *et al.* (1999) analysed the phylogenetic relationship of *A. gramineus* and three types of *A. calamus* by comparing the 700 bp sequence of a 5S-rRNA gene spacer region. *A. calamus* was classified into two chemotypes: chemotype A in which Z-asarone is the major essential oil constituent and chemotype B which contained mainly sesquiterpenoids. An intermediate type (M) of these two chemotypes in various ratios was also observed. The results revealed that the phylogenetic relationship predicted by the spacer region data correlated well with the essential oil chemotype pattern of *A. calamus*.

### 5.2.5 Functional properties and toxicology

The biological properties of calamus were reviewed by Kumar *et al.* (2000). Both the dried, pleasant smelling rhizome and its essential oil are used as aromatic, bitter carminative compositions and in bronchial troubles. The sedative-potentiating principle was found in the petroleum ether extract of rhizomes of *Acorus*. The same active principle was also obtained during steam distillation of its rhizomes. This fraction showed depressant action on normotensive dogs, inhibited the rate of contraction of frog and dog hearts, relaxed the tone of isolated intestine, uterus and bronchi and antagonized acetylcholine and histamine-induced spasm. The former action was not modified by atropinization or the latter by pre-treatment with antihistamines. Root extract exhibited antimicrobial activity against *Staphylococcus aureus*, *Escherichia coli* and *Aspergillus niger* (Rastogi and Mehrotra, 1995). The complete extract of *Acorus* rhizomes exhibited significant anti-bacterial and anti-inflammatory effects in experimental animals. The dichloromethane extract of rhizome recorded the highest aphidicidal activity. The extract was found to have fumigative toxicity to aphids and β-asarone was found to be an active ingredient in this extract. An ethanolic extract of rhizome was screened for central nervous system (CNS) activity against mice and rats. The extract exhibited a large number of actions similar to β-asarone but differed in several other respects, including the response to electroshock, apomorphine and isolation-induced aggressive behaviour, amphetamine toxicity in aggregated mice, behavioural despair syndrome in forced swimming, etc. The *Acorus* plant extract was screened for anti-implantation activity in female rats.

The insecticidal properties of alcohol extracts of rhizomes of sweet flag against the fully grown larvae of *Trogoderma granarium* was reported (Pal *et al.*, 1996). The sterilizing effect of *Acorus* oil on the female of *Trogoderma granarium* was attributed to the absorption of the terminal oocytes of the ovaries and disturbance to follicular epithelium. Oral administration of 2 ml of boiled coconut oil extract of the rhizome of *Acorus* showed anti-inflammatory activity in rats.

The rhizome extract of *Acorus* plant has produced a hypotensive response in dogs. The ethanolic extract of *Acorus* rhizome inhibited gastric secretion and protected gastroduodenal mucosa against the injuries caused by pyloric ligation, indomethacin, reserpine and cystamine administration. The extract had a highly protective effect against cytodestructive



agents. Mutagenetic and DNA damaging activity was found in calamus oil, β-asarone and commercial calamus drugs (Ramos-Ocampo and Hsia, 1987). The essential oil obtained from *Acorus* showed spasmolytic activity in isolated organs of certain experimental animals. It was found that chromosome damage in the human lymphocytes is induced by β-asarone. Because of the genotoxicity potency of β-asarone, *Acorus* should be used at a very low concentration. Feeding studies in rat using Indian calamus oil (high β-asarone) had shown death, growth depression, hepatic and heart abnormalities and serious effusion in abdominal and/or peritoneal cavities.

The essential oil of *Acorus* has shown marked nematicidal activity against larvae of root knot nematode, *Meloidogyne. incognita*, the most menacing pest of Indian soils. The minimal lethal concentration of (*Z*/*E*) asarone mixture against the second stage larvae of dog roundworm *Toxocara canis* was 1.2 mM. The calamus oil (0.1%) effectively controlled the population of *Diplodia natalensis* and *Penicillium digitatum*. The insect growth-inhibiting activity was observed in the extract of *Acorus* plant. Bioactivation of *p*-asarone was mediated via insect mixed function oxidases.

There are various reports on the toxic effect of *Acorus* on stored pests and insects. Toxicity of *A. calamus* oil vapours and rhizome powder collected from different altitudes at different temperatures to stored pests and insects such as *Sitophilus granarius*, *S. oryzae*, *Callosobruchus maculatus*, *C. phaseoli*, *Lasioderma serricorne* and *Tribolium confusum* were reported (Schmidt, *et al.*, 1991; Su, 1991; Paneru *et al.*, 1997; Rahman and Schmidt, 1999). Reddy and Reddy (2000) described a treatment based on an *Acorus calamus* powder solution for the control of *Oryzaephilus surinamensis*, *Lasioderma serricorne*, *Araecerus fasciculatus* and *Tribolium castaneum* in stored turmeric rhizomes.

A-asarone produces stimulating effects and also sedative effects similar to reserpine and chlorpromazine. High antioxidant activity was reported from the ethanolic extracts of rhizomes of *Acorus* (Acuna *et al.*, 2002).

*Acorus* is considered unsafe for human consumption by the Food and Drug Administration (FDA) because massive doses given to laboratory rats over extended time periods proved to be carcinogenic (JECFA, 1981). Increased incidence of hepatomas was also observed in rats treated with β-asarone (Wiseman *et al.*, 1987).

FDA studies have shown that only calamus native to India contains the carcinogenic β-asarone. The North American variety contains only asarone. Calamus has been banned by the FDA as a food additive and within the last few years many herbal shops have stopped recommending or dispensing it. The presence of β-asarone in flavourings and other food ingredients with flavouring properties have been reviewed by the Scientific Committee on Food. The committee analysed the implications of the presence of β-asarone in food on human health in the light of the available information and recommended limitations in exposure and use levels (SCF, 2002). The use of *Acorus* is now more medicinal than as a spice.

### 5.2.6 Uses

Attempts have been made to utilize this plant's important biological activities in the development of herbal formulations for different kinds of ailments and uses. For skin care, a bath preparation has been prepared in which the ingredients are lactose and plant extracts. This preparation provides a moisturizing effect on the skin. A number of hair-care preparations have been formulated in which *Acorus* is one of the major constituents. The decoction of *Acorus* rhizome in combination with 0.25% solution of anesthesisn (1 : 1) is suggested for alvealitis prophylaxis.

**Table 5.4** Some of the herbal tonic/medicinal drugs in which *Acorus* is one of the ingredients

| Sl no. | Drugs | Uses |
|---|---|---|
| 1. | Krumina syrup | For intestinal diseases |
| 2. | Antospray powder | Skin care for softness |
| 3. | Automer drops | To check ear infections |
| 4. | Cybil Tab | As tranquillizer (sedative) |
| 5. | Libobel drops | In liver disorders |
| 6. | Galachol | To enhance lactation |
| 7. | Sepra Tab | As mental restorative |
| 8. | Traquinil | As tranquillizer |
| 9. | Ciladin | To cure pschychosometic disorders and use as tranquillizer |
| 10. | Phortage | For sex tonic |
| 11. | Suktin | Acidity, gastrocordiac syndrome flatulence, dyspepsia, gastroentritis and peptic ulcer, etc. |
| 12. | Cilpazyme syrup | For constipation |
| 13. | Remanil Tab | In swelling of bones, joints andrheumatic pains |
| 14. | Nab Tab | In epilepsy |

*Source*: Kumar *et al.* (2000).

The extract of *Acorus* rhizome is one of the major constituents in the formulation of many general tonics (Table 5.4). *Acorus* rhizome powder has been used in the preparation of antacid tablets with purgative properties. P-tab was found to be most effective drug for patients suffering from insomnia and irritability. This is composed of eight herbal drugs, of which *Acorus* is one. The water-ethanolic extract of *Acorus* plant was found to exhibit antioxidant property and can be used in the food industry as fat oxidant. In the formulations of mosquito repellent preparations, *Acorus* is a major constituent. *Acorus* is also used in waste-water treatment such as inactivated sludge treatment in the aeration tank; secondary setting and subsequent post-treatment for increased N and P compound removal and disinfection. *Acorus* cultivation in the treatment areas enhances N and P removal and disinfection. Treatment of clarified sewage leads to the removal of microorganisms.

## 5.3 Greater galangal

*Alpinia galanga* (L.) Willd belongs to the family Zingiberaceae, and is commonly known by such names as galangal, galanga, greater galangal and Java galangal. The related species *A. officinarum* is the lesser galangal.

### 5.3.1 Production and international trade

Data on production, consumption and trade are scarce and not reliable because traders make no distinction between *A. galanga* and *A. officinarum;* both are used as the source plant for the Ayurvedic raw drug *rasna*. India is a major supplier, along with Thailand and Indonesia (Scheffer and Jansen, 1999). However, its volatile oil attracts more international interest because of its high medicinal value (http://www.indianspices.com).

### 5.3.2 Origin and distribution

Greater galangal is native to Indonesia, but has become naturalized in many parts of South and South-East Asian countries. The oldest reports about its use and existence are from



southern China and Java. It occurs frequently in the sub-Himalayan region of Bihar, West Bengal and Assam. It is currently cultivated in all South-east Asian countries, India, Bangladesh, China and Surinam (Scheffer and Jansen, 1999). It shows exuberant growth along the eastern Himalayas and in southwest India, cultivated throughout the Western Ghats (Warrier *et al.*, 1994). India exports galanga in different forms (http://www.indian spices.com).

### 5.3.3 Botany and description

Greater galanagal is a perennial, robust, tillering, rhizomatous herb, which grows up to 3.5 m tall, with a subterranean, creeping, copiously branched aromatic rhizome. The rhizomes are 2.5–10.0 cm thick, reddish brown externally, and light orange brown internally. The aerial leafy stem (pseudostem) formed by the rolled leaf sheaths is erect. The leaves are 23–45 by 3.8–11.5 cm, oblong-lanceolate, acute and glabrous. The inflorescence is terminal, erect, many flowered, racemose, 10–30 × 5–7 cm, pubescent; the bracts are ovate, up to 2 cm long, each subtending a cincinnus of two to six greenish white flowers; the bracteoles are similar to the bracts but smaller; the flowers are fragrant, 3–4 cm long, yellow-white. The fruit is a globose to ellipsoidal capsule, 1–1.5 cm in diameter, orange-red to wine red.

The anatomy of the rhizome shows a central stele surrounded by an outer cortical zone. Fibrovascular bundles are distributed throughout the cortex and steel. Numerous resin canals are also present.

### 5.3.4 Chemistry

The composition of galangal rhizomes per 100 g dry matter is: moisture – 14 g, total ash – 9 g, matter soluble in 80% ethanol – 49 g, matter soluble in water – 19 g, total sugar–9 g, total nitrogen – 3 g, total protein – 16 g, essential oil content – 0.2–1.5% (dry wt). Fresh rhizomes yield about 0.1% of oil on steam distillation with a peculiar strong and spicy odour. Earlier investigations indicated camphor, 1,8-cineole (20–30%), methyl cinnamate (48%) and probably D-pinene as the oil components. 1'-Acetoxychavicol acetate, a component of newly dried rhizomes, is active against dermatophytes, and together with another compound, 1'-acetoxyeugenol acetate, exhibits anti-tumour activity in mice. The same compounds isolated from roots showed anti-ulcer activity in rats. Oil shows potential insecticide property. Galangal root, root oil and root oleoresin are given the regulatory status 'generally regarded as safe' (GRAS) in the USA (Scheffer and Jansen, 1999). The root contains a volatile oil (0.5–1.0%), resin, galangol, kaempferid, galangin, alpinin, etc. The active principles are the volatile oil and acrid resin. Galangin has been obtained synthetically (http://www.naturedirect2u.com).

Compounds such as 1'-acetoxy chavicol acetate, 1'-acetoxyeuginol acetate and 1'-hydroxychavicol acetate and two diterpenes – galanal A and galanal B – were isolated from seeds and their structures were elucidated. Galanolactones (*E*)-8-(17),12-labdadien-15,16-dial and (*E*)-8-(17)-epoxylabd-12-en-15,16-dial were isolated from seeds and characterized. A compound, di(*p*-hydroxy-*cis*-styryl) methane, was isolated along with *p*-hydroxy cinnamaldehyde from rhizomes (Rastogi and Mehrotra, 1995). Haraguchi *et al.* (1996) have isolated an antimicrobial diterpene (diterpene 1) from *A. galanga* and the structure was elucidated by spectral data and identified as (*E*)-8-beta,17-epoxylabd-12-ene-15,16-dial.

The volatile constituents of the rhizomes and leaves of *A. galanga* from the lower Himalayan region of India were analysed by GC and GC–MS. The main constituents

identified in the rhizome were 1,8-ciniole, fenchyl acetate and β-pinene. The leaf oil contained 1,8-ciniole, β-pinene and camphor as the major constituents (Raina *et al.*, 2002).

Jirovetz *et al.* (2003) investigated the essential oils of the leaves, stems, rhizomes and roots of *A. galanga* from southern India by GC–FID (flame iuonization detection), GC–MS and olfactometry. Mono- and sesquiterpenes and (*E*)-methyl cinnamate could be identified in all the four samples and these are responsible for the characteristic odour and the reported use in (folk) medicine as well as in food products. They found that the essential oil of *A. galanga* leaf is rich in 1,8-cineole (28.3%), camphor (15.6%), β-pinene (5.0%), (*E*)-methyl cinnamate (4.6%), bornyl acetate (4.3%) and guaiol (3.5%). The stem essential oil contains 1,8-cineole (31.1%), camphor (11.0%), (*E*)-methyl cinnamate (7.4%), guaiol (4.9%), bornyl acetate (3.6%), β-pinene (3.3%) and alpha-terpineol (3.3%). 1,8-Cineole (28.4%), α-fenchyl acetate (18.4%), camphor (7.7%), (*E*)-methyl cinnamate (4.2%) and guaiol (3.3%) are the main constituents of the rhizome essential oil. The root essential oil contains α-fenchyl acetate (40.9%), 1,8-cineole (9.4%), borneol (6.3%), bornyl acetate (5.4%) and elemol (3.1%).

### 5.3.5 Cultivation and production

*A. galanga* is found in wild/semi-wild and cultivated states. The plant requires sunny or moderately shady locations. Soils should be fertile, moist but not swampy. Sandy or clayey soils rich in organic matter and with a good drainage are preferred. Wild or semi-wild types occur in old clearings, thickets and forests. In the tropics, galangal occurs up to an altitude of 1200 m.

Long tips of rhizomes are used for propagation. Soil should be well tilled before planting. Alternatively, holes, 35 cm × 35 cm and 15–20 cm deep, are dug, filled with manure mixed with soil, inorganic fertilizers and lime (for acid soils). One piece of rhizome is planted per hole, and covered with mulch. Shoots from pieces of galanga rhizome emerge about one week after planting. About four weeks after planting, three or four leaves develop. Rhizomes develop quickly and reach their best harvest quality in three months after planting. If left too long, they become fibrous and large clumps will hamper harvesting. Seeds rarely reach maturity.

Often trenches are dug to drain the field after rainfall, as rhizomes do not develop under waterlogged conditions. Usually planted along the borders of gardens, in rows at distances of 0.5–1 m square. Weeding and subsequent earthing up are carried out, respectively, one or two months after planting.

### 5.3.6 Harvesting and processing

Harvesting is done usually three months after planting (during late summer or early autumn) for market purposes. Whole plants are pulled out, shoots cut off and rhizomes washed and cleaned. Rhizomes more than four months old turn woody, fibrous and spongy and lose their value as spice. For local use, plants are left in the field almost permanently and small quantities of good quality rhizomes can always be harvested. For production of essential oil, rhizomes are harvested when plants are more than seven months old. No reliable data are present on the yield (Scheffer and Jansen, 1999).

Harvested rhizomes are washed, trimmed, dried and marketed fresh or dried after packing (Scheffer and Jansen, 1999). The dried product is ground before use. Ground rhizomes are not traded in bulk as they may be adulterated. Essential oil is also a product.



### 5.3.7 End uses

Rhizomes are bitter, acrid, thermogenic, aromatic, nervine tonic, stimulant, repulsive, carminative, stomachic, disinfectant, aphrodisiac, expectorant, bronchodilator, febrifuge, anti-inflammatory and tonic (Warrier *et al.*, 1994). They have many applications in traditional medicine such as for skin diseases, indigestion, colic, dysentery, enlarged spleen, respiratory diseases, cancer of mouth and stomach, treatment for systemic infections and cholera, as an expectorant, after childbirth (Scheffer and Jansen, 1999), in vitiated conditions of *vāta* (all the body phenomena controlled by the central and autonomic nervous systems) and *kapha* (for the function of heat regulation, and formation of various preservative fluids such as mucus, synovia, etc.). The main function of *kapha* is to provide coordination of the body system and regularization of all biological activities. Galanga is also reported to be useful in the treatment of rheumatoid arthritis, inflammation, stomatopathy, pharyngopathy, cough, bronchitis, asthma, hiccough, dyspepsia, stomachalgia, obesity, cephalagia, diabetes, tubercular glands and intermittent fevers (Warrier *et al.*, 1994).

Rhizomes show antibacterial, antifungal, antiprotozoal and expectorant activities (Scheffer and Jansen, 1999). Galangal's antibacterial effect acts against germs, such as *Streptococci, Staphylococci* and coliform bacteria. This plant is used to treat loss of appetite, upper abdominal pain, and sluggish digestion. It relieves spasms, combats inflammation and has stress-reducing properties.

In Asia, galangal is also used for arthritis, diabetes, stomach problems and difficulty in swallowing. It is especially useful in flatulence, dyspepsia, nausea, vomiting and sickness of the stomach, being recommended as a remedy for seasickness. It tones the tissues and is sometimes prescribed in fever. Galangal is used in cattle medicine, and the Arabs use it to make their horses fiery. It is included in several compound preparations. The reddish-brown powder is used as a snuff for catarrh (http://www.naturedirect2u.com). The young rhizome is a spice and is used to flavour various dishes in Malaysia, Thailand, Indonesia and China.

### 5.3.8 Functional properties and toxicology

Antifungal activity of *A. galanga* and the competition for incorporation of unsaturated fatty acids in cell growth was reported by Haraguchi *et al.* (1996). They isolated an antimicrobial diterpene (diterpene 1) and found that this compound synergistically enhanced the antifungal activity of quercetin and chalcone against *Candida albicans*. Its antifungal activity was reversed by unsaturated fatty acids. Protoplasts of *C. albicans* were lysed by diterpene 1. These results suggest that the antifungal activity of this compound is due to a change of membrane permeability arising from membrane lipid alternation. The ethanolic extract of *A. galanga* rhizome exhibited hypolipidaemic activity *in vivo*. The oral administration of the extracts (20 mg/day) effectively lowered the serum and tissue levels of total cholesterol, triglycerides and phospholipids and significantly increased the serum levels of high-density lipoproteins (HDL) in high-cholesterol fed white wistar rats over a period of four weeks. The study suggests that galanga is useful in various lipid disorders especially atherosclerosis (Achuthan and Padikkala, 1997).

A novel composition of aromatic and terpinoid compounds present in *A. galanga* showed synergistic effects with respect to immunomodulation, and effectively suppressed hypersensitivity reactions. These compounds are used for preparing medicaments for the treatment or prevention of allergic reactions and conditions, such as asthma, allergic rhinitis, anaphylaxis and autoimmune disorders, such as ulcerative colitis, rheumatoid arthritis, as well as for the alleviation of pain (Weidner *et al.*, 2002). The constituents isolated from the seeds of *A. galanga* are reported to exhibit anti-ulcer activities (Mitsui *et al.*, 1976).

### 5.3.9 Quality issues

Dried powdered rhizome is sometimes adulterated with lesser galangal (*A. officinarum*) (Scheffer and Jansen, 1999). Other species of *Alpinia* such as *A. calcarata, A. conchigera, A. mutica, A. nigra, A. rafflesiana* and *A. scabra* are sometimes substituted for the genuine drug. Inferior ginger and rhizomes of *Acorus calamus* are also used as adulterants (Anon., 1985).

The fruits of *A. galanga* are used in traditional Chinese medicine, but the dry fruits are easy to adulterate with other species and so adulterated substances may be used as a medicine in local areas. The dry fruits of the adulterants are very similar in odour, morphology, chemical constituents and anatomical characters and are difficult to distinguish. Zhao *et al.* (2001) characterized *A. galanga* and the species used as adulterants using the nuclear ribosomal DNA internal transcribed spacer (nrDNA ITS) region sequences: the molecular markers are used to distinguish the drug at DNA level.

## 5.4 Angelica

The genus *Angelica* is a unique member of the family Apiaceae (formerly Umbelliferae), for its pervading aromatic odour, entirely different from other members such as fennel, parsley, anise and caraway: here even the roots are aromatic. There are more than 40 species of *Angelica,* but *A. archangelica* (syn. *A. officinalis* Moench; *Archangelica officinalis* (Moench) Hoffm.) is the only one officially used in medicine and as a spice. As the name indicates, the folklore of North European countries and nations affirms to its merits as a protection against communicable disease, for purifying the blood, and for curing every conceivable malady. According to one Western legend, *Angelica* was revealed in a dream by an angel as a gift of Mother Angel to cure the plague. Another explanation of the name of this plant is that it blooms on the day of Michael the Archangel, and is on that account an additive against evil spirits and witchcraft. It was valued so much that it was called 'The Root of the Holy Ghost' (Grieve, 1931).

The fruit, young stem and roots are used as food additives and for flavouring (Anon., 2001), for human consumption as a beverage base such as herbal tea and liquors, in medicines (Duke, 1985) and also as an ornamental.

### 5.4.1 Origin and distribution

The crop is indigenous to Northern Europe and distributed in Temperate Asia – in regions such as Georgia, the Russian Federation (Ciscaucasia, Western Siberia) and also European countries such as Belarus, the Czech and Slovak republics, Denmark, Estonia, Finland, Germany, Iceland, Latvia, Lithuania, the Netherlands; Norway, Sweden, Ukraine, and also the European part of the Russian Federation and New Zealand. The crop seems to be widely naturalized elsewhere (Wiersema and Leon, 1999). In several London squares and parks, angelica has continued to grow, self-sown, for several generations as a garden escape; in some cases it is appreciated as a useful foliage plant, in others, it is treated rather as an intruding weed. It was exceedingly common on the slopes bordering the Tower of London on the north and west sides and the inhabitants held the plant in high repute, both for its culinary and medicinal use.

Angelica grows in temperate regions at altitude 1000–4000 m and is commercially grown in Belgium, Hungary and Germany. There are 30 or more varieties of angelicas growing around the world. China alone boasts at least ten varieties. In India, angelica is found in a natural state in Kashmir (near water channels) at altitudes of 1000–3900 m, in Himachal Pradesh, Uttar Pradesh, at altitudes of 1800–3700 m and Sikkim at 3000–3300 m. It has also been reported from Rajasthan at an attitude of 1200 m and from Bihar. Both *A. archangelica* and its related species *A. glauca* are aromatic and used as herbal spices.



### 5.4.2 Botany and description

Angelica is a stout, aromatic perennial herbaceous plant that flowers every two years. Its habit is confusing, and it is a biennial in the botanical sense of that term. The seedlings attain maturity within 12 months. The plants usually set seed in their third year of growth and the plants die off after seeding once. Rarely, plants flower in their second year.

Angelica is glabrous and it grows to a height of 2–3 m. The stems are hollow, round, jointed, channelled, smooth and purplish; the leaves are ovate, 30–90 cm, 2–3 pinnate, ultimate pinna toothed, leaflets few, ovate or lanceolate. The root is tuberous, aromatic warm, pungent and of bitter sweet taste. The roots of the common angelica are long and spindle-shaped, thick and fleshy and with many long, descending rootlets.

Angelica blossoms in July. The flowers are small and numerous, yellowish or greenish-white in colour, and are grouped into large, globular umbels. Fruits are pale yellow, oblong, 4–6 mm (1/6 to 1/4 inch) in length when ripe, with membranous edges, flattened on one side and convex on the other, which bear three prominent ribs. Both the odour and taste of the fruits are pleasantly aromatic. The schizocarps are oblong or sub-quadrate, somewhat corky, 13 mm × 6 mm. The seeds are dorsally much compressed.

### 5.4.3 Chemistry

Angelica contains an essential oil, 0.1–0.4% in fresh roots and 0.5–1% in dried root. Fruits contain 1.2–1.3% oil. Oil is extracted by prolonged steam distillation. The major constituents of the root oil are α-pinene, β-pinene, *p*-cymene, dihydrocarvone, terebangelene and other terpenes, sesquiterpene ketones, angelic acid, valeric resin, alcohols and various acids such as aconitic acid, malic acid, quinic acid, citric acid and oxalic acid. The roots contain five furanocoumarins. The medicinal properties are attributed to these compounds, namely archangelin, prangolarin, oxypeucedanin hydrate, ostsathol and osthol. These are reported to have effect in curing leucoderma. The root oil also contains angelicin, archangelicin, umbelliferone, tiglic acid, etc. Angelicin and archangelin are reported to have spasmolytic activity (Harborne and Baxter, 1993). The phellopterin from fruit is identified as 4-methoxy-7-(γ,γ-dimethylallyloxy)-psoralen by degradation and synthesis. Seed oil typically is quite a bit higher in β-phellandrene (35-65%) and lower in the musk components (pentadecanolide and tridecanolide) than the root oil. Root oil contain between 10 and 30% β-phellandrene. The seed oil also contains in addition methyl-ethylacetic acid and hydroxy-myristic acid umbelliprenin, isoimperatorin, bergapten, prangolarin, ostruthol and oxypeucedanin hydrate (Harborne and Baxter, 1993; Rastogi and Mehrotra, 1990, 1993; Anon., 2001; http://www.naturedirect2u.com).

Essential oils isolated by hydrodistillation and supercritical $CO_2$ extraction on analysis revealed that the two oils had a widely different percentage composition and the one extracted through supercritical fluid extraction (SFE) exhibited a higher number and concentration of oxygenated compounds (Paroul *et al.*, 2002).

The effect of potential precursors (cinnamic acid, phenylalanine, tyrosine) in three concentrations (0.01; 0.1; 1 mmol/l) on the growth of the culture and coumarin production

was investigated in the suspension culture of *A. archangelica*. The cultures were cultivated under constant illumination (3500 lux) and in the dark. Under constant illumination, coumarin production was decreased by the action of cinnamic acid, but not by tyrosine and phenylalanine (0.01 and 0.1 mmol/l), increased it in comparison with the culture without precursors (Siatka and Kasparova, 2002). Angelica balsam is obtained by extracting the roots with alcohol, and evaporating and extracting the residue with ether. It is a dark brown colour and contains angelica oil, angelica wax and angelicin.

Twenty solvents were tested in the extraction of compounds from the roots of angelica and the calcium-antagonistic activity of the extracts was investigated. Chloroform was found to be the best solvent for the extraction of non-polar, biologically active compounds from the roots of *A. archangelica* (Harmala *et al.*, 1992).

### 5.4.4 Functional properties and toxicology

The furanocoumarin content in the leaves is reported to be phytotoxic (Ojala, 1999). Salikhova and Poroshenko (1995) reported that the antimutagenic effect of angelica against thio-TEPA (triethylenethiophosphoramide) mutagenicity in murine bone marrow cells is greater with pretreatment (two hours before) than simultaneous treatment. A commercial preparation, STW 5, consisting of angelica extract along with eight other plant extracts, was tested for its potential anti-ulcerogenic activity against indometacin-induced gastric ulcers of the rat and found beneficial. The cytoprotective activity of the extract was assigned to its flavanoid content and free radical scavenging properties (Khayyal *et al.*, 2001).

### 5.4.5 Cultivars and varieties

One variety, Dong Quai, is used in China (http://www.naturedirect2u.com). Lundqvist and Andersson (2001) studied the genetic diversity of Angelica along the free-flowing Vindel River in northern Sweden, using starch gel electrophoresis. The diversity was found to increase downstream. Angelica is an insect-pollinated out breeder and the seeds may float for over a year. Dispersal appears to be related to the floating ability of propagules.

### 5.4.6 Cultivation and production

Propagation is through seed and root propagules. The plant is cultivated in ordinary deep, moist loam, in a shady position, as it thrives well in a damp soil and loves to grow near running water. Seeds should be sown as soon as possible after removing them from the plant; however, they can be stored in a plastic container under refrigeration. Fresh seeds are sown outdoors in autumn for exposure to frost or prechilled in a refrigerator for a few weeks before sowing in spring. Four to six-leaved seedlings are transplanted to a moist shady position, before the roots become immovable. Mulching and irrigation must be provided as required. Angelica needs plenty of fertilizer and moisture.

Red spider mites attack angelica when conditions are dry, so spraying the underside of leaves daily during dry spells is recommended. Application of sulphur on the infested plants early in the morning when the plants are damp are also practised, as the powder will stick better.

Offshoots, produced after harvest of stems, can be transplanted to 60 cm apart and provides a quick method of propagation. This method is considered inferior to that of raising by seed, which as a rule will not need protection during winter.



### 5.4.7 Harvesting and processing

Leaves are harvested in the spring before the plant blooms. The leaves, stems, seeds and roots are edible and used in cooking, candying, tisanes, teas and liqueurs. Flower stalks and leaf stalks are best when harvested in April–May while leaves are best for flavouring when harvested in June, just before flowering. Roots are dug up just before flowering and dried slowly (Westland, 1987; Clevely and Richmond, 1999).

The seeds are gathered when ripe and dried. The seed-heads should be harvested on a fine day and dry in shade. When dry they are beaten with a rod to remove seeds. Seeds are further dried and stored.

Oil of angelica, which is very expensive, is obtained from seeds by distillation with steam, the vapour being condensed and the oil separated by gravity. A mass of 100 kg of angelica seeds yield 1 kl of oil, and the fresh leaves a little less, the roots yielding only 0.15–0.3 kg.

### 5.4.8 Quality issues

Leaves, leaf stalks, flower stalks and root oil are the products. Oil is extracted from the root, fruit or seed of the plant. Fresh roots yield oils of lighter colour and more pronounced terpene content. Oil distilled from older roots is darker, more viscous and has a characteristic musk-like odour. Oil from young roots (or from the seed) exhibits a light, somewhat peppery top note missing in oils from older (2–3 yr) roots. Seed oil is colourless or very pale yellow with a strong, fresh, light peppery odour. It is sometimes used to adulterate the root oil and can be difficult to detect (http://www.naturedirect2u.com).

### 5.4.9 End uses

*In food flavouring*

Angelica is a favourite flavouring herb in Western culinary art. Leaves are used dried or fresh as a tisane, which helps in reducing fever and cold. Because of its lovely colour and scent it is often used to decorate cakes and pastry and for flavouring jams. Angelica jams and jellies are favourites. Leaf stalks are employed in confectionery. Young leaves and shoots are used to flavour wine and liquors, while the stout stems are candied as a cake decoration or cooked like rhubarb. Essential oil is used in the perfume and flavour industries. Angelica root is the main flavouring ingredient of gin. It is widely used in liqueurs such as benedictine, chartreuse, cointreau and vermouth (http://www.naturedirect2u.com).

Angelica is largely used in the grocery trade, as well as for medicine, and is a popular flavouring for confectionery and liqueurs. The appreciation of its unique flavour was established from ancient times. The preparation of angelica is a small but important industry in the south of France, its cultivation being centralized in Clermont Ferrand. The stem is largely used in the preparation of preserved fruits and '*confitures*' generally, and is also used as an aromatic garnish by confectioners. The seeds, which are aromatic and bitterish in taste, are employed in alcoholic distillates, especially in the preparation of vermouth and similar preparations, as well as in other liqueurs. From ancient times, angelica has been one of the chief flavouring ingredients of beverages and liqueurs. The seed oil is used as flavouring for beverages and also medicinally. Chopped leaves of angelica may be added to fruit salads, fish dishes and cottage cheese in small amounts. Leaves are added to sour fruit such as rhubarb to neutralize acidity. Stems are boiled with jams to improve the flavour. Young stems can be used as a substitute for celery. All parts

promote perspiration, stimulate appetite and digestion, and are used to treat ailments of the chest. Young leaves and shoots are used to flavour wines and liqueurs, while the stout stems are candied as a cake decoration. Fresh or preserved roots have been added to snuff and used by Laplanders and North American Indians as tobacco (Clevley and Richmond, 1999).

In order to retain their medicinal virtues for many years, angelica roots are dried rapidly and placed in airtight containers. Fresh root has a yellowish-grey epidermis, and yields a honey-coloured juice, when bruised, having all the aromatic properties of the plant. If an incision is made in the bark of the stems and the crown of the root at the commencement of spring, this resinous gum will exude. It has a special aromatic flavour of musk or benzoin, and can be used as a substitute for either of these. The dried root, as it appears in commerce, is greyish brown and much wrinkled externally, whitish and spongy within and breaks with a starchy fracture, exhibiting shining, resinous spots. The odour is strong and fragrant, and the taste at first sweetish, afterwards warm, aromatic, bitterish and somewhat musky. These properties are extracted by alcohol.

*In medicine*

The roots, leaves and seeds are used for medicinal purposes. The whole plant is aromatic, but the root is official only in the Swiss, Austrian and German pharmacopoeias. For medicinal use, the whole herb is collected in June and cut shortly above the root. If the stems are too thick, the leaves may be stripped off separately and dried on wire or netting trays. The stem, which is in great demand when trimmed and candied, should be cut in about June or early July.

Properties of the herb (and extract) are: antispasmodic, aphrodisiac, anticoagulant, bactericidal, carminative, depurative, diaphoretic, digestive, diuretic, emmenagogue, expectorant, febrifuge, hepatic, nervine, stimulant, stomachic and tonic. Powdered root is administered to children in warm water for stomach complaints to check vomiting. It is also used in leucoderma. All parts promote perspiration, stimulate appetite, and are used to treat ailments of the chest and digestion (Westland, 1987). It is an alternative to artificial hormones during the menopause, a remedy for menstrual problems, a tonic for anemia, and a treatment for heart disease and high blood pressure. Medieval and Renaissance herbalists noted the blood-purifying powers of angelica. It was used as a remedy for poisons, agues and all infectious maladies. The fleshy roots were chewed and burnt to ward off infection during the 14th- and 15th-century plagues. It stimulates production of digestive juices, improves the flow of bile into the digestive tract, and combats digestive spasms. The oil has been recommended for treating a weak stomach or digestive system, lack of appetite, anorexia, flatulence, chronic gastritis and chronic enteritis. It is also used to reduce accumulation of toxins, arthritis, gout and rheumatism and water retention. In the traditional Chinese medicine, angelica is used for damp, cold intestinal conditions with underlying spleen *Qi* deficiency, as well as chronic lung, phlegm, cold syndromes with painful wheezing. In aromatherapy, it is a germ killer, excellent for coughs and colds, flu, muscular aches, fatigue, migraine, nervous tension, stress and rheumatism. It has a calming effect on the digestion and is relaxing (http://www.naturedirect2u.com).

The yellow juice from the stem and root, when dry, is a valuable medicine in chronic rheumatism and gout. Taken in medicinal form, angelica is said to cause disgust for alcoholic spirits. It is a good vehicle for nauseous medicines and forms one of the ingredients in compound spirit of aniseed.



### 5.4.10 Recipes and formulations

*To preserve angelica*

Cut into 10 cm (4 inch) long pieces and steep for 12 hours in salt and water. Put a layer of cabbage or cauliflower leaves in a clean brass pan, then a layer of angelica, then another layer of leaves and so on, finishing with a layer of leaves on the top. Cover with water and vinegar. Boil slowly until the angelica becomes quite green, then strain and weigh the stems. Use 1 kg loafsugar to each kg of stems. Put the sugar in a clean pan with water to cover; boil for ten minutes and pour this syrup over the angelica and allow to stand for 12 hours. Pour off the syrup, boil it up for five minutes and pour it again over the angelica. Repeat the process, and after the angelica has stood in the syrup for 12 hours, put in a brass pan and boil until tender. Then take out the angelica pieces, put them in a jar and pour the syrup over them, or dry them on a sieve and sprinkle them with sugar: they then form candy. Confectioners have evolved their own methods of candying angelica.

*Angelica liqueur*

A delicious liqueur, which is also a digestive, preserving all the virtues of the plant, is made in this way: 28 g (1 ounce) of the freshly gathered stem of angelica is chopped up and steeped in 1.2 l (two pints) of good brandy for five days together with 28 g (1 ounce) of skinned bitter almonds reduced to a pulp added. The liquid is then strained through fine muslin and 0.6 l (1 pint) of liquid sugar added to it.

Angelica is used in the preparation of vermouth and chartreuse. Though the tender leaflets of the blades of the leaves have sometimes been recommended as a substitute for spinach, they are too bitter for the general taste, but the blanched mid-ribs of the leaf, boiled and used as celery, are delicious, and Icelanders eat both the stem and the roots raw, with butter. In Lapland, the inhabitants regard the stalks of angelica as a great delicacy. The Finns eat the young stems baked in hot ashes, and an infusion of the dried herb is drunk either hot or cold. Angelica makes a drink much in use in Continental Europe for typhus fever: pour 1.2 l (2 pints) of boiling water on 170 g (6 oz) of angelica root sliced thin, infuse for half an hour, strain and add juice of two lemons, 110 g (4 oz) of honey and 70 ml (1/8 pint) of brandy. The Norwegians use the roots for making breads.

## 5.5 Horseradish

Horseradish (*Armoracia rusticana* P. Gaertn., B. Mey. and Scherb) belongs to the family Brassicaceae (Cruciferae) and contains the distinctive mustard oils that are common to this family. The plant is known by various common names such as horseradish, red cole, creole mustard, German mustard, horse-radish root (archaic) and red horseradish.

Horseradish is a pungent herb, with leaves that are used in salads and sandwiches, and roots that are used for sauces that are added to meat. It is also used for various medical complaints. Both the leaves and roots were used extensively as medicine in Europe during the Middle Ages.

### 5.5.1 Origin and distribution

Horseradish is native to Europe and Asia (southern Russia, eastern Ukraine), but has become naturalized in North America and New Zealand, where it can be found growing along roadsides. Cultivation dates back only to about Roman and Greek times, about 2000

years ago (Simon *et al.*, 1984; Phillips and Rix, 1993; Brown, 2002). The crop was introduced into Western Europe in the 13th century.

It is grown in the USA and about $7 \times 10^6$ kg of horseradish are processed annually for consumption as food. The crop is cultivated over 600 ha (1500 acres) in the USA. In India it is found growing to a small extent in gardens in North India and hill stations of South India.

For proper growth, horseradish needs a temperature between 5 and 19°C with an annual precipitation of 50–170 cm and a soil pH of 5.0–7.5. The hardy horseradish thrives in moist, semi-shaded environments of the north-temperate regions of North America. Although the plant will grow on any soil type, best growth is in deep, rich loam soil, high in organic matter (Simon *et al.*, 1984). Principal production areas are located in the USA and, to a lesser extent, Europe.

### 5.5.2 Botany and description

Horseradish is a hardy perennial root crop, grown for the very pungent roots, which contain oil with a strong pungent odour and hot, biting taste. The plant attains a height of 0.6–0.9 m (2–3 ft) when in flower. Propagation is by planting pieces of side roots, which are taken from the main root when the latter is harvested. The roots develop entirely underground and grow to a metre (3 ft) in length. The top of the plant consists of a rosette of large paddle-shaped leaves and a flower stalk; it rarely produces seeds. White flowers, with a sweet honey scent, are produced on terminal panicles in late spring. Horseradish may be an interspecific hybrid and is reported to be generally sterile (Anon., 2001).

There are two types of horseradish: (i)'common' type with broad crinkled leaves and roots of high quality and (ii) 'Bohemian' type with narrow smooth leaves and poor-quality roots, but which is more disease resistant (Anon., 2001).

### 5.5.3 Chemistry

The root contains a pungent, acrid and vesicating volatile oil. Distillation of the dried and powdered root gives about 0.05–0.2% volatile oil. The intense pungency and aroma of horseradish are the result of isothiocyanates released from the glucosinolate sinigrin and 2-phenylethylglucosinolate by the naturally occurring enzyme myrosinase, in the presence of water. The active constituents are sinigrin (a glycoside, combined with water yields mustard oils), asparagine and resin (Karnick, 1994b). The root is a rich source of vitamin C; the fresh root contains an average of 302 mg per 100 g. Harborne and Baxter (1993) reported the presence of glucoberteroin, glucobrassicanapin, glucocapparin, glucocheirolin, glucochlearin, glucoiberin, glucoiberverin, glucolepidiin, gluconapin, glucotropaeolin and sinigrin from horseradish. Though the undisturbed root has little odour, pungency develops upon crushing or grinding the tissue. The roots are usually processed under refrigeration immediately after dicing, because of the high volatibility of the oil.

### 5.5.4 Cultivation and production

Horseradish is planted with root crowns and root cuttings. Traditionally grown as a perennial in Eastern Europe, the plant is cultivated as an annual in the USA. The originally planted root cuttings are harvested for market and the newly developed lateral roots are broken off and stored in the dark for planting during the following season. The planted roots increase in diameter, but not length, by the end of the growing season (October or November). Horseradish prefers deep, fertile soil with good moisture retention. However, it



is tolerant to most soils and grows in full sun or semi-shade. The ground should be prepared in the spring before planting and well-rotted manure and garden compost added. Crown cuttings can be taken in the spring by carefully lifting a healthy section of the plant and gently teasing out a portion of the root, with a section of the crown and at least one fresh crown bud. This should be placed in a prepared site and watered well. Root cuttings can be taken in the spring, autumn or early winter. Pieces of older roots, the thickness of a pencil, should be cut into 13–21 cm long pieces and planted at 30 cm spacing in a trench 10–13 cm deep.

### 5.5.5 Harvesting and processing

The flavour of the root is reported to be improving in cold weather. The roots, approx. 20–35 cm long are dug between October and December. Large roots should be used for flavouring sauces whereas the thinner roots can be used for propagation. Roots harvested in the spring produce a milder flavour. Leaves are picked when young in the spring and early summer and added to salads. Leaves can also be dried and stored in an airtight container.

### 5.5.6 Quality issues

The processed horseradish is sometimes adulterated with a mixture of turnips or parsnips. It is sometimes fortified with allylisothiocyanate (synthetic mustard oil) to get the desired pungency. Chemical analysis and infrared spectrum of volatile oil can detect the nature and extent of this type of adulteration, but to a very limited extent.

### 5.5.7 End uses

*Culinary uses*

Horseradish is used as an appetizing spice. The high vitamin C content present in it is attributed for its digestive and anti-scorbutic properties. Leaves are used in salads and sandwiches. Grated roots are used alone, or in combination with apple, as a spice for fish. Horseradish is made into a sauce with vinegar and cream that is used with roast beef, cold chicken or hard-boiled eggs. In Eastern Europe, it is used as a condiment in combination with beets. Leaves and roots are used as food in Germany. As a spice the horseradish root is usually grated or minced and mixed with vinegar, salt, or other flavourings to make sauce or relish. These are often used with fish or other seafood or as an appetizer with meats. The plant material is also employed as an ingredient in some ketchups and mustards. Horseradish is available in a dehydrated form.

*Medicinal uses*

The herb evidently controls bacterial infection, this effect being attributed to allylisothiocyanate. It lowers fever by increasing perspiration, acts as a diuretic, stimulant, diaphoretic, digestive and also stimulates circulation. Excess internal consumption can lead to vomiting or the development of an allergic response. It is claimed to be used in the treatment for general debility; arthritis; gout; respiratory infections; urinary infections; and fevers. It is applied externally as a poultice for infected wounds; inflammation of the pleura; arthritis and inflammation of the pericardium (Phillips and Rix, 1993; Brown, 2002). The fresh root of horseradish has been considered to be an antiseptic, diaphoretic, diuretic, rubefacient, stimulant, stomachic and vermifuge. The material has also been used as a remedy for

asthma, coughs, colic, scurvy, toothache, ulcers, venereal diseases and cancer. The roots are also used as a digestive stimulant, diuretic, to increase blood flow and also in rheumatism (Karnick, 1994b). Peroxidase enzyme is extracted from the plant root and used as an oxidizer in chemical tests, such as blood glucose determinations. Horseradish has strong irritant activity and ingestion of large amounts can cause bloody vomiting and diarrhea. Livestock feeding on tops or roots of horseradish may be poisoned. The volatiles of horseradish root are reported to have herbicidal and microbial activity.

### 5.5.8 Functional properties and toxicology

Horseradish is generally recognized as safe for human consumption as a natural seasoning and flavouring. The root and leaves are said to contain oils with antibiotic qualities. The pungency of the volatile oil has been known to clear sinuses. The root also contains useful minerals including calcium, sodium, magnesium and vitamin C.

### 5.5.9 Recipes and formulations

*Horseradish sauce*

Ingredients: full cup of thick cream (or Greek yogurt); two tablespoons of freshly grated horseradish, one teaspoon of freshly chopped parsley, two tablespoons of white wine vinegar and pinch of salt. Place the cream and horseradish in a bowl and mix gently. Add parsley and other ingredients and mix well. Keep at room temperature or store in an airtight tub. Serve with various meats or fish.

## 5.6 Black caraway

Black caraway (*Bunium persicum* Boiss Fed. (syn. *Carum bulbocastanum*) ) is a perennial aromatic spice belonging to the family Apiaceae. It is a temperate plant, naturally occurring in the dry temperate regions of the northwest Himalayas, where the winter is severe, and the ground is under snow in winter. A long chilling period is essential for germination of seeds. In India the plant occurs in the alpine areas of Himachal Pradesh and Kashmir and Utharanchal. Black caraway is often confused with black cumin (*Niglella sativa*) and caraway (*Carum carvi*).

### 5.6.1 Production and international trade

The production and export figures of black caraway are not available. The area under the crop is estimated to be about 300 ha and the annual yield is around 400–600 tonnes.

### 5.6.2 Botany and description

Black caraway is a temperate perennial; the plant habit is dwarf or tall, spreading or compact, the height ranging from 30 to 80 cm. The plant is branched, tuberous; leaves 2–3 pinnate, finely dissected, flowers white, borne on compound umbels, fruit vicid, ridged, vittae 3–5 mm long, brown to dark brown. The crop is naturally cross-pollinated. The plant has $2n = 14$ as its chromosome number. The crop is not subjected to any vigorous crop improvement work.



### 5.6.3 Chemistry

The chemical composition has not been worked out in detail. The principal constituents of the essential oil are cuminaldehyde (45.4%) and *p*-cymene (35%). Carvone, limonene, α-pinene, β-pinene, cymene and terpinene are the minor constituents (Kaith, 1981).

### 5.6.4 Cultivars and varieties

There are no approved varieties or improved cultivars. However, four distinct morphotypes are available (dwarf compact, dwarf spreading, tall compact, tall spreading).

### 5.6.5 Cultivation and production

The propagation is both vegetative (through bulbs) or through seeds. In vegetative propagation bulbs that are three or four years old and of 3–4 cm diameter are used: About $2.5 \times 10^5$–$3 \times 10^5$ bulbs are needed for a hectare (Munshi *et al.*, 1989). When seed is used, 1–1.5 kg seeds/ha is sown in the first year, and in the second year re-seeding at the rate of 200 g/ha is practised to maintain the required population. Sowing is in September–October in rows spaced at 15–20 cm, in raised beds. Germination takes place after the winter in April. During the growing period, growth and development of aerial shoot and underground tubers takes place, and in the ensuing winter the aerial portion dies out and the tubers remain dormant in the soil (Panwar 2000). A fertilizer dose of 20–25 kg farmyard manure (FYM), 60 kg of nitrogen, 30 kg of phosphorus and 30 kg potash per hectare is recommended for good yield (Panwar *et al.*, 1993, Panwar, 2000). Irrigation is recommended at peak flowering and seed formation stage (Badiyala and Panwar, 1992).

Black caraway is attacked by blight caused by *Alternaria*; rust caused by *Puccinia bulbocastanii*, powdery mildew caused by *Erysiphae polygoni* and bulb rot caused by *Fusarium solani.* However, the growers do not adopt any fungicide application. The major insect pests are white grub, hairy caterpillar, armyworms and semi-loopers (Sharma *et al.*, 1993).

### 5.6.6 Harvesting and processing

The plant takes four years from seed to seed, but when grown from 3–4-year-old bulbs, the flowering takes place in the next season itself. The seeds are ready to harvest in July. Harvesting is when the fruits turn light brown and before full ripening, to avoid shattering. Plants are cut and stacked for drying and then threshed by beating with sticks. Seeds are winnowed, dried, cleaned and stored in airtight containers.

Black caraway oil is extracted by steam distillation of crushed seeds. The oil content is about 5–14% in fresh seeds and 3–6% in dried seeds. The straw contains black caraway herb oil to the extent of 1.25%. The commercial products are seed, seed oil and solvent extracted oleoresin.

### 5.6.7 End uses

Seeds are widely used as a spice, for flavouring dishes, especially in north Indian, Persian and Mughalai dishes. The hill tribes eat the tubers either raw or after cooking. The essential oil is used in processed food industry and in perfumery. Oleoresin is used in processed foods.

Black caraway is also important medicinally and used in *Ayurvedic* medicinal formulations.

Seeds are stimulants and carminative and are used in treating diarrhoea, dyspepsia, fever, flatulence, stomachic, haemorrhoids and hiccoughs.

### 5.6.8 Quality issues

The bazaar product is always adulterated with fruits of *Bupleurum falcatum* L., coloured with walnut bark decoction and sometimes with the seeds of *Daucus carota.*

## 5.7 Capers

Capers (also known as caperberry or caperbush) are immature flower buds of *Capparis spinosa* L. (syn. *Capparis rupestris*), also known as *Capparis ovata* Desf. belonging to the family Capparidaceae. The flower buds are pickled in vinegar or preserved in granular salt. Semi-mature fruits (caperberries) and young shoots with small leaves may also be pickled for use as a spice. Two types of capers occur: *C. spinosa* (spiny in nature) and *C. inermis* (no spines). Use of this plant has been known since Biblical times (Morris and Mackley, 1999).

### 5.7.1 Origin and distribution

There is a strong association between the caper bush and oceans and seas. *Capparis spinosa* is said to be native to the Mediterranean basin, but its range stretches from the Atlantic coasts of the Canary Islands and Morocco to the Black Sea to the Crimea and Armenia, and eastward to the Caspian Sea and into Iran. Capers probably originated in the dry regions in west or central Asia (Jacobs, 1965; Zohary, 1969). Known and used for millennia, capers were mentioned by Dioscorides as being a marketable product of the ancient Greeks. Capers are also mentioned by the Roman scholar Pliny the Elder.

Dry heat and intense sunlight provide the preferred environment for caper plants. Plants are productive in zones having 350 mm annual precipitation (falling mostly in winter and spring months) and survive summertime temperatures of 40°C. However, caper is a tender plant of the cold and has a temperature hardiness range similar to the olive tree (–8°C).

Plants grow well in nutrient-poor sharply drained gravelly soils. Mature plants develop extensive root systems that penetrate deeply into the earth. Capers are salt-tolerant and flourish along shores within sea-spray zones.

### 5.7.2 Production and international trade

Locally, capers are collected from wild plants within their natural range. European sources are Spain, Greece, Dalmatia, Grenada and Balearic Islands, France and Italy (especially Sicily and the Aeolian island of Salina and the Mediterranean island of Pantelleria). Capers are also cultivated in Armenia, Algeria, Egypt, Morocco, Tunisia, Asia Minor, Cyprus and the Levant, the coastal areas of the Black Sea, and Iran. Areas with intensive caper cultivation and production are Spain (2600 ha) and Italy (1000 ha).

### 5.7.3 Botany and description

Caper plants are small shrubs, and may reach about 1 m in height. However, uncultivated caper plants are more often seen hanging, draped and sprawling as they scramble over soil and rocks. The caper's vegetative canopy covers the soil surface, which helps to conserve soil water reserves. Leaf stipules are transformed into spines. Flowers are borne on first-year branches. The flowers are pink with long tassels of purple stamens. The flowers open in the morning and close by noon.



### 5.7.4 Chemistry

Flower buds contain a glycoside, rutin, which on acid hydrolysis yields rhamnose, dextrose and quercetin. Flower buds also contain about 4% pentosans on a dry weight basis, rutic acid, pectic acid and saponin. Caper seeds yield about 35% pale yellow oil containing palmitic, stearic, oleic and linoleic acids. The root bark contains rutic acid and a volatile substance with a garlic odour. A series of isomers of the compound cappaprenols have been isolated from *Capparis.* Glucobrassicin, neoglucobrassicin and 4-methoxyglucobrassiin were identified in the roots by high-performance liquid chromatography (HPLC) (Rastogi and Mehrotra, 1995).

Two (6*S*)-hydroxy-3-oxo-alpha-ionol glucosides, together with corchoionoside C ( (6*S*, 9*S*)-roseoside) and a prenyl glucoside, were isolated from mature fruits of *C. spinosa* (Calis *et al.*, 2002).

### 5.7.5 Cultivars and varieties

Varieties have been developed for characters such as spinelessness, round, firm buds, and flavour, through selection. High-yielding caper plants and types with short and uniform flowering periods have not been developed. Some of the varieties are:

- 'enza spina' – Italian selection, form without stipular spines;
- 'spinosa comune' – Italian form with stipular spines;
- 'inermis' – without stipular spines;
- 'josephine' – one of the better Mediterranean selections;
- 'aculeata'; 'dolce di Filicudi e Alicudi' – from the Aeolian Archipelago;
- 'nuciddara' or 'nucidda' 'nocellana' – spineless, with globose buds, mustard-green colour, and strong aroma;
- 'testa di lucertola'; 'tondino' – grown on the island of Pantelleria.

### 5.7.6 Cultivation and production

Plants are grown from seeds as well as through vegetative cuttings. Caper seeds are very small, and germinate readily – but only in low percentages (Barbera and Di Lorenzo, 1984; Bond, 1990). Various factors such as unit fruit weight, fruit position on mother plant, maturity of the fruit, etc are reported to influence caper seed germination (Pascual *et al.*, 2003). Dried seeds should be initially immersed in warm water (40°C) and then allow to soak for one day. Seeds are then wrapped in a moist cloth, placed in a sealed glass jar and kept in the refrigerator for two or three months. After refrigeration, seeds should be soaked again in warm water overnight and then sown about 1 cm deep in a loose, well-drained soil medium. Young caper plants can be grown in a greenhouse (preferable minimum temperature of 10°C).

Vegetative propagation by stem cuttings is easy. Cuttings from the basal portions are collected in February, March or April. A loose, well-drained medium with heat from below is used for rooting. A dip in an indole 3-butyric acid (IBA) solution of 1.5–3.0 ppm is recommended (15 seconds). Transplanting is carried out during the wet winter and spring periods, and first-year plants are mulched with stones. In Italy, plants are spaced 2–2.5 m

apart (depending on the roughness of the terrain; about 2000 plants per hectare). A full yield is expected in three or four years. Plants are pruned back in winter to remove dead wood and water sprouts. Pruning is crucial to high production: heavy branch pruning is necessary, as flower buds arise on 1-year-old branches. Three-year-old plants will yield 1–3 kg of caper flower buds per plant. Grown from seed, California caper bushes reportedly begin to flower in the fourth year; however, Italian sources report some flowering from first year transplants. Caper plantings will live for 20–30 years. Propagation by cutting as well as seeds present serious problems which affects cultivation (Barbera and Di Lorenzo, 1984). Propagation of caper through tissue culture was also reported (Ancora and Cuozzo, 1984).

Two viruses, namely, Caper Latent Carla virus and Caper Vein Yellowing Virus, have been reported in Puglia, Italy. Viruses are transmitted by mechanical inoculation, by grafting and by vegetative propagation of cultivated varieties. Certain insect pests may also be vectors. Various fungi that infect the crop are *Albugo capparidis* De Bary, *Aschochyta capparidis* (Cast.) Sacc., *Botrytis* – grey mould, *Camarosporium suseganense* Sacc. and Speg., *Cercospora capparidis* Sacc., *Cloeosporium hians* Peck and Sacc., *Hendersonia rupestris* Sacc. and Speg., *Leptosphaeria capparidis* Pass., *Phoma capparidina* Pass., *Phoma capparidis* Pass., *Phyllosticta capparidis* Sacc. and Speg., *Septoria capparidis* Sacc., etc.

Various insect pests of capers are *Acalles barbarus* Lucas – a weevil that attacks roots; *Asphondylia capparis* Rubs. – a dipterian (Cecidomyiidae) that disfigures flower buds; *Calocoris memoralis* Sacc., *Cydia capparidana* Zeller – a lepidopteran that disfigures flower buds and *Eurydema ventralis* Kolen.

### 5.7.7 Harvesting and processing

The unopened flower buds should be picked on a dry day. Harvesting is carried out regularly throughout the growing season. The bushes are checked every morning for small, hard buds that are just at the right stage for harvesting. These buds are to be picked by hand and this labour-intensive harvesting makes this herb an expensive one. In southern Italy, caper flower buds are collected by hand about every 8–12 days, resulting in 9–12 harvests per season.

The capers are washed and allowed to wilt for a day in the sun. The wilted buds are stored in jars and covered with salted wine vinegar, brine, olive oil or in salt alone (Morris and Mackley, 1999). Capers should always be submerged in their pickling medium to prevent them from developing an off-odour. Capers are preserved either in vinegar or under layers of salt in a jar. Raw capers are bland flavoured and need to be cured to develop their piquant flavour. In Italy, capers are graded on a scale from 7 to 16, which indicates their size in millimetres. Mechanized screens are used to sort the various sized capers after being handpicked from the hillsides.

In French-speaking countries, capers are graded using the terms '*nonpareilles*' and '*surfines*'. Capers under a centimetre in diameter are considered more valuable than the larger *capucines* and *communes* (up to 1.5 cm diameter). Capers in vinegar are traditionally packaged in tall narrow glass bottles. Caper fruits (caperberry, capperone or taperone) may be used in making caper-flavoured sauces, or sometimes pickled for eating, like small gherkins.

### 5.7.8 Biological activity

Cappaprenol 13 from roots inhibited carrageenin-induced and oxyphenbutazone induced paw oedema in rats (Rastogi and Mehrotra, 1995).



### 5.7.9 End uses

Capers have a sharp, piquant flavour and add pungency, a peculiar aroma and saltiness to pasta sauces, pizza, fish, meats and salads. The flavour of caper may be described as being similar to that of a combination of mustard and black pepper. In fact, the caper's strong flavour comes from mustard oil: methyl isothiocyanate (released from glucocapparin molecules) arising from crushed plant tissues.

Capers make an important contribution to the pantheon of classic Mediterranean flavours that include: olives, rucola (argula, or garden rocket), anchovies and artichokes. Tender young shoots including immature small leaves may also be eaten as a vegetable, or pickled. More rarely, mature and semi-mature fruits are eaten as a cooked vegetable. Additionally, ash from burned caper roots has been used as a source of salt.

Capers are said to reduce flatulence and have an anti-rheumatic effect. In *Ayurvedic* medicine capers are recorded as hepatic stimulants and protectors, improving liver function. Capers have reported uses for arteriosclerosis, as diuretics, kidney disinfectants, vermifuges and tonics. Infusions and decoctions from caper root bark have been traditionally used for dropsy, anaemia, arthritis and gout. Capers contain considerable amounts of the antioxidant bioflavinoid, rutin. Caper extracts and pulps have been used in cosmetics, but there has been reported contact dermatitis and sensitivity from their use (Mitchell, 1974; Schmidt, 1979).

Chopped capers are an ingredient of a wide range of classic sauces, such as tartare, remoulade and ravigote sauces. They are also used in Italian tomato sauce, and in the famous dish of cold braised veal, *vitello tonnato*. In Britain, hot caper sauce is traditionally served with boiled mutton, salmon or pan-fried or grilled fish with the addition of a little grated lemon rind to complement the distinctive flavour. Capers are also used in other areas of Italian cooking, as flavouring in antipasti salads and as a topping on pizza. They are also used with fish and vegetable dishes in Northern and Eastern Europe (Morris and Mackley, 1999).

## 5.8 Asafoetida

Asafoetida is the dried latex (oleogum) obtained from the rootstocks (or taproots) of certain species of *Ferula* such as *F. asafoetida* L., *F. foetida* Regel, *F. alliacea* Boiss, *F. rubricaulis* Boiss, Linn. and *F. narthex* Boiss. *Ferula* belongs to the family Apiaceae. It is also known as Devil's dung, food of gods, asafetida, etc. Early records state that Alexander the Great carried this 'stink finger' to the West in 4 BC. It is also used as a flavouring agent in the kitchens of ancient Rome. This pungent, resinous gum is used widely in Indian vegetarian cooking (Morris and Mackley, 1999).

The whole plant exudes a strong characteristic smell. Several species of *Ferula* yield asafoetida. The bulk of the product comes from the official plant, *F. asafoetida*, which grows from 600 to 1200 m (2000–4000 feet) above sea level in Iran and Afghanistan. These high plains are arid in winter but are thickly covered in summer with a luxuriant growth of these plants. The cabbage-like folded heads are eaten raw by the local people.

### 5.8.1 Origin and distribution

The genus *Ferula* is indigenous to Iran and Afghanistan and in the Kashmir region of India. Major areas of occurrence are Iran and Afghanistan, followed by Turkey and Northern Kashmir. Commercially asafoetida is produced only in Iran and Afghanistan. *Ferula narthex* occurs in Northern Kashmir.

### 5.8.2 Botany and description

Asafoetida is a herbaceous perennial with fleshy, massive, carrot-shaped fleshy root covered with bristly fibres, root with one or more forks. The stem is 1.8–3 m high, solid, clothed with membraneous leaf sheaths; the leaves are radical, *ca* 45 cm long, shiny, coriaceous with pinnatifid segments and channelled petiole; there are pale green yellow flowers, about 10–20 in the main umbels and 5–6 in the partial umbels; fruits are thin, flat, foliaceous, reddish brown with pronounced vittae. *Ferula* is reported to be dioecious; the male plant producing only flowers without oleogum. It is the female plants that produce asafoetida.

### 5.8.3 Cultivars and varieties

Based on the relative flavour and quality there are various commercial varieties available. *Irani Ras*, *Irani Khada* and *Irani No. 1* are *'Irani'* varieties, whereas *Naya Chal*, *Hadda, Naya Zamin*, *Charas*, *Galmin*, *Khawlal*, *Kabuli* and *Shanbundi* are *'Pathani'* varieties.

### 5.8.4 Chemistry

Asafoetida contains about 62% of resin, 25% of gum and 7% oil, together with free ferulic acid, water, and small quantities of various impurities. In its raw state, the resin or powder has an unpleasant smell, but this completely disappears when the spice is added to preparations. The odour of asafoetida is stronger and more tenacious than that of the onion, the taste is bitter and acrid; the odour of the gum resin depends on the volatile oil.

The resin portion consists of asaresino tannol combined with ferulic acid, the other di- and trisulphides, and traces of various other compounds. The disagreeable odour of the oil is due to the disulphides. The volatile oil (6–17%) consists of sulphated turpenes, resin (40–60%), saresinatannol, ferulic acid and gum (25%) (Martindale,1996).

A sequeterpinoid coumarin (foetidin) and two coumarins (asafoetidin and ferocolicin) were isolated from roots and gum resin, respectively. Three new compounds (asadisulphide, asacoumarin and asacoumarin B) were isolated from resin prepared from roots and their structures elucidated usising $^{13}$C-NMR (Rastogi and Mehrotra, 1995). Six new sulphide derivatives (foetisulphide A, foetisulphide B, foetisulphide C, foetisulphide D, foetithiphene A and foetithiphene B) along with six known compounds were isolated and identified from ethyl acetate soluble fraction from a methanol extract of *F. foetida* (Duan *et al.*, 2002).

Luteolin exhibited antipolio virus activity, which was comparable to that of ascorbate-stabilized quercetin.

### 5.8.5 Cultivation and production

Nothing much is known about the agronomy of *Ferula*. At present it is grown probably as a poor man's crop in Iran and Afghanistan and little is known about the crop requirements.

### 5.8.6 Harvesting and processing

Asafoetida is an exudate obtained by tapping the rootstock or the thick carrot-shaped taproot of the plant. The process of tapping and asafoetida production involves the following operations.

Tapping is done in March–April following the winter. The upper part of the taproot is exposed by removing the surrounding soil and debris. Leaves are removed, leaving only a tuft of brush-like leaves at the top. The plant is allowed to remain like this for a week or so. Then the top of the rhizome along with the tuft of leaves is cut off with a sharp knife. The cut surface is then covered with leaves and earthed up to form a dome-shaped structure, probably to make the inside warm enough for the easy flow of resin from the cut end during the cool season and keep the area cool during the hot summer months. A milky juice exudes from the surface of the cut end. After four or five days the first collection of resin is given. Then a small portion of the root is again chopped off so that a fresh surface is exposed. After collecting the sap from the second cut a third cut is given. This process is repeated. Every time after the collection of resin, a fresh cut is given until the exudation stops, which takes about three months.

The resin collected is stored in pits dug in the ground. Usually the sides and bottom of the pits are plastered with mud and the top covered with leaves and twigs, leaving a small window. In the beginning asafoetida will be in the form of a sticky paste. Maturing takes place in the pits, and then the asafoetida is packed in jute bags for marketing.

A very fine variety of asafoetida is obtained from the leaf bud in the centre, but this does not come onto world market, and is only used in India, where it is known as *Kandaharre Hing*. It appears in reddish-yellow flakes and when squeezed gives out an oil.



### 5.8.7 Produce and products

There are two main types of asafoetida: *'Hing Kabuli Safaid'* is the milky white asafoetida obtained from *F. rubicaulis* and the *'Hinglal'* is the brown or red asafoetida (Irani and Pathan types). There is only one type of milky white asafoetida and two types of red asafoetida. Asafoetida is marketed in three forms – tears, mass and paste. Tears are the purest form, they are round or flat, about 15–30 mm diameter and have greyish or dull yellow colour. Mass is agglutinated tears mixed with extraneous matters. Paste is semi-solid and contains extraneous matter. Asafoetida is often adulterated with gum arabic, other gum resins, barley and wheat flour, red clay, gypsum, chalk, etc.

All forms of asafoetida are produced in Iran. The tears produced in Iran are called *'Irani Ras'* and mass is called *'Irani Hing'*. Afghanistan produces white and red varieties. The Irani and Pathani (from Afghanistan) products have the following properties.

*Irani*

Dry, blackish brown, reddish brown, or yellow in early stage, changing to deeper shades. Sweet fetid odour, sweet taste, contain wood chips except in 'Irani Ras', Alcohol solublity: soluble in 10–30%, ash insoluble in HCl: 0.5–7.75%, volatile oil: 5–10%, resin portion: 40%.

*Pathani*

Agglutinated and wet, blackish brown, reddish brown, yellow or white. Bitter fetid odour and bitter taste. Alcohol solubility: soluble in 25–50%, ash insoluble in HCl: 0.7–1.90%, volatile oil: 10–20%, resin portion: 40–60%.

*Compound asafoetida*

Natural asafoetida is very strong and as such cannot be used for cooking. For commercial uses natural asafoetida is hence blended with gum arabic and flour. This is the compound asafetida available for consumers in the market. The blending formula differs from manufacturer to manufacturer and is a trade secret.

### 5.8.8 Related products

*Galabanum*
This is known in the trade, as '*Jawashir*' or '*Gaoshir*' and is the oleoresin derived from *F. galbaniflua,* a tall herb occurring in Iran. It is obtained in a similar way to asafoetida. It initially occurs as yellowish or brownish tears and later forms lumps or masses.

The resin in galabanum contains umbelliferone combined with galbaresinotannol, galbaresinic acid and essential oil that contains D-α-pinene, β-pinene, myrecine, cadinene, L-cadinol and traces of other compounds.

*Sumbul (musk root)*
This is a product obtained from *F. sumbul* and *F. suaveolens,* both growing in Central Asia. The commercial product is the dried, sliced rhizomes that are about 10 cm long and 7 cm in diameter, dark brown externally and yellow inside. It has a bitter taste. *Sumbul* contains 17–18% resinous matter, the main constituent of which is umbellic acid, phytosterol, umbellifernone, betaine, angelic acid and valerianic acid. The essential oil (0.2–1.4%) possesses a characteristic odour and contains a sesquiterpene sumbulene, a mixture of various esters and alcohols.

*Sagapenum*
In the trade sagapenum is known as *sagbinaj*. It is an oleogum derived from *F. persica* and *F. szowitziana,* indigenous to Iran and neighbouring areas. The oleogum obtained as in the case of asafoetida, and resembles galabanum tears. Its uses are similar to those of *galabanum.*

### 5.8.9 End uses

Asafoetida is mostly used in Indian vegetarian cooking, in which the strong onion–garlic smell enhances the flavour, especially those of the Brahmin and Jain castes where onions and garlic are prohibited. It is much used in Persian cuisine also, in spite of its offensive odour, as a spice and is thought to exercise a stimulant action on the brain. It is a local stimulant to the mucous membrane, especially to the alimentary tract, and therefore is a remedy of great value as a carminative in flatulent colic and a useful addition to laxative medicine. There is evidence that the volatile oil is eliminated through the lungs, therefore it is excellent for asthma, bronchitis, whooping cough, etc. and even hysteria (Morris and Mackley, 1999). Owing to its vile taste it is usually taken in pill form, but is often given to infants through the rectum in the form of an emulsion. The powdered gum resin is not advocated as a medicine, the volatile oil being quickly dissipated. In India the fruit is also used for medicinal purposes. In traditional medicine, asafoetida is also used in hysterical afflictions and epilepsy as well as in cholera. White asafoetida is believed to be a panacea for many stomach troubles and diarrhoea.

Certain species of *Ferula* yield oleogum, related to asafoetida and used mainly for pharmaceutical purposes. They are *Galabanum*, *Sumbul* and *Sagapenum* (or *sagbinaj*). *Galbanum* has a characteristic aromatic odour and a bitter acidic taste. It is considered a stimulant, carminative, expectorant and antispasmodic. In indigenous medicine it is used as a uterine tonic and is effective as an anti-inflammatory agent. *Sumbul* is used as a sedative in hysteria and other nervous disorders and is also used as a mild gastro-intestinal stimulant.

Asafoetida oleoresin is bitter, acrid, carminative, antispasmodic, expectorant, anthelmintic, diuretic, laxative, nervine tonic, digestive, sedative and emmenagogue. It is used in flatulent colic, dyspepsia, asthma, hysteria, constipation, chronic bronchitis, whooping cough, epilepsy, psychopathy, hepatopathy, splenopathy and vitiated conditions of *kapha* and *vāta* (Warrier *et al.,* 1995).

Asafoetida is admittedly the most adulterated drug in the market. Besides being largely admixed with inferior qualities of asafoetida, it often has red clay, sand, stones and gypsum added to it to increase its weight.



### 5.8.10 Other species

Various species of the genus *Ferula* are: *F. narthex* – found in Kashmir, *F. galbaniflua* Boiss and Bulise – a tall herb occurring mainly in Iran, *F. sumbulferula* and *F. suaveolens* Aitch and Henosel – both occurring in central Asia, *F. persica* – Willd, *F. zowitziana* DC – indigenous to Iran, *F. foetida* Regel., *F. alliacea* Boiss and *F. rubricaulis* Boiss, Linn.

The Tibetan asafoetida (*Narthex asafetida/Ferula narthax*) is closely allied to *Ferula. Ferula narthex,* found in Kashmir, grows to 1.5–3 m (5–10 ft) high, possesses large leaf sheaths; upper leaves much reduced, flowers small, yellow, in single or scarcely branched compound umbels arising from within the leaf sheaths. The umbels have no involucre, the limb of the calyx is suppressed, and the stylopods are depressed and cup-shaped, styles recurved, fruit compressed at the back, dilated at the margin. The tap roots are thick, carrot-like and branched. This variety produces some of the asafoetida used in commerce.

*Scorodosma foetida*, another gigantic umbelliferous plant found on the sandy steppes of the Caspian, also is a source of commercial asafoetida. The Persian *sagapenum*, or *serapinum*, a species of *Ferula,* that was formerly imported to Bombay, is in appearance very similar to asafoetida, but does not go pink when freshly fractured, and in smell is less disagreeable than asafoetida. This species is an ingredient of Confection Rutea (*British Pharmacopoeia Codex*).

## 5.9 Hyssop

Hyssop is the flowering top of the evergreen perennial shrub *Hyssopus officinalis*, which is a valuable expectorant.

### 5.9.1 Origin and distribution

Hyssop is native to southern Europe and the temperate zones of Asia. It grows wild in countries bordering the Mediterranean Sea. It is cultivated in Europe, especially in southern France, mainly for its essential oil. In India it is found in the Himalayas from Kashmir to Kumaon at altitudes of 2435–3335 m and is cultivated in Baramullah, in Kashmir.

### 5.9.2 Botany and description

The plant grows to a height of 60 cm, branches are erect or diffuse; leaves linear–oblong or lanceolate, obtuse, entire, narrow, sessile, green and fragrant, hairy and dotted with oil-bearing glands. The plant flowers in autumn. Whorls of blueish-purple flowers are produced on long narrow spikes.

### 5.9.3 Chemistry

The herb contains volatile oil, fat, sugar, choline, tannins, carotene and xanthophyll. The

flower tops contain ursolic acid (0.49%) and a glucoside diosmin, which on hydrolysis yields rhamnose and glucose. The fresh herb contains iodine in a concentration of 14 mcg/kg. The aerial part on steam distillation yields a volatile oil, 0.15–0.30% and 0.3–0.8%, from fresh and dried materials, respectively.

Hyssop oil is colourless or greenish yellow with an aromatic, camphoraceous odour and slightly bitter taste. The major component of the volatile oil is ketone 1-pinocamphone. The content of essential oil is rather low (0.3–0.9%); it is mostly composed of cineol, β-pinene and a variety of bicyclic monoterpene derivatives (L-pinocamphene, isopinocamphone, pinocarvone). Hyssop contains large amounts of bitter and antioxidative tannins: phenols with a diterpenoid skeleton (carnosol, carnosolic acid), depsides of coffeic acid (= 3,4-dihydroxycinnamic acid) and several triterpenoid acids (ursolic and oleanolic acid) (Galambosi, 1993; Kerrola, 1994; Dordevic, 2000)

### 5.9.4 Cultivation and production

The herb is cultivated mostly in the Mediterranean region and is propagated through seeds and cuttings. It grows in hot, arid conditions in full sun, in well-drained, near-neutral sandy soil. The seeds are sown in spring season in indoors and the mature seedlings (six to eight weeks old) are transplanted to the field. The cuttings are taken in early summer and planted 20 cm apart. Irrigation during initial establishment and moderate fertilization is preferred. Over-fertilization of the crop results in more foliage with reduced flavour.

### 5.9.5 Harvesting and processing

The time of harvest depends on the type of uses. The herb is harvested fresh for cooking purposes. The herbs for processing and distilling purpose are harvested just before flowering; when the leaves contain the highest concentration of essential oil. The leaves are harvested in the morning for higher yield of oil. The leaves are dried in a dry, dark room with adequate ventilation for one or two weeks. The dried herb is stored in airtight containers in the dark. Seeds are harvested when they turn brown. Roots are harvested after the aerial parts die down.

### 5.9.6 End uses

Hyssop is used as a condiment and also in medicines. The leaves and flowering tops of hyssop are employed in flavouring for salads and soups. It is also used in the preparation of liquor and perfumes. It is also used as a pot herb.

Hyssop is considered a stimulant, carminative and expectorant and is used in colds, coughs, congestion and lung complaints. A tea made from the herb is effective in nervous disorders and toothache. It is also effective in pulmonary, digestive, uterine and urinary troubles and asthma and coughs. Leaves are stimulating, stomachic, carminative and colic and leaf juice is used for the treatment of roundworms.

Hyssop oil is used as a flavouring agent in bitters and tonics and also in perfumery. In small quantities it promotes expectoration in bronchial catarrh and asthma.

### 5.9.7 Functional properties and toxicology

Antimicrobial activity of essential oil of hyssops was investigated and the property was attributed to the linalool and 1,8-ciniole components of the essential oil (Mazzanti *et al.*, 1998).



### 5.9.8 Quality issues

Hyssop oil is occasionally adulterated with lavender or rosemary oils. Sometimes it is also mixed with camphor oil fractions.

## 5.10 Galangal

Galanga or galangal (*Kaempferia galanga* L.) which should not be confused with the greater galangal (*Alpinia galanga*), is a perennial aromatic rhizomatous herbaceous plant belonging to the family Zingiberaceae. This genus comprises about 70 species, among which *K. galanga* and *K. rotunda* are of economic value. These plants are used for flavouring food and also in medicine. Rhizome and roots are aromatic and are used as spice.

### 5.10.1 Origin and distribution

The genus is presumably native to tropical Asia and is distributed in the tropics and subtropics of Asia and Africa, but is now rarely found growing wild. It is cultivated in home gardens in India, Sri Lanka, Malaysia, Moluccas (Indonesia), Philippine Islands and South-East Asia.

### 5.10.2 Botany and description

Plants attain a height of 30 cm, but often much shorter, and have fleshy, cylindrical aromatic root tubers. The plant possesses two to a few broad, round leaves that are usually spread horizontally; leaves are sessile, ovate, deltoid-acuminate, thin deep green, and the petioles are short channelled; flowers are irregular, bisexual, white, 6–12 from the centre of the plant between the leaves, fugacious, fragrant and opening successively, bracts are lanceolate, green, short, calyx is as long as the outer bracts, short cylindrical, there are three petals, corolla tube 2.5 cm long, lobes are equal, usually spreading, lanceolate, pure white, one stamen, perfect, filament is short, arcuate, anther is two-celled, cells discrete. Flowering starts in June and ends in September, with peak flowering during July to August.

Macroscopic analysis of its powder revealed that it is has a camphoraceous odour, bitter aromatic taste and is brown in colour. The cross-section of the rhizome and root showed thin-walled parenchyma cells, fragments of thick walls of tracheids, with irregular-shaped parenchyma cells and their parts and a number of starch granules that have come out from the cells. Cytological studies showed that the somatic chromosome number of *K. galanga* is $2n = 54$ (Ramachandran, 1969).

### 5.10.3 Chemistry

*Kempferia galanga* rhizome contains about 2.5–4% essential oil. The main components of the oil are ethyl cinnamate (25%), ethyl-*p*-methoxycinnamate (30%) and *p*-methoxycinnamic acid and a monoterpene ketone compound, 3-carene-5-one (Kiuchi *et al.*, 1987). The other constituents are camphene, δ-3-carene, *p*-methoxy styrene, γ-pinene, β-myrcene, *p*-cymene, 1,8-cineole, isomyrcene, camphor, α-terpineol, *p*-cymene-8-ol, eucarvone, δ-cadinene, etc. The leaves contain kaempferol, quercetin, cyanidin and delphinidin. The root contains camphene, 1,8-cineole, camphor, borneol, cinnamaldehyde, ethyl cinnamate, quinozoline, ethyl *p*-methoxy cinnamate and quinazoline-4-phenyl-3-oxide.

The rhizome is also reported to display cytotoxic properties. The essential oil is used in flavouring curries, in perfumery and also for medicinal purposes (Bhattacharjee, 2000).

Deoxypodophyllotoxin and ethyl *p*-methoxy-*trans*-cinnamate were isolated from rhizomes; monoterpeneketone -car-3-en-5-one was isolated from rhizomes and characterized (Harborne and Baxter, 1993). Deoxypodophyllotoxin exhibited cytotoxic activity by inhibiting HeLa cells.

### 5.10.4 Cultivars and varieties

Not much work has been undertaken to identify the extent of variability in the crop. In an attempt to induce mutation, bushy mutants were induced with 7.5 krad gamma rays. Irradiation at lower doses (below 1.0 krad) stimulated the germination of rhizomes. In an evaluation of five geographical races of *K. galanga* from Kerala, significant variation was observed in rhizome and oil yields but there was little variation in oil quality. One high-yielding, cultivar Kasturi, has been released from Kerala Agricultural University (KAU). Another high yielding cultivar, Rajani, has also been identified from the germplasm collection at KAU.

### 5.10.5 Cultivation and production

Galanga requires fertile sandy soils and a warm humid climate. It thrives well up to an elevation of about 1500 m above mean sea level. A well-distributed annual rainfall of 1500–3000 mm is required during the growing period and dry spells during land preparation and harvesting.

The species is propagated by rhizome fragments. Mother rhizomes are superior to finger rhizomes. The rhizome bits are planted on beds of 1–2 m width and 25 cm height at a spacing of 40–60 $cm^2$ (IBPGR, 1981; Bhattacharjee, 2000). About 750 kg of seed rhizomes per hectare is required. Planting during the third week of May gives significantly higher rhizome and oil yields.

The mean nutrient uptake of the crop is 22.8 kg N, 28 kg $P_2O_5$ and 36.9 kg $K_2O$ per hectare. Application of 50–75 kg N, 60 kg $P_2O_5$ and 50–75 kg $K_2O$ is found to be beneficial for increased rhizome and oil yields. Application of farmyard manure at 30 tonnes/ha is superior to the application of nutrients through inorganic form of fertilizers and it increased the yield by 60%. A well-managed plantation yields about 4–6 tonnes of fresh rhizomes per hectare. The dry recovery varies from 23 to 28%. Leaf rot disease may occur during the rainy season and can be controlled by trenching the beds with 1% Bordeaux mixture.

In Kerala, cultivation of *K. galanga* is restricted to some localized tracts and the productivity of the crop is low, ranging from 2–5 tonnes of fresh rhizomes per hectare. There is an acute shortage of planting material and the absence of seed set limits the scope for breeding (Kurian *et al.*, 1993).

Propagation of this crop through tissue culture was reported by Vincent *et al.* (1992) and Geetha *et al.* (1997). The tissue cultured plants could not be used directly for field planting as it takes two crop seasons to produce enough rhizomes. However, these plants can be used for planting material production through high-density planting. Propagation by *in vitro* rhizomes is possible, and is a method that can be commercialized.

### 5.10.6 Harvesting and processing

The crop matures about six or seven months after planting. The aerial portion dries off on maturity. The rhizomes are dug out, cleaned and washed to remove soil and they are dried in sun.



The essential oil is extracted by steam distillation of sliced and dried rhizomes. The oil yield varies with season and maturity stage of the rhizome.

### 5.10.7 End uses

*Kampferia galanga* is cultivated for its aromatic rhizomes and also as an ornamental. It is used extensively as a spice throughout tropical Asia and has a long history of medicinal use. The rhizome is chewed and ingested. It is used as flavouring for rice. The rhizomes are considered stimulatory, expectorant, carminative and diuretic. They are used in the preparation of gargles and administered with honey for coughs and chest inflictions. In the Philippines, a decoction of the rhizomes is used for dyspepsia, headache and malaria. The juice of the plant is an ingredient in the preparation of some tonic preparations. The rhizomes and roots are used for flavouring food and also in medicine in South-East Asia (CSIR, 1959, 1992).

The rhizome mixed with oil is used externally for healing wounds and may be applied to rheumatic regions. A lotion prepared from the rhizome is used to remove dandruff or scales from the head. The powdered rhizome mixed with honey is given as an expectorant. The leaves are used in lotions and poultices for sore eyes, rheumatism and fever. In Thailand the dried rhizome of this plant is used as a cardiotonic (CSIR, 1959). In India the dried rhizomes, along with some other plants, are used for heart disease. It is also used for treatment of abdominal pain, vomiting, diarrhoea, and toothache with the functions of promoting vital energy circulation and alleviating pain.

The herb is used as food flavouring in Malaysia and also in perfumery. The rhizomes are used to protect clothes against insects. It is also used as a masticatory along with betel leaf and arecanut. Slices of the dried rhizome may be cooked with vegetable or meat dishes, but mostly the spice is used fresh and grated or crushed. It is essential for Javanese cooking (*Rijstafel*) and is especially used in the Indonesian island of Bali.

### 5.10.8 Functional properties and toxicology

Essential oil from the root induced glutathione-s-transferase activities in the stomach, liver and small intestine of mouse. An ethanol extract of dried rhizome showed antispasmodic activity vs histamine-induced contraction and barium-induced contraction in Guinea pigs. An ethanol–water extract indicated smooth muscle stimulant activity. Water extracts of dried rhizomes exhibited antitumour activity. Rhizome and root oils showed antibacterial activity against *Escherichia coli, Staphylococcus aureus* and antifungal activity against *Cladosporium* sp. Nematocidal activity was observed in the rhizome of *K. galanga.*

The hypolepidaemic action of the ethanolic extract of *K. galanga* was observed *in vivo.* The oral administration of the extract was effective in lowering the total cholesterol, triglycerides and phospholipid levels in serum and tissues (Achuthan and Padikkala, 1997).

## 5.11 Betel vine

The betel vine (*Piper betle* L.) is a perennial climber belonging to the family Piperaceae. Betelvine has been widely used in various parts of India and other South Asian countries for centuries. The name *Piper* is probably originated from the Sanskrit term '*Pippali*' (meaning long pepper) and the name '*betle*' might have come from the Malayalam word '*Vetila*'. It is cultivated, as a commercial crop, for its leaf, which is used as a masticatory. As a

masticatory, the betel leaf (pan) is credited with aromatic, digestive, stimulant and carminative properties. Betel chewing imparts a pleasant odour to the oral cavity and also warmth and a feeling of well-being. Hydrated lime is spread over the betel leaf and is chewed with a few pieces of arecanut (*Areca catechu*). Other spices and masticatories such as cardamom, fennel, nutmeg, clove and tobacco are also added to the betel (leaf roll) quid preparation. Betel chewing is prevalent in all south Asian countries, Indonesia, many Pacific Ocean Islands and Middle East and South-East Asia.

### 5.11.1 Production and international trade

Betel vine is commercially cultivated in countries such as India, Bangladesh, Pakistan, Malaysia, Indonesia, Sri Lanka, Thailand, Papua New Guinea, Madagascar, Bourbon and the West Indies. India is the major producer, where it is cultivated in an area of 43 000 ha, with an annual production worth Rs. 7000 millions. Bangladesh is the second largest producer. Sri Lanka is also a major producer, which exports most of its produce to Pakistan.

In India the crop is extensively cultivated in the states of Andhra Pradesh, Bihar, Gujarat, Karnataka, Kerala, Maharashtra, Madhya Pradesh, Assam, Orissa, Rajastan, Tamil Nadu, Uttar Pradesh and West Bengal. Countries such as Oman, Kuwait, Quatar, Saudi Arabia, the UAE, the UK, the USA and Nepal are the main importers. Improving the quality of the leaves, proper pre- and post-harvest handling, and improved methods of packing, storage and transportation can make manifold increase in the export of betel leaves.

### 5.11.2 Origin and distribution

According to De Candolle (1884), *P. betle* might have originated in the Malaya Archipelago. Burkill (1966) described the native place as Central and Eastern Malaysia where the crop was cultivated and spread through tropical Asia and Malaysia. Later on it reached Africa and then the West Indies. Cultivation of betel vine started in Southern Asia, but there is doubt about the exact place of domestication.

### 5.11.3 Botany and description

*Piper betle* is a perennial, dioecious climber that belongs to the dicot family Piperaceae. Male vines are cultivated and grow vigorously up to a height of 20 m, with a stem diameter of 15–20 cm. Stems are semi-woody, green or pinkish green, cylindrical or bilaterally pressed with dimorphic branching. The plant grows creeping on earth or climbing up on the trees with orthotropic vegetative branches by means of adventitious roots arising from the nodes. Roots are few, sparingly branched and short. The nodes are conspicuously swollen and the internodes are elongated. Leaves are simple, alternate, stipulate, bifarious, petiolate with 5–20 cm long, broad, cordate to obliquely ovate, thick and often unequal. Lamina is oblique at the base, slightly acuminate, acute, entire with undulate margin, glabrous, bright or dark green with reticulate venation. The leaves are aromatic and the taste varies from sweet to pungent. The petiole is usually 2–15 cm long.

Flowering is rare, mainly because the plants are replanted in every four or five years under cultivation. Plants flower when they are 8–10 years old.. The inflorescence is cylindrical, pendulous spike and flowers are naked, unisexual, dioecious, fairly long, peduncled (3–10 cm long) and oppositifolius. Female spikes are 3.5–6 cm long. Male spikes are dense, cylindrical, 8–10 cm long, sub-pendulous, consisting of numerous unisexual bracteate flowers. Fruit is a drupe, seen very rarely, often sunken in fleshy spike. There are



10–20 seeds in each fruit, but they are poor in germination. There is much variation in the chromosome numbers reported in betelvine: figures $2n = 26, 32, 52, 58, 62, 78$ and 195 have been given. The most frequent number is $2n = 78$ for the majority of cultivars and varieties (Jose and Sharma, 1984).

Cultivated betelvines are mostly male plants selected and multiplied over a period by the growers for vigorous growth and leaf production.

### 5.11.4 Chemistry

The varying taste of betel vine ranging from sweet to pungent is due to the presence of essential oils. The chief constituent of leaves is a volatile oil, known as betel leaf oil, and its amount varies in leaves from different varieties. The oil is of a clear yellow colour and is obtained from fresh leaves. The essential oil consists of euginol, cadinene, chavicol, chavibetol, cineole, sesquiterpene, allylpyrochavicol, caryophyllene, methyl euginol, hydroxy-chavicol, sitosterols, stigma sterols, etc. (Balasubrahmanyam *et al.*, 1994).

Chemical analysis of betel vine using modern analytical tools has revealed that the presence or absence and the quantity of any of these chemical constituents vary with the variety. The betel vines in the Indian subcontinent were grouped in one or other of the five varieties, *Bangla*, *Desasvari*, *Kapoori*, *Meetha* and *Sanchi*. The percentage of essential oil in each of the varieties varies from 0.10 to 1.0%. About 52 compounds have been identified in the betel leaf oil and the composition of these varies with varieties. The major constituents are monoterpenes, sesqueterpenes, oxygenated compounds, aledehydes, acids, oxides, phenols, phenolic esters and esters (Balasubramanyam and Rawat, 1990; Balasubrahmanyam *et al.*, 1994; Ravindran, 2000). The quantity of essential oil increases with maturity and also depends on the external environment. The presence of eugenol and lusitanicoside have also been reported (Harborne and Baxter, 1993).

The volatile oil of *P. betle* cultivated in the Hue area of Vietnam, obtained by steam distillation of the fresh leaves, was analysed and found to contain isoeuginol (72%) and isoeugenyl acetate (12.2%). These constituents indicated the existence of a new isoeugenol chemotype of *P. betle* (Thahn *et al.*, 2002).

### 5.11.5 Cultivars and varieties

More than 150 types and cultivars are grown by cultivators and recognized by traders in India. The most important cultivars common in India are given in Table 5.5.

Rawat *et al.* (1988) identified five distinct varieties, from the germplasm, that differ in their morphology and chemistry. They are *Bangla, Desawari, Kapoori, Meetha* and *Sanchi*. A few disease-tolerant or resistant lines were identified through the screening of cultivars. Crop improvement work is limited to germplasm evaluation and selection (Ravindran, 2000).

### 5.11.6 Cultivation and production

The suitable environment for betel vine cultivation is a cool shady area in the humid tropics with plenty of moisture in the soil. It also thrives well in areas with well-distributed high rainfall and in areas with high humidity, moderate temperature and copious rainfall. Such natural conditions are available in certain parts of Western Ghats, Assam, Meghalaya, Tripura, Kerala, and the uplands of North Kanara. The crop is grown under artificial conditions in the hot arid zones of north India under shade and irrigation. Betel vine is very

**Table 5.5** Important cultivars of betel leaf in India

| SI No. | Cultivars | Pungency* |
|---|---|---|
| 1. | Bangla (Madhya Pradesh) | P |
| 2. | Bangla (Uttar Pradesh) | P |
| 3. | Bangla Nagaram (Uttar Pradesh) | P |
| 4. | Calcutta (West Bengal) | P |
| 5. | Calcutta Bengal (West Bengal) | P |
| 6. | Deshi Calcutta (west Bengal) | P |
| 7. | Desvar Mahoba (Uttar Pradesh) | MP |
| 8. | Ghanghatte (West Bengal) | P |
| 9. | Godi Bangla (Orissa) | P |
| 10. | Halisahar Sanchi (West Bengal) | P |
| 11. | Kakir (Bihar) | P |
| 12. | Kalipatti (Maharashtra) | P |
| 13. | Kappori (Bihar) | NP |
| 14. | Kappori (Orissa) | NP |
| 15. | Karapaku (Andra Pradesh) | P |
| 16. | Karpuri (Tamil Nadu) | NP |
| 17. | Kaljedu (Andra Pradesh) | NP |
| 18. | Maghai (Bihar) | P |
| 19. | Meetha Pan (West Bengal) | Sweet |
| 20. | Nov Bangla (Orissa) | P |
| 21. | Ramtek Bangla (Maharashtra) | P |
| 22. | S. G. M. 1 (Tamil Nadu) | MP |
| 23. | Sachi Pan (Assam) | P |
| 24. | Sangli Kapoori | NP |
| 25. | Tellaku (Andra Pradesh) | NP |
| 26. | Vellai Kodi (Tamil Nadu) | NP |

*MP = mildly pungent; P = pungent; NP = non-pungent.
*Source*: Ravindran (2000).

sensitive to sudden temperature changes and is a shade-loving plant. The crop thrives in well-drained, fertile, humus-rich soil. It grows in a wide range of soil types, ranging from clay-loam to sandy, provided there is good drainage and moisture-holding capacity.

There are four main types of betel vine cultivation practice in India. It is cultivated as an inter-crop in arecanut and coconut plantations, in open conservatories with wind-breaks and live standards (in a bed system or in a trench system), in closed conservatories or as an open system in the backyards of houses. Betelvine is propagated vegetatively by hard stem cuttings. Cutting from the middle portion of a vine is the ideal planting material, as the tender as well as over-matured portions take longer time for sprouting. The planting time is determined according to the availability of suitable conditions and also on the availability of standards. The planting season in various regions is spread throughout the year. Close spacing of about 30 × 30 $cm^2$ between the vines is advisable for better leaf yield. The inter-row spacing is usually 10 to 20 cm. Micropropagation protocols for betel vine have been standardized by Nirmal Babu *et al.* (1992) and by Aminudin *et al.* (1993).

### 5.11.7 Harvesting and processing

Fresh betel leaves are usually used for chewing. Leaves are ready for harvest in four to six months. The harvested leaves are packed moist in different types of well-aerated baskets and marketed. In some places the leaves are blanched or bleached and marketed. This process leads to some changes in the chemical composition of the essential oils (Table 5.6).



**Table 5.6** Essential oil composition (%) of bleached leaves of two *Bangla* lines

| Compound | Jganathi *Bangla* | | Tamluk *Bangla* | |
|---|---|---|---|---|
| | Bleached | Control | Bleached | Control |
| Linalool | 0.12 | 0.08 | 0.44 | 0.23 |
| Chavicol | – | 0.09 | 0.31 | – |
| Safrol | 0.86 | 0.18 | – | – |
| Eugenol | 64.30 | 64.00 | 46.14 | 63.66 |
| Methyl eugenol | 0.23 | 0.07 | – | 0.11 |
| β-caryophyllene | 3.34 | 3.37 | 4.70 | 1.19 |
| L-lunalene | 1.05 | 1.23 | 1.33 | 1.12 |
| Germacrene D | 5.93 | 6.15 | 5.96 | – |
| γ-elemene | 3.80 | – | – | 4.98 |
| Eugenyl acetate | 4.12 | 3.84 | 5.25 | 5.03 |
| *f*-cadinene | 1.89 | 1.81 | 3.08 | 3.05 |
| Sesquiterpene alcohol | Traces | – | – | Traces |
| Phytol | – | – | – | 0.18 |
| Essential oil | 0.01 | 0.01 | 0.01 | 0.01 |

*Source*: Ravindran (2000).

(Ravindran, 2000). The impact of various drying methods on the quality of betel leaf has been analysed and the results reveal that the solar-dried leaves, followed by shade and sun-dried, maintained the best quality (Ramalakshmi, 2002).

### 5.11.8 End uses

The most extensive use of betel leaves is for chewing. Leaves are chewed with arecanut and lime, and with or without tobacco. Betel leaf chewing is an ancient practice in India and other countries of South-East Asia. In India it is associated with many religious and social practices. As a masticatory, it is aromatic, digestive, stimulant and carminative. However, excessive indulgence in chewing produces various afflictions of the mouth including carcinoma, mainly because tobacco is used as an accompaniment.

The leaves are stimulant, antiseptic and sialogogue. Leaf juice is used in eye afflictions. Aqueous extract is useful in throat inflammation and in alleviating coughs and indigestion. The essential oil from leaves is used in respiratory catarrh and also as an antiseptic. The oil also possesses antibacterial and antifungal activities. The oil is an active local stimulant used in the local application or gargle, also as an inhalant in diphtheria. In India the leaves are used as a counter-irritant to suppress the secretion of milk in mammary abscesses. The juice of four leaves is equivalent in power to one drop of the oil. Betel leaves possess anti-oxidant action, because of the phenols such as hydroxy chavicol present in it.

## 5.12 Pomegranate

Pomegranate, used as spice, constitutes the dried seed with the pulp of *Punica granatum*. The tree has been placed by various authorities in different orders, but is now included in the family Punicaceae. The pomegranate is mentioned in the *Papyrus of Ebers*. It is still used by the Jews in some ceremonies, and as a design has been used in architecture and needlework from the earliest times. It formed part of the decoration of the pillars of King Solomon's Temple, and was embroidered on the hem of the High Priest's ephod.

There are three kinds of pomegranate: one very sour, the juice of which is used instead of unripe grape juice; the other two moderately sweet or very sweet. These are eaten as dessert after being cut open, the seeds, strewn with sugar and sometimes sprinkled with rosewater. A wine is extracted from the fruits, and the seeds are used in syrups and preserves. For medicinal and spice purposes the sour variety is used. It is said to have originated in Western Asia and now grows widely in Mediterranean countries, China, Japan, India and in many other tropical and subtropical countries.

### 5.12.1 Botany and description

Pomegranate is a glabrous and deciduous shrub or small tree with dark grey bark. Leaves are opposite or subopposite, often fascicled on short petiole, oblong or obovate and 2.5–6.0 cm long. The flowers are terminal or axillary, solitary, large and showy and orange-red coloured. The calyx is coriaceous and persistent, prolonged above the ovary and the distal end and campanulate in shape. Petals are 1.2–2.5 cm long, thin and wrinkled. The ovary is inferior. The fruits are large, globose, 5.0–8.0 cm across, crowned by somewhat tubular limb of the calyx and indehiscent with red pulp and juicy. The seeds are angular with coriaceous testa. Flowering is in April–May and fruiting during June–August, but flowering and fruiting both also may occur at different seasons.

The dried seed is used as a spice, while the dried root is used in traditional medicine. It is marketed as quills 7–10 cm (3 to 4 inches) long. It is yellowish-grey and wrinkled outside, the inner bark being smooth and yellow, having little odour and a slightly astringent taste.

### 5.12.2 Chemistry

Various parts of the plant contain malvidin, pentose, glucosides, tannin and ursolic acid. The stem yields carbohydrates, carotene and D-mannitol. The chief constituent of the bark (about 22%) is called punicotannic acid. It also contains gallic acid, betulic acid, mannite, friedelin and four alkaloids, pelletierine, methyl-pelletierine, pseudo-pelletierine and isopelletierine. The liquid pelletierine boils at 125°C, and is soluble in water, alcohol, ether and chloroform. The drug probably deteriorates with age.

The fruits contain nicotinic acid, pectin, protein, riboflavin, thiamine, vitamin C, delphinidin diglycoside, aspartic, citric, ellagic, gallic and malic acids, glutamine and isoquercetin. The rind contains tannic acid, sugar and gum. Pelletierine tannate is a mixture of the tannates of the alkaloids obtained from the bark of the root and stem, and represents the taenicidal properties. The seeds contain asiatic and maslinic acids, pelargonidin-3, 5-diglucoside, sitosterol and β-D-glucoside. Betulic acid, granatins A and B and punicatolin are found in leaves (Chatterjee and Pakrashi, 1994). Oestrone with oestrogenic activity is isolated from the seeds of pomegranate (Harborne and Baxter, 1993).

Rastogi and Mehrotra (1995) reported the isolation of cyanidin-3-glucoside and 3,5-diglucoside, delphinidin-3-glucoside and 3,5-diglucoside from seed coat; isolation of punicafolin from leaves and its characterization as 1,2,4-*o*-galloyl 3,6(*R*) hexahydroxy-diphenoyl-β-D-glucose, granatin B corilagin, strictinin, 1,2,4,6-tetra-*o*-galloyl- β-D-glucose and 1,2,3,4,6-penta-*o*-galloyl 3,6 (*R*)-hexahydroxy-diphenoyl-β-D-glucose. Isolation of a new hydrolysable tannin-2-*O*-galloyl-4, 6-(*S*,*S*)-galloyl-D-glucose and its characterization; structures of punicalin, punicalagin (revised); determination of punicic (33.3%), nonadecanoic (5.9%), heneicosanoic (5.0%), tricosanoic (4.9%) and 13-methylstearic (1.5%), 4-methyllauric (0.5%) acids in seed oil by GC were also reported.



### 5.12.3 Cultivars and varieties

*Pinana* is a dwarf variety naturalized in the West Indies. Many horticultural varieties have been developed for culinary purposes.

### 5.12.4 End uses

*Use as spice*

The rind of the fruit is in curved, brittle fragments, rough and yellowish-brown outside, paler and pitted within. It is called Malicorium. The fruit is used for dessert, and in the East the juice is included in cool drinks. The seed dried with the pulp is used as a spice in many dishes.

*Medicinal uses*

According to Chatterjee and Pakrashi (1994), the green leaves are made into a paste and applied on eyes for conjunctivitis, and leaf juice is given in dysentery. The bark of the root and stem is considered astringent and anthelmintic and are specially used against tapeworm (Chopra, 1982). The fruit juice is cooling and refrigerant. A decoction of fruit-rind is useful in chronic dysentery and diarrhoea and this decoction, together with that of the bark of *Holarrhena antidysenterica*, is an effective remedy for dysentery (Chatterjee and Pakrashi, 1994). The pulp and seeds are stomachic (Chopra, 1982) and are also used as laxative. The flower buds are used in bronchitis. Chatterjee and Pakrashi (1994) stated that the flower buds are dried and powdered to a snuff, which is applied to epitaxis and internally used as an effective remedy in infantile diarrhoea and dysentery. The flowers are also used to stop nose bleeds. An extract of leathery pericarp is taken orally at bedtime to cure pinworm disease. The flower buds are powdered and used in dysentery and diarrhoea (Singh *et al.*, 2000). In southern Italy, a decoction of the pericarp is prepared by boiling 30 g in 1 l of water, with lemon or orange juice added. It is taken two cups a day as an astringent and to treat helminthiasis and dysentery. In Turkey, the pericarp of the fruit is dried, powdered and mixed with honey to prepare pills; three to six pills are taken internally to stop bleeding from piles. It is non-toxic and can be used for a long time.

The seeds are demulcent. The fruit is a mild astringent and refrigerant in some fevers, and especially in biliousness, and the bark is used to remove tapeworm. In India the rind is used in diarrhoea and chronic dysentery, often combined with opium. It is used as an injection in leucorrhoea, as a gargle in sore throat in its early stages, and in powder for intermittent fevers. The flowers have similar properties. The rind often causes nausea and vomiting, and possibly purging. Use of it should be preceded by strict dieting and followed by an enema or castor oil if required. It may be necessary to repeat the dose for several days. A hypodermic injection of the alkaloid may produce vertigo, muscular weakness and sometimes double vision. The root bark was recommended as a vermifuge. It may be used fresh or dried (Singh *et al.*, 2000).

The flowers yield a red dye, and with the leaves and seeds were used by the Ancients as astringent medicines and to remove worms. The bark is used in tanning and dyeing giving the yellow hue to Morocco leather. The barks of three wild pomegranates are said to be used in Java: the red-flowered *merah*, the white-flowered *poetih* and the black-flowered *hitam*.

## 5.13 Summer savory

The genus *Satureja* Linn. (Lamiaceae) comprises about 14 species of highly aromatic, hardy annual or perennial herbs or under-shrubs. Two important species of this genus are

*S. hortensis* (summer savory) and *S. montana* (winter savory) (CSIR, 1972). Summer savory (*Satureja hortensis*) is a hairy aromatic annual and is grown as a popular garden herb. The savory of commerce is the dried leaves and flowering tops, but the best class comprises only leaves (CSIR, 1972).

### 5.13.1 Production and international trade

France, the former Yugoslavia and Albania are the major producers (Anon., 2002). Savory is also cultivated in Spain, Germany and other parts of continental Europe, Canada, the UK and the USA. In India it is cultivated in Kashmir (CSIR, 1972). The Yugoslavian variety is recognized as the premier grade (McCormick – *Spice Encyclopedia*, http://www.mccormick.com/content).

### 5.13.2 Origin and distribution

The crop is indigenous to southern Europe and the Mediterranean area. It is distributed in the warmer regions of both the hemispheres. Several species have been introduced into England, but only two, the annual summer savory and the perennial winter savory, are generally grown. It grows wild in dry, light soils and on rocky hillsides on chalk and is locally cultivated for commercial use. The plant is cultivated in several areas of Iran.

### 5.13.3 Botany and description

Summer savory is an annual herbaceous plant with small erect stems, grows about 30 cm in height. The branches are pinkish, leaves dark green, petiolate, leathery, elliptical, about 1 cm long and often fascicled. The hairs on the stem are short and decurved. Lilac, pink or white flowers appear in small spikes in the leaf axils, during late summer (Rosengarten, 1969; CSIR, 1972; Tainter and Grains, 1993).

### 5.13.4 Chemistry

The herb has a thyme-like flavour. The fresh leaves contain moisture (72%), protein (4.2%), fat (1.65%), sugar (4.45%), fibre (8.60%) and ash (2.11%). The leaves contain 11.95% (dry weight basis), pentosans and also labiatic acid, ursolic acid, β-sitosterol and volatile oil (CSIR, 1972).

There are many reports on the composition of essential oil of the aerial parts and leaves of savory from different parts of the world (Ghannadi *et al.*, 2000; Opdyke, 1976; Thieme and Nguyen, 1972a,b; Hajhashemi *et al.*, 2000; Gora *et al.*, 1996). The essential oil obtained from the full flowering spice is between 0.1 and 0.15%. Savory oil is described as light yellow to dark brown liquid and comprises carvacrol, *p*-cymene, pinene, dipentane, ursolic acid, etheral oil, phenolic substances, resins, tannins and mucilage (Prakash, 1990; Karnick, 1994b).

Lawrence (1981) compared the chemical composition of savory oils from Europe, Canada and North Africa. The oil exhibited differences in *p*-cymene, myrcene and γ-terpinene contents. Prakash (1990) made a comprehensive literature survey on the chemical composition of savory oil. The seed contains fixed oil (45%) and protein (24%) on a dry basis. Ghannadi (2002) analysed the seed oil of savory collected from Iran using GC and GC–MS. The seeds yielded 0.3% of a pale yellowish oil with a pleasant spicy odour. Forty-two components were characterized, representing 96.7% of the total oil. The oil was rich in



**Table 5.7** Percentage composition of the seed oil of *Satureja hortensis* from Iran

| Compound | Percentage |
|---|---|
| Hexanol | 0.2 |
| Heptanal | 0.1 |
| α-thujene | 0.2 |
| α-pinene | 0.7 |
| Camphene | 0.1 |
| β-pinene | 0.5 |
| *p*-menth-3-ene | trace |
| Myrcene | 1.1 |
| α-phyllandrine | 0.2 |
| α-terpinine | 2.1 |
| *p*-cymene | 9.3 |
| β-phellandrene | 0.5 |
| γ–tepinene | 12.8 |
| Terpinolene | 0.2 |
| Methyl benzoate | 0.2 |
| Linalool | 0.2 |
| *Cis*-thujone | 0.1 |
| Borneol | 0.1 |
| Terpinene-4-ol | 1.1 |
| α-terpineol | 0.1 |
| Myrtenol | 0.2 |
| Cuminaldehyde | 0.3 |
| Methyl carvacrol | 0.5 |
| Bornyl acetate | 0.1 |
| Thymol | 0.3 |
| Perillyl alcohol | 0.1 |
| Carvacrol | 59.7 |
| Eugenol | 1.7 |
| Carvacrol acetate | 0.2 |
| α-copaene | 0.1 |
| β-caryophyllene | 1.2 |
| Aromadendrene | 0.1 |
| α-humulene | 0.1 |
| Germacrene D | trace |
| β-bisabolene | 1.1 |
| δ-cadinene | trace |
| Elemol | 0.1 |
| Germacrene B | 0.1 |
| Ledol | trace |
| Spathulenol | 0.2 |
| Caryophyllene oxide | 0.4 |
| Humulene epoxide | 0.2 |

*Source*: Ghannadi (2002).

monoterpenes. The major components were carvacrol (59.7%), γ-terpene (12.8%). *p*-cym-ene (9.3%, and α-terpinine (2.1%) (Table 5.7). Many of these compounds are also common in the oil from the vegetative parts.

### 5.13.5 Cultivation and production

Savory grows wild, propagated vegetatively and also through seeds. The most preferred method of propagation is through seeds. The species is cold sensitive. Seeds are sown in

well-drained soil during spring in rows 30 cm apart. Temperate climate, full sun and rich and light soil are preferred. The seedlings need thinning out, when large enough, to 15 cm apart.

The seeds may also be sown scattered, when they must be thinned out, the thinned-out seedlings being planted in another bed at 15 cm distance from each other and well watered. The seeds are very slow in germinating.

### 5.13.6 Harvesting and processing

Harvesting takes place 75–120 days after seed sowing. The harvest is dried in the shade or at 35°C and stored in closed containers. The dried leaves are brownish green in colour. It is marketed both as whole leaf, dried and ground form.

### 5.13.7 End uses

The use of savory as a culinary herb dates back to the early Romans. The leaves are gathered before flowering and the flowering shoots used fresh or dried. It is used sparingly in meat dishes and stuffings, with peas, beans and cabbage to improve their digestibility, and in liqueurs (Verghese, 2003).

Savory, which has a distinctive taste, though it somewhat recalls that of marjoram, is not only added to stuffings, pork pies and sausages as a wholesome seasoning, but fresh sprigs of it are boiled with broad beans and green peas, in the same manner as mint. It is also boiled with dried peas in making pea soup. For garnishing it has been used as a substitute for parsley and chervil (McCormick – *Spice Encyclopedia*, http://www.mccormick.com/content).

An infusion of leaves treats gastric upsets, indigestion and loss of appetite. The tea made out of this is used as a tonic. Savory has aromatic and carminative properties, and though chiefly used as a culinary herb, may be added to medicines for its aromatic and warming qualities. It was formerly deemed a sovereign remedy for the colic and a cure for flatulence, and was also considered a good expectorant (Karnick, 1994b). Flowering stalks are used as a moth repellent for cloths.

### 5.13.8 Quality issues

There are different definitions for savory, the spice of commerce, such as the plant cut down at flowering time and dried (Parry, 1969); plant freshly harvested during the flowering season (Guenther, 1974); the leaf harvested before the plant blooms or before flowering (Lewis, 1984; Prakash, 1990); the whole ground dried leaves and flowering tops (Farrell, 1990); the dried leaves of the herb (McCormick – *Spice Encyclopedia*, http://www.mccormick. com/content); whole dried plant (FCC, 1996) and dried leaves and flowering tops (CSIR, 1972).

Farrell (1985) described the US specifications for savory: savory shall be the whole or ground dried leaves and flowering tops of *S. hortensis* L. The brownish-green leaves are fragrantly aromatic with a warm, slightly sharp taste. The produce should contain about 10% total ash, 2% acid insoluble ash, 10% moisture, 25 ml volatile oil per 100 g and granulation 95% (95% of the ground product should pass through a US standard sieve No. 40).

## 5.14 Winter savory

Winter savory (*S. montana*) is a semi-evergreen bushy and woody perennial shrub, with



smaller pink or white flowers and a stronger flavour. Essential oil is extracted commercially from this species and other uses are similar to summer savory.

The stems are woody at the base, diffuse, much branched. The leaves are oblong, linear and acute, or the lower ones spatulate or wedge-shaped and obtuse. Flowering is in June; the flowers are very pale purple, the cymes shortly pedunculate. It is propagated either from seeds, sown at a similar period and in the same manner as summer savory, or from cuttings and divisions of root.

Winter savory is dried and powdered and mixed with grated breadcrumbs, 'to bread their meat, be it fish or flesh, to give it a quicker relish'. It is recommended by old writers, together with other herbs, in the dressing of trout. When dried, it is used as seasoning in the same manner as summer savory, but is not employed medicinally.

*Satureja thymbra*, which is used in Spain as a spice, is closely allied to the savories grown in English kitchen gardens, yields oil containing about 19% of thymol. Other species of *Satureia* contain carvacrol. The oil from wild plants of winter savory contains 30 or 40% of carvacrol, and that from cultivated plants still more.

## 5.15 Other

### 5.15.1 Mango ginger

Mango ginger (*Curcuma amada*) is a rhizomatous aromatic herb of the family Zingiberaceae and is cultivated throughout India, Sri Lanka, Bangladesh and in many South-East Asian countries for its rhizomes that are used as flavouring for pickles and other dishes and also valued for their medicinal properties. The fresh as well as dried rhizomes are used for flavouring curries. The fresh cut rhizomes have the flavour and the colour of mango, hence the name mango ginger. The herb attains 60–90 cm height, leaves are long, petiolate, oblong-lanceolate, tapering at both ends, glabrous, green on both sides; flowers are white or pale yellow in spikes that occur in the centre of the leaves, lip is semi-elliptic, yellow, three-lobed, the middle lobe emarginated. The ethanol extract of rhizome showed the presence of hydroxyl, carbonyl, ester and olefin functional groups in it and also methyl, methylene, methionine proteins and olefinic proteins (Jain and Mishra, 1964; Gholap and Bandyopadhyay, 1984; Rao *et al.*, 1989; Mujumdar *et al.*, 2000).

High-frequency microrhizome production from the *in vitro* shoot cultures in liquid Murashigue and Skoog medium with 5 mg $l^{-1}$ BA and 8% sucrose was reported by Nayak (2002).

The rhizomes are bitter, sweet, sour aromatic (a mixture of tastes, starting from bitter initially, turning to a sweet and then sour aromatic sensation), and cooling; used as an appetizer, carminative, digestive, stomachic, demulcent, febrifuge, alexeteric, aphrodisiac, laxative, diuretic, expectorant, anti-inflammatory and antipyretic and used in the treatment of anorexia, dyspepsia, flatulence, colic, bruises, wounds, chronic ulcers, skin diseases, pruritus, fever, constipation, hiccough, cough, bronchitis, sprains, gout, halitosis, otalgia and inflammations (Hussain *et al.*, 1992; Warrier *et al.*, 1994).

There is only very limited literature available on the pharmacological activity of the extract (Bhakuni *et al.*, 1969; Rao *et al.*, 1989). The rhizome extract of the plant exhibited an hyper-cholesteremic effect in rabbits (Pachuri and Mukherjee, 1970). The extract showed presence of an antibiotic principle with strong inhibitory activity on *Aspergillus niger* and *Trichophyton rubrum* (Gupta and Banerjee, 1972).

The rhizome is a favourite spice and vegetable owing to the rich flavour of raw mango.

The essential oils in the rhizome make it useful as a carminative and stomachic. The pulped rhizome is also used on concussions and sprains. An improved cultivar (Amba) has been developed at the high altitude research station at Pottangi, Orissa (India).

### 5.15.2 Lovage

Lovage (*Levisticum officinale* Koth.) is a perennial plant that belongs to the family Apiaceae, and is a native of Europe. Centres of lovage cultivation are located principally in central Europe. It is also found cultivated in some areas in New England, USA. It has been grown over the centuries for its aromatic fragrance, its fine ornamental qualities and, to a lesser extent, its medicinal values. All parts of the plant, including the roots, are strongly aromatic and contain extractable essential oils.

It is a pungent, clump-forming herb with rhizomatous roots and stout hollow-ridged stems up to 2.4 m. Leaves are broad and glossy; a tall flower stalk that grows 2 m high with greenish-yellow flowers in large, dense umbels are produced in summer. The fruits are ridged and golden brown in colour (Clevely and Richmond, 1999).

Chemical constituents of lovage oil are mainly phthalides and terpenoids, including *n*-butylidene phthalide, *n*-butyl-phthalide, sedanonic anhydride, D-terpineol, carvacrol , eugenol and volatile oil. The principal components of volatile oil are angelic acid and β-terpenol, coumarins, furocoumarins including psoralins, rotoside, sitosterols, resins, pinene, phellandrene, terpinine, carvacol, terpineol, isovaleric acid, umbelliferone and bergapten. Fresh leaves contain a maximum 0.5% essential oil; the most important aroma components are phthalides (ligustilide, butylphthalide and a partially hydrogenated derivative thereof called sedanolide). Terpenoids (terpineol, carvacrol) and eugenol are less important (Simon *et al.*, 1984; Karnick, 1994b).

Najda *et al.* (2003) studied the composition of various compounds in various plant parts of lovage. The phenolic acids in various plant parts were as follows: roots 0.12–0.16%, herb 0.88–1.03%, stems 0.30–0.39%, leaf 1.11–1.23% and fruits 1.32–1.41%. The quantity of tannins in various plant parts was: roots 6.6%, herb 5.3%, stems 7.4%, leaf 2.7%, and fruits 1.8%. Free phenolic acids such as chlorogenic, caffeic, *p*-coumaric and *m*-coumaric were detected using HPLC.

The crop is propagated either through seeds or through root divisions. It prefers a well-drained, fertile soil. The seeds are sown outdoors during spring in a seedbed. The roots are divided in spring or autumn and planted. Mature plants require wider space, as they are large and bulky. Deep, rich moist soil and full sun or partial shade are required for better growth. The plants need to be cut back during summer to get a continuous supply of tender leaves. Fertilization with balanced organic fertilizer is required in spring and mulching is done in summer. Young flower stalks are removed to keep the foliage fresh for longer.

Harvesting is done in the second or third year of the crop and is usually in October. Young leaves, hollow main stems before flowering, sliced dried roots of 2–3-year-old plants and ripe seeds are the useful parts. The fresh roots are generally first harvested from 2–3-year-old plants. Subsequent harvests take place every third year. The fresh roots are washed, cut into approximately 13 mm thick pieces and dried.

Leaves are used in flavouring soups, salads, casseroles and stews because of their pungent, celery-like flavour. The stems are used for candied products. Roots are peeled and cooked as a vegetable. Powdered root is sometimes used as a spice. The volatile oil extracted from the roots is highly valued for use in perfumery, soaps and creams, and it has been used for flavouring tobacco products. The seeds and seed oil are used for flavouring agents in confectionery and liqueurs.



As a medicinal plant, lovage has been used as a digestive, carminative, diaphoretic, diuretic, emmenagogue, anti-dyspeptic, expectorant, stimulant and stomachic; and also as a treatment for jaundice. Current medicinal applications include use as a diuretic and for regulation of menstrual cycle. Lovage is generally recognized as safe for human consumption as a natural seasoning and flavouring agent (Karnick, 1994b).

### 5.15.3 *Zanthoxylum* spp.

The term Szechuan pepper or Japanese pepper refers to a spice obtained from a group of closely related plants of the genus *Zanthoxylum*, belonging to the family Rutaceae and consisting of approximately 200 species with a pan-tropical distribution. It is a large genus of aromatic, prickly trees or shrubs and is mostly distributed in the Himalayan region, furthermore in Central, South, South-East and East Asia. The most important species are *Z. piperitum* DC, *Z. simulans* Hance, *Z. bungeanum* Max., *Z. schinifolium* Sieb. and Zucc, *Z. nitidum* Roxb, *Z. ovalifolium* Wight., *Z. rhetsa* Pierre., *Z. alatum* Roxb. and *Z. acanthopodium* DC. All these species are widely distributed over Asia, but are not used as a spice throughout the region. All species mentioned have their place in local cuisine. The literature often gives contradicting information on the genuine species of the spice used. *Zanthoxylum* is a confusing genus and the information available is very scanty.

Szechuan pepper or Japanese pepper is very important in the cuisine of central China and Japan, but it is also known in parts of India, especially in the Himalayan region, and in certain regions of South-East Asia. The fruit of *Z. piperitum* (Japanese pepper) is the genuine source of the spice. It is a small tree and often wrongly assumed to be part of the pepper family. The spice, which is the ground husks of the berries, is common in the Szechuan region of China, and the leaves of the plant are also used in Japan as spice. The ripe fruits of the tree open out in a similar way to star anise. This spice is also known by various common names such as anise pepper, *fagara*, Chinese brown pepper, *poivre anise*, *anispfeffer*, *pimenta de anis*, *pepe d'anis* and Szechuan pepper.

Most *Zanthoxylum* species produce pungent alkamides derived from polyunsaturated carboxylic acids, stored in the pericarp. The commonly found alkamides are α-, β- and γ-sanshool and hydroxy sanshools. Total amide content in *Z. piperitum* is as high as 3%. Non-volatile constituents such as flavonoids, terpene alkaloids, benzophenthredine alkaloids, pyranoquinoline alkaloids, etc. were also identified. The composition of leaf oil of *Z. piperitum* from Japan has been reported (Kusumoto *et al.*, 1968; Shimoda *et al.*,1997). The volatile compounds in the leaves were isolated by steam distillation and the aroma components were evaluated by an aroma extraction dilution analysis. The main components responsible for the aroma are glycosides such as (Z)-3-hexenol, C-6 compounds, citronellal, citronellol, geraniol and 2-phenylethanol (Kojima *et al.*, 1997).

Xanthoxylin and (–)-sesamin are isolated from *Z. piperitum* (Harborne and Baxtor, 1993). β-Sanshool and γ-sanshool, unsaturated aliphatic acid amides isolated from the pericarp, were found to relax the circular muscle of the gastric body, as well as contract the longitudinal muscle of the ileum and distal colon in an experimental system using the gastrointestinal tract isolated from a guinea pig (Hashimoto *et al.*, 2001). Epple *et al.* (2001) investigated the effects of a total extract from *Z. piperitum* fruit on food intake in rats and found that they failed to habituate to the stimuli.

The rust-red berries contain bitter, black seeds that are usually removed before the spice is sold. This spice is used whole or ground and is much used in Chinese cookery, especially with chicken and duck. It is one of the spices in the Chinese five-spice powder and is used

in Japanese seven-spice seasoning mix. The leaves are dried and ground to make *sansho*, a Japanese spice. In the Goa and Konkan region of India the dried immature fruits of Z. *rhesta* are used for flavouring fish and chicken preparations.

In the past the ground bark was used as a remedy for toothache in the USA. Both bark and berries are used in traditional medicines and herbal cures to purify the blood, promote digestion and as an anti-rheumatic.

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