ZINGIBERACEOUS MEDICINAL AND AROMATIC PLANTS

Green plants synthesise and preserve a variety of biochemical products, many of which are extractable and used as chemical feed stocks or as raw material for various scientific investigations and industrial utilization. Medicinal plants are generally known as "Chemical Goldmines" as they contain natural chemicals, which are acceptable to human and animal systems. All these chemicals cannot be synthesised in laboratories. Many secondary metabolites of plant are commercially important and find use in a number of pharmaceutical compounds. Human beings have been dependent on plants for their health care needs since the beginning of civilistion. Of the 2,50,000 higher plant species on earth, more than 80,000 are medicinal in nature. About 5000 species are extensively used in traditional systems of medicine and are studied in some detail. *The Red Data Book of India* has 427 entries of endangered species of which 28 are considered extinct, 124 threatened, 81 vulnerable, 100 rare and 34 insufficiently known species (Thomas, 1997).

India has one of the richest ethnobotanical traditions in the world with more than 7000 species of plants found in different agro-ecosystems and used by various indigenous systems of medicine and industries. Over 95% of the plants used by the herbal or pharmaceutical industry is collected from wild sources. Given the alarming rate of loss of biodiversity due to other well-known factors alongside the indiscriminate collection of wild medicinal plants, there is a real danger of extinction of many of our medicinal plant species. In the face of serious threat to biodiversity, it is extremely important to take urgent steps to conserve and develop medicinal plant genetic resources alongside their cultural roots in all our diverse agro-ecosystems.

Zingiberaceae family constitutes a vital group of rhizomatous medicinal and aromatic plants characterised by the presence of volatile oils and oleoresins of export value. Generally, the rhizomes and fruits are aromatic, tonic and stimulant; occasionally they are nutritive. Some are used as food as they contain starch in large quantities while others yield an astringent and diaphoretic juice. The important genera coming under Zingiberaceae are *Curcuma, Kaempferia, Hedychium, Amomum, Zingiber, Alpinia, Elettaria* and *Costus*. In the genus *Alpinia, A. galanga* is the most important one, which finds varying uses in ayurvedic preparations such as "Rasnadi powder". *Costus speciosus* is the only species in the genus *Costus* that is medicinally important. It is valued very much for its diosgenin content. In *Curcuma*, *C. longa* is the most popular one, which has been studied in greater depths already. *C. aromatica* is used in the treatment of skin diseases and is extensively used in vanishing creams. *Kaempferia galanga* has become very popular and is identified to have tremendous effect in curing bronchial and gastric diseases. Of late, it is being used in preparations of mouth washes and oral deodorants. *K. rotunda* is another related crop under this genus which has potential for great exploitation on commercial basis.

Systematic Position of Zingiberaceae Family

The systematic position of the family Zingiberaceae is as follows.

Kingdom	: Plantae
Sub-kingdom	: Phanerogamae
Division	: Spermatophyta
Subdivision	: Angiospermae
Class	: Monocotyledonae
Series	: Epigynae
Order	: Scitaminales
Family	: Zingiberaceae

A Botanical Description of the Family Zingiberaceae

Zingiberaceous Medicinal and Aromatic Plants are generally herbs, often large, with a pseudostem of convolete leaf-sheaths. Leaves are radial or cauline and usually membranous. Sheaths are generally large, clasping the stem; lamina with a strong central nerve and pinnate close secondary nerves. Petioles are short or nil. Flowers are hermaphrodite, irregular, solitary or spicate, bracts membraneous, bracteoles membranous or nil. Perianth is 2-serrate, superior, outer segments three, calyx free and imbricate or connate in an entire toothed or spathaceous tube. Inner segments are petaloid, connate in a long or short corolla tube, free or adnate to the petaloid staminodes, or 5-perfect with a six imperfect or obsolete. Anthers linear and 2-celled. Ovary is 3-celled, inferior with many ovules, anatropous and axile. Style is usually slender with 2 short stylodes, crowning the ovary. Stigma is usually entire or sub entire. Fruit is loculicidally a 3-valved capsule, or indehiscent and membranous or fleshy, usually crowned by the remains of the perianth. Seeds are often arillate, albumen floury and embryo small.

Zingiberaceae family comprises about 50 genera usually found throughout the warm regions of both hemispheres. Out of these about nine genera are reported to constitute potential medicinal and aromatic plants as listed below.

Genus	***Species***
Curcuma	*C. amada, C. longa, C. zedoaria, C. aromatica*
Kaempferia	*K. rotunda, K. galanga*
Hedychium	*H. spicatum, H. coronarium*
Amomum	*A. subulatum*
Zingiber	*Z. officinale, Z. zerumbet*
Alpinia	*A. galanga, A. calcarata, A. allughas*
Elettaria	*E. cardamomum*
Costus	*C. speciosus*
Gastrochilus	*G. pandurata*

Biotechnology in Zingiberaceous Plants

Mustafa and Hariharan (1998) have developed a new tissue culture method for the large-scale multiplication of Zingiberaceous species. Buds or propagules collected from the underground stems of these plants are sterilized with detergents or suitable sterilizing agents. The sterilized buds are asceptically inoculated in artificial nutrient medium supplied with suitable hormones and are placed under controlled temperature and light. Tissue mass (callus) or multiple buds are induced and subcultured into the media supplied with hormone combination so as to produce *in vitro* shoots and roots. About 25-30 plantlets are produced per culture tube. The shoots obtained *in vitro* are transferred to natural outdoor conditions. Plants obtained by this method are free from viruses, fungi and bacteria. They are superior in quality and more plants can be produced with in a shorter period and the progeny is uniform.

ALPINIA

Importance

This plant is cultivated for its rhizome in tropical areas of South and East India. Because of the presence of essential oil, the rhizomes are used in bronchial troubles and as a carminative. It is one of the ingredients of medicated "*Pan*" used for removing the foul smell of the mouth and getting relief in throat inflammation. In Ayurveda, "*Rasna-saptak-kwath*" and "*Rasna-adikamath*" are used as antiinflammatory decoctions. In Unani, it is an ingredient of aphrodisiac preparations, "*Majun Mugawivi ma Mumsik*", "*Majun Samagh*", and antispasmodic nervine tonic "*Majun Chobchine*" and "*Lubab Motadil*". It is also used in "*Arq Pan*" as a cardiac stimulant carminative (Thakur *et al*, 1989). They are also useful in vitiated conditions of *vata* and *kapha*, rheumatoid arthritis, inflammations, stomatopathy, pharyngopathy, cough, asthma, hiccough, dyspepsia, stomachalgia, obesity, diabetes, cephalalgia, tubercular glands and intermittent fevers (Warrier *et al*, 1993). Charaka includes rasna (Alpinia) in the *Vayasthapana Varya*, the group of drugs that are capable of maintaining the youthful vigour and strength. The officinal part is the rhizome which forms a major ingredient of preparations like *Rasnadi Kasaya, Rasnadi churna, Rasnadi taila, Asvagandharishta, etc* (Sivarajan and Balachandran, 1994). The drug stimulates digestion, purifies blood and improves voice (Chunekar, 1982).

Botany

In most of the publication on Indian Materia Medica, *rasna* is equated with an orchid *Vanda tessellata* (Roxb.) Hook ex Don. Syn. *Vanda roxbugrhii* R.Br. (Kirtikar *and* Basu, 1988; Vaidya, 1936; Nadkarni, 1954; Chopra *et al*, 1956; Kurup *et al*, 1979; Kapoor *and* Mitra, 1979; Dey, 1980). Some others consider *Pluchea lanceolata* (Asteraceae) as the real source of *rasna* (Singh and Chunekar, 1972; Sharma, 1983). This is the *rasna* of Punjab and Gujarat (Vaidya, 1982). But none of them is taken as the drug source in Kerala. Throughout South India, it is the aromatic rhizomes of *Alpinia galanga* that is accepted as the source of *rasna*. As the synonyms *elaparni* and *sugandha* suit this plant well, this is believed to be the true *rasna* by South Indian physicians. Some authors equate this plant with *Kulanjana* or *Sugandhavaca* (Nadkarni, 1954; Chopra *et al*, 1956; Sharma, 1983) giving the Malayalam equivalent of rasna, namely *Aratta*. Studies on the market samples reveal that two types of rasna are sold in South Indian markets-one with light brown colour and aromatic odour identified as the rhizomes of A. *calcarata* Rosc. locally called *peraratta* and the other less aromatic, *A.galanga*, known as the *chittaratha* or *aratta* in vernacular (Nair *et al*, 1982). The above two species are used as the drug sources in Kerala.

1. Alpinia galanga

Eng: Greater galangal, Java galangal, Siamese galangal; San:Sugandhamula,Rasna; Hin:Kulainjan; Mal:Aratta, Chittaratha; Tam:Arattai; Guj: Kolinjan; Kan: Dumba-rasmi; Mar: Kosht-Kulinjan; Tel: Pedda-dumparash-tram

Alpinia galanga (Linn.) Willd. is a perennial herb, about 2m high with lower portion covered with smooth leaf sheaths. The leaves are broadly lanceolate, 30-60cm long and 10-15cm broad. The flowers are arranged in erect, terminal panicles composed of numerous spreading dichotomous branches each with two to six, pale greenish-white faintly fragrant flowers. Fruits 1.25 cm long, oblong, constricted in the middle or even pear shaped, three sided and deep orange red in colour. Seeds are ash coloured, three angled, finely striated towards the hilum. Both the seeds and rhizomes have pungent aroma (Thakur *et al*, 1989). The plant is also described by Gamble (1987), Sivarajan and Balachandran (1994), Warrier *et al* (1993) and Kirtikar and Basu (1987).

2. Alpinia calcarata

Mal: Kolinchi.

Alpinia calcarata Rosc. is another species of the genus with much medicinal importance. It is shorter in stature but stronger in aroma than *Alpinia galanga*. It is a perennial herb with non- tuberous root-stock. Stem is slender and 0.6-1.2m high. Leaves are 15-30 x 2.5-5cm; lanceolate, acuminate, green and glossy. Flowers are numerous, large, arranged in dense panicles, 7.5-10cm long, with pubescent rachis and small ovate bracts. Calyx tube is funnel-shaped and 6-8mm long. Corolla segments are 13mm long. Lip is 2.5-3.8cm long, ovate-oblong, sessile, yellow, streaked with purple veins and emarginate. Ovary is densely pubescent with many ovules in each cell. Capsules are globose and red (Kirtikar and Basu, 1987). Developmental studies in *A. calcarata* show that the placentae intrude into the ovary chamber and fuse at the lower portion of the ovary, leaving the upper portions of the ovary chambers confluent (Mangary and Hamsa, 1991) The botanical description is also done by Sivarajan and Balachandran (1994) and Gamble (1987).

3. Alpinia allughas

San: Taraka Hin: Taro Mal: Malayinjikkuva

Another species of *Alpinia*, which has the therapeutic properties, is *A. allughas* Rosc. It is a stout perennial herb with tuberous, aromatic roots. Leaves are sessile, oblong,-lanceolate, acuminate, cuspidate, glabrate, striate and compressed. Flowers are inodorous, pink, inerect, arranged in dense panicles with pubescent rachis and small ovate cupular bracts. Lip more than 2-5cm long, pink, obovate-cuneate, or sub-orbicular. Fruit black, thin, globose and irregularly rupturing. Seeds many, small, black and angular (Kirtikar and Basu, 1987).

The three species can be distinguished as follows:
In *A. galanga*, flowers are greenish white, lip veined with red.
In *A. calcarata*, flowers are white, lip variegated with red and yellow.
In *A. allughas*, flowers are pink (Gamble, 1987).

Agrotechnology

Alpinia comes up well in tropical climate. It grows on a wide range of climate and soils. Well-drained hilly areas and places of 1400m high altitude are good for its cultivation. This is commercially propagated vegetatively by rhizomes. The field should be ploughed to a good tilth. All the stones and pebbles should be removed. Organic manures at 10t/ha are applied during land preparation. Seedbeds are prepared with 1m breadth, 2m length and 15cm height. Small pits are made at 25cm spacing above the seedbeds and 5cm long rhizomes are planted. Seedbeds are covered with dried leaves. It is irrigated immediately after planting. Regular weeding is needed during the initial stages of crop growth. This is cultivated also as an intercrop in coconut or rubber plantations. Rhizomes are dug out after cutting the top portions when the crop reaches 1.5-2 years of maturity. The average yield is 10-15 tonnes of fresh rhizomes/ha and the driage is 25-30%. The collected rhizomes are washed and cut into pieces of 5cm long and dried in sun for 4 days before sale (Prasad and Joseph, 1997).

Chemical constituents

Seeds contain 1'-acetoxychavicol acetate and 1'-acetoxy eugenol acetate, antiulcer principles caryophyllenols I and II, n-pentadecane, 7-heptadecane and fatty acid methyl esters. Rhizomes yield essential oil containing methyl cinnamate, cineole and d-pinene and sesquiterpenoids. Fresh rhizome yielded 18 monoterpenoids of which α-pinene, β-pinene and limonene as major compounds and 17 oxygen containing monoterpenoids with cineol, terpinen-4-o1, and α-terpineol as minor compounds (Husain *et al*, 1992).

The rhizome contains tannins and flavonoids, some of which have been identified as kaempferide, galangin and alpinin (Sastry, 1961). From roots, kaempferide, galangin and alpinin were isolated. From green rhizomes, a pale yellow oil with a pleasant odour can be obtained on distillation. The oil contains 48% methyl cinnamate, 20-30% cineole, camphor and probably α-pinene (Chopra *et al*, 1957). Itokawa *et al* (1987) isolated two anti tumour principles from *A. galanga*.

Fourteen flavanoids were detected by chromatography of which seven were identified as quercetin-3-methyl ether, iso-rhamnetin, kaempferide, galangin and its 3-methyl ether; 11-acetoxy chavicol acetate (I) and 11-acetoxcy eugenol acetate (II) isolated from seeds along with caryophyllene oxide, caryophyllenol II, pentadecane and 7-heptadecane (Rastogi and Mehrotra, 1991).

The essential oil from rhizomes yielded 5.6% cineole, 2.6% Methyl-cinnamate and sesquiterpenes. From fresh rhizomes,18 monoterpenes were isolated of which α-pinene (22.5%), β-pinene (36.7%) and limonene (13.8%) were major and 17-oxygen containing monoterpenes with cineol (69%), terpinen-4-ol (8.75%) and (-terpenol (6.9%) as major compounds. Seeds contain anti ulcer agents, 11- OAc chavivol-OAc and 11- OAc-eugenol-OAc; also caryophyllene, caryophyllenol I and II, pentadecane, 7- heptadecane and fatty acid Methyl- esters (Asolkar *et al*, 1992).

Twelve compounds have been characterised by GC/MS in *A. galanga*. The major compound is myrcene; 94.51% in rhizome and 52.34% in leaves (Charles *et al*, 1992).

In case of *A. allughas*, rhizomes yielded essential oil (0.05%) which contained caryophyllene oxide (23.07%), geraniol (19.93%), eudesmol (19.93%), citronellyl acetate (16.5%), citronellol (6.8%), β-caryophyllene (5.45%), α-pinene (3.84%), linalool (2.86%) (-)α-phellandrene (1.6%) and geranyl acetate (0.16%) (Rastogi and Mehrotra, 1991).

Activity

The rhizomes are bitter, acrid, thermogenic, aromatic, nervine tonic, stimulant, revulsive, carminative, stomachic, disinfectant, aphrodisiac, expectorant, broncho-dilator, antifungal, febrifuge, antiinflammatory and tonic (Warier *et al*, 1993). Rhizome is CVS and CNS active, diuretic, hypothermic. Seed is antiulcerative (Husain *et al*, 1992).

Rhizome spray in ether, over a space showed high knock down values against houseflies. Alcohol (50%) extract of rhizome is anti-amphetaminic. Unani physicians consider it good for impotence (Asolkar *et al*, 1992).

Toxicity studies on *A. galanga* was carried out by Qureshi *et al* (1992). The steam volatile oil stimulates bronchial glands when exposed to its vapours (Chopra *et al*, 1957).

Intravenous injection of a small dose of tincture or an infusion of *A. galanga* produces a sharp fall in blood pressure in experimental animals. The blood pressure, however, comes to normal in a short time. The fall in blood pressure is accompained by a rise in volume of the intra-abdominal organs like the spleen and the intestine showing that dialation of the blood vessels is one of the important constituents of the drug, and its use as a carminative is suggested (Inamdar *et al*, 1961).

The pharmacognosy and toxicology of anti-carcinogenic natural products from galanga root oil has been studied by Zheng *et al* (1993). The effect of *A. galanga* treatment on cytological and biochemical changes induced by cyclophosphamide in mice have been studied by Qureshi *et al* (1994).

The rhizomes of *A. calcarata* are anti- inflammatory (Asolkar *et al*, 1992). The physiochemical characteristics of the essential oils from leaves and roots of *A. calcarata* have been described by Rath *et al* (1994).

CURCUMA

Importance

Turmeric is mainly used as a condiment. Its rhizomes yield curcumin and also aromatic oils. Farrel (1990) states that turmeric is used in the historic times as a dye, medicine, ceremonial colour and as a magical symbol. In India, ladies anoint their bodies with turmeric paste, which is considered to be an antiseptic. Purseglove (1968 *and* 1981) states that it is a condiment and a spice among the rice eating peoples of South East Asia and Indochina. In India, Malasia and Polynesia it is used in curries for its musky flavour and yellow colour. Turmeric dyes is used in combination with some alkalies to colour silk and cotton. It is also used in several countries as a colouring material in pharmacy, confectionery and food industries. It is an essential and sacred ingredient of all social, cultural and religious functions and rites in India, especially in the South (Velayudhan *et al*, 1994).

Aiyar (1954), Kirtikar and Basu (1988), Watt (1972), Haines (1961) and Holtumn (1950) describe the various uses of Curcuma. Purseglove (1968 *and* 1981) also gives a limited account of its uses. The medicinal properties of turmeric are innumerable and very ancient. Kirtikar and Basu (1988) state that the rhizome is very pungent, bitter, healing, laxative, anthelmentic, vulnerary, tonic, alexeteric and emollient. It is used as a medicine in various kapha and vata diseases of blood. In Comboidia it is used as a tonic and antipyretic. In China it is used as a stimulant, aspirant, carminative, cordeal, emmenagogue, astringent, detergent, diuretic and matrient. It is used in Unani systems in treating, jaundice, scabies and bruises. On the whole it is used in the treatment of bronchitis, dropsy, vertigo, skin diseases, liver infections, burns, boils, elephantiasis, sprains, hysteric effects, fevers, swellings, chronic gonorrhoea, bruises, small pox, chicken pox, scorpion snake and leech bites, congestions, scabies, dyspepsia, ring worm, etc. C. aromatica Salisb. yields arrow root. Quite recently C. longa is proved to contain a chemical constituent called turmerin which is anticarcinogenic, antipyretic and antiallergic. The importance of turmeric has significantly increased due to its usefulness as pesticide, fungicide and bactericide (Velayudhan *et al*, 1994).

Origin and Distribution

Purseglove (1968) and Harlan (1975) believed that the genus originated in the Indo-Malayan region. Considering the great diversity of the genus represented by over 80 species in Indo-Malayan region, it is legitimate to consider that the genus originated in this region. But the fact that over 40 species indigenous to this country, is supportive to its Indian origin. Further, many species belonging to two subgenera of Valeton (1918) and a newly reported unique species such as *C. vamana* having stoloniferous sessile fingers adds to the cause of its Indian origin.

The genus *Curcuma* belonging to the family Zingiberaceae has a widespread occurrence in the tropical Asia and Australia. At present the crop is distributed in India, Pakistan, Malasia, Indoenasia, Myanmar, Vietnam, Thailand, Philippines, Japan, China, Korea, Sri Lanka, Nepal, South Pacific Islands, East and West African nations, Malagasy, Caribbean Islands and Central America. In India, it is widespread (Purseglove, 1968 *and* 1981) and it is cultivated in innumerable agro-ecological situations right from the coastal areas to elevations as high as 1880m in the tropics and the sub-tropics of the country. It is o reported to occur widely in Eastern and Western Ghats.

India is the largest producer of turmeric in the world accounting for 93.7% of the world production. About 90%is used internally and the rest exported, earning Rs.4.15-7.20 crores annually as foreign exchange.

***C. longa* Linn. syn. *C. domestica* Valeton.**

Eng: Turmeric; San: Haridra, Varavarnini; Hin: Haldi, halda; Ben: Haldi;
Mal: Manjal, Pachamanjal, Varattumanjal; Tam: Mancal; Kan: Haldi, Arasina; Tel: Pasapu

Importance

Turmeric occupies an important position in the life of Indian people as it forms an integral part of the rituals, ceremonies and cuisine. Due to the strong antiseptic properties, turmeric has been used as a remedy for all kinds of poisonous affections, ulcers and wounds. It gives good complexion to the skin and so it is applied to face as a depilatory and facial tonic. The drug cures diseases due to morbid *vata, pitta* and *kapha*, diabetes, eye diseases, ulcers, oedema, anaemia, anorexia, leprosy and scrofula. It purifies blood by destroying the pathogenic organisms. A paste of turmeric alone, or combined with a paste of neem (*Azadirachta indica*) leaves, is used to cure ringworm, obstinate itching, eczema and other parasitic skin diseases and in chicken pox and small pox. The drug is also useful in cold, cough, bronchitis, conjunctivitis and liver affections (Nadkarni, 1954; Kurup *et al*, 1979; Kolammal, 1979). The rhizome is the officinal part and is an important ingredient of formulations like *Nalpamaradi taila, Jatyadi taila, Narayana gula, etc.* (Sivarajan and Balachandran, 1994).

Turmeric paste mixed with a little limejuice and saltpetre and applied hot is a popular application to sprains and bruises. In smallpox and chickenpox, a coating of turmeric is applied to facilitate the process of scabbing. The smoke produced by sprinkling powdered turmeric over burnt charcoal will relieve scorpion sting when the part affected is exposed to the smoke for a few minutes. Turmeric and alum powder in the proportion of 1:20 is blown into the ear in chronic otorrhoea (Nadkarni, 1998).

"*Haridra Khand*", a compound containing powdered turmeric, sugar and many other ingredients is a well-known preparation for cold, cough and flu, and for skin diseases. In Unani system, roasted turmeric is an ingredient of "*Hab Narkachur*", used as antidysenteric for children (Thakur *et al*, 1989).

The pharmacology of *C. longa* was studied by Ammon and Wahl (1991) in detail.

Distribution

Turmeric is cultivated all over India, particularly in W. Bengal, T. N, Punjab, Kerala and Maharashtra.

Botany

C. longa Linn. syn. *C. domestica* Valeton. is a perennial herb, 60-90cm in height, with a short stem and tufts of erect leaves. Rhizome is cylindric, ovoid, orange coloured and branched. Leaves are simple, very large, petiole as long as the blade, oblong-lanceolate, tapering to the base upto 45cm long. Flowers are pale yellow, arranged in spikes concealed by the sheathing petioles and flowering bracts are pale green (Warrier *et al*, 1994). The botanical description is also done by Gamble (1987), Kirtikar and Basu (1987), Sivarajan and Balachandran (1994) and Thakur (1989).

Chemical constituents

Essential oil contains ar-turmerone, and ar-curcumene as major constituents. Some of the other compounds are α-and β-pinene, sabinene, myrcene, α-terpinene, limonene, p-cymene, perillyl alcohol, turmerone, eugenol, iso-eugenol, eugenol methyl ether and iso-eugenol methyl ether. Curcumin and related compounds have also been reported as major constituents of the rhizomes. Recently a number of sesquiterpenes have been reported from *C. longa*, viz., the sesquiterpenoids of germacrane, bisabolane and guainane skeletons (Husain *et al*, 1992).

The study of sesquiterpenes has revealed a new compound curlone (Kisoy *et al*, 1983). The crystalline colouring matter curcumin (0. 6%) is diferuloyl methane (Mathews *et al*, 1980). Stigmasterol, cholestrol, β-sitosterol and fatty acids, mainly straight chain dienoic acids are reported (Moon *et al*, 1976).

C. longa contains curcumin, alkaloid and an essential oil. Dry rhizomes of *C. longa* yield 5.8% essential oil. A ketone and an alcohol is obtained from the volatile distillate. Fresh rhizomes yield 0.24% oil containing Zingiberine (Chopra, 1980).

The essential oil (5.8%) obtained by steam distillation of dry rhizomes have been reported to contain β-phellandrene, d-sabinene, cineole, borneol, Zingiberene and sesquiterpene ketones (50%). In the recent analysis of the essential oil, turmerone (29.3%), ar-turmerine (23.6%) and sabinone (0.6%) have been identified in the ketonic fraction besides p-cymene, iso-caryophyllene, trans- β-farnesene, δ-curcumene, β-bisbolene and β-sesquiphellandrene (Lawrence, 1982).

Major constituents in leaf oil of *C. longa* were isolated by Behur *et al* (1998). Essential oils in *C. longa* from Bhutan was identified by Srimal (1997).Comparison of the commercial turmeric and its cultivated plant by their constituents was done by Uehara *et al* (1992).

Campesterol, stigmasterol, β-sitosterol, cholesterol and fatty acids were isolated from rhizomes. Fatty acids comprised of saturated straight chain, saturated iso, monoenoic and dienoic acids (Rastogi and Mehrotra, 1991).

Activity

Curcumin, the colouring agent and major constituent of *C. longa,* is said to possess local as well as systemic antiinflammatory property which has been found to compare favourably with phenylbutazone (Srimal and Dhawan, 1973). An extract of the crude drug '*akon'* containing the rhizomes exhibited intensive preventive activity against carbon tetrachloride induced liver injury *invivo* and *invitro*. The liver protecting effects of some analogs of ferulic acid and p-coumaric acid, probable metabolites of the curcuminoids have been also evaluated (Kiso *et al*, 1983).

Curcumin is antiinflammatory. Rhizome is antiprotozoal, spasmolytic, CNS active, antiparasitic, antispasmodic, antibacterial, antiarthritic (Husain *et al*, 1992).The rhizomes are also anthelmintic, carminative, antiperiodic, emollient, anodyne, laxative, diruretic, expectorant, alterative, alexertive, febrifuge, opthalmic and tonic (Warrier *et al*, 1994).

The successive extraction of *C.longa* with petroleum ether, alcohol and distilled water yielded extracts when administered on 1-7 days of pregnancy at dose levels of 100and 200mg/kg have been found to exhibit significant anti-fertility activity (Garg *et al*, 1978).

Essential oil from rhizomes is antiseptic, antacid and carminative. Effect of the oil on cardiovascular and respiratory systems is not marked, therefore, not of much importance from therapeutic point of view. Chloretic action of the essential oil is attributed to p-tolymethyl carbinol. Dye-stuff acts as a cholagogue causing contraction of the gall bladder. Anti-oxidant properties of curcuma powder is due to phenolic character of curcumin (Dey, 1980).

Rhizomes are externally effective as insect repellent against houseflies. It is found to inhibit *Clostridium botulinum.* Essential oil from rhizome showed fungitoxicity (Asolkar *et al*, 1992).

Essential oil (0.1mg/kg) in rats showed significantly more marked antiinflammatory effect than cortisone acetate (10mg/kg). The uptake, distribution and excretion of curcumin were also studied. Clinical trials showed that plant definitely reduced cough and dyspnoea (Rastogi and Mehrotra, 1991).

Protective effect of curcuminoids from *C. longa* on epidermal skin cells under free oxygen stress was analysed by Bonte *et al* (1997). Anti-inflammatory activity volatile oil of *C. longa* leaves was studied by Iyengar *et al* (1994). A comparative study on the pharmacological properties of natural curcuminoids was

carried out by Anto *et al* (1994). A clinical trial of volatile oil of *Curcuma longa* Linn. (*Haridra*) in cases of Bronchial asthma (*Tamaka swasa*) was carried out by Jain *et al* (1990).

Nematicidal activity of turmeric was studied by Kinchi *et al* (1993). Cytotoxic and tumour reducing properties of curcumin was analysed by Soudamini and Kuttan (1988). Toxicity studies on *C. longa* are also carried out by Qureshi *et al* (1992).

***C. zedoaria* (Berg.) Rosc. syn. *C. zerumbet* Roxb; *Amomum zedoaria* Christm.**

Eng: Round zedoary; San: Kachura, Shati; Hin: Kakhur; Ben: Sati; Kan: Kachora
Mal: Manjakoova, Adavi-kacholam; Tam: Kichilikizhangu, Nirvisham; Tel: Kacheramu

Importance

The rhizome of *C. zedoaria* is used as appetiser and tonic, particularly prescribed to ladies after childbirth. In case of cold, a decoction of long pepper (*Piper longum*), cinnamon (*Cinnamomum verum*), zedoary and honey is given. In Ayurveda it is an ingredient of "*Braticityadi kwatha*", used in high fever (Thakur *et al*, 1989). Root is useful in flatulence and dyspepsia, and as a corrector of purgatives. Fresh root checks leucorrhoeal and gonorrhoeal discharges. Root powder is a good substitute for many foreign foods for infants. For worms, the juice from the tubers is given to children. Juice of the leaves is given in dropsy (Nadkarni, 1982). It is an odoriferous ingredient of the cosmetics used for the cure of chronic skin diseases caused by impure or deranged blood (Nadkarni, 1998). Decoction of fresh rhizomes is used for blood purification. It is used as an ingredient in Chinese medicine for extradurnal haematomas (Asolkar *et al*, 1992).

Distribution

The round zedoary or zerumbet is mostly found in India and S. E. Asia. The plant grows wild in the Eastern Himalayas and in moist deciduous forests of coastal tract of Kanara and Kerala.

Botany

Curcuma zedoaria (Berg.) Rosc. syn. *C. zerumbet* Roxb; *Amomum zedoaria* Christm. has 4-6 leaves with 20-60cm long lamina. The leaf lamina is oblong-lanceolate, finely acuminate and glabrous on both the surfaces. Flower stalk is 20-25cm long, emerging before the leaves. Flowers are yellow, while the flowering bract is green tinged with red. Calyx is 8mm long, corolla tube is twice as long as the calyx. Capsule is ovoid, trigonous, thin smooth and bursting irregularly. Tubers are palmately branched and camphoraceous (Thakur *et al*, 1989). The botanical description of the plant is also given by Sivarajan and Balachandrann (1994), Gamble (1987) and Kirtikar and Basu (1987).

The identity of the plant sources of the drug *Karcura* is a matter of debate. There is difference of opinion among men of Ayurveda, as to whether *Sati* and *Karcura* are the same drug or different. Many authors consider them different and equate *Sati* with *Hedychium spicatum* Smith. and *Karcura* with *C. zedoaria*, both belonging to Zingiberaceae (Kurup *et al*, 1979; Chunekar, 1982; Sharma, 1983). Some others treat them to be the same and equate it with *C. zedoaria* (Kirtikar and Basu, 1988; Vaidya, 1936; Nadkarni, 1954; Kapoor and Mitra, 1979).

H. spicatum is a plant found in the Himalayas with its spikes sometimes reaching a length of 35cm. This is not available in the south, nor it has been the source of the drug in Kerala. *C. zedoaria* is available in Kerala. With its yellowish white fragrant rhizomes having a sharp pinching taste, it suits the synonymy rather well, but goes under the name *kua* in Malabar. There is some evidence to believe that the tubers of *C. zedoaria* have been the source of this drug in Kerala in the early times. The description " The leaf is like that of ginger" also suits *C. zedoaria* well. However, the source of *Karcura* in Kerala in the recent times has been *Kaempferia galanga* of the same family (Sivarajan and Balachandran, 1994).

Chemical constituents

Essential oil from rhizomes contains α-pinene, d-camphene, cineole, d-camphor, sesquiterpenes and sesquiterpene alcohols (Husain *et al*, 1992). The novel sesquiterpenoids which have been isolated and characterised are cuzerenone, epi-cuzerenone, iso-furanogermerene, curcumadiol, curcumol, curcumenol, iso-curcumenol, procurcumenol, dehydrocurdione (Hikino *et al*, 1968, 1971, 1972); germacrone-4, 5-epoxide, germacrone, germacrone furanodienone, curcumenol, iso-curcumenol, curcumanolides A and B and curcumenone (Shiobara *et al*, 1985).

The starch left after the extraction is purified and sold as a commodity of cottage industry in West-Bengal under the name '*Shoti*' (Sanjiva Rao *et al*, 1928). Ethyl-p methoxy-cinnamate has been isolated from the alcoholic extract of the plant (Gupta *et al*, 1976).

Steam distillation of the dried rhizomes yield essential oil containing α-pinene, camphor and sesquiterpenes (more than 50%) (Sanjiva Rao, 1928)

Rhizomes yield sesquiterpenes such as curcumol, curcolone, procurcumenol, isocurcumenol, furadiene and its iso-derivative, curcumadiol, dehydrocurdione and zederone (Asolkar *et al*, 1992)

Isolation of main component of essential oil-curzerone and its structure elucidation was also done. Another sesquiterpene-dehydrocurdione was isolated and characterised. Synthesis of pyrocurzerenone, curzerenone and new furanosesquiterpenoids-furadienone (I), isofuranodienone (II) and epicurzerenone-was isolated and their absolute configurations established (Rastogi and Mehrotra, 1991).

Insecticidal constituents from *C.zedoria* were identified by Pandji *et al* (1993). Isolation and structure elucidation of potential active principles of *C.zedoria* rhizomes were carried out by Joshi *et al* (1989) and that of hepatic drug inhibitors by Shin *et al* (1989).

Activity

Ethyl-p-methoxy cinnamate, isolated from *C. zedoria* inhibited the growth of *Trichophyton rubrum, Aspergillus niger, Saccharomyces cerevisiae* and *Epidermophyton floccosum* at a concentration of L 10 µg/ml. *A. fumigatus, Penicillium purpurogenum, Trignopsis variabilis, Microsporum gypseum, Sclerotium rolfsii, Geotricular candidae* and *Fusarium oxysporum* were inhibited at a concentration of L 50µg/ml. The spores of *T. rubrum* loose viability or ability to germinate when exposed to its ethanolic solution 30 µg/ml) for 2 hrs (Gupta *et al*, 1976).

The root extracts of *C. zedoria* tested at concentrations from 1-10mg/ml were found to inhibit the growth of *Entamoeba histolytica* (Ansari and Ahmad, 1991). Rhizome is stomachic, diuretic, and carminative and gastrointestinal stimulant (Husain *et al*, 1992).

Experimental evaluation of hepatoprotective activity of *C. zedoria* was done by Rana and Avadhoot (1992). Pharmacological activities of sesquiterpenes from the rhizomes were studied by Shin *et al* (1994).

***C. amada* Roxb.**

English: Mango ginger San: Amrardrakam, Karpuraharida Hin: Ama-haldi
Mal: Mangainchi Tam: Mankayinci Tel: Mamidi Allam

Importance

The rhizomes of this plant are useful in vitiated conditions of *pitta*, anorexia, dyspepsia, flatulence, colic, bruises, wounds, chronic ulcers, skin diseases, pruritus, fever, constipations, strangury, hiccough, cough, bronchitis, sprains, gout, halitosis, otalgia and inflammations (Warrier *et al*, 1994). The fresh root possesses the smell of green mango and hence the name *mango ginger*. The rhizomes are used externally in the form of paste as an application for bruises and skin diseases generally combined with other medicines. Tubers rubbed with the leaf-juice of *Caesalpinia bonduc* is given for worms (Nadkarni, 1982). Rhuizome is also used in applications over contusions and sprains (Chopra *et al*, 1980)

Distribution

Mango ginger is cultivated in Gujarat and found wild in parts of West Bengal, U. P, Karnataka and Tamil Nadu.

Botany

C. amada Roxb. is a rhizomatous aromatic herb with a leafy tuft and 60-90cm in height. Leaves are long, petiolate, oblong-lanceolate, tapering at both ends, glabrous and green on both sides. Flowers are white or pale yellow, arranged in spikes in the centre of tuft of the leaves. Lip is semi-elliptic, yellow, 3-lobbed with the mid lobe emarginate (Warrier *et al*, 1994). The plant is also described by Gamble (1987) and Kirtikar and Basu (1987).

Chemical constituents

The essential oil contains α-pinene, α-and β-curcumene, camphor, cuminyl alcohol, myristic acid and turmerone. Car-3-ene and cis-ocimene contribute the characteristic mango odour of the rhizome.

Rhizomes yield 1% essential oil containing d-α -pinene 18%, ocimene 47.2%, linalool 11.2%, linalyl acetate 9.1% and safrole 9.3% (Chopra *et al*, 1980).

Activity

Rhizome is CNS active, hypothermic and it shows potentiation of amphetamine toxicity. Tuber is trypsin inhibitor and is effective against *Vibrio cholerae* (Husain *et al*, 1992). The rhizomes are bitter, sweet sour, aromatic, cooling, appetiser, carminative, digestive, stomachic, demulcent, vulnerary, febrifuge, alexertic, aphrodisiac, laxative, diurectic, expectorant, antiinflammatory and antipyretic (Warrier *et al*, 1994).

***C. aromatica* Salisb.**

Eng: Wild turmeric; San: Aranyaharidra, Vanaharidra; Hin: Ban-haridra, Jangli-haldi; Ben: Ban Haland; Mal, Tam: Kasturimanjal, Kattumanjal; Tel: Adavi-pasupu; Kan: Kadarasina

Importance

Rhizomes are used in combination with astringents and aromatics for bruises, sprains, hiccough, bronchitis, cough, leucoderma and skin eruptions (Warrier *et al*, 1994). The rhizomes have an agreeable fragrant smell and yield a yellow colouring matter like turmeric, and the fresh root has a camphoraceous odour. The dried rhizome is used as a carminative and aromatic adjunctant to other medicines (Nadkarni, 1998). Oil is used for treatment of early stage of cervix cancer (Asolkar *et al*, 1992). Verghese (1990) established the use of mango-ginger as an exotic flavourant.

Distribution

Wild turmeric or Cochin turmeric or Yellow zeodoary is found wild throughout India and cultivated in Bengal and Kerala.

Botany

C. aromatica Salisb. is a perennial tuberous herb with annulate, aromatic yellow rhizome which is internally orange-red in colour. Leaves are elliptic or lanceolate-oblong, caudate-acuminate, 30-60cm long, petioles as long or even longer, bracts ovate, recurved, more or less tinged with red or pink. Flowers are pink, lip yellow, obovate, deflexed, sub-entire or obscurely three lobed. Fruits are dehiscent, globose, 3-valved capsules (Warrier *et al*, 1994). The plant is also described by Gamble (1987) and Kirtikar and Basu (1987).

Chemical constituents

Rhizomes yield 6.1% essential oil (Chopra *et al*, 1980). Essential oil contains α-and - β-curcumene, d-camphene and p-methoxy cinnamic acid. The colouring matter is curcumin. Numerous sesquiterpenoids of germacrone and guaiane skeletons have been identified recently (Husain *et al*, 1992). *C. aromatica* rhizomes contain ar-curcumene (18.6%), beta curcumene (25.5%) and xanthorhizol (25.7%) (Zwaving and Bos, 1992). The active constituents of oil are curcumol and curdione (Asolkar *et al*, 1992). Structures of sesquiterpenes were studied by Kuroyanagi *et al* (1990).

Activity

Rhizome has effect on respiration. It is spasmolytic and shows antagonism of amphetamine hyperactivity. Rhizome is an anti-dote for snakebite and carminative (Husain *et al*, 1992). Essential oil from rhizomes showed anthelmintic, antifungal and antimicrobial activity. Oil also showed inhibitory effect on sarcoma in mice (Asolkar *et al*, 1992).

Agrotechnology

Curcuma species are tropical herbs grown on different types of soils both under irrigated and rainfed conditions. In India, turmeric is commercially cultivated in some states but it is generally grown as a subsistence crop in backyards, kitchen gardens and interspaces of other crops in areas with high rainfall. Rich loamy soils having good drainage are ideal for the crop.

Possibilities of turmeric cultivation in the N.E. states have been discussed by Kutty (1997). Narayanan and Sulikeri (1996) worked out economics of companion cropping systems in turmeric. Studies on the growth *and* development of turmeric (*Curcumal longa* L.) varieties viz., BSR-1 and Co.1 and correlation studies on growth, yield and growth of turmeric was done by Subramanian *et al* (1998).

It is vegetatively propagated from the rhizomes (root stocks and sessile fingers are known as rounds and fingers respectively). According to Ayyadurai (1966) mother rhizomes are better planting materials than the fingers of the secondary mother rhizomes. Propagation of *Curcuma longa* L. by tissue culture was done by Suntibalala *et al* (1998).

Well developed, healthy and disease free rhizomes are selected. Rhizomes are treated with copper oxychloride fungicides and stored in cool, dry place or earthen pits plastered with mud and cowdung (KAU, 1996). Effect of some regulants on sprouting and early seedling in turmeric (*Curcumal longa* L.) under saline conditions was studied by Singh and Khan (1996).

Several authors as Sastri (1950) and Ayyadurai (1966) described different methods of planting. Planting is done either at the onset of monsoon or after it. The best season of planting is during April with the receipt of pre-monsoon showers. The land is prepared to a fine tilth during February-March.

On receipt of pre-monsoon showers in April, beds of size 3x1.2m with a spacing of 40cm between beds are prepared. Small pits are taken in the beds in rows with a spacing of 25-40cm. Finger rhizomes are planted flat with buds facing upwards and covered with soil or dry powdered cattle manure. The crop is mulched immediately after planting and 50 days after first mulching.

For commercial cultivation FYM at 25t/ha is mixed with soil and the planted material is well covered with decomposed leaves and crop residues to maintain sufficient moisture for regeneration of the rhizome. Application of NPK fertilizers is beneficial and found to increase the yield considerably. Chemical fertilizers such as nitrogen, phosphorous and potash are applied at 50kg N, 55kg P_2O_5 and 50-55kg K_2O/ha in two split doses, one at the time of planting and the other afterwards following a weeding (Velayudhan *et al*, 1994).

Response of turmeric to FYM and fertilisation was also studied by Gopalakrishnan *et al* (1997). Varietal response of different levels of nitrogen and phosphorous for quality attributes in turmeric was analysed by Rana *et al* (1993). Studies on the effect of nitrogen, phosphorous and potassium levels on growth and yield of turmeric (*Curcuma longa* L.) in the hill zone of Karnataka was undertaken by Sheshagiri and Uthaiah (1994).

Weeding is done twice at 60 and 120 days after planting, depending upon weed intensity. Earthing up is done after 60 days. Time of harvest usually extends from January-March. Harvesting is generally done at about 7-10 months after planting depending upon the species and variety, at the complete senescence of the above ground parts (KAU, 1996). The yield of turmeric is obtained as fresh weight or dry weight per ha. Varietal difference, agro-ecology, soil conditions, cultural practices, etc. influence the yield of turmeric.

Pests and Diseases

Purseglove (1981) and Hanzha (1981) reviewed the pests and diseases mainly in India.The most important pest in turmeric is the shoot-borer caterpillar (*Cichochrocis punctiferalis* Geun.). The removal of infected shoot is recommended as a control measure by Sastri (1950). Other insects of minor importance are *Udaspes foleus* Cr., and thrips (*Panchaetothrips indicus*) while *Stegolrum panaceum* attacks stored product. Dubey *et al* (1976) and Abraham and Pillai (1974) reported absence of resistance in any of the cultivars they have studied .

Dubey *et al* (1976) also noticed the attack of dipteran flies (*Mimegrella* sp.) in fresh rhizomes. Study on rhizome fly *Mimegralla coeruleifrons* (Macquart) (Diptera:Micropezidae) in turmeric and its management was undertaken by Ramesh *et al* (1994). The rhizome fly *Calobata albimana* Macq. was reported as a major pest of turmeric by Venkateswara Rao and Subbarami Reddy (1990).

According to Rao *et al* (1975) the leaf mites and lacewing bugs were the important pests of standing crop. Quite recently the scale insect is also found to infect the rhizome at maturity in the soil itself. This probably gives way to secondary infections and rot of rhizomes in storage. Shoot borers can be controlled by spraying 0.05% Dimethoate or 0.025% Quinalphos (KAU, 1996).

The two most important diseases noticed in turmeric are leaf spot caused by *Taphrena maculans* Butl. and leaf blotch by *Colletotrichum capscici* (Syd.) Butl. and Bisty. According to Sharma and Krishnamurthy (1962) the long duration types are free from leaf spot disease. Reddy *et al* (1963) reported the occurrence of resistance to this disease in turmeric. Sharma and Nambiar (1974) reported the brown rot disease in the rhizomes of *C. aromatica* type of turmeric. This was associated with *Fusarium* sp. Leaf blotch and leaf spot can be controlled by spraying Bordeaux mixture or 0.2% Mancozeb (KAU, 1996). Effect of seed dressing fungicides and organic amendments on rhizome rot of turmeric was analysed by Sreeraman Setty *et al* (1994).

Post-harvest technology

The harvested material is cleaned and the roots removed and the fingers and rounds are separated before curing, drying and polishing them to obtain turmeric of commerce. The cleaned material is half cooked with some dilute alkali solution and then dried in open sun for about 6-7 days. The concentration of the alkali solution used is 0.5-1% which helps to impart good orange colour to the tubers (Velayudhan *et al*, 1994).

Several authors such as Krishnamurthy *et al* (1975), Rao *et al* (1975), Pruthy (1975) and Ayyadurai (1966) have described curing and processing of turmeric in India. Polishing the dried turmeric is done before the produce is marketed. Changes in the quality of turmeric rhizomes during storage was studied by Goyal and Korla (1993). Effect of storage of fresh turmeric rhizomes on oleoresin and curcumin contents was studied by Zachariah and Nirmal Babu (1992).

KAEMPFERIA

Kaempferia galanga

Eng: Black thorn San: Sathi, Karcurah Hin : Kacora Ben: Chandumula
Mal: Kacholam, Kachoram, Kachuri Tam: Kacholam Tel: Candramula

Importance

Kacholam, also known as Sugandhavacha, Chandramulika or Sidhul is a rhizomatous perennial plant, the rhizomes of which yield an essential oil. The oil is utilized in the manufacture of perfumes and in curry flavouring. It is also employed in cosmetics, mouth- washes, hair tonics and toiletries. The pungent, hot, sharp, bitter and aromatic rhizomes find an important place in indigenous medicine as stimulant, expectorant, diuretic and carminative. It promotes digestion and cures skin diseases, piles, phantom tumors, coughs, oedema, fever, epilepsy, splenic disorders, wounds, asthma and rheumatism. The rhizomes are used for protecting clothes against insects and are eaten along with betel and arecanut as a masticatory. The rhizomes and leaves are attached to neck- laces and added to bath water for perfume.

Karcura (Kacholam) is a reputed remedy for all diseases caused by the morbidity of *vata* and *kapha* and is especially useful in respiratory ailments like cough, bronchitis and asthma. The drug is reported to be acrid, hot, bitter and aromatic. It cures skin diseases, wounds and splenic disorders. It promotes digestion, removes bad odour of the mouth and destroys pathogenic organisms (Aiyer and Kolammal, 1964). The officinal part is the rhizome and it is a constituent of a variety of Ayurvedic preparations like *Dasamularista, Valiya rasnadi kasaya, kaccoradi churna, Asanaeladi taila. Valiya narayana taila, etc.* The identity of the plant sources of the drug Karcura is a matter of debate. The source of Karcura in Kerala in the recent times has been *Kaempferia galanga* (Sivarajan and Balachandran, 1994).

The rhizomes and root-stocks are good for dyspepsia, leprosy, skin diseases, rheumatism, asthma, cough, bronchitis, ulcers, helminthiasis, fever, malarial fever, splenopathy, cephalalgia, inflammatory tumour, nasal obstruction, halitosis, strangury, urolithiasis, and haemorrhoids. The leaves are used for pharyngodynia, ophthalmia, swellings, fever and rheumatism (Warrier *et al*, 1995).

The tubers reduced to powder and mixed with honey are given in case of coughs and pectoral infections. The oil in which they are boiled is useful in applying to the stoppages of the nasal organs (Nadkarni, 1998). *Kaempferia galanga* is reported to have great export potential by Thomas *et al* (1998).

Origin and distribution.

The plant is supposed to have been originated in East Asia, most probably in Burma. It is widely distributed in Asia, Africa and Australia. It is grown in India, Burma, China, Nigeria, Mexico and other neighbouring countries. In India it is cultivated mainly in Kerala, Karnataka, Tamil Nadu and West Bengal. Wood (1991) has studied biogeography and evolution of *Kaempferia galanga*.

Botany

Kaempferia galanga L. sym. *K. sessilis* Koenig, *K. plantaginifolia* Salisb. and *Alpinia sessilis* Koenig, is a pentaploid with x=11. It is a handsome glabrous perennial aromatic herb with very fragrant underground parts. Leaves are two or more, spreading flat on the ground, round-ovate, thin, deep green, with short channelled petioles. Flowers are white with purplish spots in axillary fascicles, corolla tube 2.5cm long and the connective of anther is produced into a quadrate 2- lobed appendage. Fruits are oblong, 3-celled and 3-valved capsules. Seeds are arillate (Warrier *et al*, 1995). The botany of the plant is also described by Sivarajan and Balachandran (1994), Gamble (1987) and Kirtikar and Basu (1987).

Agrotechnology

Kaempferia galanga requires a warm humid climate. It thrives well upto an elevation of 1500 m. A well distributed annual rainfall of 1500 - 2500 mm during the growing period and dry spells during land preparation and harvesting are ideal. Rich loamy soil with good drainage is suitable for the cultivation of the crop. Laterite soil with heavy application of organic matter is also suited. It cannot stand water-logging.

The plant is propagated by division of rhizomes. For planting mother rhizomes are better than finger rhizomes (Rajagopalan and Gopalakrishnan, 1985). Seed rhizomes are stored in cool dry place or in pits dug under shade. Smoking of rhizomes prior to planting is beneficial for better germination and establishment of sprouts. With the receipt of pre-monsoon showers in May land is ploughed and beds of 1-2 m width, 25 cm height and convenient length are taken and sprouted seeds are planted at 15-30 cm spacing. Seed rate is 500-750 kg/ha.

Evaluation of geographical races of *Kaempferia galanga* for yield was done by Prasannakumari *et al* (1994). Effect of gamma irradiation in Kacholam (*Kaempferia galanga* L.) was studied by Kurian *et al* (1994).

Kacholam responds well to organic manuring. Application of 30 tonnes/ha of FYM or compost and mulching with leaves or straw at 15-20 tonnes/ha are recommended. Application of 50-75 kg each of N, P_2O_5 and K_2O in 2-3 splits is beneficial (Rajagopalan *et al*, 1989). Weeding is done 45 and 90 days after planting which is followed by fertilizer application and earthing up. It is a shade loving plant. Growth is better in partial shade offering great potential for its cultivation as intercrop in coconut, arecanut, banana and other widely spaced perennial crops.

Insect pests are not commonly reported in this crop. Leaf spot and rhizome rot diseases occur particularly during the rainy months which could be controlled by drenching and spraying with 1% Bordeaux mixture.

The crop is harvested 6-7 months after planting when the leaves start drying up. The rhizomes are dug out, cleaned and washed to remove the adhering soil particles.

Postharvest technology

The clean rhizomes are sliced to circular pieces of uniform size and dried for 3-5 days. The sliced and dried rhizomes are marketed. The yield, on an average, is 5-8 tonnes/ha of fresh rhizomes which on drying yields 1.5-2 tonnes/ha of dry rhizomes. The driage varies from 23 to 28%. The sliced and dried rhizomes on steam distillation for 3-5 hours yield 2-3% of essential oil. Frothing is noticed during distillation due to the presence of starch in the rhizome (Bose *et al*, 1998).

Properties and Activity

The tuberous rhizome of kacholam contains an alkaloid, starch, gum, fatty matter with a fragrant liquid essential oil and a solid white crystalline substance and mineral matter. The rhizome possesses a camphoraceous odour with somewhat bitter aromatic taste resembling that of *Hedychium spicatum.* The essential oil has the following properties.

Specific gravity at 30 ^{o}C	0.8792-0.8914
Optical rotation at 30 ^{o}C	-2^{o} 36' to –4^{o} 30'
Refractive index at 30 ^{o}C	1.4173 to 1.4855
Acid value	0.5-1.3
Saponification value	99.5-109.0

The essential oil is reported to contain over 54 components of which the major constituents are ethyl-trans-p-methoxy, cinnamate 16.5%, pentadecane 9%, 1,8-cineole 5.7%, γ-carene 3.3%, and borneol 2.7%. Terpenoid constituents amounted to 16.4% (Nerle and Torne, 1984; Anon,1991; Wong *et al*, 1992).

Insectididal constituents from *Kaempferia galanga* were isolated by Pandji *et al* (1993) Cyclohexane oxide derivatives and diterpenes were isolated by Orasa *et al* (1994). Isolation of diterpenes from *Kaempferia* species was done by Parwat *et al* (1993). The chemistry of *Kaempferia* was studied in detail by Tuntiwachwuttikul (1991).

Rhizome yields essential oil, which has antifungal activity. Ethyl-p-Methyl O-trans-cinnamate is the main compound in root (Asolkar,1992). p-Methoxycinnamic acid and its methyl and ethyl esters have been isolated from the essential oil (Rastogi and Mehrotra, 1991) Essential oil from rhizomes contain n-pentadecane, ethyl-p-methoxy cinnamate, ethyl cinnamate, carene, camphene, borneol, p-methoxystyrene, p-methoxy cinnamate, p-methoxy- trans-cinnamic acid and cinnamaldehyde. Rhizome is cytotoxic. Tuber is stimulant, expectorant, diuretic and carminative (Husain *et al*, 1992).

Kaempferia rotunda

Eng:Indian crocus San: Bhumicampaka, Bhucampaka, Hallakah Hin: Abhuyicampa Mal: Chengazhuneerkizhengu, Chengazhuneerkuva Tam: Nerppicin Kan: Nelasampiga Tel: Bhucampakamu, Kondakaluva Mar: Bhuichampa

Importance

The tubers of Indian crocus are widely used as a local application for tumours, swellings and wounds. The roots have a hot ginger-like taste. They are also given in gastric complaints. They help to remove blood clots and other purulent matter in the body. The juice of the tubers is given in dropsical affections of hands and feet, and of effusions in joints. The juice causes salivation and vomiting. In Ayurveda, the improvement formulations using the herb are *Chyavanaprasam, Asokarishtam, Baladthatryaditailam, Kalyanakaghritham, etc.* The drug "*HALLAKAM*" prepared from this is in popular use in the form of powder or as an ointment application to wounds and bruises to reduce swellings. It also improves complexion and cures burning sensation, mental disorders and insomnia (NRF, 1998; Sivarajan and Balachandran, 1994). The tubers are useful in vitiated conditions of vata and kapha, gastropathy, dropsy, inflammations, wound, ulcers, blood clots, tumours and cancerous swellings (Warrier *et al*, 1995). The decoction is applied with much benefit to wounds with coagulated blood and with any purulent matter (Nadkarni, 1998).

Distribution

The plant is distributed in the tropics and sub-tropics of Asia and Africa. The plant grows wild in shaded areas which are wet or humid, especially in forests in South India. It grows in gardens and is known for their beautiful flowers and foliage. It is also cultivated as an intercrop with other commercial crops.

Botany

Kaempferia rotunda Linn. belonging to the family Zingiberaceae is an aromatic herb with tuberous root-stalk and very short stem. Leaves are simple, few, erect, oblong or ovate-lanceolate, acuminate, 30cm long, 10cm wide, variegated green above and tinged with purple below. Flowers are fragrant, white, tip purple or lilac arranged in crowded spikes opening successively. The plant produces a subglobose tuberous rhizome from which many roots bearing small oblong or rounded tubers arise (Warrier *et al*, 1995). The description of the plant is also undertaken by Gamble (1987), Kirtikar and Basu (1987) and Sivarajan and Balachandran (1994).

Agrotechnology

The plant is a tropical one adapted for tropical climate. Rich loamy soil having good drainage is ideal for the plant. Laterite soil with heavy organic manure application is also well suited. Planting is done in May-June with the receipt of 4 or 5 pre-monsoon showers.

The seed rate recommended is 1500-2000kg rhizomes/ha. Whole or split rhizome with one healthy sprout is the planting material. Well developed healthy and disease free rhizomes with the attached root tubers are selected for planting. Rhizomes can be stored in cool dry place or pits dug under shade plastered with mud or cowdung. In vitro propagation of *Kaempferia rotunda* has been attempted by Anand *et al* (1997).

The field is ploughed to a fine tilth, mixed with organic manure at 10-15t/ha. Seed beds are prepared at a size of 1m breadth and convenient length. Pits are made at 20cm spacing in which 5cm long pieces of rhizomes are planted. Pits are covered with organic manure. They are then covered with rotten straw or leaves.

Apply FYM or compost as basal dose at 20 t/ha either by broadcasting and ploughing or by covering the seed in pits after planting. Apply fertilisers at the rate of 50:50:50 kg N, P_2O_5 and K_2O/ha at the time of first and second weeding. After planting, mulch the beds with dry or green leaves at 15 t/ha.

During heavy rainy months, leaf rot disease occurs which can be controlled by drenching 1% Bordeaux mixture. The crop can be harvested after 7 months maturity. Drying up of the leaves is the indication of maturity. Harvest the crop carefully without cutting the rhizome, remove dried leaves and roots. Wash the rhizome in water. They are stored in moisture-proof sheds. Prolonged storage may cause insect and fungus attack (Prasad and Joseph, 1997).

Properties and activity

The tubers contain crotepoxide and β-sitosterol (Husain *et al*, 1992). Rastogi and Mehrotra (1991) and Asolkar *et al* (1992) also reported crotepoxide in tubers. Tuber contains essential oil which give a compound with melting point 149°C which yielded benzoic acid on hydrolysis (Rastogi and Mehrotra, 1990). The tubers are acrid, thermogenic aromatic, stomachic, antiinflammatory, sialagogue, emetic, antitumour and vulnerary (Warrier *et al*, 1995)

COSTUS

Costus speciosus

San: Pushkara, Kashmeera, Kemuka; Hin: Kebu, Keyu, Kust; Ben: Keu, Kura Mal: Channakkizhangu, Channakoova; Tam: Kostam; Mar: Penva; Tel: Kashmeeramu

Importance

Costus is one of the plants, which contains diosgenin in its rhizome. It is widely used as starting material in the commercial production of steroidal hormones. The rhizomes are useful in vitiated conditions of kapha and pitta, burning sensation, flatulence, constipation, helminthiasis, leprosy, skin diseases, fever, hiccough, asthma, bronchitis, inflammation and aneamia. It is used to make sexual hormones and contraceptives (Warrier *et al*, 1994).

Canda, a drug formulation containing Costus as the main constituent is one of the twenty eight drugs that constitute the Eladi gana of Vagbhata which subdues vata and kapha, the effects of poison and promotes complexion (Sivarajan and Balachandran, 1994). The tuberous root-stock is the officinal part. It is bitter, astringent, cooling, digestive, stimulant and good for the heart. It cures kapha and pitta disorders, dyspepsia, fever, cough and other respiratory diseases, diabetes, oedema, blood diseases, leprosy and other skin ailments (Chunekar, 1982; Sharma, 1983).

Eladi oil, Manjishtadi taila, Asana manjishtadi taila, Manjishtadi churna, etc. are some of the preparations using the drug (Sivarajan and Balachandran, 1994). The tuber is cooked and made into a syrup or preserve which is considered to be very wholesome (Nadkarni, 1998). Root is rich in starch and also used in snake bite. The plant is often cultivated as ornamental (Chopra *et al*, 1980).

One of the constituents of indigenous drug '*Amber Mezhugu'* is useful in rheumatism. Juice of stem bark taken in burning sensation on urination. Juice of boiled plant is used in earache (Asolkar *et al*, 1992).

Distribution

The plant is widely distributed in Asia and other tropical countries like India, Nepal, Pakistan, Taiwan, Malaysia, Sri Lanka and China. In India, it occurs mostly in Arunachal Pradesh, Meghalaya, Nagaland, Tamil Nadu, Assam, Tripura and Kerala.

Botany

Costus speciosus (Koenig.) Sm. consists of two varieties viz., var. *nepalensis* Rosc., found only in Nepal and Arunachal Pradesh and var. *argycophyllus* Wall., having a wide distribution in India.

A taxonomic rank controversey regarding Costus was pointed out by Gideon (1991). The taxonomic position of the natural group comprising Costus, Dimerocostus, Monocostus and Tapeinochilos has been reviewed by him. An explanation has also been given for the preferred taxonomic rank for the Costus group.

The plant is a succulent herb with long leafy spirally twisted stems, 2-3m in height and horizontal rhizomes. Leaves are simple, spirally arranged, oblanceolate or oblong, glabrous above, silky pubescent beneath with broad leaf sheaths. Flowers are white, large, fragrant, arranged in dense terminal spikes. Bracts are bright red. The single stamen present is perfect, lip large with incurved margins. Fruits are globose or ovoid capsules with obovoid or sub- globose seeds (Warrier *et al*,1994). The botanical description is also given by Gamble (1987), Kirtikar and Basu (1987) and Sivarajan and Balachandran (1994).

The plant is reported to have shell shaped flowers (sankhini) which opens during night (Moosad, 1983). Some of the later authors have equated this plant with kebuka or kemuka (Kirtikar and Basu, 1987; Chunekar, 1982; Sharma, 1983). But kebuka has been mentioned among the bitter vegetable group in the classical literature and so is treated as a different drug (Mooss, 1984), equated with Brassica olrracea var. capitata (Brassicaceae) the common cabbage by many (Vaidya, 1936; Menon, 1976)

Agrotechnology

Costus can be raised under a wide range of agroclimatic conditions. It prefers sandy loam soil for good growth. Propagation is by rhizomes. The best season for planting is April-May. The seed rate recommended is 2-2.4t/ha.

The spacing adopted is 50x50cm. After an initial ploughing FYM or poultry manure should be applied at the rate of 30t/ha and the field is to be ploughed again irrigated and prepared to obtain a fine seed bed. Furrows are opened and the rhizome pieces are placed horizontally at a depth of 8-10cm and covered with soil. Care is taken to place the eye buds facing upwards. After 70-75 days about 90-95% sprouting is obtained.

Desiccation of the young sprouts have been observed in the hot summer months, necessitating liberal water supply during the period. As September-November is the period of maximum tuberization at least two irrigations should be given at that time. One during the sprouting period of the crop followed by two more keeps the crop fairly free of weeds.

Application of 37t/ha of poultry manure and fertilizers, 60kg P_2O_5 and 40kg K_2O /ha as a basal doze, along with 80kg N/ha applied in 3 equal split dozes will take care. Crop is harvested at the end of seven months. Harvesting includes 2 operations, cutting the aerial shoots and digging out the rhizomes. Cost of production of diosgenin ranges from Rs. 271-300/kg (Atal and Kapur, 1982).

Cultivation methods, lifting, storage, control of pests and diseases of a wild form of *Costus speciosus*, *viz*., *C.speciosus* var. *variegatus* have also been discussed by Jha *et al* (1992).

Properties and Activity

Tubers and roots contain diosgenin, 5α-stigmast-9 (11)-en-3β-ol, sitosterol- β-D-glucoside, dioscin, prosapogenins A and B of dioscin, gracillin and quinones. Various saponins, many new aliphatic esters and acids are reported from its rhizomes, seeds and roots. Seeds, in addition, contain α-tocopherol. Saponins from seeds are hypotensive and spasmolytic. Rhizomes possess antifertility, anticholinestrase, antiinflammatory, stimulant, depurative and anthelmintic activities (Husain *et al*, 1992).

Rhizomes yield diosgenin (2.12%) and tigogenin. Saponins showed estrogen like activity in albino rats similar to stilbestrol. Essential oil from rhizome showed antimicrobial activity (Asolkar, 1992). Alkaloidal fraction from rhizomes showed papaverine like smooth muscle relaxant, antispasmodic, cardiotonic, hydrochloretic, diuretic and CNS depressant activities in laboratory animals. β-amyrin stearate, β-amyrin and lupeol palmitates from leaves. The thinnest group of rhizomes contained largest amount of sapogenin (2.7%) (Rastogi and Mehrotra, 1991).

Differential diosgenin accumulation in Costus speciosus and its tissue cultures have been studied by Indrayanto *et al* (1994). They found out that the diosgenin content of field grown C. speciosus plants used in the study was high in the rhizomes and very low in the other parts of the plant. From the various types of tissue culture which have been initiated from the same cluster of plants, only shoot leaf cultures and shoots of the plantlet cultures contained diosgenin. The compound was not detected in callus cultures, root cultures and roots of the plantlet cultures.

Antifungal activity of steroid saponins and sapogenins from Costus speciosus was analysed by Singh *et al* (1992). The antifungal activity on six species of plant pathogenic fungi was tested at different concentrations. Saponin B was found to be highly effective against conidial germination of Botrytis cineria and Alternaria sp. Efficacy in controlling plant disease (s) under field conditions were also discussed.

Pharmacological studies conducted by Bhattacharya *et al* (1973) show that the rhizomes of Costus speciosus possess cardiotonic, hydrochloretic, diuretic and CNS depressant activity. Singh and Srivastava (1980) have studied the pharmacognosy of Costus speciosus (Koen.) Sm.

ZINGIBER

Zingiber officinale

Eng: Ginger; San: Ardrakam; Ben: Adrak ; Hin: Adarak; Mal: Inchi, Erukkizhangu;
Tam: Inci; Tel: Allamu, Ardrakamu; Kan: Haisunti, Ardraka

Importance

Ginger is a slender perennial herb with robust branched rhizome borne horizontally near surface soil. There are 3 primary products of the ginger rhizomes, namely fresh, preserved and dried ginger. Fresh or green ginger is consumed as a vegetable. Immature ginger preserved in sugar syrup is mainly used as a desert. Crystallized ginger is used as a sweet meat. The dried rhizomes constitute the spice and is esteemed for its flavour, pungency and aroma. It is a constituent of curry powder. It is also used in the production of ginger beer, ginger oil and ginger wine. Pressed ginger is prepared by boiling tender fleshy peeled rhizomes after which they are boiled and sold in sugar syrup. Crystallized ginger is produced in the same way, but it is dried and dusted with sugar. The rhizome yields an essential oil, but this lacks the pungent principle. It is used in the manufacture of flavouring essences and in perfumery . An oleoresin is also extracted in which the full pungency of the spice is preserved. It is used for flavouring purposes and in medicines.

It is one of the reputed drugs of Ayurvedists and and is employed in indegenous systems of medicine for very long period. Almost similar properties and uses have been attributed to the fresh rhizome called ardraka and also the dried one, known as sunthi. It promotesdigestive power, cleanses the throat and tongue, dispels cardiac disorders and cures vomiting, ascites, cough, dyspnoea, anorexia, fever, anaemia, flatulence, colic, constipation, swelling, elephantiasis and dysuria. It is also used in diarrhoea, cholera, dyspepsia, neurological diseases, diabetes, eye diseases and tympanitis. In traditional medicine ardraka is extensively used for its specific action in rheumatism and inflammation of liver (Aiyer and Kolammal, 1966; Kurup *et al*, 1979). The fresh rhiozome is used to prepare *Ardrakaghrta, Suranadighrta, Valiya cincadi leha, Mahakukkutamamsataila, etc.* The dried ginger forms an ingredient of preparations like *Indukantam kasaya, Suranadi leha, Talisapatravataka, Visvamrta, etc.* (Sivarajan and Balachandran, 1994). Clinical studies made by Singhal and Joshi (1983) and Girij *et al* (1984) prove that Zingiber officinale reduces the serum cholesterol level considerably in hypercholesterolemic rats.

The raw ginger is useful in anorexia, vitiated conditions of *vata* and *kapha*, dypepsia, pharyngopathy and inflammations. The dry ginger is useful in dropsy, otalgia, cephalalgia, asthma, cough, colic, diarrhoea, flatulence, anorexia, vitiated conditions of vata and kapha, dyspepsia, cardiopathy, pharyngopathy, cholera, nausea, vomiting, elephantiasis and inflammations. It is also used in several domestic preparations (Warrier *et al*, 1996)

It is used as a household remedy for indigestion, flatulence, dypepsia, sore throat, etc. by adding it to tea. Juice of fresh rhizome and "*Chaturbhada kvatha*" containing *Swertia chirayita*, *Tinospora cordifolia*, *Cyperus rotundus*, and ginger are given in the fevers. Ginger with kernal of castor seed is used in paralysis and with asafoetida in indigestion. In Unani system, ginger is used rather extensively in such preparations as "*Hub-gul-pista*" for clearing the respiratory system, "*Sufuf Shirin*" for dysentery, "*Majun Izaraqi*" as a tonic and "*Qurs Podina*" and "*Murraba-adrak*" as carminatives (Thakur *et al*, 1989).

In chronic rheumatism, infusion of ginger taken warm just before going to bed, the body being covered with blankets so as to produce copious perspiration, is often attended with the best results. The same treatment has also been found beneficial in colds or catarrhal attacks and during the cold stage of intermittent fever. In headache ginger paste applied to the forehead affords relief. Tooth-ache and face-ache are relieved by the same application. In the collapse stage of cholera powdered ginger rubbed to the extremities is found to check the cold perspiration, improve the local circulation, and so tends to relieve the agonising cramps of that terrible disease. Ginger with salt taken before meals is praised as a carminative; said to clean the tongue and throat, increase the appetite and produce an agreeable sensation (Nadkarni, 1998).

Ginger juice produces antimotion sickness action by central and peripheral anticholinergic antihistaminic effects (Qian and Liu, 1992). Ayurvedic attributes of ginger and different useful preparations from it have been discussed by Verma (1993).

Distribution

Ginger is believed to have originated in South Asia. It is widely grown in India, China, Sumatra, Africa, Mexico, Jamaica, Hong Kong, Australia, Nigeria, Sierra Leone and Japan. The largest producer and exporter of ginger is India where it is chiefly produced in the states of Kerala and Assam. It is a plant of very ancient civilization and the spice has long been used in Asia. It is also one of the earliest known spices in Europe and is still in large demand.

Botany

Zingiber officinale Rosc. is a slender, perennial rhizomatous herb. Leaves are linear, sessile and glabrous. Flowers are yellowish green, arranged in oblong, cylindric spikes and ensheathed in a few scarious, glabrous bracts. The rhizomes are white to yellowish brown in colour, irregularly branched, somewhat annulated and laterally flattened. The growing tips are covered by a few scales. The surface of the rhizome is smooth and if broken a few fibrous elements of the vascular bundles project out from the cut ends (Warrier *et*

al, 1996). The botanical description is also given by Gamble (1987), Kirtikar and Basu (1987), Sivarajan and Balachandran (1994) and Thakur (1989).

Agrotechnology

Ginger is a tropical plant adapted for cultivation even in regions of subtropical climate such as the highranges. It prefers a rich soil with high humus content. Being an exhausting crop, ginger is not cultivated continuously in the same field but shifting cultivation is practised. The crop cannot withstand water-logging and hence soils with good drainage are preferred for its cultivation.

Clear the field during February-March and burn the weeds, stubbles, roots, etc. in situ. Prepare the land by ploughing or digging. Construct beds of convenient length (across the slope where the land is undulating) 1m wide, 25cm high with 40cm spacing between the beds. Provide drainage channels for every 25 beds on flat lands.

Some of the popular varieties are Maran, Wynad, Manantody, Valluvanad, Ernad, Kuruppampady (Dry ginger) and Rio-De-Janeiro, China, Wynad local, Tafengiya (Green ginger).

Ginger rhizomes are used for planting. For selection and preservation of seeds, the following method is adopted .Mark healthy and disease free plants in the field when the crop is 6-8 months old and still green. Select best rhizomes free from pest and disease, from the marked plants. Handle seed rhizomes carefully to avoid damage to buds. Soak the selected rhizomes for 30 minutes in a solution of Mancozeb and Malathion to give terminal concentration of 0.3% to the former and 0.1% for the latter. Dry the treated rhizomes in shade by spreading on the floor. Store the treated rhizomes in pits dug under shade, the floor of which is lined with sand or saw dust. It is advisable to spread layers of leaves of Glycosmis pentaphylla. Cover the pits with coconut fronds. Examine the stored rhizomes at monthly intervals and remove the rhizomes which show signs of rotting. This will help to keep the inoculum level low. Provide one or two holes for better aeration. Treat the seed rhizomes similarly before planting also.

The best time for planting ginger is during the first fortnight of April, after receipt of premonsooon showers. For irrigated ginger, the best suited time for planting is middle of February (this is for vegetable ginger). Plant rhizome bits of 15g weight in small pits at a spacing of 20x20cm to 25x25cm and at a depth of 4-5cm with atleast one viable healthy bud facing upwards. Adopt seed rate of 1500kg/ha.

Apply FYM at the rate of 30t/ha and NPKfertilizers at the rate of 75:50:75 kg/ha/year. Full dose of P and 50% of K may be applied as basal dose. Half the quantity of N may be applied 60 days after planting. The remaining quantity may be applied 120 days after planting.

Immediately after planting, mulch the beds thickly with green leaves at the rate of 15t/ha. Repeat mulching with green leaves twice at the rate of 7.5t/ha, first 44-60 days and second 90-120 days after planting. Grow green manure crops like daincha and sunhemp in the interspaces of beds, along with ginger and harvest the green manure crop during second mulching of ginger beds. Remove weeds by hand weeding before each mulching. Repeat weeding according to weed growth during the fifth and sixth month after planting. Earth up the crop during the first mulch and avoid water stagnation.

For controlling the shoot borer spray Dimethoate or Quinalphos at 0.05%. For control of soft rot selecting seed rhizomes from disease free areas, treating them with copper based fungicides, digging out affected plants and drenching the beds with Cheshunt compound or 1% Bordeaux mixture to be adopted. Thiram 0.2% may be sprayed for controlling the leaf spot disease.

For vegetable ginger, the crop can be harvested from 6 months. For making dry ginger, harvest the crop between 245-260 days. For curing wash the rhizomes in water and remove the skin with sharpened bamboo. Spread uniformly on clean floor and allow to dry for 7-9 days, with occasional turning. Clean the adhering skin, bag and store in cool dry place (KAU, 1996).

High yielding mutant Mutant ginger cultivar VIKI-3 (Suravi) recorded the highest yield of 20.3 t/ha as compared to other cultivars. Based on uniformly high yield, dry ginger recovery, oleoresin and essential oil percentage, this mutant has been recommended for release under the name of Suravi (Mohanty and Panda, 1993).

Economics of ginger cultivation in Kerala was discussed by Regeena and Kandaswamy (1992). Growth rate in area, production and productivity of the crop as well as its cost of cultivation have been discussed.

In vitro induction of rhizomes in ginger was carried out by Bhat *et al* (1994). It was found that rhizomes produced on medium containing 12% sucrose gave highest germination upon transfer to soil.

Content and uptake of NPK by ginger rhizomes as influenced by irrigation and nitrogen management was analysed by Pawar and Gavande (1992). Field studies on the effects of irrigation with climatological approach and nitrogen management on content and uptake of NPK by ginger (*Zingiber officinale*) rhizomes were conducted under semiarid climatic conditions. Nitrogen content in rhizomes was maximum with irrigation at 60mm CPE. However, P and K contents were unaffected by irrigation at 80 and 100mm CPE. The maximum NPK uptake by ginger rhizomes was observed with 80kg N/ha.

The quality of ginger (*Zingiber officinale* R.) as influenced by shade and mulch was assessed by Babu and Jayachandran (1994). It was found that volatile oil content increased and fibre content decreased with increasing shade levels.

Gamma ray induced variability in vegetative and floral characters of ginger was studied by Giridharan and Balakrishnan (1992). Irradiation treatments produced inhibitory effects on sprouting of ginger rhizomes. The plant height, tiller production, leaf production and leaf area decreased with the increase in irradiation dosages.

Effect of NPK nutrition and spacing on yield attributes in ginger was studied by Singh and Neopaney (1993). A combination of 150+80+60 kg/ha with 20x20 cm spacing produced greater yield, plant height and maximum number of leaves but the greater size of rhizome was recorded with spacing of 15x30cm.

Monitoring of Mancozeb and Carbendazim residues in ginger (*Zingiber officinale* Roscoe.) following post harvest dip was carried out by Sharma *et al* (1992). Persistance of Mancozeb was found highest than Carbendazim in post harvest treated rhizomes after steeping in Mancozeb and Carbendazim solutions for 60 minutes to prevent storage rots of ginger.

Integrated management of root-knot nematode (*Meloidogyne incognita*) infecting ginger was undertaken by Mohanty *et al* (1992). Maximum yield of ginger (2.53kg/plot) and minimum gall index (2.63) in neem cake treated plots were observed.

Interaction of VA mycorrhiza with *Meloidogyne incognita* and *Pythium aphanidermatum* affecting ginger (*Zingiber officinale* Rosc.) was studied by Iyer.and Sundararaju (1993). The growth of the plants was significant when inoculated with VA mycorrhiza (VAM) fungi whereas *Meloidogyne incognita* and *Pythium aphanidermatum* inoculations suppressed the plant growth.

Activity of volatile and non-volatile substances produced by *Trichoderma viride* on ginger rhizome rot pathogens was studied by Rathore *et al* (1992).Volatile and non-volatile substances produced by *T.viride* in agar culture, affected two pathogens but *Pythium myriotylum* was more affected than *Fusarium solani*. Diffusable substances were found to inhibit ogonia formation and increase vacuolation and emptying of hyphae in *P. myriotylum.*

Properties and activity

The chemistry of *Zingiber officinale* has been the subject of sporadic study since the early nineteenth century. Ginger owes its characteristic organoleptic properties to gingerols. The odour and much of the flavour of ginger is determined by the constituents of its steam volatile oil, while the pungency is produced by nonvolatile components, known as gingerols.the essential oil is comprised mainly of mono- and sesquiterpene hydrocarbons and oxygenated compounds. The monoterpene constituents, though present in trace amounts, contribute most of the aroma of a ginger. The monoterpenes reported so far are 3-carene, α-pinene, cumene, camphene, β-pinene, myrcene, limonene, 1,8,cineole, β-phellandrene, 2-heptanol, p-cymene, methylheptenone, nonanal, decanal, neral, geranial, 2-nonanol, linalool, bornyl acetate, α-terpineol, sabinene, β-borneol and geraniol (Dodge, 1912; Kami *et al*, 1972; Nigam *et al*, 1964; Brooke, 1916; Bertram and Walbaum, 1894; Jain *et al*, 1962; Bednarczyk and Kramer, 1975; Schimmel and Co., 1905; Denniff, 1976; Thresh, 1879; Soden and Rojahn, 1900).

The sesquiterpene hydrocarbons constitute thje major fraction of the essential oil, out of which β-Zingiberene and ar-curcumene are found in high percentages, about 35-40% and 15-20% respectively. Other sesquiterpene hydrocarbons are α-Zingiberene, β-isobolane, β-D-curcumene, γ-selinene, β-farnesene, β-sesquiphellandrene, α-copaene, β-bourbonene, α-bergamotene, calamenene, cuparene, sesquithujene and sesquisabiene (Nigam *et al*, 1964; Bednarczyk and kramer, 1975; Soden and Rojahan, 1900; Connell and Jordan, 1971; Connell, 1970; Connell and Sutherland, 1969; Eschenmoser and Schumitz, 1950; Herout *et al*, 1953; Bednarczyk *et al*, 1975; Mills, 1952; Pilva *et al*, 1960; Ruzicka and Van-veen, 1929; Schreiner and Kremers, 1901; Soffar *et al*, 1944; Smith and Robinson, 1981; Terhune *et al*, 1975; West, 1939).

Cis-sesquithujene hydrate and Zingiberenol are the two hydrated sesquiterpenes reported (Terhune *et al*, 1975; Pagutte and Kinney, 1982). Several investigations have been carried out on the non-volatile pungent principles of ginger. The major pungent compounds reported are gingerols, shagaols, dihydrogingerols, hexahydrocurcumin, gingerdiols, desmethylhexahydrocurcumin, (n)-paradol, zingerone and ginger diones (Lapworth *et al*, 1917; Connell and Sutherland, 1969; Denniff *et al*, 1980; Denniff and Whitting, 1976; Connell, 1970; Lapworth and Wykes, 1970; Macleod and Whiting, 1979; Masada *et al*, 1973; Nelson, 1917; Connell and Mclachlan, 1972; Nomura and Tsurani, 1927; Nomura, 1918; Yamagishi *et al*, 1972)

(6)-Gingerol and (6)-shogaol produce an inhibition of spontaneous motor activity, and have antipyretic and analgesic effects and prolonged hexabarbital induced sleeping time; (6)-shogaol weas more active than (6)-gingerol. (6)-shogaol showed an intensive antitussive effect in comparison with dihydrocordeine phosphate. Both (6)-Gingerol and (6)-shogaol suppressed gastric contraction in situ and (6)-shogaol was more active than (6)-gingerol (Suekawa *et al*, 1984).

The methanolic extracts of rhizome of ginger showed potent, positive intropic effects in the guinea pig isolated left atria and cardiotonic principles of ginger were identified as 6-, 8- and 10-gingerol. Methanol extract of rhizome and leaves of ginger showed antioxidative properties (Shoji *et al*, 1982; Lee *et al*, 1982).

Main constituent of essential oil is d-camphene. Others included β-phellandrene , cineole, citral, borneol, gingerol, α-pinene, limonene, methylheptenone and linalool. Rhizomes contain free amino acids- asparagine and pipecolic acid . the alcoholic extract containing resinous fractions stimulates the vasomotor and respiratory centres of anaesthetized cats (Husain *et al*, 1992).

Studies on the constituents of the essential oil of Zingiber officinale was done by Xiuzhen *et al* (1992). 53 chemical constituents were separated and 34 of them were identified by means of GC/MS/DS. They were mainly citral (Z *and* E), menthene, alpha-pinene, alpha-farnesene and isofenchylalcohol

Isolation of antirhinoviral sesquiterpenes from ginger was done by Denyer *et al* (1994). The most active of these was β-sesquiphellandrene with an IC50 of 0.44 micro M vs. rhinovirus IB in vitro. 6-gingerol and 6-shogaol, the pungent constituents of *Zingiber officinale* were biotransformed by *A.niger* (Takahashi *et al*, 1993).

Activity of volatile and non-volatile substances produced by *Trichoderma viride* on ginger rhizome rot pathogens was studied by Rathore *et al* (1992). Volatile and non-volatile substances produced by *T.viride* in agar culture, affected two pathogens but *Pythium myriotylum* was more affected than *Fusarium solani*. Diffusable substances were found to inhibit ogonia formation and increase vacuolation and emptying of hyphae in *P. myriotylum.*

The essential oil exhibited remarkable repellent activity against both the kitchen insect *Periplaneta americana* and the agricultural pest *Bruchas pisorum* (Garg and Jain, 1991).

Variability in gingerol and shogaol content of ginger accessions was studied by Zachariah *et al* (1993). Eighty six ginger accessions were evaluated for oleoresin, gingerol and shogaol and the accessions were classified into high, medium and low quality types. The inter character association pattern showed that oleoresin is positively correlated with gingerol and shogaol.

Physico-chemical properties of oil

The essential oil is a pale yellow liquid with a warm spicy sweet strongly aromatic odour and sharp pungent flavour. The oil has the following properties (CSIR, 1953).

Specific gravity at 30 °C	0.868-0.880
Optical rotation at 20 °C	-28° to –45°
Refractive index at 30 °C	1.4840-1.4894
Saponification value	20

Fresh ginger contains approximately water 80%, protein 2.3%, fat 1%, carbohydrate 12.3%, fibre 2.4% and ash 1-2%. Dried ginger contains about 10% moisture and 1-3% of volatile oil of which the chief constituent is a sesquiterpene, called zingiberene ($C_{15}H_{24}$). The pungent principle of ginger is zingerone ($C_{11}H_{14}O_3$) which is present in the oleoresin. The essential oil contains approximately α-pinene 0.4%, camphene 1.1%, ß-pinene 0.2%, myrcene 0.1%, limonene 1.2%, 1,8-cineole 1.3%, ß-phellandrene 1.3%, p-cymene 0.1%, methyl heptanone 0.1%, nonanal 0.1%, decanal 0.2%, neral 0.8%, geraniol 1.4%, 2-nonanol 0.2%, linalool 1.3%, bornyl acetate 0.1%, d-borneol 2.2%, geraniol 0.1%, α-selinene 1.4%, ß-elemene 1.0%, ß-zingiberene 35.6%, ß-bisabolene 0.2%, arcurcume 17.0% and ß-farnesene 9.8% (Krishnamurthy *et al*, 1970; Kami *et al*, 1972; Akhila and Tewari, 1984).

Zingiber zerumbet

San: Sthulagranthi, Karpoora Haridra Ben: Mahabaribach Hin: Mahabaribach
Mal: Kattinji, Kattinjikua Tel: Santa pasupu, Karrallamu Kan: Kallu Shunti

The rhizomes of *Zingiber zerumbet* are used like the officinal ginger (*Z. officinale*). It is employed as a hot remedy for coughs, asthma, worms leprosy and other skin diseases. It is distributed throughout India in the tropics.

Z. zerumbet (L.) Sm. syn. *Z. spurium* Koen. syn. *Amomum spurium* Gmel. syn. *A. sylvestre* Poir. has large, not much branched root stock with a strong aromatic ginger like taste, but with some bitterness. Stem is cylindric and glabrous. Leaves are sessile, oblong-lanceolate, acuminate, glabrous, base narrowed; ligule truncate and membranous. Flowers pale sulphur yellow, arranged on ovoid ontuse spikes. Lip shorter than the corolla lobes and of a darker yellow, 3-fid; lobes obtuse, the midlobe the longest. Anther is glabrous. Stigma is minute and funnel-shaped witrh ciliate mouth. Capsules are ellipsoid, seeds oblong and black (Kirtikar and Basu, 1987). The botany is also described by Gamble (1987).

The agrotechnology is same as that of *Z. officinale*. A sesquiterpene epoxy- ketone- zerumbone has been isolated from oil of rhizomes. Essential oil's major components are camphene, zerumbone and α- and β-pinene, 3-carene, limonene, linalool, borneol, α-terpeneol, caryophyllene, cineole, camphor, β-curcumene, humulene epoxides I. II and III and humulenols I and II (Husain *et al*, 1992). Zerumbone (mp.66°C), two terpenoids-humulene monoxide and humulene dioxide; two ketones, a diepoxide, two 2-α-epoxides-himulene epoxideI (bp.104°C) and humulene epoxide II (bp.105°C) and humulenol along with β-curcumene (2%) and caryophyllene epoxide (mp.61°C) has ben isolated from the oil (Rastogi and Mehrotra, 1990).

CARDAMOM

Elettaria cardamomum

Eng: Lesser cardamom, Malabar cardamom San: Ela Ben, Hin: Chhoti elachi Mal: Yelam
Tam: Yelakkai Tel: Yelakkaya Kan: Yelakki

Importance

Cardamom is a tall herbaceous perennial with branched subterranean rhizomes from which arise several erect leafy shoots and erect or decumbent panicles. The dried capsules, the essential oil, oleoresin and tinctures are extensively used in the formulation of compounded mixtures for liquors beverages baked goods, canned foods, meats, sauces and condiments. Cardamoms are stimulant, carminative and flavouring agent. Dried cardamom fruits are used as a masticatory and in medicine. They are used for flavouring curries, cakes, bread and other culinary purposes. The essential oil is employed in perfumery and flavourings. The oleoresin has similar applications to essential oil in flavouring of processed foods but it is less used. The oil and oleoresins also find use in the preparation of aromatic, stimulant, stomachic and diuretic tinctures.

Origin and distribution

The plant has originated in India. Its natural habitat is the evergreen forests of Western Ghats. It is grown in India, Sri Lanka, Guatemala and Thailand. India is the largest producer of cardamom, with cultivation mainly confined to the southern states of Kerala, Karnataka and Tamil Nadu. About 80% of the cardamom in the international market come from India. Guatemala has now overtaken Sri Lanka that was the second largest exporter.

Botany

The plant cardamom *Elettaria cardamomum* (L.) Maton. syn. *Amomum cardamomum* L. syn. *A. repens* Sonner. syn. *Alpinia cardamomum* (L.) Roxb. has a chromosome number 2n=48. As the different races and varieties of cardamom are interfertile, the variability is so high that some confusion exists with regard to the systematics. Generally, two botanical varieties are recognized.

(1) ***Elettaria cardamomum*** **Maton var.** ***major*** **Thw.:** It is the wild cardamom of Sri Lanka and the southern half of the Western Ghats. It is a robust plant, 3 m tall, with pinkish pseudostems, broad leaves, and erect panicles; ovary and calyx subtomentose; fruits 2.5-5.0 cm long, drying to a dark brown colour, longer and seeds larger, more numerous and less aromatic than the var. minor.

(2) ***E. cardamomum*** **Maton var.** ***minor*** **Watt. (syn. var.** ***cardamomum*** **Thw.; var.** ***minuscula*** **Burkill).:** This includes most of the cultivated types. The panicle is longer, with more numerous flowers. Ovary and calyx glabrous, fruits smaller than var. major, subglobose, yellowish when dried. Seeds more aromatic. Flowers bisexual; fruits trilocular capsule with 15-20 seeds per fruit. The flowers which open from the base of the panicle upwards over a long period, are said to be self-fertile. They are visited by bees which bring about cross pollination. Several races such as Malabar, Mysore and Vazhukka are recognized under this variety.

Agrotechnology

Cardamom grows wild in the evergreen rain forests of the Western Ghats in India between 750 m and 1500 m and in Sri Lanka above 1000 m altitude. They occur in the preclimax stage of the forest. In cultivation, the crop requires an annual rainfall of 1500-4000 mm, a temperature of 10-35^{o}C and an altitude of 600-1200 m with moderate shade and protection from wind. Cardamom is generally grown in forest loamy soils rich in available phosphorus and potassium, but well drained deep loamy soils abundant in humus is ideal.

The plant is propagated vegetatively by divisions of rhizomes or by seed; the former is often used for planting small areas. Clonal propagation by tissue culture permits large scale planting of high yielding selections but is not advisable where Katte and other virus diseases are prevalent (Nadyanda *et al*, 1983). In such areas seedling progenies are advisable as virus disease is not transmitted through seeds. Seed germination is often poor and irregular. Plants propagated vegetatively come to bearing one year earlier than the seedling propagated plants. For seedling propagation, ripe capsules of desired cultivar are collected from high yielding plants during September-October. 'ICRI-1', 'ICRI-2', and 'PV-1' are the improved varieties available for cultivation.

Twelve selected clones were evaluated along with local check for yield, dry matter distribution and harvest index in a randomised block design with four replications in clonal nursery. Clones differed significantly among themselves for dry matter content and percent dry matter (to total dry matter) distribution to roots, rhizome, leaves, tillers, panicles and capsules. There was a significant distribution for harvest index

among the clones. Maximum percentage of dry matter distribution towards economic parts (capsules) was observed in selected clones viz., Sel.9, Sel.17, Sel.12, Sel.4 and Sel.10 and minimum was observed in local check indicating their differential yielding ability and superiority of selections (lines). Clones had high harvest index compared to local check (Korikanthimath and Mulge, 1998).

Seeds are extracted by gently pressing the capsules and washing 3-4 times with water to remove the mucilaginous coating on the seeds. Seeds are dried in shade for 2-3 days and sown in the nursery within a fortnight as the seeds are short-viable. Seeds can be preserved for one month in the capsule form in polythene lined gunny bags.

The seeds are sown in primary nursery from where the young seedlings are transplanted 25-30 cm apart in a secondary nursery or in polybags during June-July where they are maintained for one year and the 18 month old seedlings are finally transplanted to the main field at 1.5-3 m spacing depending on the cultivar and soil conditions. Sixty gram seeds are sown on well prepared beds of 6 m2, mulched with potha grass or straw and watered regularly. Seedlings will take 4-6 weeks to appear above ground. Shade trees like dadap, albizzia, jack, eucalyptus, red cedar and wild nutmeg are planted. Cardamom plantation is fertilized with N, P_2O_5 and K_2O at 75:75:150 kg/ha respectively. Fertilizers are applied in two split doses before and after the South-West monsoon in a circular band 20 cm wide at 30-40 cm away from the base of the clumps and incorporated into the soil. Mulching is practiced to conserve moisture, reduce weed growth and overcome dry situation. Sickle weeding is required frequently. Forking is necessary in hard soils. Trashing is carried out during June-July with the commencement of monsoon to prevent spread of diseases and expose panicles for pollination by honey bees. Maintaining four bee colonies/ha during the flowering season is recommended for increased fruit set and capsule production. Shade regulation is essential to provide optimum shade. Red cedar (*Toona ciliata* Roem.) is an ideal shade tree which sheds leaves during rainy season and thus provides natural shade regulation (KAU, 1996).

Hormonal relationship and growth regulator application effect on flowering, fruit setting and capsule shedding in cardamom was studied by Vasanthakumar and Mohanakumaran (1988). High auxin and cytokinin levels were observed after pollination. Exogenous application of NAA (40 ppm) and 2,4-D (4 ppm) increased the production of panicles and flowers and decreased the incidence of capsule shedding thereby increasing the yield.

Effect of chloromequat, daminozide ethepon and maleic hydrazide on certain vegetative characters of cardamom (*Elettaria cardamomum* Maton) seedlings was studied by Siddagangaiah *et al* (1993). Maleic hydrazide (250 ppm), daminozide (500 ppm), chloromequat (250 ppm) and ethepon (100 ppm) significantly enhanced tiller production and other vegetative characters when applied on 7 month old seedlings. These treatments were economical on cost-benefit ratios.

Effect of bio-stimulants on the growth and biomass oif secondary nursery seedlings of cardamom was studied by Vadiraj *et al*, (1992). In a nursery experiment conducted at Cardamom Research Institute, Myladumpara, five biostimulants at different concentrations were sprayed at 30 days interval for a period of 120 days. The results indicated that biostimulants such as vipul, ergostim, pure folic acid, low levels of simazine and 2, 4-D significantly increased the yield and dry matter production and also reduced the nursery period, thus helping in getting vigorous seedlings for better establishment in the field.

Cardamom thrips (*Sciothrips cardamomi*) and leaf eating caterpillars are common pests of cardamom which can be controlled by spraying 0.2% HCH or 0.03% Quinalphos. Thrips (*Sciothrips cardamomi*) incidence and green weight of capsules were significantly less in widest spacing of 2.5 x 2.5m in an eight year old plantation of Malabar type cardamom (Sidhartan *et al*, 1990)

Infestation of soft scale (*C. hesperedium*) has been reported to occur in cardamom for the first time by Singh *et al* (1994). The pest was parasitised by a hymonepteran, *C. ceroplastae* in the field.

Yield loss assessment in Nilgris necrosis infected cardamom was attempted by Sridhar *et al* (1991). It showed that plants in the early infection stage recorded less reduction in the yield in contrast to the plants in the advanced stages of infection.

Katte or mosaic virus disease is transmitted by the aphid *Pentalonia nigronervosa*. Azhukal or capsule rot caused by Phytophthora species, clump rot or rhizome rot caused by *Pythium aphanidermatum*, leaf blotch caused by *Phaeodactylum venkatesanum* and Chenthal disease are frequently observed in cardamom plantations. Multifaceted approach consisting of field sanitation, use of tolerant cultivars, repeated drenching and spraying with 1% Bordeaux mixture, is to be resorted to for effective disease control.

A methodology for evaluation of resistance in cardamom to root-knot nematode (*Meloidogyne incognita*) was developed by Eapen (1990). Nematode population was found to be inversely proportional to the initial inoculum level. Initial population of 100 and 500 nematodes consistently produced susceptible reaction in cardamom plants . initial inoculum of 500 nematodes and an exposure period of 3 months have been recommended for evaluation of resistance in cardamom.

Antifungal properties of neem products against rhizome rot of small cardamom (*Elettaria cardamomum* Maton). was studied by Dhanpal *et al* (1993). Aqueous extracts of neem-leaf, unripened neem fruits, neem-seeds and also commercially available neem-based formulations such as neem-oil, kemisal, Azabin-BSB and neem-gold were tested against rhizome rot disease caused by *Rhizoctonia solanii*. In-vitro studies showed 80-100% growth inhibition with all the products tested. Application on pot culture and plants

in the field showed that extract from neem-seed and neemgold greatly reduced the disease followed by other neem products and garlic.

Cardamom plants normally start bearing capsules from the third year of planting. Picking is carried out at an interval of 30 days during September-February and the peak period of harvest is October-November. Cardamom capsules with green colour fetch a premium price. Hence emphasis has to be given on the preservation of green colour during curing and subsequent storage. A cardamom plantation gives economical yield for 10-15 years after which replanting has to be done.

Postharvest technology

Processing of capsules is done in specially built curing houses. The harvested capsules are washed in water to remove dust and soil particles. Then they are uniformly spread and dried on wire net trays for 36-42 hours at 50-60 C. The dried capsules are rubbed on wire mesh to remove the stalk and other waste particles. This is called polishing. The polished capsules are then graded according to size by passing through a series of 7 mm, 6.5 mm and 6 mm sizes. The graded produce is stored in polythene lined gunny bags to retain the green colour and to avoid exposure to moisture. The outturn of dried capsules is 20-25% of the harvested fruits. The average yield of dried capsules is 200-300 kg/ha/year.

The fruits are crushed and steam distilled for 4 hours to recover the essential oil. The oil content is 3.5-7% which is dependent on the cultivar, stage of harvest and conditions and duration of storage. Upto 11% oil is available in seeds while it rarely exceeds 1% in husks. Cardamom oleoresin with 52-58% of oil content is produced on a relatively smaller scale.

Physico-chemical properties of oil

Cardamom oil is a greenish-yellow liquid with a warm spicy aromatic odour somewhat pungent and faintly bitter at high concentration. Rao (1925) has reported the following properties for cardamom oil.

Specific gravity at 15^{o}C	0.9264-0.9349
Refractive index at 25^{o}C	1.4603-1.4620
Optical rotation at 25^{o}C	15.1^{o} to 44.0^{o}
Acid value	0.36-1.3
Saponification value	96.5-156.4

Cardamom capsules contain 20% water, 10% protein, 2% fat, 42% carbohydrate, 20% fibre and 6% ash. The aroma and therapeutic properties are due to a volatile oil constituting 3-8% in the seeds, whose main constituents are cineole, terpineol and limonene. Nigam *et al* (1965) reported the composition of the essential oil of *E. cardamomum* var. *minuscula* as: -pinene 1.9%, sabinene 4.5%, limonene 14%, cineole 30.7%, p-cymene 1.9%, methyl heptanone 0.8%, linalool 0.9%, linanyl acetate 1.2%, ß-terpineol 0.8%, α-terpineol 3.7%, α-terpinyl acetate 28.1%, borneol 0.1%, neryl acetate 0.3%, geraniol 0.7%, nerol 1.4%, nerolidol 0.3% and heptacosane 0.5%.

A chemical investigation based on 1H NMR and MS studies revealed that the non-saponifiable lipid fraction of cardamom consisted mainly of waxes and sterols. The waxes identified were n-alkanes and n-alkenes. In the sterol fraction β-sitosterone and γ- sitosterol are newly reported. Phytol and traces of eugenyl acetate wrere also identified in cardamom for the first time (Gopalakrishnan *et al,* 1990).

Improvements in the quality of volatile oil and oleoresin of stable cardamom flavour in powder form and product development and application in different foods were presented by Raghavan *et al* (1991).

AMOMUM

Amomum subulatum

Eng: Greater cardamom, Nepal cardamom San: Sthulaila, Bhadraila Ben: Bara Ilachi
Hin: Badi Ilayaci, Bari Ilayici Mal: Peralam Tam: Periya elam, Kattelam, Perelam
Tel: Pedda Yelakaya ; Kan: Dodda yelakki

Importance

Greater cardamom or Nepal cardamom is a tall perennial herb, the seeds of which are similar in properties to the true cardamom (*Elettaria cardamomum* Maton.) for which they are often substituted. The seeds and essential oil from seeds are extensively used. Medicinally the seeds are credited with stimulant, stomachic, alexipharmic and astringent properties. For this reason, they are prescribed for the treatment of indigestion, vomiting, biliousness, abdominal pains and rectal diseases. In affections of the teeth and gums, a decoction of the seeds is used as a gargle. Seeds are used as a diuretic in cases of gravel of the kidneys and are used in headache. The essential oil from the seeds is applied locally to allay eye inflammation. In both the

indigenous and western medicines, the seeds are used as a frequent adjunct to other stimulants, bitters and purgatives, in the form of tincture of powder.

In Unani, this goes into various preparations like " *Jawarish Anarain*", which is used as a liver and stomach tonic, emetic, antiphlegmatic and in relieving biliousness; " *Dawa-i- mazmaza*" used as an exhilirant, stomachic, antidyspepsiac and also in cholera; "*Arq Gazar Ambari*", used as a cephalic and general tonic, cardiac stimulant and in palpitation of the heart; "*Ma'jun Zangibil*", used as a curative for leucorrhoea, in uteral pains and as emmenagogue, tonic during pregnanacy and as aphrodisiac; "*Naushdaroo-i-sada*", used as a stomachic, bowel tonic and curative of dysentery (Thakur *et al*, 1989).

The seeds are also useful in vitiated conditions of kapha and vata, halitosis, anorexia, dyspepsia, colic, flatulence, dysentery, cough, bronchitis, pruritus, liver congestion, hyperdepsia and gonorrhoea (Warrier *et al*, 1993).

Distrbution

The plant grows wild in Eastern Himalaya from Nepal to Sikkim. It is cultivated in North West Bengal, Sikkim and Assam between 500 and 1800m on slopes under chequered shades, preferably along the streams. The maximum production is in Sikkim, West Bengal and Assam.

Botany

Amomum subulatum Roxb. It is a herb with a leafy stem upto 90-100cm in height. The leaves are oblong-lanceolate, bright green, glabrous on both surfaces. Flowers are white and arranged in globose shortly pedunckled spikes. Bracts are reddish brown, lip ovate-cuneate, emarginate, yellowish white, filaments very short, anther crest small, truncate and entire. Fruits are reddish brown, densely echinate globose capsules. Seeds are many and held together by a viscid sugary pulp (Warrier etal, 1993). The botanical description is also attempted by Gamble (1987), Kirtikar and Basu (1987), and Thakur (1989).

Other important species belonging to the genus *Amomum* are *A. aromaticum* Roxb., *A. xanthioides* Wall. and *A. costatum* Benth.

Agrotechnology

The cultivation practices are similar to that of cardamom.

Properties and activity

The seeds of *A. subulatum* are rich source of essential oil (2.5%) (Husain *et al*, 1988). The composition of the oil has been studied to obtain 1,8-cineole (74%) and limonene (10.3%) as major components along with several minor mono- and sesquiterpenoids (Lawrence, 1970; Patra, *et al*, 1982).

The extract of the seeds has also been reported to afford a few glycosides, viz., subulin, petunidin-3,5-diglucoside, leucocyanadin-3-O- β-D-glucopyranoside along with cardamom and alpinetin (Lakshmi and Chauhan, 1976 *and*1977; Rao *et al*, 1976). Its seed oil was found to be highly active against the growth of keratinophhilic fungi (Jain *and* Agrawal, 1978).

The seeds contain a chalcone- cardamonin and a flavone-alpinetin. The glycosides-petunidin-3,5-diglucoside, leucocyanidin-3-O- β-D-glucopyranoside and subulin. Seeds on steam distillation yield an essential oil containing cineole as the principal constituent. Other constituents include α- and β-pinene, sabinene, p-cymene, terpinen-4-ol, α- and β-terpineol, nerolidol, terpinene, terpinyl acetate and bisabolene (Husain *et al*, 1992).

Structure of a new aurone glycoside-subulin was isolated from seeds (Rastogi and Mehrotra, 1991). Steam distillation of the seeds yielded 2.3% of the extract while liquid CO_2 extraction yielded 2.1% of the extract. The quality of the essential oil remained unchanged with liquid CO_2 extraction while it got deteriorated with steam distillation (Kaur *et al*, 1993).

Essential oil from *A. subulatum* showed complete inhibition (100%) of *Aspergillus flavus* at 300 ppm (Mishra and Dubey,1990).

Half-sib progeny analysis for variability, association among capsule traits and path coefficient analysis among componenets of essentialn oil in large cardamom was done by Karibasappa *et al* (1989). Half-sib progeny obtained from *'Sawney'* and *'Golsey'* cultivars was studied during 1985 for major capsule traits. Total anthocyanins, cineole content, total soluble solids of seed mucilage and seeds/capsules showed high magnitude of phenotypic coefficient of variation. Seeds/ capsules, seed mass weights and total anthocyanins showed high heritability coupled with high genetic advance. Mature seed index, total soluble solids of seed mucilage and 1000 seed weight were associated positively with oleoresin but negatively with cineole content. The seed mass weight, shell weight, mature seed index, total soluble solids of seed mucilage, seeds/ capsules and total anthocyanins had high positive direct effect on oleoresin content and negative direct effect towards cineole component, whereas the capsule weight had the reverse effect. Among the capsule traits, the seed

mass weight , mature seed index and total soluble solids of seed mucilage were effective in contributing for high oleoresin content with its low cineole component.

HEDYCHIUM

Hedychium spicatum

Eng: Spiked Ginger lily San: Gandhashati, Karchura, Karpura kachali Ben: Kapur kachari Hin: Kapur kachari Tam: Seemai kichili-kizhangu Kan: Seema kachora

Importance

Spiked ginger-lily is a leafy plant having camphoraceous horizontal rhizome.The therapeutic activity of the rhizome is due to its essential oil. The rhizome in powder form is sprinkled as an antiseptic agent and also used as a poultice for various aches and pains. It is a carminative and bronchodialator. The drug is an ingredient of some Ayurvedic preparations but rarely used in Unani system. Because of its camphotraceous odour, this drug is often considered as a substitute of Curcuma zedoaria (Thakur *et al*, 1989).

The root stock is useful in inflammations, asthma, pains, foul breath, bronchitis, hiccough,vomiting and 'tridosha' diseases of the blood. It is also used as a laxative, stomachic, carminative, stimulant, tonic to the brain, in liver complaints, diarrhoea and pains (Kirtikar and Basu, 1987).

Distribution

The plant grows wild in subtropical to temperate areas of the Himalayas, Nepal and Kumaon.

Botany

Hedychium spicatum Ham. ex Smith. syn H.album Buch-Ham. ex Wall. is a leafy plant, upto 2m tall, having camphoraceous horizontal rhizome. Leaves are sessile, broadly lanceolate, 30-60cm long and upto 10cm wide. The flowering spike may be upto25cm long. The flowrs are fragrant with pale yellow, up to 5cm long corolla tube, enclosing white staminodes and red anthers. The fruit is a gl9bose capsule; when ripe the three valves are reflexed exposing numerous small seeds embedded in a red aril (Thakur *et al*, 1989). The botanical description of the plant is also given by Gamble (1987) and Kirtikar and Basu (1987).

Properties and activity

The rhizomes yield 4% essential oil containing ethyl p-methoxy cinnamate (67.8%), ethyl cinnamate (10.2%), d-sabinene (4%), 1:4 cineole (6%) sesqutiterpenes (probably cadinene) (5.5%) and sesquiterpene alcohol (4.7%) (Chopra *et al*, 1980).

The ethanolic extract of dry rhizomes has yielded hedychenone, a furanoid diterpene, its dihydro derivative and another diterpene identified as 6-oxo- λ-7,11,14-triene-16-oic acid lactone (Sharma *et al*, 1975, 1976; Sharma and Tandon, 1983).

β-sitosterol, its β-D-glucoside and a s esquiterpene, cryptomeridol have also been isolated from the rhizomes (Sharma *et al*, 1975).

Essential oil obtained from the roots and rhizomes contained α- and β-pinene, limonene, γ-terpenene, 1,8-cineole, β-phellandrene, β-terpeneol, p-cymene and linalool. Cineole is the major constituent of the oil (Nigam *et al*, 1979).

The ethanolic extract of the rhizomes possessed antiinflammatory, analgesic and hypoglycaemic activities. The plant is CVS active (Dhar *et al*, 1973; Dhawan *et al*, 1977)).

The essential oil of rhizomes exhibited inhibitory activity against all the test bacteria and fungi. The inhibitory activity appears significant against *Shigella shigae*, *Clostridium welchii, Escherichia coli, Alternaria hellanthi, Rhizoctonia solani* and *R. bataticola*. Essential oil also showed effect on central nervous system, tranquilising effect and showed anthelmentic activity against tapeworms (Taenia solium) and earthworms (Pheritima posthuma) and was found to be better than piperazine phosphate (Dixit and Varma, 1975, 1979; Sharma, 1974; Sharma *et al*, 1980).

Rhizome have sitosterol and its glucoside, a furanoid diterpene-hedychenone and 7-hydroxyhedychenone. Essential oil contains cineole, γ-terpinene, limonene, β-phellandrene, p-cymene, linalool and β-terpeneol as major constituents. Essential oil from rhizome is anti microbial, and anthelmentic. Rhizome is antiinflammatory, hypoglycaemic, vasodialator, spasmolytic, atiasthmatic and hypotensive (Husain *et al*, 1992).

Essential oil of rhizomes showed tranquilising activity of short duration; it depressed conditioned avoidance response, rotarod response and pentobarbitone hypnosis (Rastogi and Mehrotra, 1991).

Hedychium coronarium

Eng: Common ginger-lily, Garland flower.

This plant is found throughout India, mostly in the gardens of Assam and South India. It is similar to H. spicatum. The flowers are fragrant, pure white or tinged with yellow (Gamble, 1987). It is used in the treatment of foetid nostrils. The rhizome is used as a febrifuge, tonic and antirheumatic. The base of the stem is used in swellings.

Rhizomes gave furanoditerpene-hedychenone. Essential oil contains Essential oil contains α- and β-pinene, limonene, 1:8- cineole, β-phellandrene, p-cymene, linalool β-caryophellene and its oxide and elemole invarying concentrations. The essential oil also gave borneol, methyl slicylate, eugenol and methylanthranilate.

Hedychenone is antiinflammatory. Essential oil from rhizome is anthelmintic and mild tranquiliser (Husain *et al*, 1992).

Volatile componenets of *H. coronarium* flowers were studied by Matsumoto *et al* (1993). For this the solvent extract and the headspace of H. coronarium (white ginger, ginger lily, Hnashukusha) flowers were investigated by GC/MS and GC. Of the 175 compounds identified, linalool, methyl benzonatecis-jasmone, eugenol, (E)-isoeugenol, jasmin lactone, methyl epi-jasmonate, indole, nitriles and oximes were found to make a great contribution to the scent of flowers. Total of 113 compounds were found in the headspace. The daily and the seasonal changes of the odour characteristics of *H. coronarium* flowers were considered. Qualitative differences of the volatiles obtained by thermal and solvent desorption of the headspace traps were also discussed.

GASTROCHILUS

Gastrochilus pandurata

Mal: Temu kinchi

The plant is found in Burma, Andamans, Konkan and Malay Peninsula. Its roots are used in dysentery. *Gastrochilus pandurata* Ridley. syn. *Kaempferia pandurata* Roxb. is a stemless plant with horizontal root stock with many nodose branches and thick succulent vermiform root-fibres. Leaves are few (usually 3 or 4), distichous, erect, elliptic-oblong, acute or shortly acuminate, decurrent into a long deeply channelled petiole which reaches 15cm long, glabrous and green on both surfaces. Midrib is stout; ligule short, acute and membranous. Flowers are arranged in terminal spikes, sub-sessile among the leaves. Calyx-tube long, cylindric, narrow, hyaline and 2-fid. Corolla tube long, white or pale pink, very slender, erect or curved at the top. Segments are pink, long, oblong, acute and spreading. Staminodes3, oblong or lanceolate and spreading. Lip broad, undulate and white tinged with red. Anther is erect and recurved (Kirtikar and Basu, 1987).

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