CHAPTER-II

THE PLANT
“All that man needs for health and healing has been provided by God in nature, the challenge of science is to find it.” ~ Paracelsus (1493-1541)

Nature is an important source for developing novel leads for medicines. We Indians are blessed with the knowledge of Ayurveda from ancient times, a branch of alternative medicine which stresses on the use of plant-based medicines and treatments. During the present research work two medicinally important plants viz *Nerium oleander* L. and *Zingiber officinale* Roscoe. have been chosen.

**Nerium oleander** L.

*Nerium oleander* L. is an evergreen shrub or small tree in family Apocynaceae. The family, which is commonly recognized as dogbane family, includes some 1500 species divided in about 424 genera. Nerium is widely distributed in the mediterranean region and subtropical Asia. It is an urbanite plant widely used for ornamental purposes in streets, gardens, and hospitals. Oleander flowers are showy, fragrant and colorful including red, purple, pink, and orange coloured, while white and a variety of pinks are the most common ones. Many cultivars also have double coloured flowers.

From the ancient times *Nerium oleander* L. has been considered a poisonous plant because some of its compounds exhibit toxicity, especially to animals, when consumed in high amounts. Among them few compounds have narrow therapeutic ratio (comparison of the amount of a therapeutic agent that causes the therapeutic effect to the amount that causes toxicity), thus they are used for medicinal purposes. It is known to contain active cardiac glycosides, which are used in the treatment of cardiac abnormalities, neurological disorders, dermatitis, eczema, psoriasis, herpes, sores, abscesses, warts, corns, skin cancer, ringworm, scabies, epilepsy, abortifacients, asthma,
malaria dysmenorrheal, emetics and diuretics (Henary et al., 2011; Newman, 2008; Radford et al., 1986; Duke et al., 1985; Leporatti et al., 1985; Eddouks et al., 2002; Manna et al., 2000; Zibbu et al., 2010).

Scientific name: - Nerium oleander (L.) Willd. ex Delile

Common / Vernacular names
Nerium has been known by various names according to regional languages and areas, which are as follows.

- **English**: Oleander, Rose Bay, Rose-Bay, Rose- Laurel, Rosebay
- **Sanskrit**: Ashwahan, Ashwamarak
- **Hindi**: Kaner
- **Bengali**: Raktakarabi
- **Manipuri**: Kabirei
- **Gujarat**: Kaner
- **Kannada**: Chandaatha, Kanagalu, Paddali
- **Malayalam**: Alari, Kanaviram
- **Marathi**: Karvira
- **Tamil**: Alari, Arali, Chevarali, Karaviram
- **Telugu**: Erra Ganneru, Ganneru, Hayamarakamu, Karaviravrksamu,
- **Punjabi**: Kanel, Kaner


Taxonomical classification
- **Kingdom**: Plantae – Plants
- **Subkingdom**: Tracheobionta– Vascular plants
- **Super division**: Spermatophyta– Seed plants
- **Division**: Magnoliophyta – Flowering plants
- **Class**: Magnoliopsida– Dicotyledons
- **Subclass**: Asteridae
- **Order**: Gentianales
Family: Apocynaceae – Dogbane family
Sub-family: Apocynoideae
Genus: Nerium
Species: Oleander
Botanical Name: Nerium Oleander (L.)
Chromosome number: 2n = 22 (Darlington and Wylie, 1955).
Nomen number: 25229
Herbarium number: RUBL 20900
Place on publication: Sp. pl. 1:209. 1753
Name on verified on: 24-Jan-2012 by ARS Systematic Botanists.
Last updates: 24-Jan-2012

Origin and Distribution:

Nerium oleander L. is cultivated worldwide as an ornamental plant. It is native to the Mediterranean region (Kingsbury, 1964; Hardin and Arena, 1974; Zibbu and Batra, 2010) (Plate 2.1; Fig. A and B).

Native to:

Africa

Northern Africa: Algeria, Libya, Morocco, Tunisia.
West Tropical Africa: Niger.

Asia-Temperate

Arabian Peninsula: Oman, United Arab Emirates.
Western Asia: Afghanistan, Cyprus, Iran, Iraq, Israel, Jordan, Lebanon, Syria, Turkey.
China: Yunnan.

Asia-Tropical

The Plant

Europe

*South eastern Europe*: Albania, Croatia, Greece, Italy, Malta.

*South western Europe*: France, Portugal, Spain.

**Botanical History of the Plant**

Historical use of the *Nerium oleander* L. plant for medicinal applications has been reported in ancient texts and folklore for more than 1500 years. The *Nerium oleander* L. plant has been used traditionally as folk remedies for a wide variety of maladies and conditions. Nerium is first described by Theophrastus in 300 BC in his “Enquiries into Plants” of ca.” he referred it as onotheras, which is commonly known as oleander. He wrote that when the root of onotheras (oleander) was administered in wine it made the temper gentler and more cheerful.

**General Description of Nerium oleander L.**

**Plant Habit:**

Plant *Nerium oleander* L. grows in the clayey, loamy and sandy soil as the plant is xerophytes in nature (Plate 2.2).

**Stem:** Shrub, lower portions woody, aerial, erect, cylindical, branched, solid, rough, nodes, swollen, hyaline and latex is present (Plate 2.3; Fig. A).

**Leaf:** Cauline and ramal, whorled with three leaves in each whorl, exstipulate, simple, sub-sessile, leaf base, pulvinus, lanceolate, entire, spiny, acute, glabrous, unicostate, reticulate, latex present (Plate 2.1; Fig. D and Plate 2.3; Fig. B and C).

**Inflorescence:** Terminal, dichasial cyme or panicle cyme.

**Flower:** Bracteate, bracteolate, pedicellate, complete, actinomorphic, hermaphrodite, pentamericous, hypogynous and cyclic.
Fig. A : Field grown plant of *Nerium oleander* L.
Fig. B : Flowers of *Nerium oleander* L.
Fig. C : Immature Pods of *Nerium oleander* L.
Fig. D : Leaves of *Nerium oleander* L.
Fig. A: Different plant parts of *Nerium oleander* L.
Fig. A-C: Microscopic view of different parts of *Nerium oleander* L.
A: Microscopic section of stem
B: Microscopic section of leaf
C: Closeup view of stomata
**The Plant**

**Calyx:** Sepals 5, polysepalous, twisted, purple red.

**Corolla:** Petals 5, gamopetalous, twisted, rotate, coronary outgrowths present at the throat of the corolla red/white.

**Androecium:** Stamens 5, polyandrous, epipetalous situated at the throat of the corolla filament short, anther sagittate dithecous, introse, connective appendiculate and all of them twist to form a thread like structure.

**Gynoecium:** Bicarpellary, syncarpous, ovary superior, bilocular, with many ovules in each locule placentation axile, style- filiform, stigma drum shaped.

**Fruit:** Drupe.

**Seed:** Capsule spreading seeds (pods) (Plate 2.1; Fig. D).

**Growing Requirements**

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Part, full or reflected sun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Ample is best</td>
</tr>
<tr>
<td>Soil</td>
<td>Clay, loam, sandy, acidic, alkaline</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Low, periodic pruning and litter clean up</td>
</tr>
<tr>
<td>Form</td>
<td>Tree or shrub</td>
</tr>
<tr>
<td>Seasonality</td>
<td>Evergreen</td>
</tr>
<tr>
<td>Size</td>
<td>Normally 6-8 feet</td>
</tr>
<tr>
<td>Hardiness</td>
<td>Foliage damaged at 28º F, but survives much cooler temperature</td>
</tr>
<tr>
<td>Soil pH</td>
<td>5.5 to 7.8</td>
</tr>
</tbody>
</table>

**Economic Importance**

The plant is used as a rat poison and an insecticide (Chiej, 1984; Kirtikar and Basu, 1999). The pounded leaves and bark are used as an insecticide. A green dye is obtained from the flowers. The plant is commonly
used for informal hedging in the Mediterranean (Polunin and Huxley, 1987). The leaves contain small amount of latex that can be used to make rubber, though the amount is too small for commercial utilization. The plants have extensive root system and are often used to stabilize soil in warmer areas (Niebuhr, 1970).

Chemical Composition

The main poisonous principles are cardiac glycosides. The one most studied cardiac glycosides is oleandrin, but there are more than ten other glycosides whose chemical structures and their names are well known: 5 β-cardenolides, such as oleandrine; 5 α-cardenolides, such as uzangenin-type; oleandragenin (16-Acetylgitoxigenin) (ol). The "ol" being: oleandroside (oleandrin); glucose (glucosylloleandrin); gentiobiroside (gentiobiosyl oleandrin); diginoside (nerigoside); digitoxigenin (digitalose/diginose); oleagenine - oleasides (A,E) (diginose, gentiobiose-diginose). Adyregenin is a compound with no cardiac effect. The most well known effects of oleander are due to two glycosides: nerin and an alkaloid oleandrin, which have a cardiotimulatory action and to the glycosides gentiobiosyloleandrin, gentiobiosyl-nerigoside and gentiobiosyl-beaumontoside extracted from the leaves (Mallet et al., 1994; Jayabalan et al., 1995). Oleander is also diuretic and lentive on dermatosis and contusion (Erdemoglu et al., 2003). In addition, its lymph is rich with minerals and α-tocopherol, an important antioxidant (Hussain and Gorski, 2004; Bai et al., 2007). There are also weakly active cardenolides (heterosides of uzarigenine) and inactive cardenolides (heteroside of adyergerine, of digitalose), triterpenoids, a resin, tannins, glucose, a paraffin, urosolic acid, vitamin C and an essential oil. The seeds and bark of the stem contains glucosides (oleandrine, odorosides, adigoside). The roots contain steroids.

Besides, many more important compounds have been reported from its various parts, which are mentioned in the given table (Table-2.1).
### Table 2.1

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Natural Compounds</th>
<th>Chemical Structure</th>
<th>Source/plant parts</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>α-tocopherol (Vitamin E)</td>
<td>Leaves</td>
<td>Chung, M.K. 2004</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Oleandrin</td>
<td>Leaves</td>
<td>Paper and Franz, 1989</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Urosolic acid</td>
<td>Leaves</td>
<td>Le Men and Pourrat, 1952</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Quercetin</td>
<td>Leaves and Flower</td>
<td>Thilagavathi et al., 2010; Rajendran, 2011</td>
<td></td>
</tr>
<tr>
<td>S. No.</td>
<td>Natural Compounds</td>
<td>Chemical Structure</td>
<td>Source/ plant parts</td>
<td>References</td>
</tr>
<tr>
<td>--------</td>
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<td>--------------------</td>
<td>---------------------</td>
<td>------------</td>
</tr>
<tr>
<td>6.</td>
<td>Odorosides</td>
<td><img src="image1" alt="Chemical Structure" /></td>
<td>Seed</td>
<td>Pagen 1988; Bina <em>et al.</em>, 1997</td>
</tr>
<tr>
<td>7.</td>
<td>Adigoside</td>
<td><img src="image2" alt="Chemical Structure" /></td>
<td>Seed</td>
<td>Ahmad and Basha, 2006</td>
</tr>
</tbody>
</table>
Medicinal Uses

The leaves and the flowers are cardiotonic, diaphoretic, diuretic and expectorant and sternutatory (Duke, 1985). A decoction of the leaves has been applied externally in the treatment of scabies and to reduce swelling. This is a very poisonous plant, containing a powerful cardiac toxin and should only be used with extreme caution. Because of its poisonous nature, it is only used externally. It is made into a paste with water and applied to chancres and ulcers on the penis. Oil prepared from the root bark is used in the treatment of leprosy and skin diseases of a scaly nature (Chopra et al., 1986). The whole plant is said to have anticancer properties (Duke, 1985; Zibbu and Batra, 2010).

Pharmacological Action and Toxicity:

Oleandrine is anti-inflammatory, anti-tumoral, emollient and potential apoptosis (Chopra et al., 1986; Wang et al., 2000). The hydro alcoholic and aqueous extract of the flowers is antinociceptive and cardiotonic. The leaves and the seeds provoke poisoning with nausea, vomiting, mental confusion, ventricular hyperkalaemia that can quickly end in death (Zibbu and Batra, 2010).

Antinociceptive Activity:

The aqueous and ethanol extracts of oleander leaves possess significant antinociceptive activity, but ethanolic extract was more pronounced. However, extracts were shown to induce gastric, ulcerogenicity with mice. Flowers either dried or fresh also exhibit potent antinociceptive activity (Zia et al., 1995).

Anti-inflammatory activity:

Anti-inflammatory activity assessment experiment has also verified that lipo soluble components of flowers (ethanol extracts of flowers) have the anti inflammatory activity. (Nagourney et al., 2001).
Antimicrobial Activity:

The presence of antifungal and antibacterial substances in the higher plant is well established. Plant has provided a source of inspiration for novel drug compounds, as plants derived medicines have made significant contributions towards human wealth. At the same time, Dunk and Klaus (1980), Hussain and Gorsi (2004) and reported the antimicrobial activity of leaves and roots of *Nerium oleander* against *Bacillus pumilus*, *B.subtilis*, *Staphylocoocus aureus*, *Escherichia coli* and *Aspergillus niger*.

Locomotor Activity:

Zia (1995) reported that purified fractions obtained from the methanol extract of fresh oleander leaves possess a CNS depressant activity i.e., produced reduction in locomotor activity. They also showed significant analgesic activity as indicated by inhibitory effects on acetic acid- induced and increased reaction time to thermal test.

Anticancer Activity:

The aqueous extract of *Nerium oleander* L. has been clinically investigated as an anti-cancerous agent. Oleandrin and its aglycone oleandrigenin are the active compounds that are isolated from this plant, which show the anticancerous properties. Anvirzel has also revealed cytotoxicity in human tumor cell lines with evidence of apoptosis as a principal mode of cell death (Judith *et al.*, 2001).

Antitumor activity of this novel plant extract, the relative abilities of oleandrin and oleandrigenin to inhibit FGF-2 export from two human prostate cancer cell lines, DU145 and PC3, were examined (Ahmad and Alkofahi, 1990). Anvirzel and Oleandrin are extracts of oleander, induce cell death in human cancer cells (Chopra *et al.*, 1996).
Nerium oleander L. and Calotropis procera have a cytotoxicity activity in the antitumor human cell line test with ED50 varied in the range of 0.008 to 2.13 µg/ml, depending upon the cell line used (Shawn and Pearn, 1979; Schvartsman, 1979; Siddiqui et al., 1990).

**Diuretic Effect:**

The chief active principle i.e oleandrin was found to stimulate the heart function and also had a diuretic effect. The effect of odorin on the heart of rabbits and dogs is identical with that of digitalis group, whereas neriodin is twice as active as digitoxin in Digitalis purpurea, action similar to that of oleandrin (Sen, 2009).

**Immunomodulating Activity:**

**CNS depressant activity:** After the isolation of oleandrin, a number of new chemical constituents have been isolated from this plant and their pharmacological properties have also been evaluated (Pearn, 1987). Experiments have been demonstrated that the crude alcoholic extract from the leaves has CNS depressant activity. Nerium oleander L. contains at least 2% cardiac glycosides. Rosagenin may be extracted from the bark and has a strychnine-like action. Strychnine is a highly toxic, colorless, bitter crystalline alkaloid used as a pesticide, particularly for killing small vertebrates such as birds and rodents. Several other flavones (0.5%) and volatile oils (trace amount), as well as rubber, fats, sugars and hydrocyanic acid, can be isolated from its leaves (Patwardhan et al., 2004; Sharma et al., 2008). This plant is rich with many glycosides and other important alkaloids, which are being utilized by various pharmaceutical companies to produce various medicinal products in the market, are given below (Plate 2.4).
Various commercial products of *Nerium oleander* L. available in the market
Ginger - the "root," or actually the rhizome, of the plant *Zingiber officinale* has been a popular spice and herbal medicine for thousands of years. It has a long history of being used as medicine in Asian, Indian, and Arabic herbal traditions. Confucius wrote about it in his Analects, the Greek physician, Dioscorides, listed ginger as an antidote to poisoning, as a digestive, and as being warming to the stomach in De Materia Medica, and the Koran, the Talmud and the Bible all mention ginger. Ginger is still extremely popular in the practice of phytotherapy, particularly in Traditional Chinese Medicine and Indian Ayurveda.

**Zingiber Officinale Roscoe**

*Zingiber Officinale* Roscoe is a slender grassy perennial herb, native to tropical Asia. It belongs to family *zingiberaceae* or the *ginger family*, a family of flowering plants consisting of aromatic perennial herbs with creeping horizontal or tuberous rhizomes, comprising about 52 genera and more than 1300 species, distributed throughout tropical Africa, Asia, and the Americas. The plant is widely grown for its edible rhizomes (underground stem), which have a distinctive scent and taste and is usually grown as an annual for harvesting as a spice. Ginger seems to originate from Southern China. Today, it is cultivated all over tropic and subtropical Areas.

Ginger rhizome (underground stem) is used as a spice and also as a medicine. It can be used fresh, dried and powdered, or as a juice or oil. Ginger is commonly used to treat various types of “stomach problems,” including motion sickness, morning sickness, colic, upset stomach, gas, diarrhea, nausea caused by cancer treatment, nausea and vomiting after surgery, as well as loss of appetite. In foods and beverages, ginger is used as a flavoring agent. In manufacturing, ginger is used for fragrance in soaps and cosmetics.
Scientific Name: - *Zingiber officinale* Roscoe.

Common / Vernacular names

Ginger has been known by various names according to regional languages and areas, which are as fellows.

English : Ginger  
Sanskrit : Adrakam, Ardraka  
Hindi : Adrak, Sunthi, Sonth  
Bengali : Aada  
Tamil : Inji  
Manipuri : Shing  
Maithili : Aad  
Gujarati : Adu  
Kannada : Sunthi  
Bhojpuri : Aadi  
Marathi : Nisam  
Telugu : Allam  
Punjabi : Adrak  
Nepali : Aduwa  
Sinhalese : Inguru  
Synonymus : *Amomum zingiber* L.

Taxonomical classification

Kingdom : Plantae  
Subkingdom : Tracheobionta  
Super division : Spermatophyta  
Division : Magnoliophyta  
Class : Liliopsida  
Subclass : Zingiberidae  
Order : Zingiberales  
Family : Zingiberaceae
Origin and Distribution

Indians and Chinese believed to have produced ginger as a tonic root for over 5000 years to treat many ailments, and this plant is now cultivated throughout the humid tropics, with India being the largest producer. Interestingly, ginger does not grow in the wild and thus its actual origins are uncertain. Ginger’s current name comes from the Middle English *gingivere*, but this spice dates back over 3000 years to the Sanskrit word *srngaveram*, meaning “horn root,” based on its appearance (Plate 2.5; Fig. A and B).

General Description of *Zingiber officinale* Roscoe.

Plant Habit:

Ginger is a knotted, thick, beige underground stem, called a rhizome. The stem sticks up about 12 inches above ground with long, narrow, ribbed, green leaves, and white or yellowish-green flowers (Plate 2.6).

Rhizomes - Knobbly and fleshy, covered in ring-like scars. This is the important part for food and medicine. Although the rhizomes grow underground, they are swollen stems, not roots. This is why fresh ginger is often referred to as 'stem ginger' (Plate 2.5; Fig. C and Plate 2.7).
Flowers - The flowers are bisexual, strongly zygomorphic, and often are associated with conspicuous floral bracts. The flowering spikes sprout directly from the rhizomes and are about 30 cm long. The flowers are purple with a cream-blotched base.

Fruits - Red in color. Each has three chambers containing several small black seeds. Ginger plants that are cultivated in commercial plantations don't usually bear fruit.

Leaf: linear leaves that are arranged alternately on the stem, distichous, the base sheathing and the blade mostly linear to elliptic with penni-parallel, strongly ascending veins. The leaves can reach 7 cm (2.75 in) in length and 1.9 cm (0.7 in) broad.

Inflorescence: Spike or Raceme (Plate 2.5; Fig. D)

Calyx: The perianth is in two whorls, an herbaceous or membranous 3-lobed or spathaceous tubular calyx.

Corolla: petaloid tuular corolla with 3 lobes.

Androecium: The androceium typically consists of 1 fertile, a large opposing petaloid labellum representing 2 connate staminodia, and two smaller flankng petaloid staminodia.

Gynoecium: gynoecium consists of a single compound pistil of 3 carpels, a single style nestled in a channel of the filament and anther of the fertile stamen and inferior ovary with typically 3 locules, each containing numerous axile ovules. Rarely the ovary is unilocular with parietal placentation.

Seed: Seeds round with a red aril and endosperm present.
Fig. A: Field grown plant of *Zingiber officinale* Roscoe.
Fig. B: Pot grown plant of *Zingiber officinale* Roscoe.
Fig. C: Rhizome of *Zingiber officinale* Roscoe.
Fig. D: Inflorescence of *Zingiber officinale* Roscoe.
Different plant parts of *Zingiber officinale* Roscoe.
Figs. A-C: Microscopic view of Rhizome of *Zingiber officinale* Roscoe.
Fig. A: Transfer section of rhizome
Fig. B: Transfer section of Endoderimis of rhizome
Fig. C: Transfer section of central part of rhizome
Growing Requirements

<table>
<thead>
<tr>
<th>Sun Exposure</th>
<th>Part sun, shade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Moderate rainfall</td>
</tr>
<tr>
<td>Soil</td>
<td>Sandy loam, clay loam, red loam or lateritic loam.</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Spread a thick layer of organic mulch over the soil around the plant to help promote soil moisture retention to maintain high humidity.</td>
</tr>
<tr>
<td>Form</td>
<td>Shrub</td>
</tr>
<tr>
<td>Seasonality</td>
<td>Perennial, planted in February or early March</td>
</tr>
<tr>
<td>Size</td>
<td>Normally 4-10 inches</td>
</tr>
<tr>
<td>Hardiness</td>
<td>Ginger isn't frost tolerant, and a minimum temperature of 68 degrees Fahrenheit is required for optimal growth.</td>
</tr>
<tr>
<td>Soil pH</td>
<td>6 to 6.8</td>
</tr>
</tbody>
</table>

**Chemical Components**

The ginger rhizome contains an essential oil and resin known collectively as oleoresin. The composition of the essential oil varies according to the geographical origin, but the chief constituents, sesquiterpene hydrocarbons, which are responsible for the characteristic aroma, are fairly constant.

The oleoresin contains:

- **Sesquiterpenes:** zingiberene, \( \alpha \)-curcumene, \( \beta \)-sesquiphellandrene and \( \beta \) - bisabolene

- **Phenolic compounds:** gingerols and their corresponding degradation products, shogaols, zingerone, and paradol. Zingerone and shogaols are found in small amounts in fresh ginger and in larger amounts in dried or extracted products (Govindarajan, 1982).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Natural Compounds</th>
<th>Chemical Structure</th>
<th>Source/plant parts</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>6-Gingerol</td>
<td><img src="image" alt="6-Gingerol" /></td>
<td>Rhizome</td>
<td>Nakamura, H. and Yamamoto, T., 1982</td>
</tr>
<tr>
<td>2.</td>
<td>Gingerols</td>
<td><img src="image" alt="Gingerols" /></td>
<td>Rhizome</td>
<td>Hikino, H. et al., 1985</td>
</tr>
<tr>
<td>3.</td>
<td>Shogaols</td>
<td><img src="image" alt="Shogaols" /></td>
<td>Rhizome</td>
<td>Hikino, H. et al., 1985</td>
</tr>
<tr>
<td>4.</td>
<td>Gingerdiones</td>
<td><img src="image" alt="Gingerdiones" /></td>
<td>Rhizome</td>
<td>Tao, Y., 2009</td>
</tr>
<tr>
<td>5.</td>
<td>Gingerdiols</td>
<td><img src="image" alt="Gingerdiols" /></td>
<td>Rhizome</td>
<td>Sekiwa, Y., 2000</td>
</tr>
<tr>
<td>6.</td>
<td>Paradols</td>
<td><img src="image" alt="Paradols" /></td>
<td>Rhizome</td>
<td>Oloke, J.K., 1989</td>
</tr>
<tr>
<td>7.</td>
<td>6-Dehydrogingerols</td>
<td><img src="image" alt="6-Dehydrogingerols" /></td>
<td>Rhizome</td>
<td>Jolad, S.D., 2005</td>
</tr>
</tbody>
</table>
Medicinal Uses

Anti-Emetic:

Ginger has demonstrated anti-emetic activity in both experimental models and human studies (Holtmann et al., 1989; Kawai et al., 1994). One of its constituents, galanolactone, is a serotonin receptor antagonist, which may partly explain the anti-emetic effect (Huang et al., 1991a; Mustafa et al., 1993; Yamahara et al., 1990). The anti-arrhythmic and anti-emetic effects are thought to be due to a blockade of prostaglandins (Gonlachanvit, 2003 and Sharma et al., 2005).

Gastrointestinal Activity:

Ginger extracts stimulate the flow of saliva, bile and gastric secretions (Platel & Srinivasan, 1996; 2001; Yamahara et al., 1985) and have been shown to increase gastrointestinal motility without affecting gastric emptying in several animal models and human studies (Gupta & Sharma 2001; Micklefield et al., 1999; Phillips et al., 1993). Ginger has also been observed to have prokinetic activity in mice \textit{in vivo} and antispasmodic activity \textit{in vitro} (Ghayur & Gilani 2005).

Anti-ulcer activity:

The orally administered acetone extract of ginger at a dose of 1000 mg/kg and its constituents like zingiberene and 6-gingerol at 100 mg/kg significantly inhibited gastric lesions by 97.5\%, 53.6\% and 54.5\% respectively (Yamahara et al., 1988). Other constituents demonstrating antiulcer properties in gastric ulcer models in rats include beta-sesquiphellandrene, beta-bisabolene, ar-curcumene and shogaol (Sertie et al., 1992; Yoshikawa et al., 1994).

Hypolipidaemic:

High doses of an aqueous extract of ginger (500 mg/kg) administered daily for a period of 4 weeks significantly reduced serum cholesterol level (Thomson et al., 2002). While the other study demonstrated that 250 µg ginger extract/day reduced serum triglyceride levels by 27\% in mice (Fuhrman et al., 2000).
Anti-Inflammatory and Analgesic:
The anti-inflammatory effects of ginger may be due to its in vitro inhibition of COX-1, COX-2 and lipoxygenase activity (Kobayashi et al., 1987).

Ginger also suppresses leukotriene biosynthesis by inhibiting 5-lipoxygenase. Additionally, ginger extract has shown to inhibit thromboxane synthase (Langner et al., 1998) and a ginger extract (EV.EXT.77) has found to inhibit the induction of several genes involved in the inflammatory response. These include genes encoding cytokines, chemokines, and the inducible enzyme COX-2, thus providing evidence that ginger modulates biochemical pathways activated in chronic inflammation (Grzanna et al., 2005). Moreover several studies have identified that gingerols, diarylheptanoids and minor compounds like gingenone A, 6-gingerdiol, hexahydrocurcumin and zingerone gingerdione are the key compounds responsible for anti-inflammatory and analgesic activity of ginger (Flynn et al., 1986; Kiuchi et al., 1992; Dedov et al., 2002; Onogi et al., 1992; Penna et al., 2003; Sharma et al., 1994).

Anti-Platelet:
It has been suggested that gingerols and their derivatives represent a potential new class of platelet activation inhibitors, with synthetic gingerols being found to inhibit the arachidonic acid-induced platelet release reaction in vitro in a similar dose range as aspirin possibly due to an effect on COX activity in platelets (Koo et al., 2001; Lu, 2005; Nurtjahja-Tjendraputra et al., 2003; Tjendraputra et al., 2001).

Antimicrobial and Antiparasitic:
Ginger extract has shown to have an antibacterial effect against Staphylococcus aureus, Streptococcus pyogenes, S. pneumoniae and Haemophilus collected from throat swaps of infected individuals. The minimum inhibitory concentration of ginger ranged from 0.0003-0.7 µg/mL, and the minimum
bactericidal concentration ranged from 0.135-2.04 µg/mL (Akoachere et al., 2002). Various scientists have also detected antimicrobial activity of ginger extract and its constituents e.g. 6-Gingerol, 10 Gingerol, zingerone, β-sesquiphellandrene (Yamada et al., 1992; Martins et al., 2001; Goto et al., 1990; Henry & Piggott 1987; Denyer et al., 1994).

**Antioxidant:**

Orally administered ginger significantly lowered levels of free radicals and raised the activities of endogenous antioxidants superoxide dismutase and catalase and had a sparing effect on vitamins C and E (Jeyakumar et al., 1999).

**Immunomodulation:**

*In vitro* and *in vivo* research suggests ginger extract exerts some degree of immunomodulatory activity and has been shown to significantly prolong the survival of cardiac allografts in mice (Wilasrusmee et al., 2003). Ginger oil has shown dose-dependent inhibition of T lymphocyte proliferation and IL-1-alpha secretion *in vitro* and reduced delayed type of hypersensitivity response *in vivo* (Zhou et al., 2006).

**Hepatoprotective:**

Ginger has significant hepatoprotective effects comparable to those of silymarin, according to research with experimental models of alcohol-induced liver damage (Bhandari et al., 2003).

**Antihistamine:**

Shogaols and certain gingerols exhibit dose-dependent inhibition of drug-induced histamine release from rat peritoneal mast cells *in vitro* (Yamahara et al., 1995).
Anxiolytic:

A highly non-polar fraction of a ginger extract has been shown to possess anticonvulsant, anxiolytic and anti-emetic activities in animals (Vishwakarma et al., 2002).

Antifibrotic:

Supplementation with 5 g ginger not only prevented a decrease, but also significantly increased fibrinolytic activity in 30 healthy adult volunteers who consumed 50 g fat in a meal in an open clinical study (Verma & Bordia, 2001).

Apoptosis:

A pungent phenolic substance found in ginger (6-paradol) effectively inhibits tumour promotion in mouse skin carcinogenesis. 6-Paradol and structurally related derivatives have also been shown to induce apoptosis through a caspase-3-dependent mechanism (Keum et al., 2002).

Positive Inotrope:

Gingerols and shogaols isolated from ginger have positive inotropic activity, as demonstrated on isolated heart muscle (Shoji et al., 1982; Yamahara et al., 1995). The effect of gingerol seems to be rather specific to SR Ca\(^{2+}\)-ATPase activity (Kobayashi et al., 1987).

Thermogenic:

Ginger helps to maintain body temperature and inhibit serotonin-induced hypothermia in vivo (Huang et al., 1991b; Kano et al., 1991).

Clinical Use

Although ginger is used in many forms, including fresh ginger used in cooking or chai (Indian spicy tea), pickled or glazed ginger, ethanol extracts and concentrated powdered extracts, preparations made with the root are used medicinally.
Prevention of Nausea and Vomiting:

Many clinical studies have investigated the effects of ginger in the prevention and treatment of nausea and vomiting associated with different circumstances, including pregnancy (Fischer-Rasmussen et al., 1990; Keating & Chez, 2002; Portnoi et al., 2003; Smith et al., 2004; Sripramote & Lekhyananda, 2003; Vutyavanich et al., 2001; Willetts et al., 2003), the postoperative period (Arfeen et al., 1992; Bone et al., 1990; Phillips et al., 1993b; Meyer et al., 1995; Visalyaputra et al., 1998), motion sickness (Grontved & Hentzer 1986; Lien et al., 2003; Mowrey & Clayson 1982; Schmid et al., 1994; Stewart et al., 1991) and chemotherapy (Manusirivithaya et al., 2004; Meyer et al., 1995; Sontakke et al., 2003).

Nausea of pregnancy:

There are many studies, including an observational study (Portnoi et al., 2003) and at least six RCTs (Fischer-Rasmussen et al., 1990; Keating & Chez, 2002; Portnoi et al., 2003; Smith et al., 2004; Sripramote & Lekhyananda 2003; Vutyavanich et al., 2001; Willetts et al., 2003), as well as multiple systematic reviews, including a Cochrane review, that suggest that ginger powder or extract may be safe and effective in treating nausea and vomiting of pregnancy (Boone & Shields 2005; Borrelli et al., 2005; Bryer, 2005; Dib & El-Saddik, 2004; Ernst & Pittler, 2000; Jewell 2002).

Postoperative nausea:

A meta-analysis of five randomised trials, however, including a total of 363 patients found that a fixed dose of at least 1 g of ginger was more effective than placebo for the prevention of postoperative nausea and vomiting (Chaiyakunapruk et al., 2006). Various studies have also supported that ginger plays a protective role against postoperative nausea (Bone et al., 1990; Phillips et al., 1993; Arfeen et al., 1992; Eberhart et al., 2003; Pongrojpaw & Chiamchanya, 2003; Geiger, 2005).
Motion sickness:

Commission E approves the use of ginger root for the prevention of motion sickness (Blumenthal et al., 2000). In a randomised double-blind study of seasickness involving over 1700 tourists on a whale-watching safari 300 km north of the Arctic circle, 500 mg ginger was found to be as effective for the treatment of motion sickness as several common anti-emetic medications (Schmid et al., 1994). Moreover in a second study involving 36 undergraduate men and women who reported very high susceptibility to motion sickness found that ginger was superior to dimenhydrinate (Mowrey & Clayson 1982). More recently, another double-blind, randomised, placebo-controlled crossover study showed positive benefits with ginger pretreatment on prolonging time before nausea, shortening recovery time and effectively reducing nausea (Lien et al., 2003).

Chemotherapy-induced nausea:

Powdered ginger root effectively reduced cyclophosphamide, psoralem, cisplatin induced nausea and vomiting in a randomised, prospective, crossover double-blind study, with the anti-emetic effect of ginger (Sontakke et al., 2003; Meyer et al., 1995; Manusirivithaya et al., 2004).

Musculoskeletal Disorders:

Ginger is useful in inflammation and rheumatism. A 250 mg of the ginger extract four times daily for 6 months was shown to be significantly more effective than placebo in reducing pain and disability in 29 Osteoporosis patients in a double-blind, placebo-controlled, crossover study (Wigler et al., 2003). Similarly various studies revealed that 1 g of ginger was as effective as 1.2 g of ibuprofen in the symptomatic treatment of Osteoporosis (Srivastava & Mustafa, 1992; Haghighi et al., 2005).

Migraine:

Ginger is used to prevent and treat migraine headache (Mustafa and Srivastava 1990b). This use is supported by an open-label study of 30 migraine
sufferers that reported that treatment with a sublingual ginger and feverfew preparation (GelStat MigraineO) in the initial phase of a migraine resulted in most patients being satisfied with the therapy and being pain-free or only having mild headache post-treatment (Cady et al., 2005).

Propagation

Ginger grows best in warm and sunny climates in a deep but well-draining soil or loam that is high in organic matter. The optimum soil pH for growth of ginger is between 6.0 and 6.5. The plant requires a minimum temperature of 15.5°C (59.9°F). Ginger is vegetatively propagated from small sections of the rhizome, called sets. Sets are produced by cutting a small 3–6 cm from a living rhizome and should be planted at a depth of 5–12 cm, leaving 15–35 cm between plants and 25–30 cm between rows. For optimal growth, the soil temperature at planting should not fall below 25°C (77°F). The rhizomes are harvested after the stems wither by digging them up carefully.

Various medicinal products *Zingiber officinale* Roscoe. in the market are given below (Plate 2.8).
Various commercial product of *Zingiber officinale* Roscoe available in the market