Kaempferia rotunda

Scientific Name

***Kaempferia rotunda* L.**

Synonyms

Kaempferia longa Jacq., *Kaempferia versicolor* Salisb., *Zerumbet zeylanica* Garsault (Inval.)

Family

Zingiberaceae

Common/English Names

Asian Crocus, Hainan Resurrection Lily, Himalayan Crocus, Indian Crocus, Peacock Ginger, Resurrection Lily, Round-rooted Galangal, Tropical Crocus

Vernacular Names

Bangladesh: Bhuichampa, Misri Dana
Chinese: Hai Nan San Qi, Sha Jiang
India: Bhuichampa (Bengali), Bhuichampa Bhuyicampa (Hindi), Kallu Kove, Kalluloove, Kumada Gedde, Kumudagadde, Nela Sampige, Nelasampige, Utpala Hoovu (Kannada), Cennalinirkilannu, Cennalinirkkilannu, Cennalinirkuva, Chenchineerkilang, Chengzhineer, Malankoova, Malan-Kua (Malayalam), Bhuichampa, Bhuichapa, Bhumy-Champo, Booichampa (Marathi), Bhucampaka, Bhuchampaka, Bhumicampaka, Bhumichampa, Bhumichampaka, Hallakah, Hallakam, Utpala, Utpalam (Sanskrit), Karunkuvalai, Konda-Kalava, Neerpichin, Nerpichan, Nerppicin,

Plate 1 Variegated green leaves with purple underside

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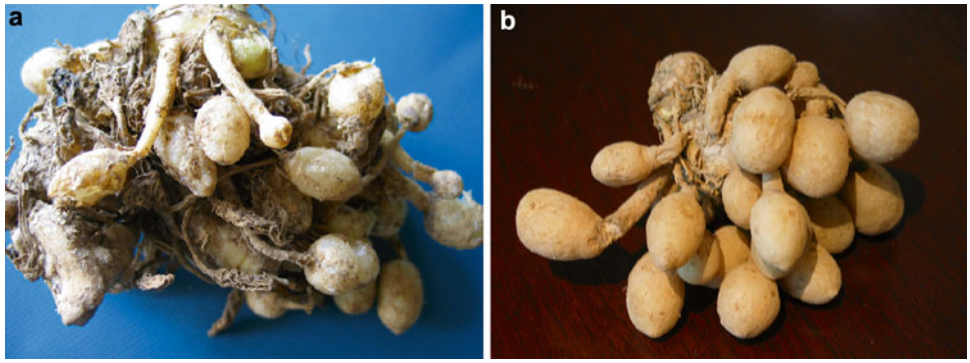

Plate 2 (**a**, **b**) Small rounded tubers

Pucanpakam, Pumicampakam, Pumicanpakam (Tamil), Bhoochampakamu, Bhucampakamu, Bhuchampakamu, Kondakalava, Kondakaluva (Telugu)

Indonesia: Ardong, Kunir Putih, Kunci Pepet (Javanese), Konjek Pote, Konce Pet, Konce Pote (Madurese), Kuncit Putih, Temu Putih (Malay), Koneng Bodas, Koneng Putih (Sundanese)

Malaysia: Ardong, Kunci Pepet, Kunir Putih, Temu Putih

Nepal: Bhui-Champha

Philippines: Gisol Na Bilóg (Tagalog)

Thailand: Ueang Din, Waan Hao Non, Waan Nonlap

Vietnam: Cẩm Địa La, Ngải Máu, Tam Thất Nam

Origin/Distribution

It is indigenous to Indian subcontinent, through Southeast Asia to Southern China.

It is cultivated in China (Guangdong, Guangxi, Hainan, Yunnan), Taiwan, India, Indonesia, Malaysia, Myanmar, Sri Lanka, Vietnam and Thailand.

Agroecology

In its native range, it occurs under partial shade, in open lower montane forests, forest margins and bamboo forest and open grasslands from sea level to 1300 m elevation. It grows on all types of soil.

Edible Plant Parts and Uses

The small ovate tubers of the roots, rhizomes, shoots and leaves are eaten fresh or cooked as vegetables. All are used as flavouring spice in Southeast Asia. Young leave as eaten as 'lalap' or 'sayor'.

Botany

Kaempferia rotunda is a small rhizomatous stemless herb to 65 cm high. Rhizomes are fleshy, short, robust subterranean bearing slender, cylindrical roots terminating in swollen, subglobose, ovate or spindle-shape, yellowish-white tubers which is 1.15 cm long and 1.2.5 cm thick (Plates 2a, b). Leaves 2-3-5 are erect, distichous, short-petiolate sheaths which are 7–25 cm long, with lamina which is oblong lanceolate to elliptical and 7–36 cm (usually 12–25 cm) long by 4-7-11 cm wide, acuminate, glabrous, puberulous below, variegated or patterned dark and pale green on either side of midvein on adaxial surface and red/maroon/purple abaxially (Plate 1). Inflorescence emerges on separate shoot from the rhizome before the leaves, with 4–6 flowers, fragrance, purple-brown bracts and 2-toothed bracteole apex. Calyx is 4–7 cm and splits on 1 side, with 3-toothed white or greenish

apex, and is a corolla tube equalling calyx; lobes are spreading, white, linear and 5 cm. Lateral staminodes are erect, white and lanceolate, with acute apex. Labellum is violet, obcordate and apically 2 cleft to base; lobes are down-curved, 3.5 × 2 cm, with acute apex. Anther's connective appendage is erect and bi-cleft. Ovary is 4–6 mm and hairy.

Nutritive/Medicinal Properties

The following compounds were isolated from the rhizomes: benzyl benzoate and the cyclohexane derivative and crotepoxide (Nugroho et al. 1996); three cyclohexane diepoxides, (−)-(1*R*,2*R*,4*R*,5*S*,6*R*,7*R*)-4-benzoyloxymethyl-3,8-dioxatricyclo[5.1.0.0^{2,4}] octane-5,6-diol 6-acetate; (+)-(1*R*,2*R*,4*R*,5*S*,6*R*,7*R*)-4-benzoyloxymethyl-3,8-dioxatricyclo-[5.1.0.0^{2,4}]octane-5,6-diol 5-acetate; and (−)-(1*R*,2*R*,4*R*,5*S*,6*R*,7*R*)-4-benzoyloxymethyl-3,8-dioxatricyclo[5.1.0.0^{2,4}] octane-5,6-diol 6-benzoate together with crotepoxide and (−)-zeylenol (Pancharoen et al. 1996); 3-deacetylcrotepoxide and 2-hydroxy-4,4′,6′-trimethoxychalcone (Jantan et al. 2004); six polyoxygenated cyclohexane derivatives identified as (−)-6-acetylzeylenol (1), four acylated derivatives of 1-benzoyloxymethyl-1,6-epoxy-cyclohexan-2,3,4,5-tetrol (3–6), a Diels–Alder adduct of 3-benzoyl-1-benzoyloxymethylcyclohexa-4,6-dien-2,3-diol (7), (−)-zeylenol (2), a triacylated derivative of salicin (9) and the cyclohexane diepoxide and crotepoxide (8) (Stevenson et al. 2007); 3-deacetylcrotepoxide (Jantan et al. 2008); 1, 2′-hydroxy-4,4′,6′-trimethoxy-chalcone and (+)-crotepoxide (Lotulung et al. 2008); [1*R*-(1α,2α,4α,5β,6α,7α)]-4-benzoyl-oxymethyl-5,6-dihydroxy-3,8-dioxatricyclo-[5.1.0.0]octan-5-yl acetate (3-deacetylcrotepoxide) (Sirat et al. 2010a); (*E*)-1-(2-hydroxy-4,6-dimethoxyphenyl)-3-(4-meth-oxyphen-yl)prop-2-en-1-one (Sirat et al. 2010b); and three known flavanones, namely, 5-hydroxy-7-methoxyflavanone; 7-hydroxy-5-methoxyflavanone and 5,7-dihydroxyflavanone (Atun et al. 2013). A lectin (designated as KRL) was purified from *Kaempferia rotunda* rhizome (Kabir et al. 2011). It was determined to be a 29.0 0 kDa polypeptide and to be a divalent ion-dependent glycoprotein with 4 % neutral sugar. Aznam et al. (2012) isolated the following flavonoids from the hexane rhizome extract: 4′-hydroxy-8-methoxy-flavanone, 6 - hydroxy-8-methoxy-flavanone and 4 ′, 8-dihydroxy-flavanone.

Three new cyclohexane oxides and ten known compounds, comprising of cyclohexane oxides, esters, carboxylic acid, labdane diterpene and flavonoids, were isolated from *K. rotunda* rhizomes from Malaysia and Indonesia (Yau 2009). Two new compounds were identified as 2-(benzoyloxymethyl)phenyl (3-O-acetyl)-ß-glucopyranoside and 3-debenzoylrotepoxide A, together with seven known compounds: crotepoxide, 4-benzoyloxymethyl-3,8-dioxatricyclo[5.1.0.02,4] octane-5,6-diol 5-acetate, 1,6-desoxypipoxide, curcumrinol C, 2′-hydroxy-4,4′,6′-trimethoxy-chalcone and naringenin 4′,7-dimethyl ether were isolated from the Malaysian species, while a new compound identified as 3-acetoxy-2-benzoyloxy-1-(benzoyloxymethyl)-cyclohexa-4,6-diene with the seven known compounds, namely, crotepoxide; 4-benzoyloxymethyl-3,8-dioxatricyclo[5.1.0.02,4]octane-5,6-diol 5-acetate; 1,6-desoxypipoxide; 6-acetylzeylenol; *trans*-docosyl ferulate; benzyl benzoate and benzoic acid, were isolated from the Indonesian species. A new polyoxygenated cyclohexane compound, (−)-3-acetyl-4-benzoyl-1-benzoyloxymethyl-1,6-diepoxycyclohexan-2,3,4,5-tetro, together with 11 constituents was isolated from *K. rotunda* methanol extract (Lallo et al. 2014).

Sereena et al. (2011) identified n-dodecane (33.1 %), stearaldehyde (37.9 %), hexadecane (6.32 %), dodecanoic acid (9.48 %) and kaurenol (12.6 %) in the dried powdered rhizome petroleum ether extract. In the rhizome essential oil, 13 compounds were identified: bornyl acetate (30.12 %), benzyl benzoate (16.6 %), camphor (7.18 %), camphene (7.54 %), borneol (5.93 %), cineol (4.16 %), caryophyllene (3.05 %), linalool (2.6 %), *n*-tetradecane (2.18 %), α-pinene (1.35 %), aromadendrene (1.31 %), β-pinene 1.13 %) and caryophyllene oxide (0.94 %)

The most abundant volatile constituents of *K. rotunda* rhizomes extracted by GC and GC–MS (EI) analyses were benzyl benzoate (69.7 %, 20.2 %), *n*-pentadecane (22.9 %, 53.8 %) and camphene (1.0 %, 6.2 %) (Woerdenbag et al 2004). *K. rotunda* rhizome yielded < 0.03 % oil (Sirat et al. 2005). Twenty-three compounds were found, among which were monterpenes (19 %), sesquiterpenes (10.1 %), esters (39.2 %) and hydrocarbons (27.3 %). The major esters were bornyl acetate (24.9 %) and benzyl benzoate (15.3 %). Pentadecane (25.4 %) and camphor (12.1 %) were the major hydrocarbon and monoterpene, respectively. The rhizome was found to be deficient in sesquiterpenoids. Fifty-one volatile compounds were isolated and identified from *Kaempferia rotunda*, and the main compounds were α-pinene (6.83 %), camphene (13.00 %), *β*-pinene (18.97 %), camphor (5.80 %) and linalool oxide (5.11 %) (Xu et al. 2012).

Leaf Phytochemicals

Flavonoids, crotpoxide, chalcones, quercetin, protocatechuic acid, β-sitosterol, stigmasterol, syringic acid and some hydrocarbons were found in the methanol leaf extract (Imam et al. 2013).

Antioxidant Activity

The chloroform-soluble rhizome extract exhibited significant scavenging effect on the on 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radicals (IC_{50} = 180 µg/mL) (Lotulung et al. 2008). Two compounds of the chloroform-soluble extract were isolated and identified. Compound 1, 2′-hydroxy-4,4′,6′-trimethoxy-chalcone was found as the active constituent (IC_{50} = 142 µg/mL). Compound 2, (+)-crotepoxide, was inactive (IC_{50} = 1516 µg/ mL). *K. rotunda* methanol rhizome extract was found to have significant antioxidant activity (Mohanty et al. 2008). The quantification of malondialdehyde (MDA) and 4-hydroxyl-2-nonenal (4-HNE) could be directly correlated with the lipid peroxidation inhibition capacity of the extract.

Antiplatelet activity

Studies reported that 3-deacetylcrotepoxide and 2-hydroxy-4,4′,6′-trimethoxychalcone from *K. rotunda* rhizome inhibited platelet-activating factor receptor binding of rabbit platelets with IC_{50} values of 45.6 and 57.4 µM, respectively (Jantan et al. 2004). They also showed that 3-deacetylcrotepoxide showed strong inhibition on human platelet aggregation induced by arachidonic acid with IC_{50} value < 84 µM (Jantan et al. 2008).

Antihyperglycaemic Activity

The methanol rhizome extract caused dose-dependent significant lowering in serum glucose levels in mice, when administered at doses of 50, 100, 200 and 400 mg per kg body weight to glucose-loaded mice as compared to control animals (Sultana et al. 2012). Highest lowering of serum glucose (39.6 %) was observed at an extract dose of 400 mg. In comparison, a standard antihyperglycaemic drug, glibenclamide, when administered at a dose of 10 mg per kg body weight, lowered serum glucose.

Antinociceptive Activity

The methanol rhizome extract demonstrated dose-dependent significant antinociceptive activity when administered to mice compared to control animals (Sultana et al. 2012). At a dose of 400 mg extract per kg body weight, the number of abdominal writhings was inhibited by 69.4 % as compared to 73.4 % inhibition obtained with a standard antinociceptive drug, aspirin, administered at a dose of 400 mg per kg body weight.

Antimutagenic Activity

The methanol rhizome extract and isolated flavanones, namely, 5-hydroxy-7-methoxyflavanone, 7-hydroxy-5-methoxyflavanone and 5,7-dihydroxyflavanone, showed significant antimutagenic effect compared to control group based on the number of micronucleated polychromatic cell erythrocytes (MNPCE) from male Balb/c mice (8–12 week) induced by cyclophosphamide (Atun et al. 2013).

Anticancer Activity

A lectin KRL from the rhizome exhibited antiproliferative activity against Ehrlich ascites carcinoma (EAC) cells with 51 % and 67 % inhibition in-vivo in mice administered with 1.25 mg/kg/day and 2.5 mg/kg/day of KRL, respectively, by injection for 5 days (Kabir et al. 2011; Kabir and Reza 2014). KRL lectin inhibited 6.2–50.5 % EAC cell growth at the range of 7.5–120 μg/ml protein concentration. The cell cycle arrests at G0/G1 phase of EAC cells. (−)-3-acetyl-4-benzoyl-1-benzoyloxymethyl-1,6-diepoxy-cyclohexan-2,3,4,5-tetro isolated from *K. rotunda* exhibited moderate cytotoxic activity against pancreatic (PSN-1) and breast (MDA-MB231) cancer cell lines but did not affect the normal TIG-3 cell line (Lallo et al. 2014).

Agglutination/Antimicrobial Activity

A lectin (designated as KRL), purified from rhizomes, was found to agglutinate different groups of human blood cells (Kabir et al. 2011). Methyl-α-D-mannopyranoside, D-mannose and methyl-α-D-glucopyranoside were the most potent inhibitors. KRL lost its activity markedly in the presence of denaturants and exhibited high agglutination activity from pH 6.0 to 8.2 and from temperature 30 to 60 ° C. The lectin showed toxicity against brine shrimp nauplii with the LC_{50} value of 18 μg/ml and strong agglutination activity against seven pathogenic bacteria. KRL inhibited the growth of six bacteria partially and did not show antifungal activity. *K. rotunda* lectin (KRL) showed agglutination activity against *Escherichia coli* and *Staphylococcus aureus*, with partial inhibition of their growth (Kabir and Reza 2014).

Wound Healing Activity

Methanol and aqueous extracts of *K. rotunda* leaves exhibited significant wound healing activity in albino mice (Imam et al. 2013). In the incision wound model, a significant increase in skin breaking strength was observed in the extract-treated groups. In the excision of the wound of the animal model, both extracts affected the contraction rate significantly.

Antiviral Activity

K. rotunda rhizome hexane extract was found to have strong activity against H5N1 AI virus, and the methanol extract exerted lower antiviral activity (Aznam et al. 2012).

Anthelmintic Activity

The alcoholic rhizome extract exhibited significant anthelmintic activity at highest concentration of 100 mg/ml against *Pheretima posthuma* and *Ascaridia galli* (Agrawal et al. 2011).

Traditional Medicinal Uses

Kaempferia rotunda is used in folk medicines in Bangladesh for treatment of high blood sugar level and pain (Sultan et al. 2012). *Kaempferia rotunda*, known as kunci pepet or kunir putih in Indonesia, has been traditionally used in abdominal pain, wounds and diarrhoea colic disorder and as sputum laxative (Atun et al. 2013). Rhizomes and tubers are used in cosmetics, in perfumery and in various 'jamu' (traditional Indonesian herbal medicine) preparations in Indonesia. In Java the rhizomes are used for stomach ailments

and as a cooling medicine; the leaves are used for poulticing in India (Burkill 1966). In the Philippines rhizomes are used for gastric disorders and externally mixed with coconut oil as a cicatrizant (Stuart 2013). In India, rhizomes are used for treating mumps and for wounds and bruises (Chopra et al. 1986). An ointment of the powder is useful in healing wounds. The juice of the rhizomes is taken internally and acts as a resolvent of phlegm, of dropsical affections of the hands and feet and of effusions in joints. The rhizomes are used in local medicine by grinding (fresh or dried) and making a paste with water in Nepal. This paste is mixed with other herbs and applied to sprains and covered with a bandage.

Other Uses

Kaempferia rotunda is planted as an ornamental plant for its variegated foliage and flowers. Its rhizomes are used in perfumery and cosmetics for dyeing and as tranquiliser.

The rhizome also has insecticidal activity. The rhizomes are also used in preparations to prevent insect moths in the clothes. Extracts from rhizomes of *Kaempferia rotunda* rhizome extract when incorporated into artificial diets displayed significant insecticidal activity against neonate larvae of the pest insect, *Spodoptera littoralis*, in chronic feeding bioassay at a concentration of 2500 ppm (Nugroho et al. 1996). Its bioactive constituent, benzyl benzoate, exhibited insecticidal activity when applied topically (LC_{50}, 5.6 µg/cm), suggesting detoxification in the larval gut when applied orally. Another constituent crotepoxide was less active in the chronic feeding bioassay (LC_{50}, 1450 ppm) and was inactive in the residue–contact bioassay. The methanol extract of the rhizomes of *K. rotunda* and (−)-2-acetyl-4-benzoyl-1-benzoyloxymethyl-1,6-epoxycyclohexan-2,3,4,5-tetrol (2-acetylrotepoxide B; 6) exhibited antifeedant activity against larvae of *Spodoptera littoralis* (Stevenson et al. 2007). (−)-Zeylenol (2) also showed antifeedant activity, whereas (−)-6-acetylzeylenol (1) was inactive.

Comments

The plant is propagated by using fragments of the rhizomes.

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