

AYURVEDIC AND THERAPEUTIC SIGNIFICANCE OF QUEEN OF SPICES,  
ELETTARIA CARDAMOMUM MATON (CHOTI ELAICHI)

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## ABSTRACT

*Elettaria cardamomum* Maton, commonly called 'Green Cardamom' in English and 'Choti Elaichi' in Hindi, is an important aromatic spice that belongs to the family *Zingiberaceae*. It is used in food and confectionery due to its extraordinary flavor and aroma. The plant is mainly characterized by its rich volatile oil content comprises of many important phytochemical constituents such as 1, 8-cineole,  $\alpha$ -thujene,  $\alpha$ -pinene, sabinene,  $\beta$ -pinene,  $\beta$ -myrcene and  $\alpha$ -terpinene etc. The plant is famous in various folk medication systems around the world whereas it has special mentions in many of the ancient Ayurvedic works of literature including *Charak Samhita*, *Sushruta Samhita* and *Bhavaprakasha*. It is used in number of Ayurvedic polyherbal formulations. The plant exhibits many important therapeutic activities like anti-microbial, anti-cancer, anti-inflammatory, gastro-protective, neuroprotective and anti-oxidant etc. The aim of the present review is to summarize the therapeutic and pharmacological potential of *Elettaria cardamomum* along with its importance in the traditional medication systems.

**KEYWORDS:** Choti Elaichi, Rasapanchak, 1, 8-Cineole,  $\alpha$ -Thujene, Anti-cancer.

## INTRODUCTION

Since ancient times, natural resources are being used as the primary source of therapies. Plants are enriched with various secondary metabolites with unique structural diversity and extraordinary biological properties which serves as the potential source of many important drugs.<sup>[1,2]</sup> There is a vast variety of medicinal plants with a treasure house of volatile oils and *Elettaria cardamomum* Maton (figure 1) is one of a kind.<sup>[3]</sup> It is commonly called as 'Green Cardamom' in English and 'Choti Elaichi' in Hindi and belongs to the family *Zingiberaceae* which is comprised 53 genera and almost 1300 different species which are evenly distributed in South and South-East Asia. The plants of this family have an effective role in the food, cosmetics, perfumery and pharmaceutical industries due to their color, taste, odor and extraordinary chemical profile that consists of alkaloids, carbohydrates, proteins, phenolic acids, flavonoids, and diarylheptanoids and essential oils.<sup>[4-6]</sup> *Elettaria cardamomum* is an important spice and also entitled as 'Queen of Spices'. It is categorized under the world's most expensive and commercially important spices and considered as 3<sup>rd</sup> most expensive spice after saffron and vanilla. It is believed that the botanical name of the plant has been originated from the popular South Indian language, Tamil. The colloquial Tamilian word 'Elettari' means cardamom seeds. Sarawak (Malaysia) and Borneo region are regarded as the main diversity centers of the genus *Elettaria* because these areas have

marked the presence of eight different species. However, India is also known as *Elettaria cardamomum* local home. There are three known varieties of the plant viz. Malabar, Mysore and Vazhuka. The ancient Assyrians, Egyptians, Arabians, Mesopotamians and Chinese were the known establishers of a vast network of trade arrangements for cardamom and other spices with India. It is extensively used in curries and confectioneries as a flavoring and spicy ingredient due to its well-established gastronomic value and flavoring properties. Most of the cardamom production is consumed by India and Saudi Arabia to add flavor in coffee and tea. In some areas of India, people use rhizomes of the plant as spice and condiment. A wide portion of the population in Scandinavia, Germany and Russia uses *Elettaria cardamomum* for flavoring cakes etc.<sup>[7-14]</sup> Apart from its uses in food as an extraordinary spice, it is a medicinal plant of great significant therapeutic value due to the presence of diverse of phytochemical constituents like alkaloids, steroids, terpenoids, phenols, glycosides, carbohydrates, tannins, proteins and anthocynins. Its volatile oils usually comprised phenolic and flavonoid constituents. However, starch, protein, waxes and sterols also constitute to the content of the volatile oil. The fruits and seeds of the plant are mainly used for medicinal purposes. They are used in many folkloric cultures around the world in many different formulations to treat a variety of human ailments such as flatulence, indigestion, digestive, kidneys and urinary disorders and

also considered as a diuretic, carminative, aromatic stimulant.<sup>[15-19]</sup> Ancient Indian Ayurvedic and Unani practitioners and ancient Greek and Roman physicians used *Elettaria cardamomum* for treating indigestion, bronchitis, asthma and constipation, anorexia, diarrhoea, dyspepsia, epilepsy, hypertension, cardiovascular diseases, ulcers, gastro-intestinal disorders and vomiting.<sup>[20,21]</sup> The pharmacological activities of the plant are anti-microbial, anti-cancer, immuno-stimulant, gastro-protective, anti-hypertensive, anti-oxidant and anti-inflammatory etc. India has a monopoly in

cardamom trade. However, a decline in its production as well as exports has been faced. Many allegations have been put on the Indian Government for this decline. To maintain a standard in the production and export business of cardamom, India needs to take advantage of the World Trade Organization (W.T.O.) agreements' different provisions which are related to the trading of the spices trade.<sup>[22]</sup> The vernacular names and taxonomy of *Elettaria cardamomum* are given in table no. 1 and 2 respectively.



Figure 1: *Elettaria cardamomum*.

Table 1: Vernacular Names.

English	Green cardamom, lesser cardamom
Hindi	Choti Elaichi
Sanskrit	Chandra, Chandarbala, Dravidi, Kapotavarna
Kannada	Elakki
Telugu	Yelakkapallu
Malayalam	Elam
Marathi	Velachi
Bengal	Choti Elachi
Gujarati	Chot Elach

Table 2: Taxonomical Classification.

Taxon	Taxonomic Rank
Kingdom	Plantae
Division	Magnoliophyta
Class	Liliopsida
Order	Zingiberales
Family	Zingiberaceae
Genus	<i>Elettaria</i>
Species	<i>cardamomum</i>
Common Name	Choti Elaichi

#### Botanical Description<sup>[22]</sup>

*Elettaria cardamomum* is a perennial herbaceous plant with chromosome number  $x=12$  and  $2n=48$  which shows its tetraploid nature. The plant attains a height of 2-5 m and is propagated from underground rhizomes by vegetative division. The aerial stem of the plant is developed from encircling, of the leaf sheaths. The leaves are dark green, lanceolate with acuminate tip and

have 30-35 cm length and 7-10cm width. From the axils of underground stems, the tillers have emerged. Vegetative buds of the plant are produced mainly in the monsoon season. Flowers developed from the rhizomes. They give the appearance of a panicle possessing having long cane-like peduncle with nodes and internodes. 2-4 panicles usually arise from the swollen base of tillers. Flowers are bisexual, irregular and white with the pink

streak at the central lip. The occurrence of cross pollination is very common. The labellum is indistinctly 3 lobed and oval in shape. There is a presence of tubular, 3 toothed calyx which is split on the one side. The 3 lobed corolla has its larger lobe on the posterior side. There is an absence of connective appendages in the fertile stamen but has a short crest which is present below or above the stigma. Anthers have 2 lobes, adnate to the filament with vertical dehiscence. The pollen grains vary in size from 75-120 microns to diameter. There is a presence of funnel shaped stigma which has cilia around a small cavity. The ovary of the flower is inferior, trilobular and has axial placentation with numerous ovules in each carpel. The fruits are usually called as capsules which are green to golden yellow, ellipsoidal or spherical in shape, non-dehiscent and fleshy. Fruits get leathery on drying. Each capsule has 12 to 32 seeds that have white mucilaginous coat. Seeds turn black on ripening.

### Geographical Distribution<sup>[23-31]</sup>

It is a native plant of evergreen forests of Western Ghats of Southern Indian states including Kerala, Karnataka and Tamil Nadu, altitude ranging from 900- 1400 m above sea level. Kerala produces about 70% of the total cardamom in India whereas Karnataka and Tamil Nadu produce 20 and 10% respectively. It is the most important cash crop of Sikkim with the largest area of production in the country. It is also found in countries like Guatemala, Pakistan, Denmark, Sweden, England, Russia, Sri Lanka, Nepal, Indonesia, Costa Rica, Mexico, Thailand, El Salvador, Malay Archipelago, Vietnam, Papua New Guinea, Cambodia, Laos, and Tanzania. Guatemala is considered the largest producer of *E. cardamomum* in the world. It usually grows in moderate to highlands at an elevation of 600 m above sea level to 1400 m.

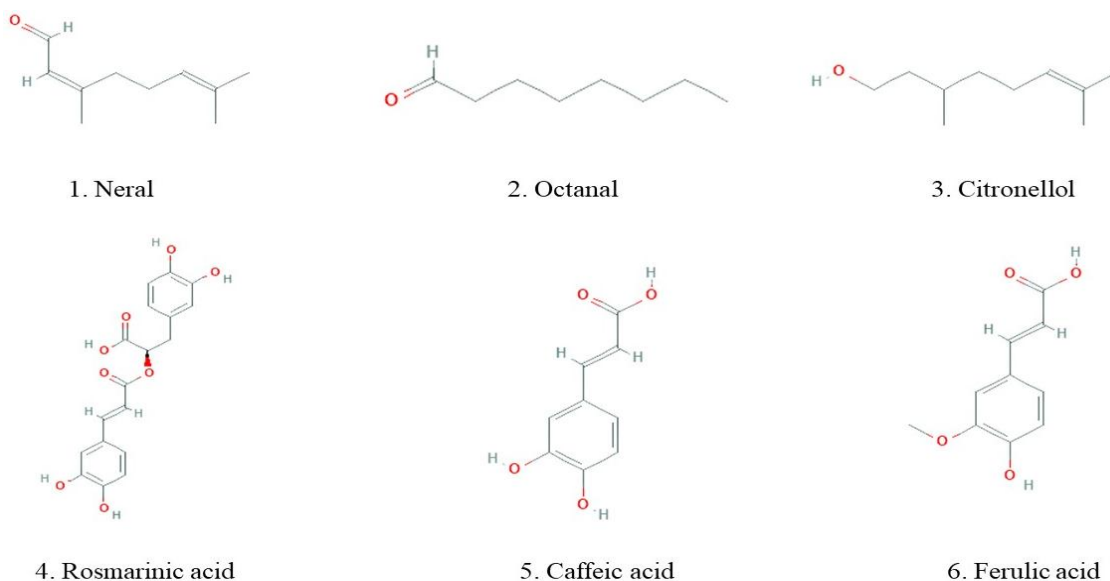
### Phytochemistry

The phytochemistry of *Elettaria cardamomum* is composed of many important phytochemical constituents. Many research studies have been done to evaluate its phytochemical profile. For instance, Katri et al., reported the presence of carbohydrates, phenols, flavonoids, saponins, glycosides, steroid, alkaloids and vitamins. They identified almost 90 phytochemical constituents from the methanol extract of the leaves by gas chromatography- mass-spectrometry.<sup>[32]</sup> *Elettaria cardamomum* is mainly known for essential oils which are mainly aromatic volatile oils that provide significant taste and aroma to the plant. Alagupalamuthirsolai et al., identified many compounds from the essential oil from capsules by gas-chromatography mass spectrometry (GC-MS) method. The compounds isolated were mainly monoterpenes ( $\alpha$ -thujene,  $\alpha$ -pinene, sabinene,  $\beta$ -pinene,  $\beta$ -myrcene,  $\alpha$ -terpinene, 1, 8-cineole,  $\gamma$ -terpinene, 4-thujanol,  $\alpha$ -terpinolene, linalool and terpinen-4-ol), monoterpene aldehyde (neral and geranial), sesquiterpene alcohol ((e)-nerolidol), fatty aldehyde (octanal), monoterpene ester (neryl acetate and

linalyl acetate), monoterpene alcohol (geraniol, nerol) and cyclic monoterpene ester (borneol acetate)<sup>[33]</sup>. Ashokkumar et al., evaluated 22 diverse accessions of cardamom for its chemical contents. They confirmed the presence of  $\alpha$ -thujene,  $\alpha$ -pinene, sabinene,  $\beta$ -pinene,  $\beta$ -myrcene, 3-carene,  $\alpha$ -terpinolene, limonene, 1-8, cineole,  $\beta$ -cymene,  $\gamma$ -terpinene,  $\beta$ -linalool, terpinen-4-ol,  $\alpha$ -terpineol,  $\beta$ -terpineol,  $\beta$ -citral, nerol, linalyl acetate,  $\alpha$ -citral,  $\alpha$ -terpinyl acetate, geranyl acetate, p-cresol,  $\gamma$ -cadinene and nerolidol.<sup>[34]</sup> Savan et al., identified 67 compounds from the essential oil of the plant by GC-MS method in which 1,8-cineole, linalool and  $\alpha$ -terpinyl acetate were the major compounds.<sup>[35]</sup> Thomas et al., identified 22 common compounds from the essential oils of Indian, Guatemalan and Sri Lankan cardamoms by GC-MS. They reported that Indian cardamom comparatively contains high amount of 1,8-cineole and  $\alpha$ -terpinyl acetate than the other two varieties.<sup>[36]</sup> The presence of these compounds along with Methyl-eugenol, trans-nerolidol, citronellol, Phellandrene, limonene, 1,8, cineole,  $\gamma$ -terpinene,  $\beta$ -cymene, terpinolene, and  $\alpha$ -terpinyl many other compounds have been reported by many studies<sup>[37,38]</sup>. Moulai-Hacene et al., confirmed the presence of polyphenolic acids (rosmarinic acid, caffeic acid, ferulic acid, etc.) and many flavonoids (kaempferol, chrysin, galangin, pinocembrine, quercetin, etc.) by using high-pressure liquid chromatography with an UV detector (HPLC-UV).<sup>[39]</sup> The leaf extract of the plant contains 2-propenoic acid, 3-phenyl-, methyl ester, eucalyptol, hexadecanoic acid, ethyl ester, 9, 12,15- octadecatrienoic acid, (Z, Z, Z), vitamin E and octadecanoic acid whereas the seed extract contains  $\alpha$ -ionone, eucalyptol, 1,6-octadiene-3-ol, cinnamaldehyde, (E) and terpinen-4-ol, 1,6,10-dodecatrien-3-ol.<sup>[40]</sup> Al-Yousef et al., identified almost 47 compounds from the aqueous extract of *E. cardamomum* fruits by using ultra-performance liquid chromatography-electrospray tandem mass spectrometry (UPLC-ESI-MS/MS). The compounds identified were taxifolin quinoil hexoside, protocatheoyl glucoside, citric acid, gallic acid, protocatechuic acid, chlorogenic acid isomer, neochlorogenic acid, umbelliferone, cryptochlorogenic acid, cyanidin-3-o-acetyl rhamnoside, chlorogenic acid isomer, pelargonidin-3-o-feruloyl glucoside, cyanidin-3-o-coumaroyl glucoside, kaempferol or luteolin-3-o-glucoside, quercetin-3-o-glucoside, protocatechualdehyde, isorhamnetin-3-o-diglucoside, chlorogenic acid isomer, pelargonidin-3-o-glucoside, kaempferol or luteolin-3-o-hexoside, peonidin-3-o-hexoside, naringenin-7-o-hexoside, peonidin-3-o-coumaroyl glucoside, cyanidin-3-o-hexoside, azelaic acid, cyanidin-3-o-malonyl hexoside, delphinidin-3-o-feruloyl hexoside, cyanidin-3-o-malonyl hexoside, kaempferol or luteolin-3-o-acetyl hexoside, cyanidin-3-o-acetyl hexoside, apigenin-7-o-acetyl hexoside, peonidin-3-o-coumaroyl hexoside, peonidin-3-o-feruloyl hexoside, cyanidin-3-o-rutinoside, cyanidin-3-o-cinnamoyl glucuronide, pelargonidin-3-o-diacetyl hexoside, caftaric acid, sinapic acid, maslinic acid, maslinic acid isomer, vanillin, malvidin-3-o-feruloyl

glucuronide, methyl salicylic acid, cyanidin-3-o-coumaroyl hexoside, delphinidin-3-o-acetyl rhamnoside,

catechin derivative, delphinidin-3-o-acetyl rhamnoside and one unknown compound.<sup>[41]</sup>



**Figure 2: Chemical Structures of Some of the Phytochemical Constituents of *Elettaria cardamomum*.**

### Traditional and Modern View

#### Ayurvedic View

The surgical compendium of Ayurveda i.e. *Sushruta Samhita* defines health as the balanced state of *Doshas* (three biological humors i.e. kapha (water & earth), pitta (fire) and vata (space & air), dhatus (seven body tissues), digestion, peace of soul, mind and senses<sup>[42-44]</sup>. *Elettaria cardamomum* is one of such plants which have a very

high significance. It is mentioned in almost each Ayurveda literature (refer to table 3)<sup>[45]</sup>. It is useful in vata and kapha disorders<sup>[46]</sup>. It is unique physicochemical properties i.e. rasapanchak (refer to table 4) which make it use vast array of Ayurvedic formulations used against various diseases. It is mostly used as prakshepa/ aawapa dravya (drugs used as additive) in the formulations.

**Table 3: Classification of *Elettaria cardamomum* as per different Ayurvedic Literatures.**

Classical Texts	Category
Charaka samhita	Swasahara Mahakashaya, Angamardaprashamana mahakashaya, Katukaskandha, Shirovirechana
Sushruta samhita	Eladi gana
Astanga hridaya	Eladi gana, Trijatata, Chaturjatata
Dhanvatari nighantu	Shatapushpadi varga
Sodhala nighantu	Shatapushpadi varga
Hridayadipaka nighantu	Pittalam Kaphavataghna varga
Shadarasa nighantu	Katudravya skandha
Madanapala nighantu	Karpuradi varga
Kaiyadeva nighantu	Oshadhi varga
Bhavaprakasha nighantu	Karpuradi varga
Raj nighantu	Pippalyadi varga
Mahaushadhi nighantu	Trijaat, Chaturjaat
Priya nighantu	Haritakyadi varga
Nighantu aadarsha	Aardrakadi varga
Gunaratnamala	Karpuradi-sugandh varga

**Table 4: Rasapanchak of *Elettaria cardamomum* as per Ayurveda.**

Sanskrit/English	Sanskrit/English
Virya/Potency	Sheeta/Cold
Vipak/Metabolic Properties	Kattu/Pungent
Guna/Physical Properties	Laghu/Light, Ruksa/Dry
Rasa/Taste	Kattu/Pungent, Madhur/sweet

**Properties of *Elettaria cardamomum***

**Mutrakrichrahara:** It acts as a diuretic agent therefore helpful in dysuria and urinary retention.

**Arshahara:** It is used against piles and hemorrhoids

**Shwasahara:** It is used against asthma and chronic respiratory disorders.

**Kasahara:** It is used against cough and cold.

**Hrudya:** It acts as a cardiac tonic.

**Rochna:** It improves taste and treats anorexia.

**Deepana:** It enhances digestion.

**Vatahara:** It is useful against neuralgia, paralysis, constipation and bloating.

**Pittartihara:** It is helpful against gastro-intestinal tract pain and burning sensation.

**Ayurvedic Formulations of *Elettaria cardamomum***

**Eladi Vati:** It is made up of *Elettaria cardamomum* along with few other herbs and used to treat cough, cold, fever and vomiting.<sup>[47]</sup>

**Aragwadharistam:** It is a polyherbal formulation made up of many herbs including *Elettaria cardamomum* and useful in skin disorders.<sup>[48]</sup>

**Vasakadyarishtam:** This polyherbal formulation has *Elettaria cardamomum* as one of its main ingredients. It is effective in the treatment of cough, cold, chest congestion asthma and related diseases like bronchitis, inflammation and hemoptysis.<sup>[49]</sup>

**Abana:** It is a herbomineral Ayurvedic preparation that is useful in the treatment of Alzheimer's disease.<sup>[50]</sup>

**Talisapatradi Choornam:** It is a polyherbal formulation used in Ayurveda for the treatment of respiratory and digestive disorders.<sup>[51]</sup>

**Sitopaladi:** It is a very popular polyherbal Ayurvedic formulation made up of *Piper longum*, *Elettaria cardamomum*, *Bambusa bambos*, *Cinnamom zeylanicum* and Crystalline Sugar which is mainly used in the treatment of respiratory disorders.<sup>[52]</sup>

**Chyawanprash:** This polyherbal formulation is made up of a number of medicinal plants consists of *Elettaria cardamomum* as one of the ingredient. It is used to strengthen digestive system and enhances food absorption, treats hyperacidity, dyspepsia and flatulence, peptic ulcers and gastritis, improves memory power, and cardiac functioning.<sup>[53]</sup>

**Avipattikar Churna:** This polyherbal formulation is made up of 14 herbs among which *Elettaria cardamomum* is one of the main ingredients. It is used in treating hyperacidity.<sup>[54]</sup>

**Shunthyadi churna:** It is used in the treatment of bronchial asthma. As per the reported clinical study carried out by Jadav et al., on 23 patients, shunthyadi

churna is useful in breaking down the pathogenesis of bronchial asthma.<sup>[55]</sup>

**Baladi Manduram:** Kumar et al., reported the effectiveness of this important polyherbal formulation in the management of *Amlapitta* (hyperacidity). They carried out a non-randomized, single-armed, open-labeled clinical trial on thirty patients with *Amlapitta* symptoms. The administration of 500 mg of *Baladi Manduram* twice a day for one month after meals showed symptoms of relief.<sup>[56]</sup>

**Sivathai Chooranam:** It is made up of 11 important medicinal herbs including *Elettaria cardamomum*. It is used in the treatment of constipation.<sup>[57]</sup>

**Folk View**

The utilization of plants in various cultures for medicinal purposes reflects their rich ethnobotanical significance.<sup>[58]</sup> *Elettaria cardamomum*, an ancient herbal plant is traditionally used in many folk cultures throughout the world against a variety of diseases. For instance, the plant is used in the treatment of cancer in the traditional Moroccan medication system.<sup>[59]</sup> In Rif, Morocco, the seed decoction is used against respiratory disorders.<sup>[60]</sup> In Izarène, the fruit decoction is traditionally used as a remedy to respiratory diseases.<sup>[61]</sup> In Barnala, Pakistan, people use *Elettaria cardamomum* against kidney related disorders.<sup>[62]</sup> The fruits are used against nausea and vomiting in Khushab, Pakistan whereas in other many other areas it is used traditionally as a remedy to treat diabetes.<sup>[63-65]</sup> In lower areas of Bhutan, people use the fruits of the plant against kidney and cold related diseases.<sup>[66]</sup> Seed powder of *Elettaria cardamomum* is used in the treatment of vomiting and urinary infections in Malaipandaram tribe of Kerala.<sup>[67]</sup> The fruits are used against constipation and piles in Bellary, Karnataka.<sup>[68]</sup> In Kani tribals, Tirunelveli hills of Western Ghats, fruit powder is orally used to treat headache and rheumatism.<sup>[69]</sup> In the rural regions of Kozhikode District, Kerala, people use seed decoction of the plant in postnatal care<sup>[70]</sup>. In Jaisinghpur, Himachal Pradesh, people traditionally use *Elettaria cardamomum* decoction against lung ailments.<sup>[71]</sup> In Medinpur District, West Bengal, women use fruits against infertility and dysmenorrhea.<sup>[72]</sup> Tribals of Simalwara Region, Rajasthan, use fruits to prevent abortion.<sup>[73]</sup> The Mullu kuruma tribe, Kerala, uses seeds of the plant against stomach related issues and epilepsy.<sup>[74]</sup> Seed powder is used to enhance appetite in Mundakunnu village of the Nilgiri hills.<sup>[75]</sup>

**Modern View**

In the 21<sup>st</sup> century, the demand of herbal drugs used in the traditional medicine systems such as Ayurveda, Siddha and Unani (ASU) has been increased but at the same time these drugs are very prone to either unintentional adulteration or intentional adulteration. Adulteration lowers down the rate of effectiveness of the herbal products which leads to adverse health

impacts.<sup>[76,77]</sup> The herbal drug preparations with the proper standardization have proved to be the important key in the building of the bridge between traditional herbal medicines and modern pharmaceuticals.<sup>[78]</sup> Standardization is usually the necessary information and the control required in the product formation. It is a set of standards or inherent characteristics, constant parameters, definitive qualitative and quantitative values that are required to ensure the quality, efficacy, safety and reproducibility of the herbal drugs. The standardization information includes data of the raw drug, morphological identification, microscopic & molecular analysis and chemotypic identification by various chromatographic methods (gas-chromatography, liquid-chromatography, thin-layer chromatography, high performance liquid chromatography), spectrometry methods (mass spectrometry, nuclear magnetic resonance spectroscopy, ultraviolet-visible spectrophotometry, infrared spectroscopy and optical emission spectroscopy), biological methods such as DNA fingerprinting and genetic markers and bioassays.<sup>[79,81]</sup>

#### Reported Pharmacological and Therapeutic Activities of *Elettaria cardamomum*

*Elettaria cardamomum* is associated with many important pharmacological and therapeutic activities. Many research studies have been done on the plant to evaluate its pharmacological and therapeutic significance. Some of the reported activities of the plant are discussed below:

##### Anti-microbial

Aneja et al., studied the anti-microbial potential of *Amomum subulatum* and *Elettaria cardamomum* fruit extracts against *Streptococcus mutans*, *Staphylococcus aureus*, *Lactobacillus acidophilus*, *Candida albicans* and *Saccharomyces cerevisiae*. The acetone, ethanol and methanol extracts of the plants were found to be anti-microbial. They showed activity against all the pathogens except *L. acidophilus*. *S. aureus* was the most susceptible pathogen in case of *Elettaria cardamomum* which was followed by *C. albicans*, *S. cerevisiae* and *S. mutans*. Acetone extract exhibited the largest zone of inhibition in case of *Elettaria cardamomum*.<sup>[82]</sup> Singh et al., also reported the anti-microbial activity of essential oils of seeds and pods of the plant against bacterial strains (*Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli* and *Salmonella typhi*) and fungal strains (*Aspergillus terreus*, *Penicillium purpurogenum*, *Fusarium graminearum* and *Penicillium madriti*). The methanol and ethanol extract of the plant exhibited significant activity against *A. terreus*.<sup>[83]</sup> Islam et al., evaluated the methanol seed extract of *Elettaria cardamomum* against gram positive bacterial strains (*Staphylococcus aureus*, *Streptococcus-β-haemolytica*, *Bacillus subtilis*, *Bacillus megaterium* and *Sarcina lutea*) as well as gram negative bacterial strains (*Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Shigella dysenteriae*, and *Shigella sonnei*). The

extract showed highest inhibitory actions all the tested microorganisms but the highest activity was observed against *Salmonella typhi*.<sup>[84]</sup>

##### Anti-cancer

Elguindy et al., studied the chemoprotective potential of geraniol against diethylnitrosamine (DNA) induced hepatocellular carcinoma in rat models. The study revealed that oral administration of the extract at the dosage of 100 and 200 mg/kg for 7 days before the induction of hepatocellular carcinoma caused a decrease in the levels of tumor necrosis factor (TNF), interleukin-1 (IL-1) and nuclear factor kappa light chain enhancer of activated B cells (NF-κB). The chances of liver injury were reduced by geraniol treatment. The inhibition of ornithine decarboxylase (ODC) was also seen. It also caused a decrease in the formation of hepatic malondialdehyde (MDA) and reduced glutathione (GSH) was also increased in the models. The activities of antioxidant enzymes viz., catalase (CAT), superoxide dismutase (SOD), glutathione peroxidase (GPx), glutathione reductase, and glutathione-S-transferase (GST) in the liver were increased.<sup>[85]</sup> Another study carried out by Elguindy et al., reported chemo preventive actions of geraniol in DNA-induced oxidative stress in the kidney and brain of rat models.<sup>[86]</sup> Hashim et al., reported the anti-cancerous nature of *Elettaria cardamomum* oils in an *in-vitro* study where oils inhibited the DNA adducts formation by aflatoxin B1 in a reaction mediated by microsomal enzyme.<sup>[87]</sup> Rajan et al., reported a significant cytotoxic activity of gold nanoparticles synthesized from the aqueous extract of *Elettaria cardamomum* seeds against HeLa cancer cell lines.<sup>[88]</sup> Almeer et al., carried out an *in-vivo* study to evaluate the anti-cancer potential of *Elettaria cardamomum* in ehrlich ascites tumor (EST) cells bearing mice models. The individual and combined effects of the plant with anti-cancer drug cyclophosphamide were examined after treatment of 10 days. The results indicated the reduction in tumor size. An elevation in the mean survival time of EST bearing models was observed. A modulation in the apoptotic-related genes and proteins was also seen.<sup>[89]</sup> Qiblawi et al., reported the effective chemo-protective activity of 0.5 mg of cardamom powder in suspension in 7,12-dimethylbenz[a]anthracene-initiated and croton oil-promoted mouse skin papillomagenesis at pre-, peri-, and post-initiation stages. It was observed that powder reduced the tumor incidence, tumor burden, and tumor yield values. The cumulative number of papillomas was also noticed.<sup>[90]</sup>

##### Immuno-stimulant

Raksamiharja et al. reported the effective immunostimulating effects of *Elettaria cardamomum* distillate (ECD) in chemotherapy as a co-chemotherapeutic agent to reduce the adverse impact of doxorubicin. The study was carried out on 30 female Sprague Dawley rat models. It was observed that ECD in a dose-dependent manner significantly increased the

amount of lymphocyte, white blood, CD4+ and CD8+ cells in doxorubicin treated models.<sup>[91]</sup>

#### Anti-diabetic

Aghasi et al., carried out a clinical trial on eighty overweight or obese patients with type 2 diabetes to evaluate the effects of *Elettaria cardamomum* on blood glucose, lipids and oxidative stress status in the patients. The administration of 3 g/d *Elettaria cardamomum* for 10 weeks produced effective results in all the selected parameters which suggested its effectiveness in the management of type 2 diabetes.<sup>[92]</sup> Zahedi et al., carried out a randomized clinical trial on 83 diabetic patients to evaluate the effect of *Elettaria cardamomum*. The administration of 3 g of ground green cardamom's fruit or rusk powder for 10 weeks caused a marked reduction in serum levels of vascular cell adhesion molecule (VCAM), Intercellular Adhesion Molecule (ICAM), E-selectin, and interleukin-6 (IL-6). It also reduced the inflammatory biomarkers. The study suggested that cardamom supplementation helped in the improvement of serum levels and inflammatory biomarkers in diabetes mellitus.<sup>[93]</sup>

#### Gastroprotective

Jamal et al., subjected the methanolic extract (TM), essential oil (EO), petroleum ether soluble (PS) and insoluble (PI) fractions of methanolic extract of *Elettaria cardamomum* for evaluating their gastroprotective actions in rat models in which gastric lesions were induced by aspirin, ethanol and pylorus ligation. The study revealed that all the subjected fractions exhibited a marked inhibition in gastric lesions which were induced by ethanol and aspirin whereas no inhibitory actions were noticed in case of pylorus ligation. TM showed more potent activity at the dosage of 500 mg/kg. PS fraction showed best results against aspirin-induced gastric ulcer.<sup>[94]</sup> Farah et al., reported the anti-ulcer property of *Elettaria cardamomum*. The study was carried out on rat models with gastric lesions induced by aspirin and ethanol. The essential oils and petroleum ether soluble fraction caused the marked inhibition of gastric lesions.<sup>[95]</sup>

#### Neuroprotective

Chowdhury et al., studied the neuroprotective effects of *Elettaria cardamomum* in Alzheimer's disease (AD). They subjected the alpha-terpinyl acetate for its neuroprotective actions. The study revealed that the subjected compound inhibited the acetylcholinesterase (AChE) enzyme and butyrylcholinesterase (BuChE) enzyme as well as it reduced the neurotoxicity (induced by  $\beta$ -amyloid (A $\beta$ ) peptides) and oxidative stress (induced by hydrogen peroxide). It also exhibited antioxidant capacity, and anti-amyloidogenic activities.<sup>[96]</sup>

#### Anti-hypertensive

Verma et al., evaluated the anti-hypertensive activity of *Elettaria cardamomum* fruit powder in patients with

stage 1 of primary hypertension. The administration of 3g powder for 12 weeks caused a decrease in systolic, diastolic and mean blood pressure. An increase in fibrinolytic activity and anti-oxidant status was also observed.<sup>[97]</sup>

#### Anti-oxidant

Bhatti et al., subjected the methanolic extract of *Elettaria cardamomum* for the evaluation of its anti-oxidant potential by using thiocyanate method. 70% methanol was found to be a good solvent for the anti-oxidants extraction because it had high polarity. The observed percentage inhibition of peroxidation was about 84.2-90 %.<sup>[98]</sup>

#### Anti-inflammatory

Arpitha et al., subjected the volatile and non-volatile fractions of *Elettaria cardamomum* seeds in paw edema-induced Wistar rat models. It was revealed from the study that components of the non-volatile (resin) portion of cardamom viz., polyphenols, fatty acids, and sterols were found to be effective anti-inflammatory agents.<sup>[99]</sup>

#### Toxicity

Malti et al., reported the incidence of *Elettaria cardamomum* toxicity in Swiss albino mice models. The oral treatment of the models with 0.003 and 0.3 mg *Elettaria cardamomum* for seven days caused a marked increase in creatine phosphokinase level. It also caused morphological perturbation in the heart. The inhibitory actions of glyceraldehyde 3-phosphate dehydrogenase were also observed along with the increase in thiobarbituric acid reactive substances, succinate dehydrogenase and catalase activities. The results indicated the toxicity of plant in the models which affected the energy metabolism and oxidative stress.<sup>[100]</sup>

#### CONCLUSION

*Elettaria cardamomum* is one of the most common aromatic spice belonging to the family *Zingiberaceae*. It is extensively used in cooking due its flavor and aroma. Many studies have been carried out to explore its pharmacological aspect which suggested that it is associated with many important biological activities like anti-microbial, anti-cancer, anti-oxidant, anti-inflammatory, anti-hypertensive, neuroprotective and gastro-protective and indicated that many potential drugs can be developed from this plant. The present study was carried out to explore each aspect of the plant i.e. its photochemistry, pharmacology along with its morphology and distribution. And it is very evident from the collected data, that *Elettaria cardamomum* is worth more than just a spice. Also, some special measures need to be taken to enhance its production.

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**Conflict of Interest**

The authors declare no conflict of interest.

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