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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, α-thujene, α-pinene, sabinene, β-pinene, β- myrcene and α-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, α-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.[1,2] 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.[3] 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.[4-6] *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 3rd 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, Myssore 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.[7-14] 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.[15-19] 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.[20,21] 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.[22] 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	*Elettaria*
Species	*cardamomum*
Common Name	Choti Elaichi

Botanical Description[22]

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 dehisce. 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, trilocular 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 turns black on ripening.

Geographical Distribution[23-31]

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 to1400 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.[32] *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 (α-thujene, α-pinene, sabinene, β-pinene, β- myrcene, α-terpinene, 1, 8-cineole, z-β-ocimene, γ-terpinene, 4-thujanol, α-terpeinolene, 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) [33]. Ashokkumar et al., evaluated 22 diverse accessions of cardamom for its chemical contents. They confirmed the presence of alpha-thujene, α-pinene, sabinene, β- pinene, β-myrcene, 3-carene, alpha-terpenolene, limonene, 1-8, cineole, β-cymene, gama-terpnene, β-linalool, terpinen-4-ol, alpha-terpineol, β-terpineol, β-citral, nerol, linalyl acetate, alpha-citral, alpha-terpinyl acetate, geranyl acetate, p-cresol, gama-cadinene and nerolidol.[34] 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.[35] 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 á - terpinyl acetate than the other two varieties.[36] The presence of these compounds along with Methyl-eugenol, trans –nerolidol, citronellol, Phellandrene, limonene, 1,8, cineole, y-terpinene, p-cymene, terpinolene, and alpha-teripinyl many other compounds have been reported by many studies [37,38]. 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).[39] 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.[40] 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 quinoyl hexoside, protocatechoyl 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.[41]

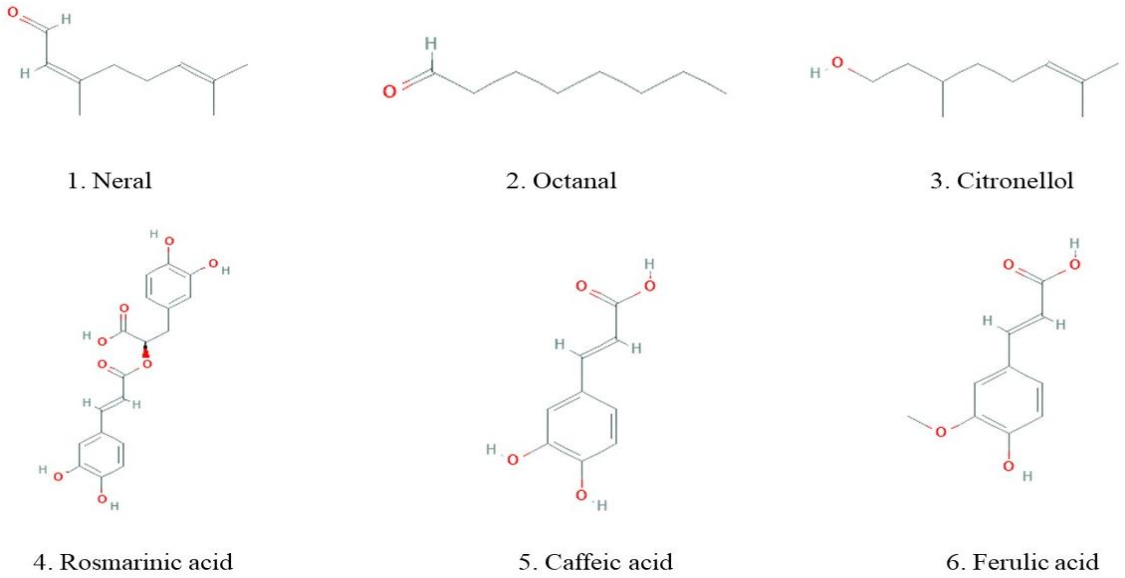

Figure 2: Chemical Structures of Some of the Phytochemical Constituents of *Elettaria cardamomum*.

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 [42-44]. *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) [45]. It is useful in vata and kapha disorders [46]. 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, Trijataka, Chaturjataka
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.[47]

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

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.[49]

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

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

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

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.[53]

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.[54]

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, shuthyadi churna is useful in breaking down the pathogenesis of bronchial asthma.[55]

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.[56]

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

Folk View

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

Modern View

In the 21st 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.[76,77] 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.[78] 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.[79,81]

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 evaluates 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.*[82] Singh et al., also reported the anti-mocrobial 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* [83]. 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*.[84]

Anti-cancer

Elguindy et al., studied the chemoprotective potential of geraniol against diethylnitrosamine (DENA) 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-Stransferase (GST) in the liver were increased [85]. Another study carried out by Elguindy et al., reported chemo preventive actions of geraniol in DENA-induced oxidative stress in the kidney and brain of rat models [86]. 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 [87]. 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.[88] 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.[89] 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-initiational stages. It was observed that powder reduced the tumor incidence, tumor burden, and tumor yield values. The cumulative number of papillomas was also noticed.[90]

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.[91]

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.[92] 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.[93]

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 asprin, ethanol and pylorous ligature. 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.[94] 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.[95]

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 β-amyloid (Aβ) peptides) and oxidative stress (induced by hydrogen peroxide). It also exhibited antioxidant capacity, and anti-amyloidogenic activities.[96]

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.[97]

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 %.[98]

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.[99]

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.[100]

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.

REFERENCES

1. Daoudi A, Benboubker H, Bousta D, Aarab L. Screening of fourteen, Moroccan medicinal plants for immunomodulating activities. Moroccan J Biol, 2008; 4-5(2008): 24-30.
2. Elangovana ND, MuthusamyJeyam. Phytochemical Screening, GC-MS Analysis and In Vitro Antioxidant Activities of Important Spices - Elettaria cardamomum, Zingiber Officinale and Trachyspermum ammi. International Journal of Research and Analytical Reviews, 2018; 5(4): 238-252.
3. Balaji S, Chempakam B. Mutagenicity and Carcinogenicity Prediction of Compounds from Cardamom (Elettaria cardamom Maton.). Ethnobotanical Leaflets, 2008 Sep 12; 12: 682-9.
4. Pattanayak M, Nayak PL. Green synthesis of gold nanoparticles using Elettaria cardamomum (ELAICHI) aqueous extract. World J Nano Sci Technol, 2013; 2: 01-5.
5. Ewais EA, Aly MM, Ismail MA, Abdel Shakour EH, Hassanin MF. Antimicrobial Activities of Solanum Incanum, Elettaria Cardamomum and Zingiber Officinale, used traditionally to treat pathogenic microbes. Scientific Journal of Flowers and Ornamental Plants, 2014 Dec 1; 1(3): 253-63.
6. Ivanović M, Makoter K, Islamčević Razboršek M. Comparative study of chemical composition and antioxidant activity of essential oils and crude extracts of four characteristic Zingiberaceae Herbs. Plants (Basel), 2021 Mar; 10(3): 501.
7. Kaushik P, Goyal P, Chauhan A, Chauhan G. In vitro evaluation of antibacterial potential of dry fruitextracts of Elettaria cardamomum Maton (Chhoti Elaichi). Iranian journal of pharmaceutical research: IJPR. 2010; 9(3): 287.
8. Alam A, Rehman NU, Ansari MN, Palla AH. Effects of Essential Oils of Elettaria cardamomum Grown in India and Guatemala on Gram-Negative Bacteria and Gastrointestinal Disorders. Molecules, 2021 Jan; 26(9): 2546.
9. Zakir M. Review on Breeding Method and Achievements of Cardamom (Elettaria cardamomum Maton) and Future Prospects. International Journal

of Research in Agriculture and Forestry, 2019; 6(12): 16-23.
10. Abu-Taweel GM. Cardamom (Elettaria cardamomum) perinatal exposure effects on the development, behavior and biochemical parameters in mice offspring. Saudi journal of biological sciences, 2018 Jan 1; 25(1): 186-93.
11. Govindarajan VS, Narasimhan S, Raghuveer KG, Lewis YS, Stahl WH. Cardamom—Production, technology, chemistry, and quality. Critical Reviews in Food Science & Nutrition, 1982 Mar 1; 16(3): 229-326.
12. Nair TR, Kutty MG. Cardamom (Elettaria cardamomum) in Kerala, India. Forest products, livelihoods and conservation, 2004; 1: 130-47.
13. Ratan O, Mili R, Tag H. Ethnobotany of the Galo community of Arunachal Pradesh, India. East Himalayan Society for Spermatophyte Taxonomy, 2016; 10(2): 248-61.
14. Reyes T, Luukkanen O, Quiroz R. Small cardamom—precious for people, harmful for mountain forests. Mountain Research and Development, 2006 May; 26(2): 131-7.
15. Mehvish S, Barkat MQ. phytochemical and antioxidant screening of amomum subulatum, , Emblica Officinalis, Rosa Damascene, Santalum Album And Valeriana officinalis and their effect on stomach, liver and heart. Matrix Science Pharma (MSP), 2018; 2(2): 21-6.
16. Sharma S, Sharma J, Kaur G. Therapeutic uses of *Elettaria cardamomum.* International Journal of Drug Formulation and Research, 2011; 2(6): 102-108.
17. Islam MS, Sarwar AK. The Garo Tribe's Ethnobotanical Knowledge about Medicinal Plants. Jordan Journal of Natural History, 2020; 7: 93-107.
18. D Waghmare S. Ethnobotanical Survey on Antiurolithiatic Activity of Some Medicinal Plants. International Research Journal on Advanced Science Hub, 2020 Aug 1; 2(8): 268-75.
19. Srinath J. Application of Spices in Dentistry- A Literature Review. Int J Drug Develop Res., 2014; 6(2): 1-9.
20. Bhaswant M, Poudyal H, Mathai ML, Ward LC, Mouatt P, Brown L. Green and black cardamom in a diet-induced rat model of metabolic syndrome. Nutrients, 2015 Sep; 7(9): 7691-707.
21. Sudhakar P, Hari CK, Divya R. Role of Indian spices in CNS disorders: A review. Journal of Medicinal Plants, 2020; 8(4): 171-5.
22. James J. Impact of WTO Reforms on Indian Cardamom. International Journal of Social Science and Economic Research, 2019; 4(3): 2385-2399.
23. Ashokkumar K, Murugan M, Dhanya MK, Warkentin TD. Botany, traditional uses, phytochemistry and biological activities of cardamom [Elettaria cardamomum (L.) Maton]–A critical review. Journal of ethnopharmacology, 2020 Jan 10; 246: 112244.
24. Ashokkumar K, Murugan M, Dhanya MK, Raj S, Kamaraj D. Phytochemical variations among four distinct varieties of Indian cardamom Elettaria cardamomum (L.) Maton. Natural product research, 2020 Jul 2; 34(13): 1919-22.
25. Kuriakose G, Sinu PA, Shivanna KR. Domestication of cardamom (Elettaria cardamomum) in Western Ghats, India: divergence in productive traits and a shift in major pollinators. Annals of Botany, 2009 Mar 1; 103(5): 727-33.
26. Vutakuri N, Somara S. Natural and herbal medicine for breast cancer using Elettaria cardamomum (L.) Maton. Int J Herb Med, 2018; 6(2): 91-6.
27. Heryanto R, Syukur C. Study of Genetic Diversity and Relationship of 100 Cardamom (Elettaria cardamomum) Lines Based on Morphological Characters. InIOP Conference Series: Earth and Environmental Science 2021 Apr 1; 752(1): 012046.
28. Cyriac A, Paul R, Anupama K, Sheeja TE, Babu KN, Parthasarathy VA. Isolation and characterization of genomic microsatellite markers for small cardamom (Elettaria cardamomum Maton) for utility in genetic diversity analysis. Physiology and Molecular Biology of Plants, 2016 Apr; 22(2): 219-29.
29. Mal D, Gharde SK. Medicinal uses of Cardamom: A review. Journal of Emerging Technologies and Innovative Research, 2019; 6(1): 977-980.
30. Vijayabanu C, Vijayanand V, Pratheesh M, Rethna RJ. A Study of Marginal Cardamom Farmers Livelihood and Occupational Pattern in Munnar District. Indian Journal of Science and Technology, 2016 Jul; 9(27): 1-4.
31. Ashokkumar K, Dhanya MK, Murugan M, Haritha KV, Nimisha M, Aiswarya S. Assessment of variation in volatile oil content in cardamom [Elettaria cardamomum (L.) Maton]. Electronic Journal of Plant Breeding, 2020 Dec 31; 11(04): 1007-14.
32. Khatri P, Rana JS, Jamdagni P, Sindhu A. Phytochemical screening, GC-MS and FT-IR analysis of methanolic extract leaves of Elettaria cardamomum. International Journal of Research-Granthaalayah, 2017 Feb 28; 5(2): 213-24.
33. Alagupalamuthirsolai M, Sivaranjani R, Ankegowda SJ, Murugan M, Krishnamurthy KS, Aravind S, Asangi H. A Study of Essential Oil Constituents from Capsules, Physiological and Quality Parameters of Small Cardamom Ecotypes [Elettaria cardamomum (L.) Maton] Growing in the Western Ghats, India. Journal of Essential Oil Bearing Plants, 2020 Nov 1; 23(6): 1253-64.
34. Ashokkumar K, Vellaikumar S, Murugan M, Dhanya MK, Ariharasutharsan G, Aiswarya S, Akilan M, Warkentin TD, Karthikeyan A. Essential oil profile diversity in cardamom accessions from southern India. Frontiers in Sustainable Food Systems, 2021 Apr 29; 5: 137.

35. Savan EK, Küçükbay FZ. Essential oil composition of Elettaria cardamomum Maton. Journal of Applied Biological Sciences, 2013; 7(3): 42-5.
36. Thomas E, Jaleel K, Zachariah TJ, Syamkumar S, Sasikumar B. GC MS analysis of essential oil of export grade Indian, Guatemalan and Sri Lankan cardamoms. Journal of Medicinal and Aromatic Plant Sciences, 2009; 31(3): 206-8.
37. Khan MA. A Review on beneficialpotential of Elettaria cardamomum(Cardamom):"Queen of Spices". Journal of Emerging Technologies and Innovative Research, 2018; 5(10): 354-357.
38. Korikanthimathm VS, Prasath D, Rao G. Medicinal properties of cardamom Elettaria cardamomum. Journal of Medicinal and Aromatic Plant Sciences, 2000; 22: 683-5.
39. Moulai-Hacene F, Boufadi MY, Keddari S, Homrani A. Chemical Composition and Antimicrobial Properties of Elettaria cardamomum Extract. Pharmacognosy Journal, 2020; 12(5): 1058-1063.
40. Ajit A, Brijeetha PD, Varkey P. A Mini Review on The Bioactive Compounds in Dried Cardamom Seed And its Leaf. World Journal of Pharmaceutical Research, 2020; 9(14): 1410-1423.
41. Al-Yousef HM, Alqahtani AS, Hassan WH, Alzoubi A, Abdelaziz S. Chemical Profile, In Vitro Antioxidant, Pancreatic Lipase, and Alpha-Amylase Inhibition Assays of the Aqueous Extract of Elettaria cardamomum L. Fruits. Journal of Chemistry,2021 May 29; 2021: 1-10.
42. Torwane NA, Hongal S, Goel P, Chandrashekar BR. Role of Ayurveda in management of oral health. Pharmacognosy reviews, 2014 Jan; 8(15): 16.
43. Hankey A. CAM modalities can stimulate advances in theoretical biology. Evidence-Based Complementary and Alternative Medicine, 2005 Feb; 2(1): 5-12.
44. Lad V. The human constitution. Ayurveda: The Science of SelfHealing. Lotus Press, Wilmot, 1985; 26-36.
45. Dattatray S, Kamini B, Mohanlal J. The queen of spices and ayurveda: a brief review. Int. J Res. Ayurveda Pharm, 2016 Sep; 7(4): 1-7.
46. Gupta N. A Review on concept of Vishaghna dravya (anti-toxic drugs) in ayurveda. The Healer. 2021 Feb 3; 2(1): 95-99.
47. Dixit N, Maurya SD, Sagar BP. A Comprehensive Review of Eladi Vati. Indian Journal of Research in Pharmacy and Biotechnology, 2013 May 1; 1(3): 382.
48. Mohammad H, Prabhu K, Rao MR, Sundaram RL, Shil S, Vijayalakshmi N, Dinakar S. The GC MS Study of one Ayurvedic Medicine, Aragwadharishtam. Alcohol, 2019; 8(122.1): 13248162.
49. Kumar MH, Prabhu K, Rao MR, Sundaram RL, Shil S, Kumar SA. The GC MS study of one Ayurvedic medicine, Vasakadyaristam. Research Journal of Pharmacy and Technology, 2019; 12(2): 569-73.
50. Parle M, Vasudevan M. Memory enhancing activity of Abana®: an Indian ayurvedic poly-herbal formulation. Journal of health science, 2007; 53(1): 43-52.
51. Rao MR, Ravi A, Narayanan S, Prabhu K, Kalaiselvi VS, Dinakar S, Rajan G, Kotteeswaran N. Antioxidant study and GC MS analysis of an ayurvedic medicine 'Talisapatradi choornam'. Int J Pharm Sci Rev Res, 2016; 36(1): 158-66.
52. Sharmila D, Poovarasan A, Pradeep E, Saha T, Rao MR, Prabhu K. The GC MS study of one Ayurvedic formulation" Sitopaladi". Research Journal of Pharmacy and Technology, 2021 Feb 1; 14(2): 911-5.
53. Wagh VD, Patil SV, Surana SJ, Wagh KV. Medicinal plants used in preparation of polyherbal ayurvedic formulation Chyawanprash. Journal of Medicinal Plants Research, 2013 Oct 10; 7(38): 2801-14.
54. Yadav Y, Sharma KC, Rajesh K, Arun S. An Updated Review on Recent In-Vitro, In-Vivo and Clinical Researches of Avipattikar Churna. Scholars International Journal of Traditional and Complementary Medicine, 2019; 2(6): 113-123.
55. Rajnik Jadav AD, Varsakiya J. A clinical study of Shunthyadi churna in the management of Tamaka shwasa WSR to bronchial asthma. Journal of Ayurvedic and Herbal Medicine, 2018; 4(2): 48-52.
56. Kumar HK, Sridurga CH, Rao DB. Clinical efficacy of Baladi Manduram in the management of Amlapitta. Ayu., 2017 Jul; 38(3-4): 133.
57. Sujeethasai K. Pharmacological Analysis of Sivathai Chooranam (Poly Herbal Formulation) in Siddha Medicine - A Literature Review. International Journal of Recent Scientific Research, 2020; 11(5): 38494-38497.
58. Rahman AH, Alam MS, Khan SK, Ahmed F, Islam AK, Rahman MM. Taxonomic studies on the family Asteraceae (Compositae) of the Rajshahi division. Research Journal of Agriculture and Biological Sciences, 2008; 4(2): 134-40.
59. Daoudi A, EL Youbi AE, Bagrel D, Aarab L. In vitro anticancer activity of some plants used in Moroccan traditional medicine. Journal of Medicinal Plants Research, 2013 May 3; 7(17): 1182-9.
60. Chaachouay N, Benkhnigue O, Fadli M, El Ibaoui H, El Ayadi R, Zidane L. Ethnobotanical and Ethnopharmacological Study of Medicinal and Aromatic Plants Used in the Treatment of Respiratory System Disorders in the Moroccan Rif. Ethnobotany Research and Applications, 2019 Jun 23; 18: 1-6.
61. Zidane L, Douira A. Ethnobotanical study of plants used in the treatment of respiratory diseases in a population bordering the forest of Izarčne. 0 Journal of Pharmacy & Pharmacognosy Research, 2020; 8(5): 392-409.
62. Ishtiaq M, Maqbool M, Hussain T, Azam S, Mushtaq W. Ethnomedico Profile of Indigenous

flora of Tehsil Barnala, district Bhimber, Pakistan. Journal of Medicinal Plants, 2016; 3(2): 97-104.
63. Qureshi R, Maqsood MU, Arshad MU, Chaudhry AK. Ethnomedicinal uses of plants by the people of Kadhi areas of Khushab, Punjab, Pakistan. Pak J Bot, 2011 Feb 1; 43(1): 121-33.
64. Ahmad M, Qureshi R, Arshad M, Khan MA, Zafar M. Traditional herbal remedies used for the treatment of diabetes from district Attock (Pakistan). Pak J Bot., 2009 Dec 1; 41(6): 2777-82.
65. Yaseen G, Ahmad M, Zafar M, Sultana S, Kayani S, Cetto AA, Shaheen S. Traditional management of diabetes in Pakistan: ethnobotanical investigation from traditional health practitioners. Journal of ethnopharmacology, 2015 Nov 4; 174: 91-117.
66. Wangchuk P, Pyne SG, Keller PA. Ethnobotanical authentication and identification of Khrog-sman (lower elevation medicinal plants) of Bhutan. Journal of ethnopharmacology, 2011 Apr 12; 134(3): 813-23.
67. Thomas VP, Jose J, ST SM, Thomas BT. Ethnobotanical significance of Zingiberales: a case study in the Malaipandaram tribe of Southern western Ghats of Kerala. Indian Journal of Traditional Knowledge (IJTK), 2020 May 15; 19(2): 450-8.
68. Siddalinga MS, Vidyasagar GM. Medicinal plants used in the treatment of gastrointestinal disorders in Bellary district, Karnataka, India. Indian Journal of Traditional Knowledge, 2013; 12(2): 321-325.
69. Ayyanar M, Ignacimuthu S. Ethnobotanical survey of medicinal plants commonly used by Kani tribals in Tirunelveli hills of Western Ghats, India. Journal of ethnopharmacology, 2011 Apr 12; 134(3): 851-64.
70. Anvar K, Haneef J. Ethnobotanical plants used for postnatal care by traditional practitioners from Kozhikode district, Kerala, India. Intenational Journal of Research in Pharmacy and Chemistry, 2015; 5(4): 570-81.
71. Dhiraj RS, Anjna KD. Studies on traditional herbal pediatrics practices in Jaisinghpur, district Kangra (Himachal Pradesh, India). Global Journal of Research on Medicinal Plants & Indigenous Medicine, 2013 Apr 1; 2(4): 219.
72. Chaudhury S, Singh H, Bharati KA. Quantitative analyses on ethnogynecological remedies used by Lodhas of Paschim Medinipur district, West Bengal, India. Indian Journal of Traditional Knowledge, 2017; 6(2): 325-332.
73. Gupta U, Solanki H. Herbal folk remedies used in treatment of Gynecological disorders by tribals of Simalwara Region, Dungarpur, Rajasthan. International Journal of Pure and Applied Sciences and Technology, 2013 Jul 1; 17(1): 100.
74. Silja VP, Varma KS, Mohanan KV. Ethnomedicinal plant knowledge of the Mullu kuruma tribe of Wayanad district, Kerala. Indian Journal of Traditional Knowledge, 2008; 7(4): 604-612.
75. Manikandan PA. Folk herbal medicine: A survey on the paniya tribes of Mundakunnu village of the Nilgiri hills, South India. Ancient Science of life, 2005 Jul; 25(1): 21.
76. Kumar SP. Adulteration and substitution in endangered ASU medicinal plants of India: a review. Int J Med Arom Plants, 2014 Mar; 4(1): 56-73.
77. Mosa KA, Soliman S, El-Keblawy A, Ali MA, Hassan HA, Tamim AA, Al-Ali MM. Using DNA barcoding to detect adulteration in different herbal plant-based products in the United Arab Emirates: proof of concept and validation. Recent patents on food, nutrition & agriculture, 2018 May 1; 9(1): 55-64.
78. Zhang J, Wider B, Shang H, Li X, Ernst E. Quality of herbal medicines: challenges and solutions. Complementary therapies in medicine, 2012 Feb 1; 20(1-2): 100-6.
79. Kunle OF, Egharevba HO, Ahmadu PO. Standardization of herbal medicines-A review. International Journal of Biodiversity and Conservation, 2012 Mar 20; 4(3): 101-12.
80. Nikam PH, Kareparamban J, Jadhav A, Kadam V. Future trends in standardization of herbal drugs. Journal of applied pharmaceutical science, 2012; 2(6): 38-44.
81. Woodley SB, Mould RR, Sahuri-Arisoylu M, Kalampouka I, Booker A, Bell JD. Mitochondrial Function as a Potential Tool for Assessing Function, Quality and Adulteration in Medicinal Herbal Teas. Frontiers in Pharmacology, 2021 Apr 26; 12: 814.
82. Aneja KR, Joshi R. Antimicrobial activity of Amomum subulatum and Elettaria cardamomum against dental caries causing microorganisms. Ethnobotanical Leaflets, 2009; 2009(7): 3.
83. Singh G, Kiran S, Marimuthu P, Isidorov V, Vinogorova V. Antioxidant and antimicrobial activities of essential oil and various oleoresins of Elettaria cardamomum (seeds and pods). Journal of the Science of Food and Agriculture, 2008 Jan 30; 88(2): 280-9.
84. Islam S, Rahman A, Sheikh MI, Rahman M, Jamal AH, Alam F. In vitro antibacterial activity of methanol seed extract of elettaria cardamomum (L.) maton. Agriculturae Conspectus Scientificus, 2010 Sep 22; 75(3): 113-7.
85. Elguindy NM, Yacout GA, El Azab EF, Maghraby HK. Chemoprotective effect of Elettaria cardamomum against chemically induced hepatocellular carcinoma in rats by inhibiting NF-κB, oxidative stress, and activity of ornithine decarboxylase. South African journal of botany, 2016 Jul 1; 105(2016): 251-8.
86. Elguindy NM, Yacout GA, El Azab EF. Amelioration of DENA-induced oxidative stress in rat kidney and brain by the essential oil of Elettaria cardamomum. Beni-Suef University Journal of Basic and Applied Sciences, 2018 Sep 1; 7(3): 299-305.

87. Hashim S, Aboobaker VS, Madhubala R, Bhattacharya RK, Rao AR. Modulatory effects of essential oils from spices on the formation of DNA adduct by aflatoxin B1 in vitro. Nutrition and Cancer, 1994; 21(2): 169-175.
88. Rajan A, Rajan AR, Philip D. Elettaria cardamomum seed mediated rapid synthesis of gold nanoparticles and its biological activities. OpenNano, 2017 Jan 1; 2: 1-8.
89. Almeer RS, Alnasser M, Aljarba N, AlBasher GI. Effects of Green cardamom (Elettaria cardamomum Maton) and its combination with cyclophosphamide on Ehrlich solid tumors. BMC complementary medicine and therapies, 2021 Dec; 21(1): 1-3.
90. Qiblawi S, Al-Hazimi A, Al-Mogbel M, Hossain A, Bagchi D. Chemopreventive effects of cardamom (Elettaria cardamomum L.) on chemically induced skin carcinogenesis in Swiss albino mice. Journal of medicinal food, 2012 Jun 1; 15(6): 576-80.
91. Raksamiharja R, Sy K, Novarina A, Sasmito E. Elettaria cardamomum distillate increases cellular immunity in doxorubicin treated rats. Indonesian Journal of Cancer Chemoprevention, 2012 Oct 31; 3(3): 437-43.
92. Aghasi M, Ghazi-Zahedi S, Koohdani F, Siassi F, Nasli-Esfahani E, Keshavarz A, Qorbani M, Khoshamal H, Salari-Moghaddam A, Sotoudeh G. The effects of green cardamom supplementation on blood glucose, lipids profile, oxidative stress, sirtuin-1 and irisin in type 2 diabetic patients: a study protocol for a randomized placebo-controlled clinical trial. BMC complementary and alternative medicine, 2018 Dec; 18(1): 1-6.
93. Zahedi SG, Qorbani M, Nasli-Esfahani E, Aghasi M, Khoshamal H, Keshavarz A, Sotoudeh G. The effects of Elettaria cardamom supplementation on inflammatory markers and vascular function in patients with type 2 diabetes mellitus: A mechanism-based randomized clinical trial. Journal of Herbal Medicine, 2021 Feb 1; 25: 100403.
94. Jamal A, Javed K, Aslam M, Jafri MA. Gastroprotective effect of cardamom, Elettaria cardamomum Maton. fruits in rats. Journal of ethnopharmacology, 2006 Jan 16; 103(2): 149-53.
95. Jamal A, Siddiqui A, Aslam M, Javed K, Jafri MA. Antiulcerogenic activity of Elettaria cardamomum Maton. and Amomum subulatum Roxb. seeds. Indian Journal of Traditional Knowledge, 2005; 4(5): 298-302.
96. Chowdhury S, Kumar S. Alpha-terpinyl acetate: A natural monoterpenoid from Elettaria cardamomum as multi-target directed ligand in Alzheimer's disease. Journal of Functional Foods, 2020 May 1; 68(2020): 103892.
97. Verma SK, Jain V, Katewa SS. Blood pressure lowering, fibrinolysis enhancing and antioxidant activities of cardamom (Elettaria cardamomum). Indian Journal of Biochemistry and Biophysics, 2009; 46: 5003-506.
98. Bhatti HN, Zafar F, Jamal MA. Evaluation of phenolic contents and antioxidant potential of methanolic extracts of green cardamom (Elettaria cardamomum). Asian Journal of Chemistry, 2010 Jul 1; 22(6): 4787.
99. Arpitha S, Srinivasan K, Sowbhagya HB. Anti-inflammatory effect of resin fraction of cardamom (Elettaria cardamomum) in carrageenan-induced rat paw edema. PharmaNutrition, 2019 Dec 1; 10(2019): 100165.
100. El Malti J, Mountassif D, Amarouch H. Antimicrobial activity of Elettaria cardamomum: Toxicity, biochemical and histological studies. Food chemistry, 2007 Jan 1; 104(4): 1560-8.