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A MINI REVIEW ON THE BIOACTIVE COMPOUNDS IN DRIED CARDAMOM SEED AND ITS LEAF

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ABSTRACT

The extensive convenience and approval of synthetic compounds for addressing human health have quite a few side effects in addition to higher prices. Exploring natural bioactive compounds is of utmost interest and demand. Cardamom has been used traditionally for numerous therapeutic benefits and are relevant in the light of modern pharmaceutical perspective. This review inspects and presents consolidated information on the the phytochemical profile of cardamom seed and leaf extracts and superficially addresses the common extraction methods adapted in literature. An online survey was conducted on the traditional uses, phytochemical composition, and bioactive components of cardamom seed and leaf extract. Pertinent data were obtained from several electronic scientific databases (Science Direct, Elsevier, Web of Science, PubMed, Springer, ACS publications, Taylor and Francis, Wiley On-line Library and Google Scholar), and additional information was obtained from textbooks and local prints and scripts. Studies on the chemical composition and physico-chemical properties of the seed and leaf extracts of cardamomum depict a higher yield extract value from seeds than their leaves. Both seed and leaf extracts are known to have numerous therapeutic benefits as anti-bacterial, anti-microbial, anti-carcinogenic, anti-oxidant, anti-inflammatory and anti-ulcerogenic and gastro-protectory agents. Modern pharmacology researchers have made attempts in establishing many traditional uses of Cardamom. However, systemic studies on the phytocompounds which may possess new biological activities are lacking. Thus, more studies on the pharmacological mechanisms of its main active compounds need to be conducted keeping in mind therapeutic aspects, toxicity and adverse effects.

KEYWORDS: Cardamom seed, Cardamom Leaf, Phytochemical composition, Bioactive compounds.

1. INTRODUCTION

Cardamom sometimes called cardamon or cardamum, is a spice made from the seeds of several plants in the genera Elettaria. It is native to the East originating in the forests of the western ghats in southern India, where it grows wild. Now it is also grown in Sri Lanka, Guatemala, Indo China and Tanzania. In the cardamom plant, lanceolate and dark green leafy shoots arise from the rhizome.[1] It also bears spindle-shaped fruits, with a thin papery outer shell and small black seeds. The two most common varieties of the cardamom are the green cardamom, which comes from the species Eletteria cardamomum and the Black cardamom from the species Amomum subulatum. Both of these varieties have been widely used in traditional medicine for the control of asthma, teeth and gum infections, cataracts, nausea, diarrhea, as well as cardiac, digestive and kidney disorders.[2] The presence of a wide range of bioactive compounds in the cardamom such as terpinene, cineol, limonene, sabinene etc. are known to play an important role for the pharmacological action. Traditionally, the volatile oil present in the seed containing myrcene, D-Iimonene, methyl heptenone, β-pinene, linalool acetate, terpinyl acetate etc. is commonly used as an anti-bacterial, anti-oxidant, anti-inflammatory and anti-ulcerogenic agent[2],[3] Considering the multipurpose use of cardamom for numerous therapeutic applications, this review aims to consolidate the bioactive compounds profile of its seed and leaf extracts in light of traditional and modern pharmaceutical outlooks.

2. MATERIALS AND METHODS

An online survey was conducted on the traditional uses, phytochemical composition, and bioactive compounds of cardamom seed and leaf extract. Pertinent data were obtained from several electronic scientific databases (Science Direct, Elsevier, Web of Science, PubMed, Springer, ACS publications, Taylor and Francis, Wiley On-line Library and Google Scholar), and additional information was obtained from textbooks and local prints and scripts.

3. MAJOR PHYTOCHEMICAL COMPOUNDS OF CARDAMOM SEED EXTRACTS

The major constituent of the seed is starch, while the fruit husk is made of crude fiber. The dried fruit contains steam volatile oil, fixed fatty oil, pigments, proteins, cellulose, pentosans, sugars, starch, silica, calcium oxalate and minerals. Of which, the volatile oil is the most

functionally important constituent of cardamom.[1] Cardamom seeds contain 2.8–6.2% volatile oil, 10% protein, 1–10% fixed oil and up to 50% starch. The phytochemical screening of cardamom seed extracts showed the presence of phenolic compounds, flavonoids, alkaloids, tannins and saponins as depicted in **Table 1**.

These include Alpha-ionone, Eucalyptol, Santolina alcohol, 1,6-octadiene-3-ol,3.7-dimethyl-, 2,6-octadiene-1-ol,3-ol,3,7-dimethyl-,(Z)-, Cinnamaldehyde,(E)-, Terpinen-4-ol, 1,6,10-Dodecatrien-3-ol,3,7,11-trimethyl-, Acetic acid and 1-methyl-1-(4-methyl-5-oxy-cy).The aroma and flavor of the cardamom are attributed to the essential oils which are composed of mainly α-terpinyl acetate (20– 55%) and 1,8-cineole (20–60%). It is also seen that the Cardamom essential oil showed diversity in chemical composition with respect to plant chemo types, climatic conditions, harvesting time and the nutritional status.[1]

4. MAJOR PHYTOCHEMICAL COMPOUNDS OF CARDAMOM LEAF EXTRACT

The preliminary phytochemical analysis of ethanolic extract of Elettaria cardamomum leaf showed the presence of flavonoids, tannins, phenolic compounds, terpenoids, alkaloids, saponins phytosterols, carbohydrates, proteins, fixed oils and fatty acids[4], as shown in **Table 1**. These constitute 1,8-cineole, smaller amounts of limonene, α-terpenyl acetate, α-terpineol, borneol, camphor and α-pinene. The presence of various compounds like Vitamin E, Squalene, Eucalyptol, Stigmast-5-en-3-ol, 2,3-dihydro5, 7-dihydroxy-2-pheny, Octadecanoic acid, Phytol and Hexadecanoic acid in the methanolic extract of Elettaria cardamomum leaf extract was revealed by Gas chromatography and Mass spectroscopy analysis.

5. APPROACHES OF EXTRACTION FROM CARDAMOM SEED AND LEAF

As the availability of cardamom leaf is year around, it can easily be stored for up to seven days at a temperature of 2-7°C prior to extraction. Liquid-liquid extraction and solid-liquid extraction are the commonly used extraction methods. These conventional techniques of extraction were widely accepted because of their ease of use, efficiency, and wide-range applicability. However, these methods include the use of solvents like alcohol, acetone etc. Here, the seeds and leaves on drying are finely powdered and subjected to a suitable solvent like 80% methanol. These solvents contribute to hazardous effects on human health. Accordingly, new methods like ultrasound-assisted extraction, microwave-assisted extraction, ultrasound-microwave assisted extraction, supercritical fluid extraction, and subcritical fluid extraction are used because of their simplicity, smaller extraction time and reduced organic

solvent consumption[5] Supercritical fluid extraction is used for the extraction of lipids, essential oil, alkaloid and glycoside. It is the simplest and economical way to extract valuable constituents. The main disadvantage is the high-pressure operating conditions. High-pressure vessels are expensive and bulky. Another technique is the Soxhlet extraction method. It is a widely used technique, and the intention is to make the extraction process continuous. It is used for extraction of volatile oils and lipids. However, the disadvantages of Soxhlet extraction are requirement of highly pure solvents, use of hazardous and flammable liquid organic solvent, potential toxic emission during extraction, and it is a time-consuming process.[6]

In supercritical carbon dioxide extraction, the solubility of cardamom oil is high. The maximum amount of extract can be obtained from cardamom seed through a single extraction.[7] A recent study on isolation of rosemary oil performed a comparison between hydrodistilation and supercritical CO2 extraction. Here, both techniques yielded substantially the same main compounds. But the SFE (Supercritical fluid extraction) yielded additional traces of other oxygenated terpenes, sesquiterpenes and diterpenes.[8] Another method of extraction of essential oil from cardamom seed was explored using the SFME (solvent-free microwave extraction) technique. This has been compared with the conventional hydro-distillation method. It is reported that variables like extraction time, power and moisture content, all have positive influence on the oil yield using the SFME method. It was also found that in SFME the 1,8-cineole fraction decreased with time, power and moisture content while the opposite was true for a-terpinyl acetate.[9] Essential oil is preferably located in vacuoles inside the cellular structure, and a large mass transfer resistance in the solid phase characterizes their extraction process when vapor is used as a distillation medium.[10] On comparing the volatile fraction obtained by solvent extraction (SE) to that obtained by SFE for extract quality, the extract obtained by SE was not only polluted by the organic solvent, but it also contained cuticular waxes that worsened the quality of the oil[10] Steam distillation is another most commonly used method for extracting essential oils. Many traditional distillers favor this method for distilling most oils as they claim that none of the newer methods produce better quality oils. However, a recent study revealed that extraction of cardamom essential oil by solvent extraction method had high extraction efficiency as compared to steam distillation method.[11] Another study reports the influence of ultrasonic assisted extraction (UAE) followed by hydro distillation of Elettaria cardamomum L. seeds in facilitating short time extraction, improved efficiency and good quality cardamom essential

oil[12] GC-MS aided phytochemical analysis from the published studies revealed that the major components of cardamom essential oils varied depending on the extraction conditions of the extraction method adapted. Though several advanced (supercritical fluid extraction, subcritical extraction liquid, solvent-free microwave extraction) and conventional (hydrodistillation, steam distillation, hydrodiffusion, solvent extraction) methods have been discussed for the extraction of cardamom essential oil, advanced methods are considered as the most promising extraction techniques due to less extraction time, low energy consumption, low solvent used and less carbon dioxide emission. Additionally, a strong need for strandardization is advocated as the phytochemical composition is seen to vary based on the parameters used in the chosen method of extraction.

6. BIOACTIVITY OF CARDAMOM SEED AND LEAF COMPOUNDS

6.1 Anti-Inflammatory Property

E. cardamomum seeds possess anti-inflammatory activity. In Carrageenan-induced rat paw oedema the oil extract of Elettaria cardamomum seeds, in doses of 175 and 280 microliters/kg were found to reduce the inflammation.[13] The hexane extract of *Elettaria repens* is rich in polyphenols, flavonoids, and terpenoids. It also seen to be effective against carrageenan-induced acute inflammation and paw edema in rats.[14]

6.2 Anti-Microbial Property

Antimicrobial activity is exhibited by the extracts from E.cardamom against oral microbes. The essential oils from Cardamom showed marked inhibitory effects to pathogenic and spoilage microorganism.Cardamom extracts showed strong antibacterial activity against important Gram-negative periodontal pathogens including *A. actinomycetemcomitans, F. nucleatum, P. gingivalis,* and *P. intermedia.* This activity is likely related to the presence of high amounts of 1,8-cineol.[15] Ethanolic extract of E. cardamomum was reported to possess antibacterial effect at the dose of 512µg/ml.[16] Cardamom Essential oils -loaded Chitosan nano-capsules were observed to be highly effective in controlling multi drug resistant *E. coli* and MRSA (Methicillin-resistant S.aureus) *in vitro* without showing any signs of toxicity to human cells.[17],[18]

6.3 Anti-Oxidant Property

Essential oil of cardamom acts as an antioxidant and helps scavenging free radicals, thus reducing cellular ageing.[19],[2],[20] Terpenoids and Phenol play an important role in antioxidant activity of cardamom.[21]

6.4 Anti-Carcinogenic Property

In a study of Inhibition of lipid peroxidation and enhancement of GST (Glutathione-S-transferase) activity by cardamom and cinnamon during chemically induced colon carcinogenesis in swiss albino mice, the levels of both hepatic and colonic GST levels were considerably increased following treatment with cardamom.[22]

A. compactum can reduce the side effects of postoperative chemotherapy for carcinoma of the large intestine and improve the immune function of patients so that it can increase the effectiveness of chemotherapy. The most important role in anticancer activity was attributed to the capability to inhibit multiple oxidation reactions. This was aided by bioactive compounds such as flavonoids and triterpenoids within the cardamom extracts. The structure of these bioactive compounds contribute to the antioxidant activity as they contain a hydroxyl group that can donate hydrogen atoms to free radicals.[23]

6.5 Anti-Ulcerogenic Activity

Pertroleum ether soluble fractions(PS) of methanolic extract, and essential oils(EO) showed significant ulcerogenic effect in aspirin and ethanol induced ulcers. Essential oils present in cardamom shows gastro protective action. They have inhibitory effect in over production of some product if 5-lipoxygenase pathway.[24]

6.6 Gastro-Protective Activity

Petroleum ether soluble extract of E.cardamom was found best for gastro protective activity which inhibited lesions by nearly 100% at 12.5 mg/kg in the aspirin-induced gastric ulcer. Methanolic extract also possess gastroprotective effect.[2,25] The phenolic compounds present in cardamom extraction may be responsible for gastroprotection.[26]

6.7 Medicinal Uses For Asthma

Crude extract of cardamom was found to contain alkaloids, flavonoids, saponins, sterols and tannins. The flavonoids are well known for their bronchodilator activity. The presence of such class of compounds in cardamom is likely to contribute in its airway relaxing action.[27]

6.8 Gut Modulatory and Blood Pressure Lowering

Gut excitatory and inhibitory effects are also exhibited by cardamom, which are mediated through cholinergic and Ca^{++} antagonist mechanisms respectively and seen to lower the BP by combination of both pathways.[28],[29]

The therapeutic potential of cardamom extract from both leaf and seed is depicted in **Figure 1** in line to the earlier mentioned phytochemical composition as summarized in **Table 2** and **Table 3**.

Figure 1: Bioactive properties of cardamom leaf and seed extracts.

Table 1: Qualitatitive Phytochemical Profile Of Cardamom Seed And Leaf Extracts.

Sample	Alkaloids	Flavonoids	Phenol	Glycoside	Saponins	Quinone	Tannins	Essential oils	Terpenoids
Cardamom Seed	+ [1]	+ [1],[2]	+ [1]	+ [1]	+ [1]	+ [32]	+ [1],[32]	+ [1],[2],[33]	+ [2],[34]
Cardamom Leaf	+ [4]	+ [4]	+ [4]	+ [4]	+ [4][5]	* [*Not Reported*]	- [4]	+ [4],[34]	- [4]

Table 2: Bioactive Compounds In Elettaria Cardamom Leaf Extracts.

Sl no	Name of Component	Activity
1	2-Propenoic acid, 3-phenyl-, methyl ester[4]	Anti arthiritic, Anti-oxidant, Cancer Preventive, Additive.
2	Eucalyptol[1]	Antinociceptive, Anti-inflammatory, Antioxidant, Antitumorigenic, Antibacterial.
3	Hexadecanoic acid, Ethyl ester[4]	Antioxidant, Hypocholesterolemic, Nematicide, Antiandrogenic, Hemolytic 5-Alpha reductase Inhibitor
5	9, 12,15- Octadecatrienoi c acid, (Z, Z, Z)[4]	Anti-inflammatory, Hypocholesterolemic, Cancer preventive, Hepatoprotective,

		Nematicide,
6	Vitamin E[4]	Antiaging, Analgesic, Antidiabetic, Anti-inflammatory, Antioxidant, Antidermatitic, Antileukemic, Antitumor, Anticancer, Hepatoprotective, Hypocholesterolemic, Antiulcerogenic, Antispasmodic, Antibronchitic, Anticoronary
7	Octadecanoic acid[4]	Hypercholesterolemic, Antiarthiritic, Anti-inflammatory, Hepatoprotective, Nematicide, Antimicobial.

Table 3: Bioactive Compounds In Elettaria Cardamom Seed Extracts.

Sl no	Name of Component	Activity
1	Alpha. -ionone[30]	Antifungal activity
2	Eucalyptol[1]	Antinociceptive, Anti-inflammatory, Antioxidant, Antitumorigenic, Antibacterial
3	1,6-octadiene-3-ol[35–37]	Anti-listeria, Antimicrobial, Antibacterial
4	Cinnamaldehyde, (E)[38–40]	Antimicrobial, Antibacterial, Antifungal Activity
5	Terpinen-4-ol[41]	Antimicrobial, Anti-oxidant, Anticarcinogenic, Antiviral, Antibacterial, Anti-inflammatory, Antifungal, Antibiofilm
6	1,6,10-Dodecatrien-3-ol[42]	Antioxidant, Antibacterial, Anti-leishmanial, Anticancer activity,

		Anti-ulcer

7 DISCUSSION

Studies on the phytochemical composition of the seed and leaf extracts of *cardamomum* depict a higher yield extract value from seeds than their leaves, by water or water-steam distillation. The essential oil of cardamom seeds ranged from 3.30- 4.52%, while that from leaves were 0.99-1.08%. The distillation method did not significantly affect the yield, whereas the material which was used (seeds and leaves) significantly affected the yield. The cardamom seeds also contained greater volatile oil than in the leaves.[30] On qualitative comparison of the phytochemical composition it is seen that, in cardamom leaf extracts, tannin, terpinoids and quinine are absent. Here, the terpinoids are known to exhibit anti-cancer effects. Whereas, tannins exhibit antioxidant, antimicrobial, antihelmintic, antiviral and anti-inflammatory activity. Quinines also do have anti tumour and anti-cancer activity.[31] However, other constituents in the phytochemical composition of Eletteria cardamomum extracts of the leaf, as discussed earlier do show bioactivity for therapeutic application. This report offers a platform of using Elettaria cardamomum leaf extracts in addition to its seed extracts, as a herbal alternative for many diseases.

8 CONCLUSION

This review presents information on the bioactive compounds of cardamom extract from its seed and leaf. Modern pharmacology researchers have made attempts in establishing many traditional uses of Cardamom. However, systemic studies on the phytocompounds which may possess new biological activities are lacking. Thus, more studies on the pharmacological mechanisms of its main active compounds need to be conducted keeping in mind therapeutic aspects, toxicity and adverse effects. We hope this review will build a foundation for further study and the development of better therapeutic agents and healthy products from Cardamom.

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CONFLICT OF INTEREST

No conflict of interest has been declared by the authors.

AUTHOR CONTRIBUTION

Amita Ajit: Conceptualization; Methodology; Investigation; Resources; Supervision; Project administration; Validation; Visualization; original drafting; review & editing.

Brijeetha P. D.: Literature Search; Resources; data acquisition, manuscript preparation, Original drafting.

Prashanth Varkey: Conceptualization; Project Administration and Manuscript Review.

REFERENCES

1. Ahmed H, Ramadhani A, Erwa I. PHYTOCHEMICAL SCREENING, CHEMICAL COMPOSITION AND ANTIBACTERIAL ACTIVITY OF ESSENTIAL OIL OF CARDAMOM. World J Pharm Res., 2019; 8: 1166–75. https://doi.org/10.20959/wjpr20199-15504.
2. Ashokkumar K, Murugan M, Dhanya MK, Warkentin TD. Botany, traditional uses, phytochemistry and biological activities of cardamom [Elettaria cardamomum (L.) Maton] – A critical review. J Ethnopharmacol, 2020; 246: 112244. https://doi.org/10.1016/j.jep.2019.112244.
3. Rajathi AA, Sundarraj AA, Leslie S, PragalyaaShree MM. Processing and Medicinal Uses of Cardamom and Ginger – A Review. J Pharm Sci., 2017; 9: 6.
4. Khatri P, Rana JS, Jamdagni P, Sindhu A. Phytochemical screening, GC-MS and FT-IR analysis of methanolic extract leaves of Elettaria cardamomum. Int. J. Res., 2017. https://doi.org/10.5281/zenodo.345669.
5. Brglez Mojzer E, Knez Hrnčič M, Škerget M, Knez Ž, Bren U. Polyphenols: Extraction Methods, Antioxidative Action, Bioavailability and Anticarcinogenic Effects. Molecules, 2016; 21: 901. https://doi.org/10.3390/molecules21070901.
6. Shinde VM, Mahadik K. Supercritical fluid extraction: A new technology to herbals. Int. J. Herb, 2019. /paper/Supercritical-fluid-extraction-%3A-A-new-technology-Shinde-Mahadik/efa5a43f3141427266487b1d0bf1230ced6d25d8 (accessed October 13, 2020).
7. Gopalakrishnan N, Narayanan CS. Supercritical carbon dioxide extraction of cardamom. J. Am. Chem. Soc., 2002. https://doi.org/10.1021/jf00011a018.
8. Reverchon E, Senatore F. Isolation of rosemary oil: Comparison between hydrodistillation and supercritical CO2 extraction. Flavour Fragr J., 1992; 7: 227–30. https://doi.org/10.1002/ffj.2730070411.

9. Lucchesi ME, Smadja J, Bradshaw S, Louw W, Chemat F. Solvent free microwave extraction of Elletaria cardamomum L.: A multivariate study of a new technique for the extraction of essential oil. J Food Eng, 2007; 79: 1079–86. https://doi.org/10.1016/j.jfoodeng.2006.03.029.
10. Marongiu B, Piras A, Porcedda S. Comparative Analysis of the Oil and Supercritical CO2 Extract of Elettaria cardamomum (L.) Maton. J Agric Food Chem., 2004; 52: 6278–82. https://doi.org/10.1021/jf034819i.
11. Md S, Hm S, Ar S. Studies on extraction of essential oils from spices (Cardamom and Cinnamon). Int J Chem Stud, 2018; 6: 2787–9.
12. Morsy NFS. A short extraction time of high quality hydrodistilled cardamom (Elettaria cardamomum L. Maton) essential oil using ultrasound as a pretreatment. Ind Crops Prod, 2015; 65: 287–92. https://doi.org/10.1016/j.indcrop.2014.12.012.
13. Korikanthimathm V, Prasath D, Rao G. Medicinal properties of Elettaria cardamomum. J Med Aromat Plant Sci., 2001; 22/23.
14. Kandikattu HK, Rachitha P, Jayashree GV, Krupashree K, Sukhith M, Majid A, et al. Anti-inflammatory and anti-oxidant effects of Cardamom (Elettaria repens (Sonn.) Baill) and its phytochemical analysis by 4D GCXGC TOF-MS. Biomed Pharmacother, 2017; 91: 191–201. https://doi.org/10.1016/j.biopha.2017.04.049.
15. Souissi M, Azelmat J, Chaieb K, Grenier D. Antibacterial and anti-inflammatory activities of cardamom (Elettaria cardamomum) extracts: Potential therapeutic benefits for periodontal infections. Anaerobe, 2020; 61: 102089. https://doi.org/10.1016/j.anaerobe.2019.102089.
16. Kumar R, Patia S, Kumar R, Ahmed MdT, Khara S, Laskar M, et al. ANTIMICROBIAL POTENTIAL OF VOLATILE OIL ISOLATED FROM CARDAMOM. Indian Res J Pharm Sci., 2017; 4: 1196–200. https://doi.org/10.21276/irjps.2017.4.4.5.
17. Jamil B, Abbasi R, Abbasi S, Imran M, Khan SU, Ihsan A, et al. Encapsulation of Cardamom Essential Oil in Chitosan Nano-composites: In-vitro Efficacy on Antibiotic-Resistant Bacterial Pathogens and Cytotoxicity Studies. Front Microbiol, 2016; 7: 1580. https://doi.org/10.3389/fmicb.2016.01580.
18. Binimeliz MF, Martins ML, Filho JCCF, Cabral LM, Cruz AG da, Maia LC, et al. Antimicrobial Effect of a Cardamom Ethanolic Extract on Oral Biofilm. Nat. Oral Care Dent. Ther., John Wiley & Sons, Ltd., 2020; 121–31. https://doi.org/10.1002/9781119618973.ch8.

19. Dutta S, Bhattacharjee P. Microencapsulation of enzyme-assisted supercritical carbon dioxide extract of small cardamom by spray drying. J Food Meas Charact, 2017; 11: 310–9. https://doi.org/10.1007/s11694-016-9398-9.
20. Nanasombat S, Wimuttigosol P. Antimicrobial and antioxidant activity of spice essential oils. Food Sci Biotechnol, 2011; 20: 45–53. https://doi.org/10.1007/s10068-011-0007-8.
21. Kapoor IPS, Singh B, Singh G, Isidorov V, Szczepaniak L. Chemistry, antifungal and antioxidant activities of cardamom (Amomum subulatum) essential oil and oleoresins. Int J Essent Oil Ther., 2008; 2: 29–40.
22. Bhattacharjee S, Rana T, Sengupta A. Inhibition of lipid peroxidation and enhancement of GST activity by cardamom and cinnamon during chemically induced colon carcinogenesis in Swiss albino mice. Asian Pac J Cancer Prev APJCP, 2007; 8: 578–82.
23. Juwitaningsih T, Jahro IS, Sari SA. Evaluation of North Sumatera Cardamom seed (Amomum compactum) Extract as Antibacterial and Anticancer. J Phys Conf Ser., 2020; 1485: 012019. https://doi.org/10.1088/1742-6596/1485/1/012019.
24. Jamal A, Siddiqui A, Aslam M, Javed K, Jafri MA. Antiulcerogenic activity of Elettaria cardamomum Maton. and Amomum subulatum Roxb. seeds, 2005; 4: 5.
25. Jamal A, Javed K, Aslam M, Jafri MA. Gastroprotective effect of cardamom, Elettaria cardamomum Maton. fruits in rats. J Ethnopharmacol, 2006; 103: 149–53. https://doi.org/10.1016/j.jep.2005.07.016.
26. Jafri MA, Farah, Javed K, Singh S. Evaluation of the gastric antiulcerogenic effect of large cardamom (fruits of Amomum subulatum Roxb). J Ethnopharmacol, 2001; 75: 89–94. https://doi.org/10.1016/S0378-8741(00)00398-6.
27. Khan A, Khan QJ, Gilani A-H. Pharmacological basis for the medicinal use of cardamom in asthma. Bangladesh J Pharmacol, 2011; 6: 34–7.
28. Gilani AH, Jabeen Q, Khan A, Shah AJ. Gut modulatory, blood pressure lowering, diuretic and sedative activities of cardamom. J Ethnopharmacol, 2008; 115: 463–72. https://doi.org/10.1016/j.jep.2007.10.015.
29. Kanthlal SK, Joseph J, Paul B, M V, P UD. Antioxidant and vasorelaxant effects of aqueous extract of large cardamom in L-NAME induced hypertensive rats. Clin Exp Hypertens, 2020; 42: 581–9. https://doi.org/10.1080/10641963.2020.1739699.
30. Altemimi A, Lakhssassi N, Baharlouei A, Watson DG, Lightfoot DA. Phytochemicals: Extraction, Isolation, and Identification of Bioactive Compounds from Plant Extracts. Plants, 2017; 6. https://doi.org/10.3390/plants6040042.

31. Mazumdar J, Pathak D, Kumria R. Evaluation of Antacid Activity of Microemulsion Formulation of Blend of Essential Oil. Int J Pharm Sci Drug Res., 2015; 7: 163–7.
32. Hussain SA, Hameed A, Fu J, Xiao H, Liu Q, Song Y. Comparative in vitro analysis of anti-diabetic activity of Indo-Pak black cardamom (Amomum subulatum Roxb.) and Chinese black cardamom (Amomum tsao-ko Crevost et Lemaire). Prog Nutr., 2018; 20: 403–14. https://doi.org/10.23751/pn.v20i3.6196.
33. Bisht VK, Negi JS, Bh AK, ari, Sundriyal RC. Amomum subulatum Roxb: Traditional, phytochemical and biological activities-An overview. Afr J Agric Res., 2011; 6: 5386–90. https://doi.org/10.5897/AJAR11.745.
34. Huang M, Lu J-J, Huang M-Q, Bao J-L, Chen X-P, Wang Y-T. Terpenoids: natural products for cancer therapy. Expert Opin Investig Drugs, 2012; 21: 1801–18. https://doi.org/10.1517/13543784.2012.727395.
35. Gao Z, Van Nostrand JD, Zhou J, Zhong W, Chen K, Guo J. Anti-listeria Activities of Linalool and Its Mechanism Revealed by Comparative Transcriptome Analysis. Front Microbiol, 2019; 10. https://doi.org/10.3389/fmicb.2019.02947.
36. Herman A, Tambor K, Herman A. Linalool Affects the Antimicrobial Efficacy of Essential Oils. Curr Microbiol, 2016; 72: 165–72. https://doi.org/10.1007/s00284-015-0933-4.
37. Silva VA, Sousa JP, Guerra F, Pessôa HLF, Freitas AFR, Coutinho H, et al. Antibacterial activity of the monoterpene linalool: Alone and in association with antibiotics against bacteria of clinical importance. Int J pharmaco phytochem Res., 2015; 7: 1022–6.
38. He Z, Huang Z, Jiang W, Zhou W. Antimicrobial Activity of Cinnamaldehyde on Streptococcus mutans Biofilms. Front Microbiol, 2019; 10. https://doi.org/10.3389/fmicb.2019.02241.
39. OuYang Q, Duan X, Li L, Tao N. Cinnamaldehyde Exerts Its Antifungal Activity by Disrupting the Cell Wall Integrity of Geotrichum citri-aurantii. Front Microbiol, 2019; 10. https://doi.org/10.3389/fmicb.2019.00055.
40. Siddiqua S, Anusha BA, Ashwini LS, Negi PS. Antibacterial activity of cinnamaldehyde and clove oil: effect on selected foodborne pathogens in model food systems and watermelon juice. J Food Sci Technol, 2015; 52: 5834–41. https://doi.org/10.1007/s13197-014-1642-x.
41. Shapira S, Pleban S, Kazanov D, Tirosh P, Arber N. Terpinen-4-ol: A Novel and Promising Therapeutic Agent for Human Gastrointestinal Cancers. PloS One, 2016; 11: e0156540. https://doi.org/10.1371/journal.pone.0156540.

42. Chan W-K, Tan LT-H, Chan K-G, Lee L-H, Goh B-H. Nerolidol: A Sesquiterpene Alcohol with Multi-Faceted Pharmacological and Biological Activities. Molecules, 2016; 21: 529. https://doi.org/10.3390/molecules21050529.