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Review on spice oil, oleoresins, and its applications

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Abstract
Spices have been utilised as culinary flavouring and traditional medicine worldwide since prehistoric times. This approach was used by ancient Egyptians. Phytochemicals including linalool, found in coriander, piperine, found in black pepper, cinnamaldehyde, found in cinnamon, and eugenol, found in cloves, have been extracted from their spices. Cinnamon contains cinnamaldehyde. Spices include strong antioxidants, which have several health benefits. These advantages include those that are good for the heart, don't cause cancer, mutations, or inflammation. Antioxidants are abundant in spices. Spice-derived essential oils fight bacteria, fungi, yeasts, and microbial toxins. Polyphenols in spices prevent bacteria, fungus, and yeasts from growing. This article reviews the latest studies on spices' phytochemical composition and antioxidant benefits, as well as the field's implications. The website also lists some of the seasonings with the greatest phytochemical contents.

Keywords: Antimicrobial activity black pepper, cardamom, chemistry, clove, ginger, garlic, medicinal and pharma logical activity

Introduction

Spices are a group of diverse crop products that improve the flavor and taste of human food as well as being widely used in cosmetics, fragrances, and pharmaceuticals (Ali *et al*., 2015) [8]. Due to their flavor and pungency, spices are crucial in creating delicious food (Mubeen *et al*., 2009) [69]. India has several inherent advantages over other nations when it comes to the production and consumption of spices, including a wide range of agro-climatic conditions for production, each spice being available in innumerable cultivars and variations that are suited to different climates, cost-effective labor, a significant domestic market, a long history of employing spices and their derivatives in cooking, health care, and cosmetics (Shinoj and Mathur, 2006) [94].

Since spices improve flavor and texture and can occasionally be used as preservatives, the majority of Indians and those living in the Indian subcontinent like using them in their food. Spice production and consumption are highest in India. The production and export of spices is a relatively small but important part of India's economy, and the country enjoys a comparative manufacturing advantage. India is the world's preeminent producer of spices. People use spices like paper, nutmeg, ginger, turmeric, garlic, cinnamon, onions, and cardamom, among others, all throughout the world (Shambharkar and Ghormare, 2017) [90].

According to the definition of spice, they are "vegetable substances used to flavor, season, and provide aroma to dishes" (FAO, 2005). It is possible to extract spices from flowers, leaves, fruits, roots, seeds, or bark. Spices are aromatic plant chemicals. These are dried plant parts, unlike "herbs," which are made from herbaceous (non-woody) plant leaves, they differ significantly from "Herbs" in a number of important ways (NCDEX, 2012) [71]. For thousands of years, people have employed spices, a class of culinary additives, to improve the flavor and sensory appeal of food. These spice ingredients give the cuisine its unique flavor, aroma, or piquancy in addition to color, and some may change the dish's texture (Nadkarni and Nadkarni, 1976) [70]. The Government of India's Spices Board has categorized spices into five main groups based on their origin.

Cardamom, ginger, and garlic are just a few of the 63 spices that are grown in India. This nation is also the birthplace of many other spices, including the 63 that are grown there. Invaders brought with them spices like vanilla, mace, nutmeg, cinnamon, clove, and chilies. India, which is renowned as the origin of spices, has a long history of trade with the prehistoric civilizations of Rome and China. Indian spices are currently the most in-demand globally due to their unmatched scent, texture, medicinal properties, and flavor.

Spices have the largest domestic market in the world in India. During the months of April to June 2016, India's total export of spices reached 226,225 tonnes, valued at US$621.78. This is a 3% year-over-year increase (Spices Board of India, 2016) [103].

A typical Indian currently spends 4.40 percent of their total food budget on spices, or 3.25 kilograms, per year. Whole spices or blends of spices are both consumed in India. Mixed spices account for 39% of Indian households' overall spice spending, per NSS statistics. The relative importance of spices is shifting throughout time as a result of shifting Indian households' eating patterns, preferences, and tastes (Srivastava, 2017) [106]. The acreage and production of spices for 2016–17 increased from the equivalent statistics a year before, according to the Department of Agriculture, Cooperation and Farmers Welfare's second advance estimate. Around 71 lakh tonnes of spices are expected to be produced, which is a 1.3% increase from the previous year (Gould, 2017) [34].

One of the most significant aspects that influence a consumer's meal choice is flavor. The development and use of flavors of the highest caliber are crucial components in the production and marketing of food products. Because they contain essential oils that are rich in flavor molecules, spices are a special type of commodity. Due to the high caliber of the little amounts of essential oil contained within them, they are in the concentrated form and have a characteristic flavor that depends on the essential oil's composition. Spice oil and oleoresins are significant flavoring sources. Spices are used in all forms of food and drink, including fish vegetable products, meat, bread, convenience meals, and beverages (SowBhagya, 2006) [101].

The cytoplasm of cells creates essential oils, which are tiny droplets located between cells. They smell and burn. They are mixtures of fragrant substances or fragrant and odorless compounds. A fragrant material is a chemically pure component that is volatile under normal conditions and can help society due to its perfume (Sonwa, 2000) [99].

Essential oils are rich in numerous bioactive components with antioxidative and antibacterial properties, making them a useful tool for extending the storage life of food goods. In spite of this, essential oils have shown promise as a natural alternative to synthetic preservatives (Juana and Manuel, 2018) [52].

Cinnamaldehyde is the most prevalent compound in bark essential oil, and its concentration can range from 90% to 62% to 73%, depending on the technique of extraction used-steam distillation has a higher concentration than Soxhlet extraction. Hydrocarbons and oxygenated chemicals make up the remaining minor volatile substances (i.e., Eugene acetate, B-caryophyllene, benzyl benzoate, cinnamyl acetate, and linalool). The main ingredients in cinnamon essential oil are caryophyllene and (E)-cinnamyl acetate, which is extracted from the fruit and blossoms of the spice (Jayaprakash *et al*., 1997) [49].

Types

Black pepper oil, olibanum resinoid parsley seed oil, zingiber oil, turmeric oil, coriander seed oil, ajowan seed oil, capsicum (chili) oil, cassia bark oil, cardamom oil, celery seed oil, white pepper oil, paprika oil, cinnamon bark oil, juniper berry oil, clove oil, cumin seed oil, date extract, nutmeg oil, fennel seed oil, ginger oil, mace oil, galangal oil.

The concentrated version of herbs and spices is known as oleoresins. Oleoresins can be manufactured using a variety of plant sources and from diverse plant sections. The principal components of the plant are:

- Fruit
- Seeds
- Roses and rhizomes

Major oleoresins include, among others

- Paprika (fruit)
- Curcuma (rhizome)
- Peppercorns (seeds)
- Ginger (rhizome)

Black pepper oleoresin *(Piper nigrum)*

Description

The Piperaceae family, which includes approximately 1000 species with a distribution in the tropics and subtropics, includes black pepper. It is also referred to as black gold, kaali-mirch, peppermint, and black pepper. India's coastal regions are where it first appeared, but today its plantations have spread to various regions of the world, including Brazil, Vietnam, Indonesia, Ceylon and Malaysia (Polovka and Suhaj, 2010; Srinivasan, 2008; Thanuja *et al*., 2002) [80, 104, 107].

Fig 1: Black pepper

Botany

Sizes of 8–20 cm in length and 4–12 cm in breadth for the simple, alternate leaves have been recorded (Sasikumar *et al*., 1992) [86]. The petiole grove is 2–5 cm in length. In India, black pepper plants begin to bloom 2 to 3 years after being planted in May through July, the south-east monsoon season. The lengths of the fruiting spikes range from 3 to 15 cm. The first blossom emerges on top of the spike 15–20 days after the spike's appearance and lasts for roughly 6–10 days. On plagiotropic branches, a pendulous spike emerges opposite the leaves in a glabrous inflorescence (Catchpole *et al*., 2003.) [17] While cultivated flowers are monoecious, blooms in the wild are typically dioecious. Black pepper primarily self-pollinates, while protogyny is also seen (Parthasarathy *et al*., 2007) [79].

Chemistry

Black pepper contains 0.16% phosphorus, 0.66% potassium (K), 0.16% magnesium and 0.20% calcium (Ca), as well as proteins 25.5%, fat 5.3%, fibres 23.6%, carbohydrates 37.4%, and moisture 4.7% (Pradeep *et al*., 1993; Al-Jasass, F. M., & Al-Jasser, M. S. 2012) [81, 9]. Black pepper includes terpenes

and nitrogen-containing compounds (Clery *et al*., 2006; Jagella, T., & Grosch, W. 1999) [19, 45]. The primary fragrance components of black pepper are myrcene, limonene, methyl propanol, phellandrene, 2- and 3-methylbutanal, linalool, 3-methylbutyric acid, and butyric acid. Black pepper's aftertaste of must and mould is brought on by the compounds 2,3-diethyl-5-methylpyrazine and 2-isopropyl-3-methoxypyrazine (van Ruth *et al*., 2019) [109]. Research using proton transfer reaction-mass spectrometry on forty white pepper and ninety black pepper samples revealed that the black pepper samples had significantly higher intensities for 41% (52 out of 128) of the masses (Jagella, T., & Grosch, W. 1999) [45]. Black pepper had larger amounts of most volatile organic compounds than white pepper, except for five low-intensity molecules: butanoic acid (m/z 89), its isotope (m/z 90), ethyl propionate (m/z 103), and methyl isovalerate (m/z 117) (Jagella, T., & Grosch, W. 1999) [45]. Because of these discoveries, we now know why white pepper has such a subtle flavour. Due to its light hue, white pepper is frequently used throughout Europe (Jin CQ *et al*., 2013) [50].
Black pepper includes 0.66% potassium (K), 0.20% calcium (Ca), 0.16% phosphorus, and 0.16% magnesium (Mg), as well carbs of 37.4%, proteins of 25.5%, fibres of 23.6%, moisture of 4.7%, and fat of 5.3% (Pradeep *et al*., 1993; Al-Jasass, F. M., & Al-Jasser, M. S. 2012) [81, 9]. Black pepper contains nitrogen-containing chemicals and terpenes (Clery *et al*., 2006) [19]. Black pepper's primary fragrance components are myrcene, phellandrene, limonene, linalool, methyl propanal, 2- and 3-methylbutanal, butyric acid, and 3-methylbutyric acid. 2,3-diethyl-5-methylpyrazine and 2-isopropyl-3-methoxypyrazine create black pepper's musty and mouldy aftertaste (van Ruth *et al*., 2019) [109]. Proton transfer reaction-mass spectrometry was used to compare 90 black pepper and 40 white pepper samples. The black pepper samples had higher intensities for 41% (52 out of 128) of the masses than the white pepper samples (Jagella, T., & Grosch, W. 1999) [45] [45]. Except for five low-intensity molecules-butanoic acid (m/z 89), its isotope (m/z 90), ethyl propionate (m/z 103), and methyl isovalerate (m/z 117)-most volatile organic compounds were found in black pepper at higher concentrations than in white pepper (Jagella, T., & Grosch, W. 1999) [45]. These findings explain white pepper's delicate taste. White pepper's light colour makes it popular in Europe (Jin CQ *et al*., 2013) [50].

Medicinal and pharmacological

Black pepper oil is laxative, antitoxic, aphrodisiac, antiseptic, rubefacient, antispasmodic, digestive, diuretic, tonic, and febrifuge (especially of the spleen).

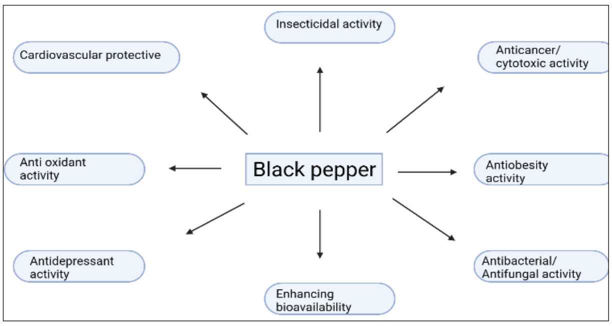

Fig 2: Medicinal and Pharmacological properties of black pepper

Anti-microbial activity

The proliferation and advent of pathogenic bacteria that are resistant to drugs has resulted in a reduction in the effectiveness of conventional antimicrobial therapy. Consequently, it is getting harder and harder to treat infections. Novel medicines must be developed to address this emerging problem while sparing currently used broad-spectrum antibiotics (Spaulding *et al*., 2018) [102].
Another research (Karsha and Lakshmi, 2010) [54] indicated that acetone extract was more effective than dichloromethane extract against a wide range of bacteria, with the largest antibacterial effect shown against S. aureus (ZOI 14-20 mm). Also, the methanolic extract was found to be effective against a variety for phytopathogenic fungi, with the greatest level of inhibition being seen against Puccinia recondite (Park *et al*., 2012) [77].

Cardamom *(Elettaria cardamomum)*

Description

Native of South Asia According to many sources (Akgul, 1993; El Malti *et al*., 2007; Rajan *et al*., 2017; Ashokkumar *et al*., 2020) [5, 22, 83, 10], *Elettaria cardamomum* L. is a perennial rhizomatous herbaceous plant that may grow to a height of 2-5 metres.

Fig 3: Cardamom

Botany

Southern Indian states, Malaysia, Sri Lanka, Guatemala, Tanzania, Mexico, Indonesia, Nepal, Costa Rica, and Costa costa are major producers. Evidence for this may be found in several studies (El Malti *et al*., 2007; Ashok kumar *et al*., 2020; Souissi *et al*., 2020) [22, 10, 100]. El Malti *et al.* (2007) [22] and Singh *et al*. (2008) [97] both note that Morocco is an important cardamom grower. In the southern region of India, between 900 and 1,400 metres in height, cardamom is farmed in protected areas termed Cardamom Hill Reserves that span a total area of 1050 square kilometres (Ashokkumar *et al*., 2020) [10]. About 30 to 35 centimetres in length and 10 to 15 centimetres across, an is lanceolate green or dark green with glabrous leaves are an impressive sight. White flowers decorate it. 120 days after blooming, triangle-shaped, oval, capsule-shaped fruits begin to develop. When fully ripe, fruit changes from a greenish hue to a golden or reddish hue. Each capsule may hold anywhere from 12 to 32 seeds, depending on the variety. Various authors (Akgul, 1993; Agaoglu *et al*., 2006; Rajan *et al*., 2017; Ashokkumar *et al*., 2020) [5, 3, 83, 10] use the terms "little," "green," and "real" cardamom to describe this spice.

Chemistry

Cardamom's signature aroma is created by the combination of two major ingredients: a-terpinyl acetate and 1,8-cineole (Olivero-Verbel *et al.*, 2010) [72]. Nerol, a-terpinyl acetate, terpineol, and geranyl acetate are the primary chemical components responsible for the oil's pleasant aroma and flavor, whereas 1,8-cineole is responsible for its unpleasant one. The volatile oil of E. cardamomum from Tehran (Iran) was analysed, and it was discovered that in along with terpinene and fenchyl alcohol, 1,8-cineole and -terpineol were found to be important components (Marongiu *et al*., 2004) [66]. Among the fatty acids, cardamom oil contains 30.8, 51.3 and 17.9 g/ 100 g of oil of total saturated fatty acids, total mono unsaturated fatty acid and total unsaturated fatty acid, respectively. The fatty acids and their breakdown products have a major role in several pathogen defense strategies in plants (Kachroo and Kachroo, 2009) [53]. Cardamom oil also contains several forms of tocopherols namely, α-tocopherol (10.4 mg/kg of oil), γ-tocopherol (4.3 mg/kg of oil) and δ-tocopherol (1.6 mg/kg of oil) (Parry *et al*., 2006) [78].

The volatile oil of E. cardamomum seeds sourced from southern India has concentrations of 1.8% cineole, 4.7% terpineol, 4.05% limonene, and 56.87% terpinyl acetate. (Savan and Kucukbay, 2013) [87]. The primary components of cardamom essential oils from various areas in India were reported to be 1,8-cineole (7.23-11.76%), 1,8-terpinyl acetate (61.65-68.10%), and 1,8-terpineol (2.91-5.51%) by Sharma *et al*. (2011) [93]. (Gochev *et al*., 2012) [32]. a-terpineol (9.8%), A-terpinyl acetate (44.3%), linalool (8.6%), and 1,8-cineole (10.7%), were found to be the primary components of Gorakhpur cardamom oil. In addition, 36.8 percent terpinyl acetate, 29.2 percent 1,8-cineole, 5.21 percent linalyl acetate, 3.91 percent sabinene, and 3.11 percent linalool were found in an extract of cardamom seeds from Guatemala (Singh *et al*., 2008) [97].

Medicinal and pharmacological properties

Cardamom has been used as a treatment for a wide variety of conditions since antiquity, including asthma, bronchitis, constipation, indigestion, dyspepsia, anorexia, vomiting, hypertension, ulcers, diarrhoea, epilepsy, gastrointestinal problems, and cardiovascular ailments by both Western and Eastern medical practitioners. Black cardamom is utilised similarly in Ayurvedic and Unani medicine for a wide variety of gastrointestinal, genitourinary, liver, and rectal problems and infections (Samir *et al*., 2015) [85].

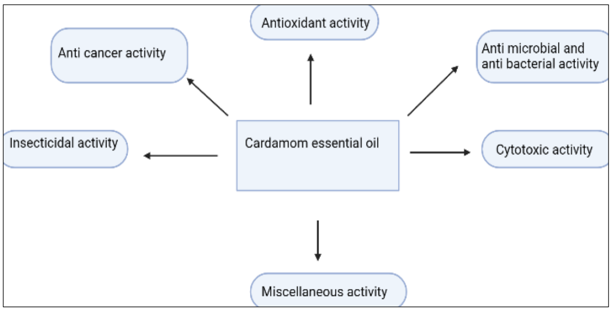

Fig 4: Medicinal and pharmalogical properties of cardamom

Antimicrobial activity

Compounds with antibacterial characteristics may be found in abundance in essential oils. According to (Faydaoglu & Surucuoglu, 2013) [25]. Extracts of any kind from fruit and seeds that were rich in essential oil were often employed in studies examining the cardamom plant's antibacterial effect. Most of these extracts have been shown to have antibacterial properties in a variety of *in vitro* studies, particularly against Escherichia coli, Staphylococcus aureus, and Bacillus cereus, three key pathogenic pathogens. This has been shown by many groups (Kubo *et al*., 1991; Singh *et al*., 2008; Ozkan *et al*., 2018) [56, 97, 75]. One research demonstrated that cardamom essential oil was effective in preventing the development of a variety of pathogenic and multi-antibiotic-resistant bacteria. This was shown to be the case (El Malti *et al*., 2007) [22]. Bacteria such as Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans, Prevotella intermedia, and Fusobacterium nucleatum were reported to be inhibited by cardamom fruit and seed extracts (Souissi *et al*., 2020) [100].

Other activities

According to (Jafri *et al*., 2001) [44], the fruits' crude methanolic extract has anti-ulcer action in albino rats. It has also been observed that the soluble fractions of petrol, methanol, and ethyl acetate are effective against ethanol-induced ulcers (Farah *et al*., 2005) [24], stomach ulcer risk reduced by 60% after using aspirin (Farah *et al*., 2005) [24], people with ischemic heart disease (IHD) who take medications that show hepato-protective action against ethanol-induced liver damage (Bisht *et al*., 2011) [12]. As a result, regular substantial cardamom consumption may have a number of positive health effects. This essay's lower portion on larger viewpoints discusses the advantages and usefulness of several things.

Clove *(Syzygium aromaticum L.)*

Description

Clove (*Syzygium aromaticum* L.) is a member of the Myrtaceae family (130-150 genera and 3000 species), one of the most widely used plant families in the food industry due to its distinctive organoleptic and medicinal characteristics (Devkota and Adhikari-Devkota, 2020) [20].

Fig 5: Clove

Botany

It's native to eastern Indonesia's Maluku islands, but it's now grown worldwide (Hussein *et al*., 2019). The clove tree contains a solitary, 1-2 cm long blossom and is made up of leaves and buds (Saeed *et al*., 2021). Kasai *et al*., (2016) outlined the clove flowering bud's development through three stages: 1, characterised by a green colour and the budding stage; 11, characterised by a pink colour and the flowering stage; and 11, characterised by a red colour and the fruiting stage. They also emphasised that the clove bud is at its most valuable when it is fully opened.

Chemistry

Hydroxybenzoic acids, Flavonoids, hydroxyphenyl propenes, and hydroxycinnamic acids, come from clove. The bioactive component in clove is eugenol, and its concentration varies from 9381.70 to 14650.00 mg per 100 g of new plant material. The highest concentration of phenolic acid is found to be gallic acid concentration (783.50 mg/100 g new weight). (Shan *et al.*, 2005) [91]. Also present in clove are the phenolic acids elagic, caffeic, salicylic, and ferulic. Kaempferol, quercetin, and its glycosilated derivatives are also present in trace levels. Aerial clove has significant essential oil. This oil's chemical composition is usually determined using GCMS (Hanif *et al.*, 2011; Hanif *et al.*, 2011; Shahzadi *et al.*, 2017; Javed *et al.*, 2012) [38, 9, 48]. Eugenol (70–85%), eugenyl acetate (10–15%), and beta-caryophyllene (5–12%) make up good clove bud's volatile oil (15–20%). Clove's pleasant scent comes from minor ingredients such α- and β-humulene, methyl amyl ketone, benzaldehyde, kaempferol, methyl salicylate, gallotannic acid, and crategolic acid (Mittal *et al.*, 2014) [68].

Medicinal and pharmacological uses

Therapeutic cooked cloves. Clove flavours onions, tomatoes, salads, herbal drinks, and soups. It flavours meats, biscuits, gums, pickles, spicy fruits, sandwiches, soft drinks, candies, puddings, chocolates, pastries, Soaps, toothpastes, and perfumes contain volatile oil. "Kretek" cigarettes are clove-tobacco. Clove destroys bacteria in mouthwashes, dental creams, throat sprays, and toothpaste. Toothache alleviation. Zinc oxide and eugenol temporarily cure cavities (Cai *et al.*, 1996) [16]. Clove flavonoids reduce edoema. Clove oil aromatherapy relieves arthritis. Honey heals skin. Water-clove paste cures wounds. Clove improves nausea, flatulence, and diarrhoea. Germ-fighting clove oil. Athletic foot heals. Clove oil treats asthma, colds, coughs, sinusitis, and bronchitis. Cloves cure lung and skin cancers. Clove lowers diabetics' glucose. Eugenol dissolves clots. Clove oil reduces cramping. Cloves slow retinal and muscle atrophy. Cloves relieve restlessness, headaches, and fatigue. Clove oil relieves migraines. Memory is improved by clove. anti-mosquito (Trongtokit *et al.*, 2005) [108]. Antioxidant cloves. Blueberries diminish clove oil 400-fold. Cloved animals. Clove oil treats dog and cat ear infections. Peppermint tea with cloves and ginger relieves dog vomiting three times a day.

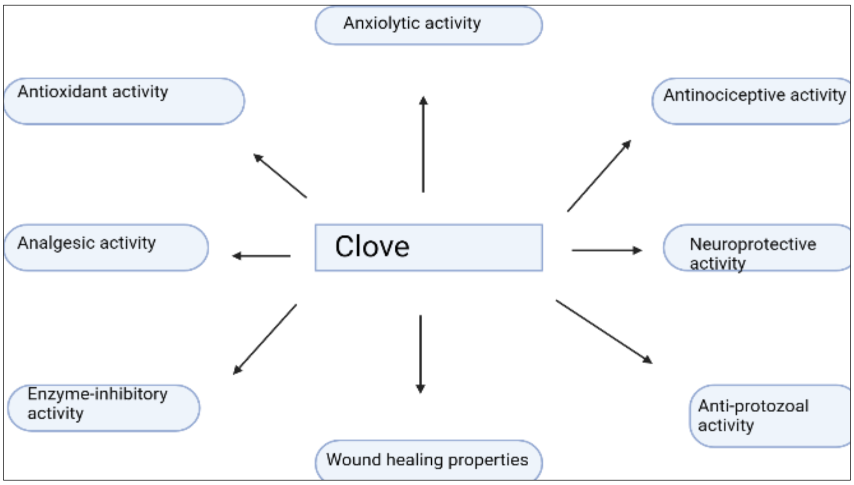

Fig 6: Medicinal and Pharmalogical properties of clove

Antimicrobial activity

The effectiveness of essential oils from the plant *Syzygium aromaticum* & Rosmarinus officinalis against multidrug-resistant distinguishes of Acinetobacter baumannii, Pseudomonas aeruginosa, Staphylococcus aureus, and Enterococcus feacalis, as well as ATCC27853 and ATCC29213 are both lab-grown strains. Both oils inhibited tested strains at Clove oil beginning at 0.312-1.25% (v/v) and rosemary oil from 0.312-5% (v/v) (Abdullah *et al.*, 2015) [2]. Clove extract (ethanolic) and clove oil were compared for antiseptic properties against food-borne microorganisms. Agar well diffusion examined 10 bacteria and 7 fungi. Standard food preservative was sodium propionate. Clove oil was more antimicrobial than enzyme and sodium propionate extract. In another investigation, five different dermophytes were pitted against clove oil. Microsporum canis, Trichophyton mentagrophytes, Trichophyton rubrum, Microsporum gypseum, and Epidermophyton floccosum. 0.2mg/ml inhibited all fungal strains by 60% (Park *et al.*, 2007) [76]. Using dilution, cup, and paper disc diffusion tests, the antibacterial properties of clove, mint, cinnamon, ginger, mustard, and garlic were evaluated within the organisms Escherichia coli, Bacillus cereus, and Staphylococcus aureus. Clove, mustard, and cinnamon inhibited best at 1%, 3% garlic inhibited. Comparable concentrations of mint and ginger showed little inhibitory effects. (Sofia *et al.*, 2007) [98]. Against 25 strains of bacteria, including those accountable for food-borne, animal, and plant illnesses, the antimicrobial properties of the essential oils of Myristica fragrans, *Piper nigrum*, Thymus vulgaris, *Syzygium aromaticum*, Origanum vulgare, and Pelargonium graveolens was evaluated. Volatile oils inhibited dose-dependently (Dorman and Deans 2000) [21].

Other effects of clove

The antiviral medication eugenin, extracted from clove buds, is effective at a 10 microliter/ml concentration in combating the Herpes simplex virus (Chaieb *et al.*, 2007) [18]. Other significant qualities of clove include its antipyretic (Feng and Lipton, 1987) [26], free radical scavenging (Gulcin *et al*., 2004; Jirovetz *et al*., 2006) [36, 51], anticancerous (Zheng *et al*., 1992) [112], antithrombotic (Srivastava, 1990), the reduction of inflammation (Ghelardini *et al*., 2001) [31] effects. Cloves add their value-added derivatives are widely used to flavor food and confections. Numerous industrial and medical uses exist for clove oil. So far, most research has concentrated on the volatile compounds found in cloves. In the food industry, their value as antiviral and antibacterial agents can be used.

GARLIC *(Allium sativum L.)*

Description

The garlic family, Allium, includes the species *Allium sativum* L. Allium and allied taxa' taxonomic placement has been up for debate for a while (Fritsch and Friesen, 2002) [30].

Fig 7: Garlic

Botany

With narrow, flat leaves and small, white blooms, garlic is a perennial bulbous plant that can withstand cold temperatures. Its height ranges from 30 to 100 cm (Janick, 1979) [47]. Unlike the hollow onion, which has a hollow shape, garlic is round, smooth, and solid the entire way along. The bloom stems of many garlic plants are absent. The cloves, also known as the small bulblets that make up the bulb, are encased in a papery white or pinkish substance that forms a thin sheath around the bulb. Cloves can range in size from 6 to 35 (Bose and Som, 1986) [15].

Chemistry

The major constituents of garlic are linoleic acid, alliin, selenium, ajoene, scordinins, diallyldisufide, allicin, diallylsulfide, and 2-vinyl- 4H-1,2 dithiin, (Li, 2010) [60]. Most of the sulphur found in whole garlic cloves is of two types found in equal quantities; glutamyl-S- alkylcysteines and s- alkylcysteine sulfoxides The most abundant sulphur compound in garlic is allin (S-allylcysteine sulfoxide), which is present at 10 mg/g in fresh garlic or 30 mg/g dry (Lawson, 1998) [59]. Garlic is composed of very strong organosulfur compounds that serve as secondary metabolites. These compounds are responsible for the pungent smell and taste of raw garlic and act as defence against predators (Block, 2010).

Medicinal properties

The therapeutic properties of garlic come straight from nature. More than two hundred unique compounds are found in garlic, and they have the potential to shield the human body against a broad range of ailments. It has anti-tumor effects and may destroy germs and fungus as well as reduce blood pressure, cholesterol, and blood sugar levels. In addition, it strengthens the immune system, which aids in the preservation of wellness (Abdullah *et al*., 1988) [1]. The lymphatic system may be boosted, which speeds up the elimination of waste. Stroke, Cancer, virus infections, and heart disease are all preventable thanks to the protective effects of antioxidants, which neutralize dangerous free radicals. Garlic's Sulphur-containing components shield the body by increasing the synthesis of helpful digestive enzymes (Mansell and Reckless, 1991) [65].

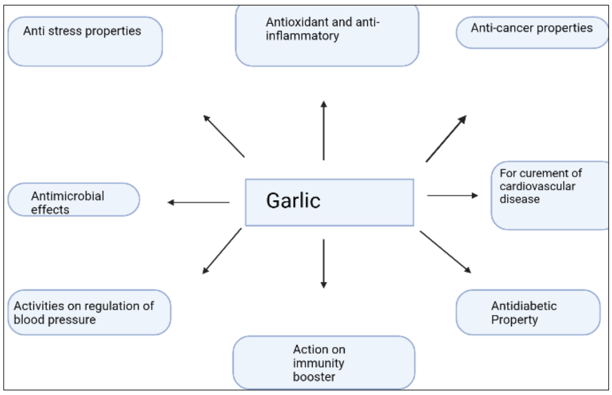

Fig 8: Medicinal and Pharmalogical properties of garlic

Antimicrobial properties

Antibacterial and antifungal properties of garlic have been studied extensively (Guo 2014; Shang *et al*., 2019; Liu *et al*., 2017) [37, 92, 63]. Specifically, the Campania region of Italy's "Rosato" and "Caposele" garlic varieties were studied for their antibacterial properties. Although both varieties inhibited Aspergillus versicolor and Penicillium citrinum, a Rosato was diversity prevented Penicillium expansum more effectively than the Caposele variety (Fratianni *et al*., 2016) [29]. Furthermore, Burkholderia cepacia was effectively inhibited by AGE (Wallock-Richards *et al*., 2014) [110]. The growth of Staphylococcus aureus, Escherichia coli, and Bacillus subtilis were all stymied by garlic oil (Guo, 2014) [37]. By penetrating cells and organelles, disabling cellular structure, and releasing cytoplasm and macromolecules, garlic oil was able to inhibit the growth of Penicillium funiculosum (Li *et al*., 2014) [62]. The activation of essential genes involved in the process of oxidative phosphorylation, the cell's life cycle, and the breakdown of proteins in the endoplasmic reticulum was also linked to garlic oil's ability to disrupt normal Candida albicans metabolism (Li *et al*., 2016) [61]. The stomach bacteria Helicobacter pylori was inhibited by raw garlic treatment in a clinical trial (Zardast *et al*., 2016) [111]. Garlic's ability to kill germs depends on the variety and method of preparation used. Garlic oil is the primary antibacterial agent, and it works by disrupting the cellular structure and metabolic processes of bacteria.

Ginger *(Zingiber Officinale)*

Description

Among the most well-known types of the genus Zingiber is the ginger rhizome. The most common spice from the Zingiberaceae family, used to flavour food and drink. Ginger has been used for several purposes throughout history. Health issues, digestive aid, and the alleviation of stomach queasy feelings. Ginger is a perennial herb with a tuberous root. The stems are straight, angled, round, and connected to a rhizome. Soft, one-meter-tall leaf sheaths are responsible for the yearly outlay. Fresh slices of ginger candy, ginger powder, crystallised ginger, ginger rhizome, and ginger syrup are all common uses for this versatile root. Fresh ginger is used in a wide range of Chinese and Indian cuisines, including both meat and vegetable dishes, as well as drinks and other culinary preparations (Shukla and Singh, 2006) [96]. Ginger's is a natural dietary item that has been shown to reduce inflammation and fight cancer (Nalini and Manju 2005) [64].

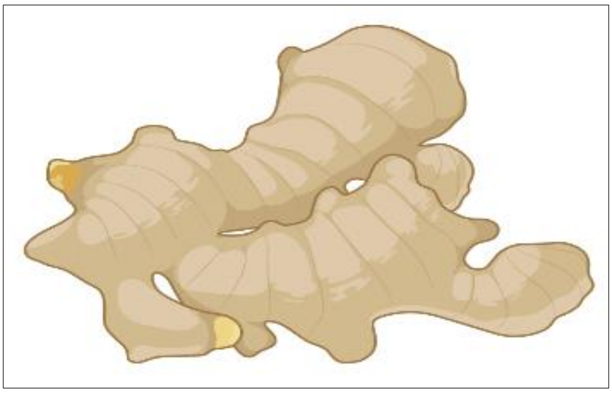

Fig 9: Ginger

Botany

Depending on the cultivar and environmental conditions, rhizomes may be anywhere from 7-15 cm in length and 1-1.5 cm in width (Awang 1992; Bisset and Wichtl 1994) [11, 13]. The outer surface is buff in colour and longitudinal striated or fibrous. Ginger is grown commercially in India, Mexico, China, Southeast Asia, West Indies, and other locations. The ginger varieties Nadia, Himgiri, Suruchi, China, Ernad, Surabi, Maran, Suprabha, and varad, all have great potential. In contrast to IISR Rejatha, which is rich in essential oil, IISR Varada is ideal for use with fresh ginger, dried ginger, and sweets.

Chemistry

Ginger contains a number of active compounds, such terpenes and oleoresin (also known as ginger oil). Oleoresin, a non-volatile spicy component, and volatile oils account for another 1% to 3% of ginger (Zick *et al*., 2008) [113]. Sesqui-terpene hydrocarbons and phenolic chemicals like gingerol and shogaol have been isolated from terpene (Hasan *et al*., 2012) [40], and preparations of the lipophilic rhizome have produced potentially active gingerols that can be transformed into shogaols, zingerone, and paradol. There are more than 400 chemicals found in ginger, with Terpenes, carbohydrates (50-70%), phenolic compounds, and lipids (3%-8%) making up the bulk of the rhizomes (Grzanna *et al*., 2005) [35]. Farnesene, curcumene, Zingiberene, sesquiphellandrene, and bisabolene are all terpenes found in ginger, whereas ginger paradols and shogaol are phenolic chemicals. The volatile oils gingerols (23-25%) and shogaol (18-25%) make up the majority of the spice's volatiles and are responsible for its distinctive aroma and taste. Minerals, vitamins (including nicotinic acid and vitamin A), and amino acids additionally exist (Langner *et al.* 1998; Shukla and Singh 2007) [57, 95]. Zingiberene and bisabolene are examples of the aromatic compounds. Other compounds related to gingerol or shogaol (1-10%) have been reported in ginger rhizome, such as 6-gingerdiol, 6-gingerdione, 10-gingerdiol, 4-gingerdiol, 6-paradol, diaryl-heptanoids, 1-dehydrogingerdione, 8-gingerdiol, and 10-gingerdione (Michiein *et al*.2009, Elaissi *et al*. 2011, Hossain *et al.* 2011) [67, 23, 41].

Medicinal and Pharmacological Properties

The pharmacological effects of ginger-based herbal medicines have been established. Ayurvedic texts by Vagbhata, Charaka, Chakra-dutta, and Sushruta among others, all have descriptions of a plant they call Sunthi. In pharmacology, the drug is the dried medicinal component of the plant, which is referred to as an appetiser in ayurveda. Historically, ginger has been used to alleviate a wide range of medical issues, including those related to the digestive system (Gosh *et al*. 2011, Latona *et al*. 2012, Grzanna *et al*. 2005) [33, 58, 35]: arthritis, nausea, flu-like, colic, vomiting, menstrual cycle, diarrhoea, rheumatism, cardiac problems, dyspepsia like symptoms. Its pungent flavour, pleasant scent, and high oleoresin concentration have made it a sought-after spice ingredient across the globe (Onwuka *et al*., 2002) [73]. Soaps and cosmetics utilise it for aroma, and it's also used to add taste to food and drink (Alam, 2013) [6]. The anti-nausea effects of ginger are assumed to come from the spice's direct effect on the digestive tract. Thus, it is employed to forestall sickness prior to motion sickness, chemotherapy, and surgical procedures. It has been widely used to treat morning sickness in pregnant women (Langner *et al*., 1998) [57]. To improve digestion, ginger is used for diarrhoea, nausea, bloating, dyspepsia, vomiting, heartburn, flatulence, gas, and lack of appetite (pain or discomfort after eating). Warming ginger has antiviral properties that make it useful for treating the common cold and influenza (Qidwai *et al*., 2003) [82].

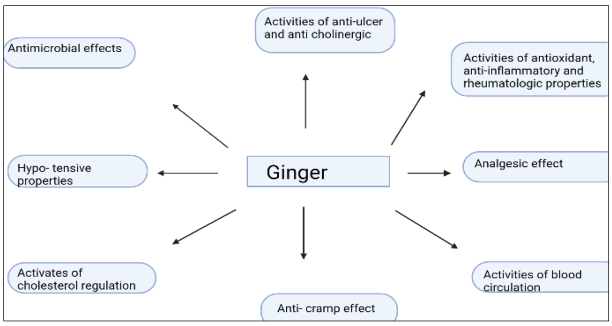

Fig 10: Medicinal and pharmalogical properties of ginger

Antimicrobial activity

Although Penicillium brevicompactum builds on ginger root causing languish throughout storage after harvest (Overy and Frisvad 2005) [74], ginger has been indicated to have an antibacterial properties particularly against certain Staphylococci species as well as displays antifungal properties with a broad spectrum of fungal organisms including Candida albicans. Researchers showed that ginger's antibacterial efficacy was greatest against Salmonella spp. and weakest against Escherichia coli, respectively (Islam *et al*., 2014) [43]. Ginger extract was more effective against most Gram-negative bacteria than it was against Staphylococcus aureus.

Conclusion

Spices contain sulphur, alkaloids, phenolic chemicals, phenolic diterpenes, vitamins, and tannins. Spices have phenolic diterpenes. However, these species' chemical structures and biological activities are complicated. This article shows that spices' antioxidants help combat chronic diseases. Spices are anticarcinogenic, cardioprotective, anti-inflammatory, antihyperglycemic, antioxidant, digestive stimulant, and antibacterial. Bioactive component characterization and clinical human model pharmacological effects are needed. Spice phytochemicals reduce food spoilage and disease. Spices and essential oils can taste edible or biodegradable items or coat active food packaging. Product use improves.

References

1. Abdullah TH, Kandil O, Elkadi A, Carter J. Garlic revisited: therapeutic for the major diseases of our times? J Natl Med Assoc. 1988;80:439-445.
2. Abdullah BH, Hatem SF, Jumaa W. A comparative study of the antibacterial activity of clove and rosemary essential oils on multidrug resistant bacteria. Pharmaceutical and Biosciences Journal; c2015. p. 18-22.
3. Ağaoğlu S, Dostbil N, Alemdar S. Antimicrobial effect of seed extract of cardamom (*Elettaria cardamomum* Maton). YÜ Vet Fak Derg. 2006;16(2):99-101.
4. Ahmed LI, Ibrahim N, Abdel-Salam AB, Fahim KM. Potential application of ginger, clove and thyme essential oils to improve soft cheese microbial safety and sensory characteristics. Food Bioscience. 2021;42:101177.
5. Akgül A. Baharat bilimi ve teknolojisi. Gıda Teknolojisi Derneği Yayınları. 1993;15:111-113.
6. Alam P. Densitometric HPTLC analysis of 8-gingerol in Zingiber officinale extract and ginger containing dietary supplements, teas and commercial creams. Asian Pacific J Trop Biomedicine. 2013;3(8):634-638.
7. Ali BH, Blunden G, Tanira MO, Nemmar A. Some phyto-chemical, pharmacological and toxicological properties of ginger (Zingiber officinale Roscoe): a review of recent research. Food Chem Toxicology. 2008;46(2):409-420.
8. Ali N, Hashim NH, Shuib NS. Natural occurrence of aflatoxins and ochratoxin A in processed spices marketed in Malaysia. Food Additives & Contaminants: Part A. 2015;32(4):518-532.
9. Al-Jasass FM, Al-Jasser MS. Chemical composition and fatty acid content of some spices and herbs under Saudi Arabia conditions. The scientific world journal; c2012.
10. 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;246:112244.
11. Awang DVC. Ginger. Canad Pharma J. 1992;125:309-311.
12. Bisht VK, Negi JS, Bhandari AK, Sundriyal RC. Amomum subulatum Roxb: Traditional, phytochemical and biological activities-An overview. African J Agric Res. 2011;6(24):5386-5390. DOI: 10.5897/AJAR11.745
13. Bisset NG, Wichtl M. Herbal Drugs and Phytopharmaceuticals- A handbook for practice on a scientific basis. Wichtl M, Bisset NG (eds.), Boca Raton, FL: CRC Press; c1994.
14. Block E, Dane AJ, Thomas S, Cody RB. Applications of direct analysis in real time mass spectrometry (DART-MS) in Allium chemistry. 2-Propenesulfenic and 2-propenesulfinic acids, diallyl trisulfane S-oxide, and other reactive sulfur compounds from crushed garlic and other Alliums. Journal of agricultural and food chemistry. 2010;58(8):4617-4625.
15. Bose TK, Som MG. Vegetable crops in India; c1986.
16. Cai L, Wu CD. Compounds from *Syzygium aromaticum* possessing growth inhibitory activity against oral pathogens. Journal of natural products. 1996;59(10):987-990.
17. Catchpole OJ, Grey JB, Perry NB, Burgess EJ, Redmond WA, Porter NG. Extraction of chili, black pepper, and ginger with near-critical CO2, propane, and dimethyl ether: analysis of the extracts by quantitative nuclear magnetic resonance. Journal of Agricultural and Food Chemistry. 2003;51(17):4853-4860.
18. Chaieb K, Hajlaoui H, Zmantar T, Kahla-Nakbi AB, Rouabhia M, Mahdouani K, *et al*. The chemical composition and biological activity of clove essential oil, Eugenia caryophyllata (*Syzygium aromaticum* L. Myrtaceae): a short review. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 2007;21(6):501-506.
19. Clery RA, Hammond CJ, Wright AC. Nitrogen-containing compounds in black pepper oil (*Piper nigrum* L.). Journal of Essential Oil Research. 2006;18(1):1-3.
20. Devkota HP, Adhikari-Devkota A. Cold pressed clove (*Syzygium aromaticum*) oil. In Cold Pressed Oils. Academic Press; c2020. p. 273-276.
21. Dorman HD, Deans SG. Antimicrobial agents from plants: antibacterial activity of plant volatile oils. Journal of applied microbiology. 2000;88(2):308-316.
22. El Malti J, Mountassif D, Amarouch H. Antimicrobial activity of *Elettaria cardamomum*: Toxicity, biochemical and histological studies. Food chemistry. 2007;104(4):1560-1568.
23. Elaissi A, Salah K, Mabrouk S, Larbi K, Chemli R. Antibacterial activity and chemical composition of 20 Eucalyptus species essential oils. Food Chem. 2011;129:1427-1434.
24. Farah AJ, Siddiqui A, Aslam M, Javed K, Jafri MA. Antiulcerogenic activity of *Elettaria cardamomum* Maton. and Amomum subulatum Roxb. seeds. Indian J Tradit Know. 2005;4(3):298-302.
25. Faydaoğlu E, Energin E, Sürücüoğlu MS. Ankara Üniversitesi Sağlık Bilimleri Fakültesinde okuyan öğrencilerin kahvaltı yapma alışkanlıklarının saptanması. Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi. 2013;2(3):299-311.
26. Feng J, Lipton JM. Eugenol: antipyretic activity in rabbits. Neuropharmacology. 1987;26(12):1775-1778.
27. Ficker CE, Arnason JT, Vindas PS, Alvarez LP, Akpagana K, Smith Ml. Inhibition of human pathogenic fungi by ethno-botanically selected plant extracts. Mycoses. 2003;46(1-2):29.
28. Food and Agriculture Organization, Herbs, spices and essential oils: post-harvest operations in developing

countries, by M. Douglas, J. Heyes and B. Smallfield, Rome; c2005.
29. Fratianni F, Riccardi R, Spigno P, Ombra MN, Cozzolino A, Tremonte P, *et al*. Biochemical characterization and antimicrobial and antifungal activity of two endemic varieties of garlic (*Allium sativum* L.) of the campania region, southern Italy. Journal of medicinal food. 2016;19(7):686-691.
30. Fritsch RM, Friesen N. Evolution, domestication and taxonomy. In Allium crop science: recent advances Wallingford UK: CABI publishing; c2002. p. 5-30.
31. Ghelardini C, Galeotti N, Di Cesare Mannelli L, Mazzanti G, Bartolini A. Local anaesthetic activity of beta-caryophyllene. Farmaco (Societa chimica italiana 1989) 2001;56(5-7):387-389.
32. Gochev V, Girova T, Stoilova I, Atanasova T, Nenov N, Stanchev V, *et al*. Low temperature extraction of essential oil bearing plants by liquefied gases. 7. Seeds from cardamom (*Elettaria cardamomum* (L.) Maton). Journal of BioScience & Biotechnology, 2012, 1(2).
33. Gosh AK, Banerjee S, Mullick HI, Banerjee J. Zingiber Officinale: a natural gold. Int; c2011.
34. Gould GW. (ed.), New methods of food preservation, 1st ed. Blackie Academic & Professional, London. United News of India; c2017.
35. Grzanna R, Lindmark L, Frondoza C. Ginger-a herbal medicinal product with broad anti-inflammatory actions. J Medicine Food. 2005;8(2):125-132.
36. Gülçin İ, Şat İG, Beydemir Ş, Elmastaş M, Küfrevioğlu Öİ. Comparison of antioxidant activity of clove (Eugenia caryophylata Thunb) buds and lavender (*Lavandula stoechas* L.). Food chemistry. 2004;87(3):393-400.
37. Guo Y. Experimental study on the optimization of extraction process of garlic oiland its antibacterial effects. African Journal of Traditional, Complementary and Alternative Medicines. 2014;11(2):411-414.
38. Hanif MA, Al-Maskari MY, Al-Maskari A, Al-Shukaili A, Al-Maskari AY, Al-Sabahi JN. Essential oil composition, antimicrobial and antioxidant activities of unexplored Omani basil. Journal of Medicinal Plants Research. 2011;5(5):751-757.
39. Hanif MA, Al-Maskri AY, Al-Mahruqi ZMH, Al-Sabahi JN, Al-Azkawi A, Al-Maskari MY. Analytical evaluation of three wild growing Omani medicinal plants. Natural product communications. 2011;6(10):1934578X110060-1010.
40. Hasan HA, Rasheed Raauf AM, Abd Razik BM, Rasool Hassan BA. Chemical composition and antimicrobial activity of the crude extracts isolated from Zingiber officinale by different solvents. Pharmaceut Anal Acta. 2012;3:184.
41. Hossain MA, Shah MD, Sang SV, Sakari M. Chemical composition and antibacterial properties of the essential oils and crude extracts of Merremia borneesis. J King Saud Univ-Sci. 2011;24:243-249.
42. Hussein MM, Abd El-Hack ME, Mahgoub SA, Saadeldin IM, Swelum AA. Effects of clove (*Syzygium aromaticum*) oil on quail growth, carcass traits, blood components, meat quality, and intestinal microbiota. Poultry science. 2019;98(1):319-329.
43. Islam K, Rowsni AA, Khan M, Kabir MS. Antimicrobial activity of ginger (Zingiber officinale) extracts against food-borne pathogenic bacteria. Int J Sci, Environment Technol. 2014;3(3):867-871.
44. Jafri MA, Farah KJ, Singh S. Evaluation of the gastric antiulcerogenic effect of large cardamom (fruits of Amomum subulatum Roxb.). J Ethnopharmocol. 2001;75:89-94. DOI: 10.1016/S0378-8741(00)00398-6
45. Jagella T, Grosch W. Flavour and off-flavour compounds of black and white pepper (*Piper nigrum* L.) III. Desirable and undesirable odorants of white pepper: III. Desirable and undesirable odorants of white pepper. European Food Research and Technology. 1999;209:27-31.
46. Jagella T, Grosch W. Flavour and off-flavour compounds of black and white pepper (*Piper nigrum* L.) II. Odour activity values of desirable and undesirable odorants of black pepper: II. Odour activity values of desirable and undesirable odorants of black pepper. European Food Research and Technology. 1999;209:22-26.
47. Janick J. Horticultural science, Freeman & Co., San Fransisco; c1979. p. 544.
48. Javed S, Mushtaq S, Khokhar I, Ahmad R, Haider MS. Comparative antimicrobial activity of clove and fennel essential oils against food borne pathogenic fungi and food spoilage bacteria. African Journal of Biotechnology. 2012;11(94):16065-16070.
49. Jayaprakasha GK, Singh RP, Pereira J, Sakariah KK. Limonoids from Citrus reticulata and their moult inhibiting activity in mosquito Culex quinquefasciatus larvae. Phytochemistry. 1997;44(5):843-846.
50. Jin CQ, Jia YX, Dong HX, Zhou JW, Sun GF, Zhang YY, *et al*. Stir-fired white pepper can treat diarrhea in infants and children efficiently: a randomized controlled trial. Am J Chin Med. 2013;41(4):765-772.
51. Jirovetz L, Buchbauer G, Stoilova I, Stoyanova A, Krastanov A, Schmidt E. Chemical composition and antioxidant properties of clove leaf essential oil. Journal of agricultural and food chemistry. 2006;54(17):6303-6307.
52. Juana FL, Manuel VM. Introduction to the special issue: application of essential oils in food systems. Foods. 2018;7(56):1-4.
53. Kachroo A, Kachroo P. Fatty Acid-derived signals in plant defense. Annu Rev Phytopathol. 2009;47:153-176.
54. Karsha PV, Lakshmi OB. Antibacterial activity of black pepper (*Piper nigrum* Linn.) with special reference to its mode of action on bacteria; c2010.
55. Kasai H, Shirao M, Ikegami-Kawai M. Analysis of volatile compounds of clove (*Syzygium aromaticum*) buds as influenced by growth phase and investigation of antioxidant activity of clove extracts. Flavour and Fragrance Journal. 2016;31(2):178-184.
56. Kubo I, Himejima M, Muroi H. Antimicrobial activity of flavor components of cardamom *Elettaria cardamomum* (Zingiberaceae) seed. Journal of agricultural and food chemistry. 1991;39(11):1984-1986.
57. Langner E, Greifenberg S, Gruenwald J. Ginger: history and use. Adv Therapy. 1998;15(1):25-44.
58. Latona DF, Oyeleke GO, Olayiwada OA. Chemical analysis of ginger root. IOSR J Applied Chem. 2012;1(1):47-49
59. Lawson LD. Garlic: a review of its medicinal effects and indicated active compounds. Blood. 1998;179:62.
60. Li R, Chen W.-C, Wang W.-P, Tian W.-Y, Zhang X.-G.

Extraction of Essential Oils from Garlic (*Allium sativum*) Using Ligarine as Solvent and Its Immunity Activity in Gastric Cancer Rat. Med. Chem. Res. 2010;19:1092-1105. [Google Scholar] [CrossRef]
61. Li WR, Shi QS, Dai HQ, Liang Q, Xie XB, Huang XM, *et al*. Antifungal activity, kinetics and molecular mechanism of action of garlic oil against Candida albicans. Scientific reports. 2016;6(1):22805.
62. Li WR, Shi QS, Liang Q, Huang XM, Chen YB. Antifungal effect and mechanism of garlic oil on Penicillium funiculosum. Applied microbiology and biotechnology. 2014;98:8337-8346.
63. Liu Q, Meng X, Li Y, Zhao CN, Tang GY, Li HB. Antibacterial and antifungal activities of spices. International journal of molecular sciences. 2017;18(6):1283.
64. Manju V, Nalini N. Chemopreventive efficacy of ginger, a naturally occurring anticarcinogen during the initiation, post-initiation stages of 1, 2 dimethylhydrazine-induced colon cancer. Clinica Chimica Acta. 2005;358(1-2):60-67.
65. Mansell P, Reckless JP. Garlic. BMJ: British Medical Journal. 1991;303(6799):379.
66. Marongiu B, Piras A, Porcedda S. Comparative analysis of the oil and supercritical CO2 extract of *Elettaria cardamomum* (L.) Maton. Journal of Agricultural and food chemistry. 2004;52(20):6278-6282.
67. Michiein EM, Salvador AA, Reihi CA, Smania AJr, Smania EF. Chemical composition and antibacterial activity of Cordia veribenacea extracts obtained by different methods. Bioresource Tech. 2009;100:6615-6623.
68. Mittal M, Gupta N, Parashar P, Mehra V, Khatri M. Phytochemical evaluation and pharmacological activity of *Syzygium aromaticum*: a comprehensive review. Int J Pharm Pharm Sci. 2014;6(8):67-72.
69. Mubeen H, Naeem I, Taskeen A, Saddiqe Z. Investigations of heavy metals in commercial spices brands. New York Science Journal. 2009;2(5):155-200.
70. Nadkarni KM, Nadkarni AK. Indian Materia Medica, Mumbai, India: Popular Prakashan Pvt. 1976.
71. NCDEX, Spice Fundamental Report; c2012.
72. Olivero-Verbel J, González-Cervera T, Guette-Fernandez J, Jaramillo-Colorado B, Stashenko E. Chemical composition and antioxidant activity of essential oils isolated from Colombian plants. Braz J Pharmacogn. 2010;20:568-574.
73. Onwuka GI, Nwokoha GU, Asumugha GN. Evaluation of processing methods for the production of ginger drinks. Proceedings of 26th Annual NIFST Conference, Owerri; c2002.
74. Overy DP, Frisvad JC. Mycotoxin Production and Postharvest Storage Rot of Ginger (Zingiber officinale) by Penicillum brevibacterium. J Food Prot. 2005;68(3):607-609
75. Özkan OE, Olgun Ç, Güney B, Mahmut GÜR, Güney K, Saim ATEŞ. Chemical composition and antimicrobial activity of Myristica fragrans & *Elettaria cardamomum* essential oil. Kastamonu University Journal of Forestry Faculty. 2018;18(2):225-229.
76. Park MJ, Gwak KS, Yang I, Choi WS, Jo HJ, Chang JW, *et al*. Antifungal activities of the essential oils in *Syzygium aromaticum* (L.) Merr. Et Perry and Leptospermum petersonii Bailey and their constituents against various dermatophytes. Journal of Microbiology. 2007;45(5):460-465.
77. Park UH, Jeong HS, Jo EY, Park T, Yoon SK, Kim EJ, *et al*. Piperine, a component of black pepper, inhibits adipogenesis by antagonizing PPARγ activity in 3T3-L1 cells. Journal of agricultural and food chemistry. 2012;60(15):3853-3860.
78. Parry J, Hao Z, Luther M, Su L, Zhou K, Yu L. Characterization of cold-pressed onion, parsley, cardamom, mullein, roasted pumpkin, and milk thistle seed oils. J Am Oil Chem Soc. 2006;83:847-854.
79. Parthasarathy VA, Sasikumar B, Nair RR, George KJ. Black Pepper: Botany and Horticulture. In; Hort Rev. 2007;33:173-266.
80. Polovka M, Suhaj M. The effect of irradiation and heat treatment on composition and antioxidant properties of culinary herbs and spices-A review. Food Reviews International. 2010;26(2):138-161.
81. Pradeep KU, Geervani P, Eggum BO. Common Indian spices: nutrient composition, consumption and contribution to dietary value. Plant foods for human nutrition. 1993;44:137-148.
82. Qidwai W, Alim SR, Dhanani RH, Jehangir S, Nasrullah A, Raza A. Use of folk remedies among patients in Karachi Pakistan. J Ayub Medical College Abbottabad. 2003;15(2):31-33.
83. Rajan A, Rajan AR, Philip D. *Elettaria cardamomum* seed mediated rapid synthesis of gold nanoparticles and its biological activities. OpenNano. 2017;2:1-8.
84. Saeed M, Khan MS, Alagawany M, Farag MR, Alqaisi O, Aqib AI, *et al*. Clove (*Syzygium aromaticum*) and its phytochemicals in ruminant feed: an updated review. Rendiconti lincei. Scienze fisiche e naturali. 2021;32:273-285.
85. Samir Q, Sasikumar D, Moez AF. Chemopreventive effect of cardamom (*Elettaria cardamomum* L.) against benzo (a) pyrene-induced forestomach papillomagenesis in Swiss Albino Mice. J Environ Pathol Toxicol Oncol. 2015;34(2):95-104.
86. Sasikumar B, George JK, Ravindran PN. Breeding behaviour of black pepper. Indian Journal of Genetics and Plant Breeding. 1992;52(01):17-21.
87. Savan EK, Küçükbay FZ. Essential oil composition of *Elettaria cardamomum* Maton. Journal of Applied Biological Sciences. 2013;7(3):42-45.
88. Sen S, Chakraborty R, De B, Mazumder J. Plants and phytochemicals for peptic ulcer: An overview. Pharmacognosy Reviews. 2009;3(6):270.
89. Shahzadi I, Nadeem R, Hanif MA, Mumtaz S, Jilani MI, Nisar S. Chemistry and biosynthesis pathways of plant oleoresins: Important drug sources. International Journal of Chemical and Biochemical Sciences. 2017;12:18-52.
90. Shambharkar AC, Ghormare NV. Identification and Quantification of Active Chemical Compounds from Daily Used Spices by GC-MS. International Journal of Pharmacy and pharmaceutical research. 2017;10(2):1-8.
91. Shan B, Cai YZ, Sun M, Corke H. Antioxidant capacity of 26 spice extracts and characterization of their phenolic constituents. Journal of Agricultural and Food Chemistry. 2005;53:7749-7759.
92. Shang A, Cao SY, Xu XY, Gan RY, Tang GY, Corke H, *et al*. Bioactive compounds and biological functions of

garlic (*Allium sativum* L.). Foods. 2019;8(7):246.
93. Sharma S, Sharma J, Kaur G. Therapeutic uses of Elettaria cardomum. International journal of drug formulation and research. 2011;2(6):102-108.
94. Shinoj P, Mathur VC. Analysis of demand for major spices in India. Agricultural Economics Research Review. 2006;19(2):367-376.
95. Shukla Y, Singh M. Cancer preventive properties of ginger: a brief review. Food Chemical Toxicol. 2007;45(5):683-690.
96. Shukla Y, Singh M. Cancer preventive properties of ginger: a brief review. Food and chemical toxicology: an international journal published for the British Industrial Biological Research Association. 2006;45(5):683-690.
97. 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;88(2):280-289.
98. Sofia PK, Prasad R, Vijay VK, Srivastava AK. Evaluation of antibacterial activity of Indian spices against common foodborne pathogens. International journal of food science & technology. 2007;42(8):910-915.
99. Sonwa MM. Isolation and Structure Elucidation of Essential Oil Constituents. Comparative Study of the Oils of Cyperus alopecuroides, Cyperus papyrus, and Cyperus rotundus. Ph.D. degree, University of Hamburg, Germany; c2000.
100. 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.
101. Sowbhagya HB. Newer Chemical & Technological Approaches for the Preparation of Flavourant in Selected Spices (Doctoral dissertation, University of Mysore); c2006.
102. Spaulding CN, Klein RD, Schreiber IVHL, Janetka JW, Hultgren SJ. Precision antimicrobial therapeutics: the path of least resistance?. NPJ biofilms and microbiomes. 2018;4(1):4.
103. Spices Board of India. Spices Industry in India, Export of Spices From Indian Spices Market; c2016.
104. Srinivasan K. Reason to season: spices as functional food adjuncts with multiple health effects. Indian Food Industry. 2008;27(5):36-47.
105. Srivastava KC. Antiplatelet components from common food spice clove (Eugenia caryophyllata) and their effects on prostanoid metabolism. Planta Medica. 1990;56(06):501-502.
106. Srivastava S. Changing consumption pattern of spices across India. In Spices Handbook; c2017. p. 54-58.
107. Thanuja TV, Hegde RV, Sreenivasa MN. Induction of rooting and root growth in black pepper cuttings (*Piper nigrum* L.) with the inoculation of arbuscular mycorrhizae. Scientia Horticulturae. 2002;92:339-346.
108. Trongtokit Y, Rongsriyam Y, Komalamisra N, Apiwathnasorn C. Comparative repellency of 38 essential oils against mosquito bites. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 2005;19(4):303-309.
109. Van Ruth SM, Silvis IC, Ramos ME, Luning PA, Jansen M, Elliott CT, *et al*. A cool comparison of black and white pepper grades. Lwt. 2019;106;122-127.
110. Wallock-Richards D, Doherty CJ, Doherty L, Clarke DJ, Place M, Govan JR, *et al*. Garlic revisited: antimicrobial activity of allicin-containing garlic extracts against Burkholderia cepacia complex. PLoS One. 2014;9(12):e112726.
111. Zardast M, Namakin K, Kaho JE, Hashemi SS. Assessment of antibacterial effect of garlic in patients infected with Helicobacter pylori using urease breath test. Avicenna journal of phytomedicine. 2016;6(5):495.
112. Zheng GQ, Kenney PM, Lam LK. Sesquiterpenes from clove (Eugenia caryophyllata) as potential anti-carcinogenic agents. Journal of natural products. 1992;55(7):999-1003.
113. Zick SM, Djuric Z, Ruffin MT, Litzinger AJ, Normolle DP, Alrawi S, *et al*. Pharmacokinetics of 6-gingerol, 8-gingerol, 10-gingerol, and 6-shogaol and conjugate metabolites in healthy human subjects. Cancer Epidemiol Biomarkers Prev. 2008;17:1930-1936.