A Project Titled

ESSENTIAL OILS AND ITS PROPERTIES (CLOVE OIL AND CINNAMON OIL)

A DESSERTATION REPORT

Submitted in Partial Fulfilment for the Degree of M.Sc

(Biochemistry)

BY

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STATEMENT

I hereby declare that the matter presented in this dissertation entitled, **Essential Oils and its properties(Clove oil and Cinnamon oil)** is based on the results of investigations carried out by me in the school of chemical sciences, Goa university under the supervision of '**Dr.Prachi Torney'** and the same has not been submitted elsewhere for the award of a degree or diploma.

KRUTIKA K. NAIK

CERTIFICATE

This is to certify that the dissertation entitled, **'Essential oils and its properties (clove oil and cinnamon oil)'** is a Bonafide work carried out by **Miss. Krutika K.Naik** in partial fulfillment of the requirements for award for the award of the degree of Master of Science in Chemistry at school of chemical sciences, Goa university.

School of chemical sciences

Goa University

CERTIFICATE

This is to certify that the dissertation entitled, **‘Essential oils and its properties (clove oil and cinnamon oil)’** is a Bonafide work carried out by **Miss. Krutika K.Naik** under my supervision in partial fulfillment of the requirements for award for the award of the degree of Master of Science in Chemistry at school of chemical sciences, Goa university

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ESSENTIAL OIL AND ITS PROPERTIES (CLOVE OIL AND CINNAMON OIL)

ABSTRACT

Essential oils have various health benefits, they are widely used as antimicrobial, antioxidant property. Essential oil activity on microorganisms .Studies have been done specifically on two spices clove oil and cinnamon oil and their extraction techniques. Essential oil of clove and cinnamon was extracted from various parts of plants with different composition of compound was obtained. They contain variety of volatile component such as eugenol , β-caryophyllene , α-humulene, cinnamaldehyde in large composition. This review presents various biological applications beneficial for human health such as antimicrobial, antioxidant, anticancer ,antivairal ,antifungal ,antidaibetic and antialergic activity. Essential oil components are known to contribute to the self-defense of plants against infectious organisms. Therefore, use of essential oils of spices and herbs present a better choice than synthetic chemical additives, especially for food production, which has become popular and is widely accepted by consumers.

INTRODUCTION

Essential oils are found to be volatile, natural, complex mixture of compounds and are known by its strong odor they are formed by aromatic plants as secondary metabolites. Mostly they contain various types biological properties. (Amr M. Bakry, 2015)[1]. Essential oils are valuable and can be obtained from different parts of the plants like bark, flowers and fruits, leaves, roots and stems and are stored in secretory cells, cavities, canals, epidermic cells or glandular trichomes. (F. Bakkali, 2008)[3] (Burt*, 2004)[2]The term 'essential oil' is thought to derive from the name coined in the 16th century by the Swiss reformer of medicine, Paracelsus von Hohenheim; he named the effective component of a drug Quinta essentia. About 3000 estimated essential oils are known, of which about 300 are commercially important— destined chiefly for the flavours and fragrances market. (Burt*, 2004)[2] They are usually obtained by steam or hydro-distillation first developed in the Middle Ages by Arabs. (F. Bakkali, 2008)[3]Most of the essential oils are liquid at room temperature while some could have a solid or resinous appearance. Color of these oils varies from pale yellow to emerald green and from blue to dark brownish red. (Pateiroa, 2020)[4] They are mostly considered to be suitable substitution for chemical additives for use in the food industries. Oxidation, chemical interaction, or volatilization compositions of essential oils may be change accordingly. To limit the composition degradation/loss during processing and storage, and to control the delivery of the compound at the desired time and site, encapsulation is beneficial prior to use in foods or beverages. (Amr M. Bakry, 2015)[1]

Essential oils are known for their antiseptic properties, i.e. bactericidal, virucidal and fungicidal, and medicinal properties and their fragrance they are also used in embalmment, preservation of foods and as antimicrobial, analgesic, sedative, anti-inflammatory, spasmolytic and locally anesthetic remedies (F. Bakkali, 2008)[3].They have potential sources of noval antibacterial compounds specially against antibacterial pathogens. Their chemical composition and particularly phenolic compounds of these oils are major active components, which effectively inhibit the growth of microorganisms by disrupting the bacterial membrane integrity which lead to the change in the electron flow, the driving force of protons and active transport causes the coagulation of cell contents. In nature, essential oils have a very important role in the protection of the plants as antibacterial, antiviral, antifungal, insecticides and also against herbivores by reducing their appetite for such plants. They also may attract some insects to favour the dispersion of pollens and seeds, or repel undesirable others. (F. Bakkali, 2008)[3] Because of this antimicrobial efficiency, essential oils could be used to control food spoilage and food borne pathogenic bacteria such as E.*coli* (Hanen Falleh, 2021)[5] The antimicrobial properties of essential oils from plants was used empirically for many centuries, but only recently it has been studied scientifically. There is lot of research that is being compiled on the antimicrobial activity of various plant oil extracts and their specific components for possible application in fields ranking from food industry to dentistry. (Pateiroa,2020)[4]. There are several methods for extracting essential oils. Some of these methods include use of liquid carbon dioxide or microwaves, and mainly low or high pressure distillation employing boiling water or hot steam. This can vary in extraction product with reference to quality, quantity and in composition according to climate, soil composition, plant organ, age and vegetative cycle stage. So, in order to obtain essential oils of constant composition, they have to be extracted under the same conditions from the same organ of the plant which has been growing on the same soil, under the same climate and has been picked in the same season. Most of the commercialized essential oils are chemotyped by gas chromatography and mass spectrometry analysis. Essential oils or some of their components are found to be used in perfumes and make-up products, in sanitary products, in dentistry, in agriculture also in as food preservers and additives, and as natural remedies. For example, d-limonene, geranyl acetate or d-carvone are employed in perfumes, creams, soaps, as flavour additives for food, as fragrances for household cleaning products and as industrial solvents. Moreover, essential oils are used in massages as mixtures with vegetal oil or in baths, but most frequently in aromatherapy. Some essential oils appear to exhibit particular medicinal properties that have been claimed to cure one or another organ dysfunction or systemic disorder. (F. Bakkali, 2008)[3]

MECHANISMS OF ESSENTIAL OILS ON MICROORGANISMS

The mechanisms by which Essential oils damage bacteria are largely dependent on their composition. Usually, antimicrobial activity can originate from the flow of reactions implicating the total bacterial cell, it's because of the fact that the essential oils are composed of many groups of chemical compounds and thereof act in different ways. Generally, Gram-positive bacteria and Gram-negative bacteria are differently susceptible to the action of Essential Oils, due to the structural differences of their cell wall of these two groups of bacteria. It is due to the presence of peptidoglycan with in the cell wall there is higher susceptibility of Gram-positive bacteria , which makes the hydrophobic molecules more easy to have access within the cell, acting therein with cytoplasm. The cell wall of Gram-negative bacteria has outer membrane, that is consist of a double layer of phospholipids linked to the peptidoglycan layer by lipopolysaccharides. This allows these bacteria to exhibit greater resistance to the penetration of essential oils and their components. Some of the hydrophobic molecules can be capable of entering into the cell, only through the access given by the porins, proteins that form water-filled channels distributed all over the cell wall. Gram-negative bacteria have even more resistant to hydrophobic antibiotics due to different cell wall compositions, the mechanism through which the Essential Oils or their components act on microbial cells include simultaneous actions, ranging from cell wall degradation, they also damage to the cytoplasmic membrane and membrane proteins, as well as to a reduction of the proton-motive force until to damage to the ATP synthesis mechanism. Essential Oils have lipophilic character which allows them to penetrate the cell membrane and remain between the phospholipids which affect the synthesis of membrane lipids, with a consequent change of membrane structure and with an alteration of its permeability. Essential oils can also affect directly also the morphology of bacterial cell, by altering it irreversibly, to cause the complete destruction of the entire microbial cell scaffolding. (Filomena Nazzaro, 2019)[6]

CLOVE OIL

FIG. 16.1 The clove plant during flowering period. *Courtesy: Wikipedia* (*https://en.wikipedia.org/wiki/Clove*).

FIG. 16.2 Image of cloves—dried flow buds.

Clove (*Syzygium aromaticum L.*) buds and flowers are used for synthesis of essential oils. Clove bud is a single flower of length 1-2 cm, while a clove flower has eight stages of clove bud development, such as young bud, budding-1, budding-2, budding-3, full-budding, flowering, initial fruiting, and full fruiting .Apart from the utilization of clove flowers in the cigarette industry, clove also used produce essential oil with good yield ranging from 10% to 20%.

Generally, the buds produce higher oil yield than the branches (5–10%) or leaves (1–4%). The phenological stage effects the yield and quality of clove bud oil. Eugenol is the main component of clove oil, it has strong antioxidant activity. Antioxidant is an important property, which is able to reduce the impact of free radical activity. Natural antioxidants contained in clove oil are preferred more often as they are safe and easy to obtain. (Faisal Nur Alfikri, 2020)[7]

FIG. 16.3 *Syzygium paniculatum* (magenta cherry or Bush cherry) maintained at the Kew Botanical Garden (United Kingdom). Image of floral features (A) and fruits (B) that are incredibly similar with other species of the genus make the taxonomy a difficult task.

COMPOSITION OF CLOVE OIL

In composition of clove essential oils almost 30 compounds have been identified. Eugenol is found to be the major compound, accounting for at least 50%. The remaining 10–40% consist of eugenyl acetate, β-caryophyllene, and α-humulene therefore around 99% is composed of these compounds. Less than 10% is trace components such as diethyl phthalate, caryophyllene oxide, cadinene, α-copaene, 4-(2- propenyl)-phenol, chavicol, and α-cubebene, among others.

Below table shows chemical composition of essential oil clove bud extracted by hydrodistillation.

Compound	(%)
Eugenol	76.23
β-Caryophyllene	11.54
Caryophyllene oxide	4.29
Eugenyl acetate	1.76
α-Caryophyllene	0.64
β-Selinene	0.25
α-Selinene	0.16
Eucalyptol	0.14
4-Allylanisole	0.13

(−)-β-Cadinene	0.12
Anethol	0.11
2-Pinene	<0.1
α-Pinene	<0.1
Methyl salicylate	<0.1
Chavicol	<0.1
α-Muurolene	<0.1
α-Copaene	<0.1
Valencene	<0.1
Jasmone	<0.1
Ledol	<0.1
Globulol	<0.1
Cedrene	<0.1

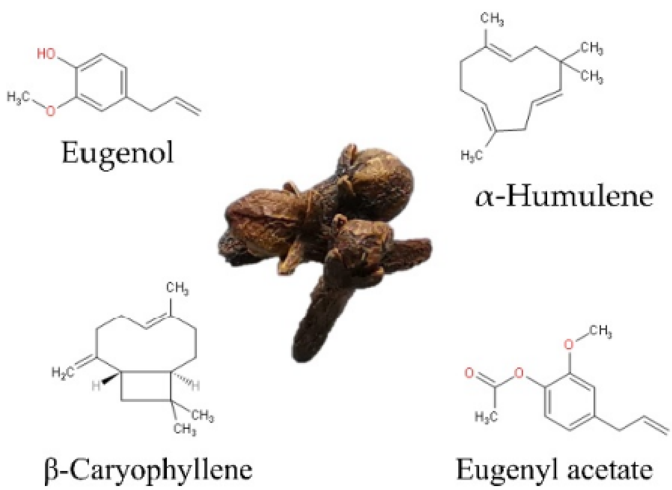

Figure 1. Chemical structure of main compounds of clove (*S. aromaticum* L.) essential oil.

EUGENOL

Eugenol is a phenylpropanoid compound found in *S. aromaticum L., Cinnamomum spp., P. nigrum, Zingiber officinale, Origanum vulgare, and T. vulgaris.* Eugenol is a volatile compound having color from colorless to light yellow. It has low water solubility (approximately 2460 mg/L at 25°C), a strong odor, and an intense flavor. Different methods of extraction including microwave assisted extraction with intention of maximizing eugenol content, environmentally friendly method of extraction with microwave methods (Kapadiya et al., 2018. Eugenol is considered safe for various clinical applications , its abundance in clove oil makes its extraction from this natural source economically viable. The inhibition of voltage-gated Na^+ channels modulate the analgesic effects of eugenol. Eugenol induces the activation of transient receptor potential cation channel V1 (TRPV1), an effect similar to local anesthetics such as lidocaine. Eugenol showed potential anticancer activity against colon, gastric, breast, prostate, and skin cancer, as well as melanoma and leukemia. Eugenol is responsible for inhibiting tumor proliferation and formation, increases reactive oxygen species (ROS), generates apoptosis, and has a genotoxic effect in different cancer cells. It has showed a cumulative effect in the treatment of neuropathic pain. Although the Food and Drug Administration (FDA) has confirmed the safety of clove essential oil as a dietary supplement but recently more attention is paid towards the toxicity occurs due to cytotoxic activity against human fibroblasts and endothelial cells. It was also reported that eugenol showed a spermicidal effect in vitro and allergic efficacy when used in dentistry. (Haro-González, 2021)[10]

EUGENYL ACETATE

Eugenyl acetate is a phenylpropanoid derivative of eugenol which is responsible for antibacterial, anticancer, antimutagenic, antioxidant, and anti-virulence activity. It showed inhibition of 94.5, 92.1, and 100% at 200 µg/mL against *Fusarium moniliforme, Harpophora oryzae*, and *Rhizoctonia solani*, respectively. Eugenyl acetate is said to be as a potent antioxidant agent; it showed 90.30% DPPH(2,2-diphenly-1-picryl-hydrazyl-hydrate) free radical scavenging at 35 µg/mL, and 89.30% NO free radical scavenging at 60 µg/mL. It also showed a potential antifungal activity against *Candida* spp. and inhibited biofilm formation capacity. (Musthafa, 2016)[16] Pasay et al. (2017)[38] reported high toxicity against human scabiesmites . Eugenyl acetate also showed 100% toxicity against *Artemia salina* at 0.3 µg/mL. The low lethal concentrations obtained for eugenyl acetate could also indicate toxicity to other organisms, such as disease vector insect larvae. Pasay et al. (2017)[38] Eugenyl acetate had an LC50 of 0.1 mg/mL against *Aedes aegypti*, showing potential utility as a larvicide. The larvicidal action occurs mainly due to interference with the octopaminergic system. In food and cosmetic industries the demand for the antioxidant, antimicrobial, antitumor, and larvicidal properties have increased.

β-CARYOPHYLLENE

Clove essential oil contains β-caryophyllene that belong to the sesquiterpene class of terpenoids. β-Caryophyllene is found in clove (*S. aromaticum L.*), hemp (*Cannabis sativa L.*), black pepper *(P. nigrum L.*), *Eugenia cuspidifolia*, *Eugenia tapacumensis*, and guava leaves *(Psidium cattleianum Sabine*). β-Caryophyllene is insoluble in water but can be soluble in ethanol. It has been found to have antimicrobial, anticarcinogenic, antiinflammatory, antioxidant, anxiolytic-like, and local anesthetic effects and anticancer properties and they also act against prostate, breast, pancreatic, skin, leukemia, lymphatic, and cervical cancer. According to the latest studies β-caryophyllene decreases cell growth and proliferation in colon cancer by interfering with the stages of tumor development and reducing the activity of extracellular matrix metalloproteinases. β-Caryophyllene also act as a chemosensitizer by improving the effectiveness of drugs against tumor cells. It is also effective against *Anopheles subpictus* (LC50 = 41.66 μg/mL), *Aedes albopictus* (LC50 = 44.77 μg/mL), and *Culex tritaeniorhynchus* (LC50 = 48.17 μg/mL). These results found indicates that β-caryophyllene contain high antioxidant activity. (Haro-González, 2021)[10]

α-HUMULENE

α-Humulene is a sesquiterpene which belongs to terpenoids and found in *S. aromaticum L.*, *Senecio brasiliensis, Humulus lupulus L.*, and *Salvia officinalis L*. This compound has shown anti-inflammatory and antitumor activity in lung, colon, prostate, and breast cancer. (Lesgards, 2014) According to some studied reported (Haro-González, 2021)[10], α-humulene demonstrated antiproliferative activity and alteration of the mitochondrial cell membrane in colon cancer cells. It can also improve the antiproliferative effect of cytostatic drugs and other anticancer bioactivities. Nguyen et al.(2017)[12] reported that α-humulene inhibits the activity of the CYP3A enzyme, a drug-metabolizing enzyme in humans' and rats' liver microsomes . (Fernandes et al. 2007)[13] reported that the oral treatment with α-humulene and β-caryophyllene (50 mg/kg) produced comparable anti-inflammatory effects with dexamethasone treatment in model mice and rats. α-Humulene prevents the generation of TNFα, while β-caryophyllene only decreases its release. In addition, they reduce the production of prostaglandin E2, the inducible expression of nitric oxide synthase, and cyclooxygenase. α-Humulene exhibited larvicidal activity against three types of vector mosquitoes, *An. Subpictus* (LC50 = 10.26 µg/mL*), Ae. albopictus* (LC50 = 11.15 µg/mL), and *Cx. tritaeniorhynchus* (LC50 = 12.05 µg/mL) but was shown to be safe for *Gambusia affinis* (LC50 = 1024.95 µg/mL). It showed larvicidal LC50 of 20.86 µg/mL and EC50 of 77.10 µg/mL on *Helicoverpa armigera* eggs. α-Humulene has also been used against beetle species that attack stored products. The toxicity of α-humulene against *Sitophilus granarius* was LC50 = 4.61 µL/mL, and it reduced the respiration rate of *S. granarius* at 1 and 3 h after exposure. (Haro-González, 2021)[10]

EXTRACTION OF ESSENTIAL OIL

The dried clove buds were powdered and 50 g of clove powder was taken in 1000 ml round bottomed flask (RBF) and distilled water (500 ml) was added to it. The extraction of essential oil was carried out by hydro distillation method using Clevenger apparatus for four hours so as to obtain maximum yield of essential oil. The same process was repeated three times to obtain sufficient quantity of essential oil. The essential oil was separated from aqueous layers using diethyl ether which was evaporated and essential oil was dried over anhydrous sodium sulphate. (Kamalpreet Kaur, 2019)[18]

The calculation of percentage yield of the essential oil was done by: Yield percentage = [(Weight of the essential oil extracted (g) / Weight of the sample taken (g)] x 100 (Kamalpreet Kaur, 2019)[18]

CONVENTIONAL/CLASSICAL EXTRACTION METHODS

The conventional extraction methods are done by the distillation process by heating a plant matrix to recover essential oil. The extraction involves injecting steam or water, which then crosses the plant matter from the bottom up and carries the volatile materials together with the water as if they were a single component. Since essential oil is immiscible in water, it makes easy to remove by decanting. The Hydrodistillation and Steam distillation methods are most preferred method for extraction essential oils. They are easy to operate, have high reproducibility, and they do not use organic solvents. However, these methods have several drawbacks, such as long extraction time, the use of large volumes of solvent

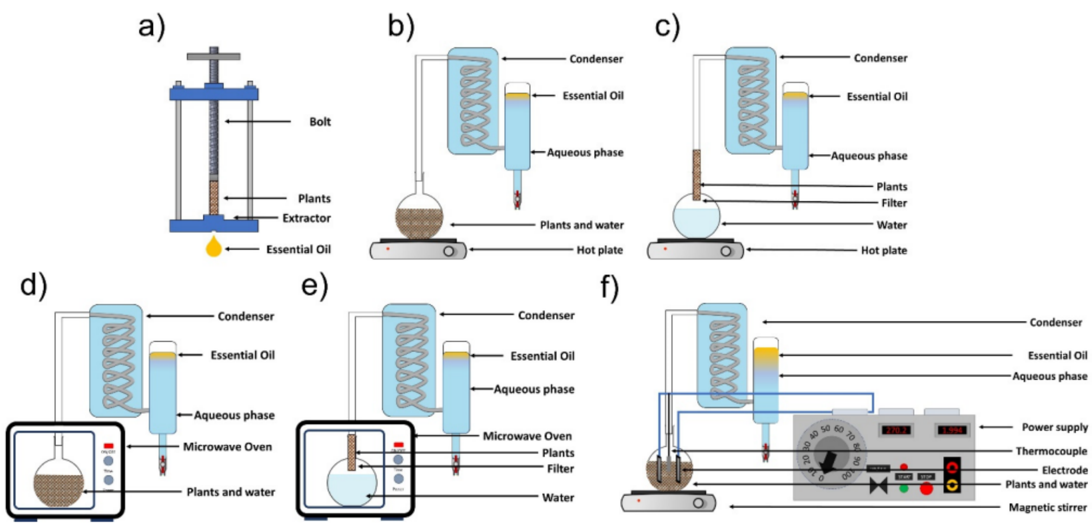

Figure 2. Essential oil extraction methods: (**a**) cold pressing, (**b**) hydrodistillation, (**c**) steam distillation, (**d**) microwave-assisted hydrodistillation, (**e**) microwave-assisted steam hydrodistillation, and (**f**) ohmic heating-assisted hydrodistillation

and energy and possible thermal degradation and hydrolysis of some of the components of interest from prolonged contact with boiling water or steam. However, these compounds resulting from hydrolysis belong to the final composition of Essential oils. It is important to know that the conventional methods of extracting essential oils have few adjustable parameters that can control the selectivity of the processes and the final concentration of the essential oil. (Haro-González, 2021)[10]

ADVANCED/INNOVATIVE EXTRACTION METHODS

Advanced extraction methods are microwave-assisted extraction (MAE), ultrasonic-assisted extraction (UAE), subcritical fluid extraction, and supercritical fluid extraction (SFE). They improve extraction performance, reduce extraction time and energy consumption to obtain organic extracts. These methods improve organic compound extraction yield by applying microwave or ultrasonic energy that can destroy the cell walls of the plant matrix, allowing the compounds to flow better from the biological material. These extracts preserved their antimicrobial and antioxidant properties. MAE reduces amount of energy consumption, heating time, and organic extract degradation. Ultrasonic waves from 20 to 100 kHz can be applied by direct contact with the sample (ultrasound system coupled with a probe) or indirectly through the walls of the sample container (ultrasonic bath). Acoustic power and wave frequencies applied in liquid media can produce the acoustic cavitation phenomenon, where the creation, expansion, and implosion of bubbles enhance the selectivity of target molecules. SFE is used to selectively remove chemical compounds using a solvent in its supercritical state, typically carbon dioxide. Additionally, co-solvents such as methanol, ethanol, or water change the density, viscosity, and solvation power of the supercritical solvent, promoting the extraction of specific compounds. The SFE process reduces undesirable organic pollutants, toxins, and pesticide residues present in the biological material. In the composition of essential oils and organic extract depend on the species, the phenological stage, agroecological conditions , pretreatment, processing conditions , and extraction method. (Haro-González, 2021)[10]

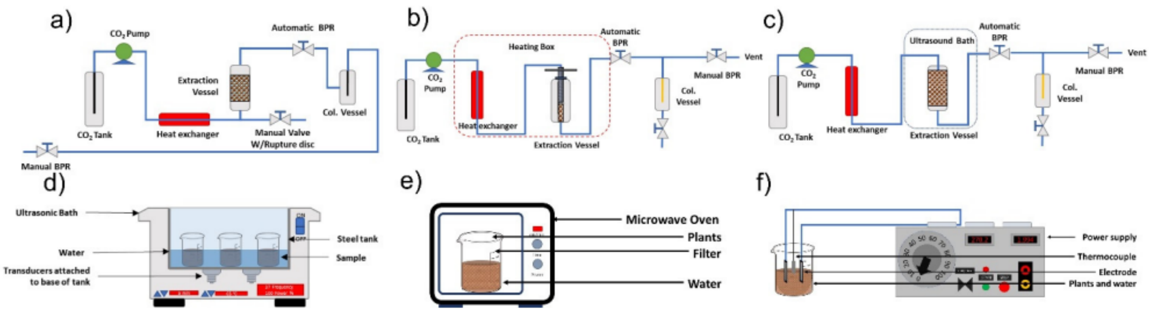

Figure 3. Organic extract extraction methods: (**a**) supercritical fluid extraction, (**b**) cold pressing-assisted supercritical fluid extraction, (**c**) ultrasound-assisted supercritical fluid extraction, (**d**) ultrasound-assisted extraction, (**e**) microwave-assisted extraction, and (**f**) ohmic heating-assisted extraction (Hatami et al. [20] and Fragoso-Jiménez et al. [51]).

BIOLOGICAL ACTIVITIES OF CLOVE ESSENTIAL OIL

Clove essential oil has shown different health benefits, mainly due to the eugenol content. However, the other compounds have various health benefits too. (Parker, 2017)[14]

ANTIMICROBIAL:

Clove essential oil has shown broad-spectrum inhibitory activity against pathogens. Clove Essential oils or their active compounds containing hydroxyl group (-OH) are highly antimicrobial. (Silviya R. Macwan*, 2016)[39] The antibacterial mechanism is due to the -OH groups located at the meta and ortho positions, respectively, in the main chemical composition. These functional groups has properties to interact with the cytoplasmic membrane of microbial cells. Clove Essential Oil can permeate through the cell membrane due to its lipophilic properties. The interaction of Clove essential oil with polysaccharides, fatty acids, and phospholipids give rise to loss of cellular membrane integrity, leakage of cellular contents, and interference with the proton pump activity which leads to the death of cell. Clove essential oil can inhibit Gram-negative bacteria (*E.coli, Salmonella, Klebsiella pneumoniae, Erwinia carotovora, Agrobacterium,* and *Pseudomonas aeruginosa*) and Gram-positive bacteria *(S.aureus, Streptococcus,* and *L. monocytogenes), Aspergillus(A. flavus, A. parasiticus,* and *A. ochraceus*), *Penicillium, C. albicans,* and yeast. Clove essential oil inhibits Gram-positive bacteria to a greater extent than Gram-negative bacteria. This is responsible for the diffusible mucopeptide layer in Gram-positive bacteria that makes them susceptible to antimicrobial agents. Complex layer of the lipopolysaccharide in the outer cell membrane of Gram-negative bacteria can significantly reduce the diffusion rate of lipophilic antibacterial compounds through the cell membrane. Likewise, food-related pathogens have shown greater sensitivity to Clove essential oil than probiotics and fungi. (Haro-González, 2021)[10]

ANTIOXIDANT

Clove essential oil has the antioxidant compounds eugenol, eugenyl acetate, β-caryophyllene, and α-humulene, which protect cells from free radical oxidation. Diseases such as cancer, arteriosclerosis, Alzheimer's disease, and Parkinson's disease are related to the presence of reactive oxidation species. Clove essential oil has shown scavenging activity on radicals and inhibition of lipid peroxidation. Antioxidant activity of clove oil is due to its hydroxyl group present in eugenol on the aromatic ring. The phenolic compounds transfer electrons or hydrogen atoms and neutralize them to free radicals which results in a blocking of oxidative process. Clove essential oil has a protective effect on biochemical changes and histopathological injuries in the kidney, liver, and brain induced by reactive oxidation species. The main reactive oxidation species changes inhibited were increased lipid parameters (HDL-C, TC, LDL-C, and VLDL), blood electrolyte (Na^+ , K^+ , and Cl^-) and creatinine levels in the liver, hepatic enzymes, blood urea, increased liver and kidney weight, increased serum creatinine, and decreased total protein and albumin. (Haro-González, 2021)[10]

INSECTICIDAL:

Insect-borne diseases are a daily challenge to public health. Some species are invasive urban pests, transmitting numerous pathogenic microorganisms that causes allergic reactions and asthma in young and older people. Commonly used insecticides can give rise to many health problems and have long-lasting adverse effects over environment. Moreover, an increase in resistance against insecticides has been reported. Due to this, investigations have focused on developing natural insecticides based on essential oils to control agricultural and urban pests However, their high volatility decreases the time during which essential oils remain in the human body, so sometimes several applications are required in a day. Clove essential oil has shown high levels of repellency and fumigant toxicity on flea, aphids, nymphal instars, mites, imported red fire ants, *C. pipiens*, and American and German cockroaches. The oviposition-deterrent activity of clove essential oil can be found in other mosquito species (*Anopheles stephensi, An. subpictus, Ae. aegypti, C. pipiens, Ae. albopictus, Culex quinquefasciatus,* and *Cx. tritaeniorhynchus*). It targets the egg stage as an oviposition deterrent and the larval stage as a larvicide against *Ae. japonicus, Ae. aegypti*, and *Cx. quinquefasciatus*. Clove essential oil has shown repellent action in the laboratory and field settings against adult *Ae. aegypti, Ae. cinereus*, and *Ae. communis*

The primary targets of clove essential oil and other essential oils are octopamine and gamma-aminobutyric acid (GABA) receptors and transient receptor potential (TRP) channels. The dose– response ratio of clove essential oil showed an increased mortality rate with increasing concentration . Clove essential oil increased permeability activity on the cell membrane, disrupted the cytoplasmic membrane, and interacted with proteins, ATPase, histidine decarboxylase, amylase, and protease enzymes, which were also inhibited. Lambert et al.(2020)[19] evaluated the activity of clove essential oil against adult *C. felis felis* and the development of their eggs. The LC50 was 5.70 µg/cm2 against adult fleas and 0.30 g/cm2 against flea eggs; however, the insecticidal activity of eugenol was three times higher. Toledo et al.(2020)[20] reported that it had activity against aphids, but not against ladybugs. They reported an LC95 of 0.17 µL/cm2 for aphids, while the same dose only had a lethality of less than 18% for *Corymbia maculata*. The ladybugs that were exposed to clove essential oil did not exhibit impaired locomotion ability. Therefore, it was concluded that the application of clove essential oil represents an alternative to control aphid infestations. Elzayyat et al.(2018)[21] evaluated the insecticidal activity against adults and larvae of *Culex pipiens*, and reported an LC50 of 0.374 and 0.036%, respectively. Neupane et al(2019)[22]. observed that clove essential, eugenol, and eugenyl acetate applied at 4.0 mL/cm2 provided 95, 85, and 87% mortality of German cockroaches, respectively. They also reported repellency for 30 min by applying 80% clove essential oil. Reuss et al(2020)[23] observed that clove essential oil functions as an oviposition repellent and a larvicide, with an LC50 of 17 mg/L. clove essential oil and its main constituents are products that have low toxicity to mammals and zero residual concentration. Its application is limited to plague insect control, which is essential to prevent infestations in the environment.

ANTIVIRAL:

Clove essential oil has shown antiviral activity against Ebola , influenza A virus , and herpes simplex virus types 1 and 2 . Recent studies by (de Oliveira, 2019)[15]stated that eugenol derivatives could inhibit the activity of the West Nile Virus by providing a promising compound against flaviviruses such as dengue, Zika, and yellow fever. According to the recent studies it has been said , eugenol as a possible inhibitor of the initial stage of HIV-1 infection because it can reduce virus replication. Eugenol can increase lymphocyte production and so the lymphocyte proliferation capacity of eugenol may be responsible for its anti-HIV-1 activity . clove essential oil has demonstrated antiviral activity against *Feline calicivirus*, which is used as a substitute for human norovirus. For this reason, the application of clove essential oil in the process of washing fruits and vegetables eliminates any viral load that may exist. In addition, the application of clove essential oil in cleaning wipes allows the decontamination of surfaces. Furthermore, Clove essential oil has been shown to increase the resistance of tomato plants to tomato yellow leaf curl virus more than moroxydine hydrochloride. (Haro-González, 2021)[10]

ANTINOCICEPTIVE

Nonsteroidal anti-inflammatory drugs(NSAIDs) are the most widely used drugs to treat inflammatory nociceptive pain. Their principal mechanism is cyclooxygenase (COX) inhibition, decreasing the prostaglandins that cause nociceptive pain. The antinociceptive and anti-inflammatory activities of eugenol are related to COX^{-2} inhibition and vanilloid transient receptor potential (TRPV) by high-voltage Ca^{2+} current inhibition in primary afferent neurons. This antinociceptive response is related to opioid, cholinergic, and α^{2-} adrenergic receptors, but not serotoninergic receptors. The antinociceptive effect of eugenol is probably related to gamma-aminobutyric acid (GABA) receptor modulation, because eugenol administration inhibits GABA receptor currents in trigeminal ganglion neurons and inhibits GABA $\alpha1\beta2\gamma2$ expressed in these neurons. (Haro-González, 2021)[10]

ANTI- INFLAMMANTORY AND WOUND HEALING

Oxidative stress and inflammation have similar processes in many pathophysiological conditions such as diabetes, hypertension, and cardiovascular and neurodegenerative diseases. The anti-inflammatory properties of clove essential oil and eugenol are comparable to diclofenac gel, reducing inflammation by 60 to 20% after 3 hr. Likewise, induced wounds in rats treated with clove essential oil showed a significant contraction of more than 95% in the first 15 days. These results demonstrate that animals treated with clove essential oil went through similar healing to those treated with neomycin, which is currently used to control inflammation and heal wounds. Therefore, the chronic and acute side effects of synthetic antibiotics can be avoided, especially if they are given frequently. Clove essential oil inhibited important antiproliferative biomarkers whose activity depends on their concentration. It decreased the levels of inflammatory biomarkers such as VCAM-1, IP-10, I-TAC, and MIG, in addition to inhibiting the tissue remodeling protein molecules collagen I, collagen III, M-CSF, and TIMP-1. (Haro-González, 2021)[10] The application of Clove essential oil can reduce epidermal thickness and the number of inflammatory cells expressing COX-2 without affecting COX-1. (Nikoui, 2017)[25] Eugenol acts as an anti-inflammatory and inhibits the expression of COX-2 and reduces the production mediators of inflammation. Eugenol has also been reported to not alter IL-8 levels in human skin keratinocytes but to target other pro-inflammatory cytokines in pre-inflamed human dermal cells. These results suggest that clove essential oil possesses anti-inflammatory activity and favors wound healing. (Haro-González, 2021)[10]

ANALGESIC

Headache, joint pain, toothaches, and oral hygiene issues have traditionally been treated with aromatherapy and clove essential oil. The clove essential oil and eugenol are safe, effective, and inexpensive analgesics .The analgesia produced by clove essential oil in acute corneal pain appears to depend on the cholinergic activity. The analgesic and local anesthetic effects of eugenol can be modulated by its inhibitory effect on voltage-gated channels (Na^+ and Ca^{2+}) and activation of TRPV1. The analgesic effects of clove essential oil and eugenol are very similar to those of lidocaine. Clove essential oil has potential for use in painful procedures, to minimize the effects of harmful stimuli for ethical reasons, and to ensure the welfare of the animal, avoiding stress and its negative consequences. (Haro-González, 2021)[10]

ANESTHETIC

Clove essential oil is recognized as an anesthetic at low concentrations (50–500 µL/L) in vertebrates and invertebrates without side effects. It induces anesthesia faster, has brief reflex recovery, that shows a low mortality rate without affecting external stimulus response. Recent studies showed that topical application of clove essential oil and eugenol reduces corneal sensitivity in rats similar to lidocaine. The maximum level and duration of anesthesia depends on the concentration and time of its exposure, which differs between chemicals (Haro-González, 2021)[10]. Eugenol is used in lot of applications, such as a local anaesthetic in dentistry and also as an ingredient in dental cement for temporary fillings. (Chaieb, 2007)[24]Clove essential oil efficiently induces anesthesia in Nile tilapia, cardinal tetra, ringed cichlid, and angelfish ,they affect swimming ability and balance, and also decrease the response to external stimuli until complete immobilization. Depending on the concentration of the dose, the time to achieve full anesthesia is decreased. Furthermore, there are no side effects of clove essential oil based on the concentration and time of exposure when recovering from anesthesia. Clove essential oil is an effective anesthetic for red claw crayfish and other crustaceans, including *Nephrops norvegicus* and grass shrimp. Induction and recovery times increase with increased crayfish size as it is are related to the oxygen demand. Absorption and elimination of clove essential oil are measured by the oxygen consumption rate, the relationship between the body and the gill surface, and the gill infusion rate. Size is inversely related to the efficacy of anesthesia. For invasive and painful procedures, the use of clove essential oil is recommended due to its better anesthetic effect. (Haro-González, 2021)[10]

ANTICANCER:

The eugenol, α-humulene, and β-caryophyllene components of clove essential oil, which have cytotoxic and antitumor activity which has been used as alternatives in the prevention and co-treatment of cancer. (Lee, 2018)[26] suggested that essential oils reduce the side effects of chemotherapy, which include nausea, vomiting, loss of appetite, and weight loss. The anticancer activity is mainly attributed to the antioxidant and anti-inflammatory activity, since the production of reactive oxidation species specifically activates signaling pathways and contributes to the development of tumors by regulating cell proliferation, angiogenesis, and metastasis. Clove essential oil has been tested against different cancer types, such as colon, lung , breast, pancreatic, leukemia , cervical, and prostate. The anticancer properties occurs due to the activation of detoxifying enzymes, the destruction of DNA by oxidative stress, antimetastatic and cytotoxic activity, decreased viability, cell cycle arrest or apoptosis, the reduction of phosphate-Akt expression levels, and MMP-2 and protein leakage. Clove essential oil has shown a low cytotoxic effect on normal cells, improving their antiproliferative activity . (Haro-González, 2021)[10]

CINNAMON OIL

Figure 1.1 Bark of *Cinnamomum Zeylanicum*

Figure 1.2 Leaves of *Cinnamomum Zeylanicum*

Cinnamon is a most commonly used spice for over several centuries by different cultures around the world. It is found in different parts of a tropical evergreen tree belonging to the genus *Cinnamomum* (Leo M.L. Nollet, 2017)[29]. The genus *Cinnamomum* (*Laureaceae* family) consists of 250 species of wooden plants native to China, Southeast Asia, and Australia (MiroslavaKačániová*, 2021)[27]. Various reports have discussed about numerous properties of cinnamon and it major components not only with reference to human health but also for agricultural applications (Leo M.L. Nollet, 2017)[29].Essential oils derived from plants have been used as flavoring agents in food and beverages and, due to the presence of their antimicrobial compounds they have potential as natural agents for food preservation (Shang-Tzen Chang a, 2001)[30].

In Eastern and Western countries, the bark of cinnamon has been a popular natural spice since ancient times and is been traditionally used in treatments for gastritis, blood circulation disturbances, dyspepsia and inflammatory diseases. The essential oil obtained from the bark and the young branches of cinnamon has been widely known to be used for medicine, food and cosmetic additives due to its unique properties, such as its antioxidant, antifungal and antibacterial activities. Products containing *C. cassia* oil may also be used as potential repellents and antitumor agents (ShileiGeng, 2010)[28]. Essential oil obtained from the leaves of the *Cinnamon osmophloeum* exhibits strong activity against bacteria, termites, mosquitoes, mildew and other biological agents. Cinnamon is the most commonly used ingredient in seasoning, sauces, bakery confection and drinks etc. According to food and drug administration cinnamon is recognized as a safe food additive. (MiroslavaKačániová*, 2021)[27]

COMPOSITION OF CINNAMON OIL

Chemical compositions of cinnamon oil varies depending on various factors such as the part of the plant used, age of the tree, growing season, location and the method used during extraction. According to the studies done it is been found that different parts of the cinnamon plant have different primary constituents, cinnamaldehyde is majorly found in the bark oil, eugenol is found in the leaf oil and camphor in roots and bark oil of cinnamon plant (Khalid Haddi, 2017)[29]

Below table shows the chemical composition of different parts of cinnamon oil.

Part of the plant	Compound
Leaves	Cinnamaldehyde: 1.00 to 5.00% Eugenol: 70.00 to 95.00%
Bark	Cinnamaldehyde: 65.00 to 80.00% Eugenol: 5.00 to 10.00%
Root bark	Camphor: 60.00%
Fruit	*trans*-Cinnamyl acetate (42.00 to 54.00%) and caryophyllene (9.00 to 14.00%)
C. zeylanicum buds	Terpene hydrocarbons: 78.00% *alpha*-Bergamotene: 27.38% *alpha*-Copaene: 23.05% Oxygenated terpenoids: 9.00%
C. zeylanicum flowers	(E)-Cinnamyl acetate: 41.98% *trans-alpha*-Bergamotene: 7.97% Caryophyllene oxide: 7.20%

The major components of the essential oil obtained from the bark of *C. zeylanicum* are eugenol, cinnamaldehyde, and linalool whereas *C. cassia* bark contains cinnamaldehyde, cinnamic acid, cinnamyl alcohol and coumarin. Other species of *Cinnamomum* were found to have lower contents of cinnamaldehyde. Some constituents frequently observed in cinnamon bark oil include eugenol, eugenol acetate, cinnamyl acetate, cinnamyl alcohol, methyl eugenol, benzaldehyde, cuminaldehyde, benzyl benzoate, linalool, monoterpene hydrocarbons (e.g., pinene, phellandrene, and cymene), carophyllene, and safrole.

Cinnamon leaf oil also contains many of the major constituents that is present in cinnamon bark oil (e.g., cinnamaldehyde, cinnamyl acetate, eugenol acetate, and benzaldehyde), also other minor compounds, like humulene, isocaryophyllene, alpha-ylangene, coniferaldehyde, methyl cinnamate, and ethyl cinnamate .Other minor constituents also reported to be found in cinnamon essential oil include oligopolymericprocyanidins, cinnamic acid, phenolic acids, pentacyclicditerpenes, cinnzeylanol and its acetyl derivative cinnzeylanine, and the sugars mannitol, l-arabinod-xylanose, l-arabinose, d-xylose, and α-d-glucose, as well as mucilage polysaccharides. Many nonvolatile compounds e.g., cinncassiols, cinnzeylanol, cinnzeylanin, anhydrocinnzeylanol, anhydrocinnzeylanin, several benzyl isoquinoline alkaloids, flavanol glucosides, coumarin, b-sitosterol, cinnamic acid, protocatechuic acid, vanillic acid, and syringic acid) have been also noted to be found in cinnamon essential oils. (Khalid Haddi, 2017)[29]

CINNAMALDEHYDE

Cinnamaldehyde is known to be 3-Phenyl-2-propenal.It is a pale yellow liquid having a warm, sweet, spicy odor and pungent taste reminiscent of cinnamon. It is naturally found in the essential oils of Chinese cinnamon (*Cinnamomum cassia, Blume*) (75–90%) and Ceylon cinnamon (*Cinnamomumzeylanicum, Nees*) (60–75%) as a primary component in the steam distilled oils. It also occurs in many other essential oils at lower levels. Greater than 95% of the consumption of cinnamaldehyde occurs in flavor uses where a spicy, cinnamon character is needed. It is used in a large range of products including bakery goods, confection, and beverages and also in toothpastes, mouthwashes and chewing gum. Other uses include its capability as an animal repellent, its use in compositions to attract insects and demonstration of a positive antifungal activity. (Cinnamaldehyde has been efficiently isolated in high purity by fractional distillation from cassia and cinnamon bark essential oils and it is also used in manufacturing protocols for the preparation of natural benzaldehyde through a retro-aldol process.) (Sulaiman, 2013)[43] Trans-Cinnamaldehyde (t-Cinnamaldehyde or (E)-Cinnamaldehyde) was reported to be the main constituent of cinnamon essential oil and extracts. This molecule have a major contribution to cinnamon’s organoleptic and antibacterial properties.

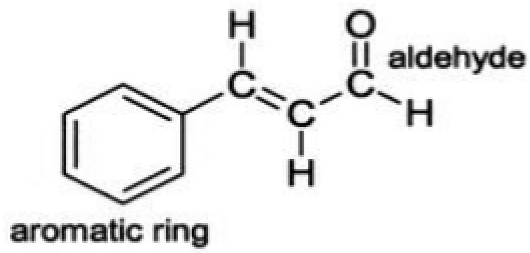

Figure 2.1 Cinnamaldehyde

A study of the antimicrobial properties of the main constituents of *C. zeylanicum* essential oil showed that cinnamaldehyde was the most active against the two oral pathogens (*S. mutans* and *Streptococcus sobrinus*), with inhibition zones ranging from 4.2 to 5.7 cm. *C. zeylanicum*, due to its main constituent t-Cinnamaldehyde, showed the highest antibacterial activity against several bacteria, with clinical significance among all the tested Essential oils (cumin (*Cuminumcyminum*), *C. verum*, cardamom (*Amomumsubulatum*), and clove (*S. aromaticum*). (Yanakiev, 2020)[32]

EUGENOL

Eugenol is another powerful substance present in cinnamon Essential Oil, although it is commonly associated with clove. Since it is one of the most abundant compounds in cinnamon essential oil. (Yanakiev, 2020)[32]Eugenol is a phenylpropene which is an allyl chain substituted guaiacol. Eugenol is a member of the phenylpropanoids class of chemical compounds. It is of pale yellow oily liquid extracted from certain essential oils especially from clove oil, cinnamon, basil and bay leaf. It is slightly soluble in water and soluble in organic solvents and has a spicy, clove-like aroma. Eugenol is used in making perfumeries, flavorings, essential oils and also in medicine as a local antiseptic and anesthetic. It was preferred to used in the production of isoeugenol for the manufacture of vanillin, though most vanillin is now produced from phenol or from lignin. Eugenol derivatives or methoxyphenol derivatives are used in perfumery and flavoring.They are also used in formulating insect attractants and UV absorbers, analgesics, biocides,and antiseptics. Eugenol consist of significant antioxidant, anti-inflammatory and cardiovascular properties,in addition to analgesic and local anestheticactivity.(Sulaiman,2013)[43]

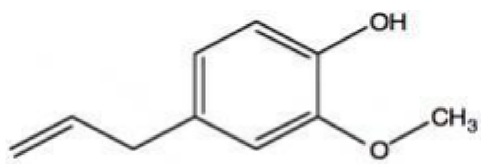

Figure 2.2: Eugenol

CAMPHOR

Camphor is an aromatic, volatile, terpene ketone derived from the wood of *Cinnamomum camphora* or synthesized from turpentine. Camphor oil is distingushed into four different fractions like white, brown, yellow, and blue camphor. 46 White camphor are used in the form of aromatherapy and in OTC products (brown and yellow fractions contain the carcinogen safrole, and are not normally available). OTC products vary in form and camphor content the external products contain 10% to 20% in semisolid forms or 1% to 10% in camphor spirits. It can be used as a topical rubefacient and antipruritic agent. (Camphor is rapidly absorbed from the skin and gastrointestinal tract, and toxic effects can occur within minutes of exposure).In humans intoxication like emesis, abdominal distress, excitement, tremors, and seizures followed by CNS depression characterized by apnea and coma. Fatalities have taken place in humans by ingesting 1 to 2 g of camphor-containing products, although the adult human lethal dose has been reported to be 5 to 20 g. Excess ingestion in the children can result in hepatotoxicity and neurotoxicity.(Elizabeth A. Hausner)[42]

METHOD OF EXTRACTION OF ESSENTIAL OIL

For the extraction of the essential oil, steam distillation and Soxhlet extraction methods were used. Steam distillation is considered to be the simplest and cheapest method to extract the essential oil from cinnamon. Steam distillation is mostly used in extraction of various types of essential oils. This process is cheaper than other extraction methods. It does not require any solvent and is preferred to be safer method compared to other methods. The advantage of steam distillation method is that it is relatively cheap to operate at basic level, and the properties of the oils produced by this method are not altered. As steam reduces the boiling point of a particular component of the oil, it never decomposes in this method. Apart from being economical, it is also relatively faster compared to other methods. Soxhlet extraction is also one of the traditional methods used for the isolation of metabolites from plant material. Analytes having medium to low volatility that may play a role for the aroma and quality of oil extracted from the plant material are extracted by this technique. The correct choice of solvent is important in order to get a good yield from the extraction as well as to prevent the loss of volatiles. The solvent used in this method is indicative of the polarity of the compounds extracted. The extraction usually is carried out for a long period. Disadvantage of this technique is that because of the long heating period, the analytes are exposed to high temperatures, which can lead to the thermal degradation of some compounds. The recovered sample is diluted and has to be concentrated further, by evaporation. During this step there is chance of loss of volatiles can taking place.(Y.C.Wong*, 2014)

BIOLOGICAL ACTIVITIES OF CINNAMON OIL

ANTIBACTERIAL

Cinnamon oils have been widely studied for their antimicrobial effects on various bacteria. Cinnamon oils and extracts, as well as their major components cinnamaldehyde and eugenol, have been found to exhibit antimicrobial effects on both gram-positive and gram-negative bacteria such as *Salmonella enterica*, *Escherichia coli* and *Listeria monocytogenes*. El-Baroty et al. (2010) found that cinnamon essential oil exhibited a strong antibacterial activity against *Bacillus subtilis*, *Bacillus cereus*, *Staphylococcus aureus*, *Streptococcus faecalis*, and *Micrococcus luteus* and gram-negative bacteria *Alcaligenesfaecalis*, *Enterobacter cloacae*, *Pseudomonas aeruginosa, Klebsiellapneumoniae*, and *Serratiamarcescens* . Cinnamon bark oil and its major components showed antibacterial effects on the major respiratory and gastrointestinal tract pathogens *Haemophilusinfluenzae*, *Streptococcus pneumoniae*, *Streptococcus pyogenes*, and *S. aureus*. Antibacterial activities of cinnamon bark oil and cinnamaldehyde have been attributed to considerable alterations in the structure of cell envelopes . The membrane permeability may be affected by an inhibition of energy generation, probably due to the inhibition of glucose uptake or utilization of glucose. The cinnamaldehyde of the biofilm is partially caused by the down regulation of quorumsensing systems. The antibacterial actions of natural extracts of cinnamon have been suggested to be a relevant tool in the control of pathogens of aquatic animals. (Khalid Haddi, 2017)[29]

ANTIFUNGAL

Cinnamaldehyde is the main component oil in a leaf of cinnamon that have antifungal activity, compare with the other compositions for cinnamon it has the ability to prevent the growth of fungi. (Yaseen & Mohammed, 2020)[41] Based on several in vivo and in vitro studies, cinnamon essential oils and its major components have been found to exhibit significant inhibitory effects against several fungi, including *Coriolus versicolor, Laetiporussulphureus, Eurotium* spp*.,* *Aspergillus* spp., and *Penicillium*. Trans-Cinnamaldehyde is a component in the oil of C.

zeylanicum, was found to be the most active compound against 17 micromycetes . Singh et al. (2007)[34], using several methods to study the antifungal efficacy of cinnamon essential oil and its oleoresin, reported that the volatiles elicited from the essential oils extracted from cinnamon leaves were found to be 100% antifungal against *Aspergillus niger*, *Aspergillus terreus*, *Fusariummoniliforme*, *Fusariumgraminearum, Penicilliumcitrinum,* and *Penicilliumviridicatum,* but not against *A. ochraceus* and *A. terreus*. The leaf oleoresin showed complete mycelial zone inhibition for *P. citrinum*, and volatiles elicited from the essential oils extracted from cinnamon barks showed complete inhibition against fungi such *as F. graminearum, F. moniliforme, P. citrinum, P*. *viridicatum*, and *A. terreus* (Singh et al. 2007)[34]. Moreover, Singh et al.(2007)[34] also suggested that among cinnamon oil constituent that is cinnamaldehyde possessed the best antifungal activity. Cinnamon oils and extracts showed good antifungal activities against important plant diseases.

<u>ANTICANCER</u>

Drugs used to treat cancer have shown Side effects and health complications. Therefore, recent research has focused on plant medicine and the therapeutic effect of herbal extracts alone or synergy with common cancer drugs that applicated in tumor treatment. Cinnamon have proven wide effective treatment ability after being linked to chemical drugs for cancer. The death of cell plays main roles in the initiation and progression of tumor. Complementary treatments from cinnamon extract have antitumor properties have been noticed owing to their activity in interfering with the oncogenic molecular pathway. (Yaseen & Mohammed, 2020)[41] Cinnamaldehyde has been shown to posses antitumor activity through inhibiting cell proliferation and inducing cell apoptosis. (Yaseen & Mohammed, 2020)[41] (herwiani w, 2016)[40] suggested that cinnamon has the potential to be developed as anticancer, researcher have to confirm the activity as well as safety of this plant, further investigation on its anti cancer properties is in progress.

<u>DAIBETIC</u>

Diabetes mellitus is disorder of glucose metabolism related for deficiency of insulin caused by an autoimmune attack on the β cells of the pancreas and insulin resistance (Yaseen &

Mohammed, 2020)[41]. Effect of Cinnamon represent by shown to have insulin mimetic properties because its active substances rise glucose uptake by activating insulin receptor kinase activity, autophosphorylation of the insulin receptor, and glycogen synthase activity. it has been stated that cinnamon increases glycogen synthasis activity .Studies found how can glycemic control in diabetics; by increase insulin secretions using limited doses of cinnamon (5, 10, and 20mg/kg). (Yaseen & Mohammed, 2020)[41] cinnamon hypoglycaemic activity may be recognized to numerous mechanisms of action comprising the stimulation of insulin release and insulin receptor signaling the activation and regulation of enzymes involve in carbohydrate metabolism ,glycolysis gluconeogenesis, stimulation of cellular glucose uptake and increased glucose transpoter4 receptorsynthesis. Another study shown that cinnamtanin B1, a proanthocyanidin isolated from the stem bark of Ceylon cinnamon, stimulates the phosphoryllation of the insulin receptor beta subunit on adipocytes as well as other insulin receptor.

ANTI-ALLERGY

Cinnamaldehyde showed a therapeutic effect on allergic diseases regarding mucosal cells. Study showed the bioactive of trans-cinnamaldhyde that extracted from cinnamon this major compounds effect on allergen-specific immune responses. The results of the study showed that Cinnamaldehyde, significantly inhibited dendritic cells maturation and subsequent allergen-specific T cell proliferation as well as Th1 and Th2 cytokine production (Yaseen & Mohammed, 2020)[41].

ANTIOXIDANT ACTIVITY

Antioxidant compounds present in foodstuffs play an important role in human life in acting as health-protecting agents. The antioxidants are one of the key additives used in fats and oils. Even in the food processing industries antioxidants have been used to delay or prevent spoilage of food. Spices and medicinal plants are considered as sources of beneficial antioxidants against various diseases. Antioxidants have been considered the most important drivers in the progress and existence of humans, as they respond to free radicals and damage in metabolic diseases and age-related syndromes of humans and other animals. (PasupuletiVisweswara Rao1, 2014)[31]. A study on rats reported that the administration of the bark powder of *C. verum* (10%)

for 90 days produced antioxidant activities as indicated by cardiac and hepatic antioxidant enzymes, lipid conjugate dienes, and glutathione (GSH). Different flavonoids isolated from the cinnamon have a free-radical-scavenging activities and antioxidant properties. A study on the inhibitory effects of cinnamaldehyde and other compounds of cinnamon on nitric oxide production revealed that cinnamaldehyde possesses potential activity against the production of nitric oxide as well as the expression of inducible nitric oxide. The essential oils and some of the major compounds present in cinnamon including (E)-cinnamaldehyde, eugenol, and linalool, were investigated in reference to peroxynitrite induced nitration and lipid peroxidation. In a comparative study among 26 spices, cinnamon shows the highest antioxidant activity, indicating that it can be applied as an antioxidant used in foods. Another study investigated the effectiveness of a mixture of spices on oxidative stress markers as well as the antioxidant activity in high fructose-fed insulin-resistant rats. The mixture that consisted of 1 g/100 g cinnamon bark, showed a significant antioxidant activity compared to the fructose alone group. Volatile oils from *C. zeylanicum* showed significant biological activities. A preliminary study on *C. malabatrum* leaves was conducted in various types of extracts (n-hexane, alcoholic, and aqueous extracts) to determine the presence of phenolic compounds, which indicate antioxidant activity. All of the extracts had moderate amounts of phenolic compounds and showed potential activity against hydrogen peroxide, nitric oxide, and lipid peroxide free radicals. A recent study investigated the antioxidant properties of several parts (i.e., the leaves, barks, and buds) of *C. cassia*. In addition to the antioxidant activity, cinnamon can be used as a preservative in cakes and other food products.

ADVANCED GLYCATION END PRODUCTS (AGEs)

Different types of phenolic and flavonoid compounds have been isolated from cinnamon. Epicatechin, catechin, and procyanidin B2, which are the phenolic compounds isolated from cinnamon, showed noteworthy and potentially inhibitory activities on the formation of AGEs. These antiglycation activities of the phenolic compounds not only are attributed to their antioxidant activities but also are associated with the entrapping capabilities of reactive carbonyl species, such as methylglyoxal (MGO), an intermediate reactive carbonyl of AGE formation. The inhibition of AGE formation by trapping the reactive carbonyl species could be a logical therapeutic approach to treat diabetes and its complications. (Pasupuleti Visweswara Rao1, 2014)[31]

CONCLUSION

Essential oils of clove and cinnamon components are responsible for several health benefits. Eugenol, β-caryophyllene, α-humulene, eugenyl acetate, cinnamaldehyde are the main volatile compounds with antioxidant, antimicrobial, anti-inflammatory, analgesic, antiviral, and anticancer properties. The phenolic components are most active and appear to act principally as membrane permeabilisers. Gram-positive organisms are generally more sensitive to Essential oils than gram-negative organisms. They also show potential as a natural preservatives and also as natural source of antioxidant which are used in pharmaceutical applications. Clove oil is non toxic to fish and acts as an anaestheic for fish species. Essential Oils obtained from edible plants and are safe for humans and environment. Distillation technique is an effective method for isolating components of essential oil with high boiling point. This preserves the structural integrity of the essential compounds by allowing the distillation process to occur at temperature below the actual boiling points of the components. Despite lot of studies carried out, some of the properties and applications have not yet been thoroughly investigated. There are possibilities for investigating the effect of Essential Oil against other diseases and its future application in industries such as pharmaceuticals, foods, cosmetics, dentistry, agriculture, and others.

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