A Vital Role of Syzygium Aromaticum (Clove) in Health Care System

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Abstract: Clove, often referred to as Syzygium aromaticum, is an important plant in traditional medicine systems because of its many medicinal uses. This abstract explores its chemical composition, oil extraction methods, characterisation techniques, identification of important oil components, analytical techniques, and its many biological system uses. Clove contains a number of bioactive substances that contribute to its pharmacological effectiveness, including as acetyl eugenol, caryophyllene, and eugenol. Clove oil is extracted using a variety of methods, including solvent extraction and steam distillation, which enriches the oil with medicinal ingredients. The key ingredients in clove oil are found using methods like gas chromatography-mass spectrometry (GC-MS), which makes a thorough study of its chemical composition possible. Complex analytical techniques help measure and evaluate the strength and purity of medicines containing clove oil. Clove has a range of biological actions, such as antioxidant, anti-inflammatory, and antibacterial qualities, indicating its promise in a number of medicinal uses. Studies conducted in vitro demonstrate clove's effectiveness against microorganisms, blocking inflammatory processes, and exhibiting anti-oxidant properties, opening the door for possible medicinal uses. The thorough investigation of Syzygium aromaticum indicates that it has significant promise in herbal healthcare systems and that more study is necessary to fully realize its medicinal advantages. This abstract offers a succinct synopsis of the in vitro research, biological uses, extraction, characterisation, chemical composition, and analytical methods associated with clove as an essential herbal medication.

Key words: Eugenol, Phytoconstituent, Pharmacological activity, Steam distillation, Hydro distillation, Antiviral, Anesthetic, Anti-inflammatory, Antioxidant, Antibacterial.

INTRODUCTION

Eugenia caryophyllus, a tree belonging to the Myrtaceae family, produces cloves as its fragrant flower blooms. They are mostly used as spices and are indigenous to Indonesia's Maluku Islands. The main countries where cloves are harvested for trade include Tanzania, Madagascar, Sri Lanka, Indonesia, India, and Pakistan. However, Madagascar and Indonesia are the top producers of oil from clove buds.Clove oil comes in three varieties: bud oil, leaf oil, and stem oil. Eugenia caryophyllus flowerbuds are used to make bud oil. It mostly consists of 60–90% eugenol, along with caryophyllene, eugenyl acetate, and other trace amounts. Eugenia caryophyllus leaves are the source of leaf oil. Eugenol makes about 82–88% of its composition, with eugenyl acetate and other trace amounts. Stem oils derived from Eugenia caryophyllus twigs.Ninety to ninety-five percent of it is eugenol, with a few additional trace amounts. Eugenol is a substance that contributes significantly to the flavor of cloves. Seventy-two to ninety percent of the essential oil produced from cloves is eugenol, which is primarily responsible for the clove fragrance.[1,2] The traditional medical approach, which relies on the use of herbal treatments, is still very much a part of the healthcare system. Because they are natural products with fewer side effects and greater efficacy than synthetic competitors, therapeutic plants have gained more popularity in recent decades [3, 4]. Approximately 80% of people on the planet now receive the majority of their primary healthcare from traditional medicine [5]. Many herbal plants have pharmacological properties that make them useful for food preservation, embalming, and other processes. They also contain anti-inflammatory, antibacterial, spasmolytic, analgesic, and local anesthetic properties [6, 7]. Numerous plant species have been shown to possess pharmacological properties linked to their phytoconstituents, which include tannins, alkaloids, glycosides, saponins, flavonoids, steroids, and terpenes [6]. Herbal treatments have been shown to be an important source for the discovery of new pharmaceutical compounds that have been utilized to treat serious illnesses up to this point. These discovered phytochemicals are thought to be an exceptional main compound in the hunt for novel and potent medications.[7]Clove, or Syzygium (S.) aromaticum, is a dried flower bud of the Myrtaceae family that is native to Indonesia's Maluku islands but has lately been grown in many locations around the world [8,9]. The commercial portion of the clove tree consists of its buds and leaves, and the production of blooming buds starts four years after the tree is planted. After that, at the pre-flowering stage, they are harvested manually or with the use of a natural phytohormone [8]. It's interesting to note that they are widely used in the perfume and medical industries. Clove is one of the spices that, because of its antioxidant and antibacterial qualities, may be substituted for chemical preservatives in a variety of foods, particularly those that involve the processing of meat [10]. Certain fragrant herbs, such as cinnamon, oregano, clove, thyme, and mint, have been shown in several studies to possess antibacterial, antiviral, anticarcinogenic, and antifungal properties. Nonetheless, due to its strong antioxidant and antibacterial properties, clove has drawn a lot of attention among other spices [11]. The presence of several chemical ingredients in high quantities with antioxidant activity is thought to be responsible for clove's efficient involvement in the suppression of various degenerative diseases[12,13].

CHEMICAL COMPOSITION

Eugenol is generally regarded as the primary constituent of clove oil, followed by β-caryophyllene and smaller quantities of other substances like benzyl alcohol, however the exact ratios can differ greatly. discovered that there was 78% eugenol, 13% β-caryophyllene, and 34.10% benzyl alcohol concentration in the remaining 76.64% of the sample. Using GC-MS analysis, we have determined the composition of a clove essential oil sample that was obtained using hydro-distillation. A high concentration of eugenol (88.58%), eugenyl acetate (5.62%), β-caryophyllene (1.39%), 2-heptanone (0.93%), ethyl hexanoate (0.66%), humulenol (0.27%), α-humulene (0.19%), calacorene (0.11%), and calamenene (0.10%) was found in the 36 components identified by the chemical analysis, as indicated in Table 1. These statistics show the variety of natural oil while also agreeing with the findings of previous investigations.[14–16]

Extraction Methods of Clove Essential Oil:

Hydro Distillation:

Two popular old CEO extraction methods that are often associated with high costs, substantial pollutants, and low work efficiency are hydro distillation (HD) and organic solvent extraction. The limitations of the conventional extraction approach are now addressed by a few innovative techniques that have been created in response to technological advancements and the green idea. Examples of hydro distillation techniques include enzyme-assisted (EAHD), ultrasound-assisted (UAHD), and microwave-assisted (MAHD). According to European Pharmacopeia, an apparatus akin to a Clevenger was utilized to extract the essential oil from the wood of Aquilaria malaccensis. The wood was immersed in water for seven days before to extraction in order to accelerate the release of the essential oil. Next, a heating mantle connected to the Clevenger received 100 g of A. Malaccensis wood that had been air dried and shrunk in size, together with the required amount of distilled water. The sample mixtures were brought to a boil at 100°C and one atmosphere pressure in order to produce steam that included both water and essential oil. This material was collected in a Clevenger jar and concentrated. The excess condensed water from the extraction process was refilled into the flask. This is the simplest and usually least cost distillation process available. Powders and very hard materials, such as wood, nuts, or roots, tend to react most favorably to hydro distillation. This method's main advantages are that it produces more oil, processes faster, and uses less steam. The plant material is heated during the distillation process either by passing it through a steam stream or by immersing it in boiling water. Under the heat and steam, the plant material's cell walls rupture and crumble, releasing the essential oils. The essential oil components and steam are conveyed through a pipe and directed into a cooling tank, after which they revert to liquid and are placed in a vat. It is easy to separate crude oils from water and siphon out the resultant liquid, which is a mixture of oil and water, since crude oils are not soluble in water. Essential oils that are lighter than the water will cover the surface. Diagrammatic illustration of the process.[17]

Steam Distillation:

The conventional method for separating volatile compounds from plant matter to produce essential oils is distillation. Essential oils from aromatic plants evaporate when they are exposed to steam or boiling water during the distillation process. When distilling two immiscible liquids, water and essential oil, at boiling temperature, the combined vapor pressures equal ambient pressure, which facilitates the restoration of the essential oil. Consequently, the components of essential oils evaporate at a temperature similar to that of water, although often boiling at 200–300°C. The essential oil-infused rising steam enters the little cooling tube. The length of the distillation process, the operating pressure, the temperature, and—most importantly—the kind and quality of the plant material all affect how much essential oil is extracted. Essential oils from plants are usually extracted at a rate of 0.005 to 10%. Historically, there have been three distinct evaporation techniques: steam distillation, water-steam distillation, and water distillation. "Indirect" steam distillation is another name for the method of distilling water. This procedure entails boiling plant material after it has been soaked in water. Steam is created when water boils, and that steam contains volatile oils. Next, cooling and humidification are used to separate the oil and water. Not only is this process sluggish, but materials and perfumes degrade over time in the presence of heat. The leafy plant material is held on a grill over hot water in the steam technique, and the steam travels through the plant material. Take care when placing the leaves on the grill to achieve equal steaming and complete extraction. The most common technique for obtaining essential oils is "direct" steam distillation. There is no water in the distillation tank itself during this process. Rather, an external source introduces steam into the tank. The essential oils are released from the sacs containing the oil molecules when the steam bursts them. .. Condensation and segregation are currently established procedures. Apart from the above stated techniques, there exist several more refined ways for identifying organic scent components and essential oils. These methods include molecular distillation, dry distillation, vacuum distillation, continuous distillation, turbo-distillation, hydro-diffusion, and cold expression. All of these traditional extraction methods have significant disadvantages, including low yields, the production of contaminants, and restricted stability. During the hydro-distillation and steam distillation procedures, the oil evaporated as the steam bubbled through the flask of vegetation. There, the steam condenses as the emerging combination of vaporized water and oil passes through a coil that is regularly cooled and has access to water. utilized to extract the essential oil and condensed water is becoming more and more popular; in very rare circumstances, centrifugation is employed.[18]

Super Critical Fluid Extraction:

The green technique known as supercritical fluid extraction (SFE) can function at low pressures and near room temperature thanks to the use of supercritical CO2 (SC-CO2), which is nonflammable, nontoxic, noncorrosive, and easy to handle. In bulk quantities, supercritical CO2 (SC-CO2) is cheap, readily available, and very pure. It may solubilize lipophilic molecules while maintaining the bioactive compounds' healing or functioning properties (Figure 8). This approach is environmentally friendly and widely recognized as safe (GRAS). Supercritical fluid extraction (SFE) is an extraction process that has received accolades for exceptional performance ever since it was first introduced. In addition to the food and pharmaceutical sectors, SFE is currently widely employed in a wide range of areas, including toxicology, chemistry, the environment, textiles, petrochemicals, and polymers. Over the past three decades, there have been major advancements in the field of supercritical fluid technology, which have pushed the extraction of natural plant materials using this form of extraction. This approach has been defined as an ecologically benign technology. These natural sources might include microalgae, plants, and algae, among other things. The use of nontoxic organic solvents, short extraction times, improved pollution control, and high selectivity are other goals of this approach. Diffusion, density, dielectric constant, and viscosity are among the fluid properties that form the basis of SFE. In order to produce a supercritical fluid, particular parameters like temperature and pressure are usually changed. Under these circumstances, there is a fluid between the liquid and the gas in issue because the SF's viscosity and density are comparable to those of the gas. Stated differently, the condition of a fluid in which all of its characteristics are identical to those of a gas is known as its supercritical state. Furthermore, SFs are better at transporting than liquids because, in contrast to liquid solvents, they have a density that can be altered by varying the temperature and pressure. SFE is dependent on the density, dielectric constant, diffusivity, and viscosity of the fluid and usually involves adjusting certain parameters, such as temperature and pressure, to produce a supercritical fluid. Because the SF's density and viscosity are comparable to those of the liquid and gas in issue, under similar circumstances, a fluid exists between the two. Stated differently, the condition of a fluid in which all of its characteristics are identical to those of a gas is known as its supercritical state. Furthermore, SFs are better at transporting than liquids because, in contrast to liquid solvents, they have a density that can be changed by varying the temperature and pressure.[19]

Microwave-Assisted Hydro Distillation:

Microwave-assisted Hydro-distillation (MAHD) combines traditional solvent extraction with rapid heating in the microwave field. This enables substantial time savings, enabling the recovery to be completed in a few short minutes. To combine microwave heating with traditional HD, MAHD was developed and applied to the extraction of essential oils from Xylopia aromatica (Lamarck) and Lippia alba (Mill).[20] For use in scientific settings when extracting essential oils from different varieties of aromatic plants.[21] used a free solvent to build a Microwave Assisted Distillation (MAD). Solvent-free microwave extraction (SFME) was developed by Chemat in 2015.[22] This process, which is based on a very simple principle, involves using a microwave to dry distill a fresh plant matrix without the need of water or any other organic solvent. SFME is not the same as modified microwave-assisted extraction (MAE), which use organic solvents, or modified hydro-distillation (HD), which needs a lot of water. The in-situ water content of plant material was selectively heated, causing the glands and oleiferous receptacles to explode. By using water in an azeotropic distillation process, the essential oil is thus extracted from the plant material and allowed to evaporate. Refluxing the surplus water into the extraction vessel will return the original water to the plant material. Citrus fruits, aromatic herbs like thyme, basil, and mint, as well as spices like ajowan, cumin, and star anise, have all been treated with this technique. It has also been used to preserve the quality of postharvest rosemary leaves and has been found to be a viable method of extracting essential oil from rosemary and other fragrant herbs. Using a traditional MAHD method, 100 grams of rosemary were cooked for 30 minutes at atmospheric pressure with the addition of 300 milliliters of water. In this amount of time, the sample's essential oils were all sufficiently extracted. Everybody had at least three extractions done.[23]

CHARACTERIZATION OF CLOVE OIL & ANALYTICAL TEACHNIQUES

FTIR and GCMS spectrum analysis were used to assess the content and characteristics of clove oil; the findings were then compared to a commercial product of 100% pure clove oil. ATR-FTIR mode was used to test a few drops of clove oil in order to compare the compounds' functional groups for resemblance. In addition to ATR data, mass-to-charge (m/z) measurements of clove oil contents have been made using GC-MS. The TraceGOLDTM TG-1MS column (length 30 m; ID 0.25 mm; film thickness L of 1% diluted sample in m) was used to separate the clove oil. Using a split ratio of 1/50, 1 □0.25 methanol was injected into the column. The instrument technique has been modified to apply gradient elution, which provides good compound separation. The system was initially set to 50 degrees Celsius. Subsequently, the temperature was raised by 10 degrees Celsius per minute and held for one minute at 100 degrees. Next, it was raised by 5 degrees Celsius per minute and held for one minute at 140 degrees, then by 2 degrees Celsius per minute at 160 degrees, and at last by 5 degrees Celsius per minute at 245 degrees. Clove oil components' mass-to-charge (m/z) was measured using the electrospray ionization method (EI). The injector and detector temperatures were designed to be at 280°C, while the ion source temperature was kept at 250°C. Helium gas served as the mobile phase, eluting and separating the sample down the column at a flow rate of 1 mL/min. By comparing the mass spectra library (NIST MS) with the molecular weight (m/z), the chemical components of clove oil are identified. The process of extracting clove oil used steam hydro distillation, which took many hours to complete. The distillate was then separated using a separatory funnel and n-hexane to obtain a maximum yield of 7.04 percent, which was reached in just six hours.[24]

Identification of Essential Oil:

Instrumental and physiochemical analysis, which encompasses both qualitative and quantitative examination, may be used to demonstrate the purity of an essential oil. While quantitative analysis seeks to detect the percentage of compounds present in the oil, qualitative analysis is used to ascertain the components of the oil. Essential oil purity should be measured in accordance with ISO standards, AFNOR recommendations, GRAS approval, or national policies [25]. More than 100 national standards bodies are part of the worldwide federation known as ISO (International Organization for Standardization). Nonetheless, France's national standardizing authority and an ISO member is the Association Française de Normalisation (AFNOR) [26]. Odor, color, consistency, optical rotation, solubility, refractive index, specific gravity, acid value, ester value, and ester value following acetylation are some of the metrics used to identify physicochemical qualities. Every parameter has a standard technique that has been defined. However, the chemical makeup of essential oils is ascertained by instrumental investigation employing GC-MS. Compounds are identified using the retention time and/or Kovats index, and the standard compound should be used to quantify the peak in the chromatogram [27].

It is a difficult undertaking to dissect and analyze the chemistry of essential oils. It might be challenging to identify certain essential oils since many of the constituents are only found in trace amounts. The majority of analytical techniques used in EO analysis are based on chromatographic processes, which aid in both component separation and identification. The volatile components of essential oils are typically analyzed using gas chromatography (GC), while the nonvolatile ingredients are typically analyzed using liquid chromatography (LC). Nuclear magnetic resonance (NMR) spectroscopy, mass spectrometry, high performance liquid chromatography (HPLC), and gas chromatography (GC) are common modern techniques for figuring out the contents of essential oils. Chromatographic techniques are used to separate essential oils into their constituent parts so that they may be recognized using specific methodologies. These techniques are based on the interactions between the stationary phase and the molecules to be examined. Thin layer chromatography, various forms of liquid column chromatography, and gas chromatography are among the techniques available for EOs. Furthermore, certain spectroscopic methods, like infrared spectroscopy and ultraviolet spectroscopy, measure the interaction of infrared radiation with matter through absorption, emission, or reflection, respectively, and are based on the visible light's reflectance or absorption. In the modern period, a number of methods, including as HPLC, SFC, and counter current chromatography (CCC), have been developed and used for EO analysis. By using hyphenated methods, spectrometers and chromatographic separation machines may be coupled online to produce structural details about the components that enable identification.[28–30]

Mechanism of Action:

More antioxidants and antibacterials than many other fruits, vegetables, and spices are found in clove. Although it originated in Indonesia, clove is now grown all over the world, especially in the Brazilian state of Bahia. This plant has a lot of promise for use in medicinal, cosmetic, food, and agricultural applications because it is one of the richest sources of phenolic chemicals like eugenol, eugenol acetate, and gallic acid. Clove oil has also historically been used as a scent or as a spice to flavor meals. In addition, topical analgesics contain clove oil. Curiously, research on the effects of clove oil on neuropathic pain and vaginal candidiasis has been promising. The FDA has categorized clove oil as generally regarded as safe (GRAS) for usage in dental cement and food additives.The primary ingredient is the phenol "eugenol," which may be found in clove oil in amounts of up to 85%. Clove oil is used to germinate Escherichia coli, Staphylococcus aureus, and Pseudomonas aeruginosa. Clove oil is thought to suppress prostaglandin production, hence reducing painful sensations. Eugenol, the main ingredient in clove oil, is thought to have anticancer qualities. In one research, eugenol-treated HL-60 cells showed symptoms of mortality such as DNA breakage and the formation of DNA ladders during agarose gel electrophoresis. Research has indicated that eugenol produces reactive oxygen species (ROS), which in turn triggers the mitochondrial permeability transition (MPT), lowers bcl-2 levels, releases cytochrome c into the cytosol, and eventually results in apoptotic cell death.[31]

CLOVE USED IN BIOLOGICAL SYSTEM

Antiviral activity:

In general, the constituents of essential oils have a strong effect on viruses, and phenylpropanoids, monoterpenols, and monoterpenals have all demonstrated antiviral activity in vitro.[32] discovered that the hepatitis C virus could not replicate when Syzygium aromaticum extract was added (≥90% inhibition at 100 µg/mL).[33] isolated and identified an anti-HSV compound, eugeniin, from the extracts of Syzygium aromaticum, which showed specificity in inhibiting HSV-1 DNA polymerase activity

Antioxidant capacity:

Plant phenolics, which are present in all parts of the plant, including the fruit, seeds, and leaves, are a rich source of natural antioxidants.[34] Eugenol, the primary component of clove oil, is responsible for many of its antioxidant qualities[35]. There are several ways that antioxidant activity might manifest itself, including chelating metal ions and scavenging radicals. According to reports, eugenol takes part in photochemical processes.[36] and displays strong antioxidant activity[35] and photocytotoxicity.[37,38] found that the antioxidant action of 0.005% clove oil was identical to that of standard butylated hydroxytoluene at a concentration of 0.01%.%. It has strong chelating ability against Fe+3, which prevents the production of hydroxyl radicals.[38] Clove oil exhibits strong antioxidant properties and can be employed in medicinal applications as well as being a readily available natural antioxidant source.[39]

Anaesthetic activity:

Eugenol has several uses, including as a component of dental cement for temporary fillings and as a local anesthetic in dentistry.[40] Compared to other local anesthetics, it is comparatively easy to administer and may be used at lower concentrations[41]. therefore there is no need for a withdrawal period because it is quickly digested and eliminated.[42] Research has demonstrated its efficacy in sedating fish species, including rainbow trout, Oncorhynchus mykiss Walbaum [43, 41], and channel catfish.[44] In juvenile and sub-adult tambaqui fish, eugenol at 65 mg/L has been demonstrated to safely and successfully induce all phases of anesthesia within the specified period. Its effectiveness in treating other tropical species and its fatal dosage should be the main areas of future investigation.[45]

Anti-inflammatory:

Oxidative stress and inflammation are closely related processes in many pathophysiological conditions, such as diabetes, hypertension, and neurological and cardiovascular diseases.[46] Similar to diclofenac gel, CEO and eugenol have anti-inflammatory properties that reduce inflammation from 60% to 20% in just three hours. In a similar vein, mice given CEO treatment for wounds caused showed a striking 95% reduction in size during the first 15 days. According to these results, wound healing in mice treated with CEO was shown to be on par with that of animals treated with neomycin, an anti-inflammatory drug that is routinely used to hasten wound healing. Therefore, it is feasible to stop synthetic antibiotics from having harmful effects that are both acute and long-term, especially if they are taken often.[47]

In-vitro Studies of Eugenia Caryophyllus :-

Anti-inflammatory Activity:

The paw edema test, which is generated in mice using carrageenan, was used to examine the anti-inflammatory properties of clove oil. In summary, 0.02 ml of a newly made solution of the phlogistic agent carrageenan in saline (10 mg/ml) was sub-plantarly injected into each mouse's right hind paw in three groups of six mice each. Mice given intraperitoneal (i.p.) injections of carrageenan (30 minutes before to treatment, both positive and negative control mice received indomethacin and normal saline. Using a micrometer (Mitutoyo, Japan), paw thickness was measured both before and three hours after carrageenan injection. The degree of acute inflammation and edema was determined by measuring the increase in paw thickness. For each mouse, the percentage suppression of the inflammatory response was calculated relative to mice treated with saline, and the formula was as follows:

Percent inhibition = 100 [(EPT/CPT)] x 100 where CPT stands for control paw thickness and EPT for experimental paw thickness.

Analgesic activities:

The previously published writhing acetic acid test was utilized to assess any potential peripheral effects of the oil as an analgesic. In summary, 10 ml/kg of 0.6% v/v acetic acid was injected prior to the administration of clove oil, aspirin, or a comparable volume of saline (negative control) intraperitoneally. After that, each mouse spent 20 minutes in an observation cage. The amount of hind limb stretches and abdominal muscular contractions, which indicate a writhing reaction, was tallied. The amount of abdominal constrictions in mice treated with aspirin or clove oil prior to treatment was used to measure the antinociceptive activity in comparison to control animals. The following formula was utilized to determine the percentage of inhibition during writhing.

Percent inhibition = [control mean - treated mean] x 100/control mean

Antipyretic test:

The antipyretic test was conducted using a brewer's yeast model of pyrexia. A lubricated digital thermometer (SK-1250 MC, Sato Keiryoki Mfg.) was used to measure the temperature for 60 seconds after being placed about 2 cm into the rectum. Mice were treated with a 20% w/v aqueous solution of brewer's yeast injected subcutaneously (s.c.) below the neck for eighteen hours prior to treatment, in order to produce hyperthermia. Just before to the yeast injection, the initial measurement was taken. Each mouse's rectal temperature was measured after 17 hours. For the purpose of the study, every mouse with an elevated rectal temperature of at least 0.78C was chosen. The baseline measurement for this rectal temperature was provided. I.P. administration of saline, paracetamol, and clove oil was done. The difference in rectal temperature at 0.5, 1, 2, and 3 hours from the baseline data was used to measure each mouse's reaction. The following formula was used to compute the percentage inhibition of fever (% if): Percent if = (PYT- PDT) x 100/PYT

where, PYT represents post-yeast temperature and PDT represents post-drug treatment [15]

Targeting Action:

As a cultural value, the frequent use of traditional medicinal herbs in families is passed down from generation to generation. Taking into account the aforementioned viewpoints, the current investigation set out to ascertain the impact of an aqueous infusion of clove oil and miswake on the ability of oral viridans group streptococci to produce glucan, specifically in relation to decreased GTF activity. One of the most important virulence factors of the primary etiological pathogen of dental caries, Streptococcus mutans, is GTFs. Every study that is currently available suggests that extracellular polysaccharides, in particular the glucans produced by S. mutans GTFs, have a role in the cariogenicity of dental biofilms. As a result, blocking GTF activity and the resulting synthesis of polysaccharides may reduce the pathogenicity of cariogenic biofilms, offering a different approach to stop dental caries. Thus far, natural compounds have been identified as the primary and mainly untapped source of GTF inhibitors. Many of these inhibitors have been found in natural products. These comprise flavonoids, proanthocyanidin oligomers, polymeric polyphenols, catechin-based polyphenols, and a few additional substances originating from plants. Another source of GTF inhibitors includes synthetic compounds, metal ions, and oxidizing agents. Some of these new molecules are produced using templates from existing inhibitors' key structures, or they are found by structure-based virtual screening. While a number of agents have demonstrated strong inhibitory activity against bacterial cell adhesion, caries development, and glucan synthesis by GTFs in animal models, a great deal of research needs to be done to determine the exact mechanism of action, biological safety, cariostatic efficacies, and overall impact on the oral community. Rather of eliminating cariogenic bacteria from the microbial population, GTFs suppression is a method that has the potential to significantly reduce tooth caries. In this sense, clove oil was chosen because it is readily available, does not suffer from seasonal fluctuations, and has long been used as a home remedy for a variety of dental conditions, including toothaches. On the other hand, miswak is a natural tooth brush that is widely used around the world. It is a readily available, reasonably priced source with several pharmacological qualities, such as antimicrobial, antifungal, antiprotozoal, and anti-plaque effects.[50]

CONCLUSION

Cloves, as the aromatic flower buds of the Syzygium aromaticum tree, hold a multifaceted significance that transcends their culinary allure. Their importance extends to the realms of both traditional medicine and modern science, thanks to their remarkable mechanisms, diverse chemical composition, and intricate extraction processes. The key compound, eugenol, plays a pivotal role in clove's therapeutic effects, demonstrating anti-inflammatory, analgesic, and antibacterial actions. The rich chemical composition of cloves, including eugenol, caryophyllene, and acetyleugenol, not only imparts their distinctive flavor but also contributes to their extensive range of applications. The art of extracting clove oil through methods like steam distillation and solvent extraction allows us to harness the concentrated essence of this spice for use in aromatherapy, perfumery, and various health-related treatments. In the world of botanical treasures, cloves emerge as a captivating and versatile gem, offering both sensory delight and potential wellness benefits to those who explore their intricacies.

REFERENCE

[1] Lawless J. The illustrated encyclopaedia of essential oils. The completed guide to the use of oils in aromatherapy and herbalism, health and well-Being. Element Books. Longmead, Shaftesbury, Dorset; 1992.

[2] Kamatou GP, Vermaak I, Viljoen AM. Eugenol—from the remote Maluku Islands to the international market place: a review of a remarkable and versatile molecule. Molecules. 2012; 17(6): 6953-81.

[3] Lawless J. The illustrated encyclopaedia of essential oils. The completed guide to the use of oils in aromatherapy and herbalism, health and well-Being. Element Books. Longmead, Shaftesbury, Dorset; 1992.

[4] Kamatou GP, Vermaak I, Viljoen AM. Eugenol—from the remote Maluku Islands to the international market place: a review of a remarkable and versatile molecule. Molecules. 2012; 17(6): 6953-81.

[5] Ekor, M. The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. Front. Pharmacol. 2014, 4, 177. [CrossRef] [PubMed]

[6] Batiha, G.E.S.; Beshbishy, A.A.; Tayebwa, D.S.; Shaheen, M.H.; Yokoyama, N.; Igarashi, I. Inhibitory effects of Uncaria tomentosa bark, Myrtus communis roots, Origanum vulgare leaves and Cuminum cyminum seeds extracts against the growth of Babesia and Theileria in vitro. Jap. J. Vet. Parasitol. 2018, 17, 1–13.

[7] Beshbishy, A.M.; Batiha, G.E.S.; Adeyemi, O.S.; Yokoyama, N.; Igarashi, I. Inhibitory effects of methanolic Olea europaea and acetonic Acacia laeta on the growth of Babesia and Theileria. Asian Pac. J. Trop. Med. 2019, 12, 425–434.

[8] Cortés-Rojas, D.F.; de Souza, C.R.; Oliveira, W.P. Clove (Syzygium aromaticum): A precious spice. Asian Pac. J. Trop. Med. 2014, 4, 90–96. [CrossRef]

[9] Batiha, G.E.S.; Beshbishy, A.A.; Tayebwa, D.S.; Shaheen, M.H.; Yokoyama, N.; Igarashi, I. Inhibitory effects of Syzygium aromaticum and Camellia sinensis methanolic extracts on the growth of Babesia and Theileria parasites. Ticks Tick. Borne Dis. 2019, 10, 949–958. [CrossRef]

[10] Chomchalow, N. Spice production in Asia—An overview. In Proceedings of the Conference IBC's Asia Spice Markets 96 Conference, Singapore, 27–28 May 1996.

[11] Shan, B.; Cai, Y.Z.; Sun, M.; Corke, H. Antioxidant capacity of 26 spice extracts and characterization of their phenolic constituents. J. Agric. Food Chem. 2005, 53, 7749–7759. [CrossRef]

[12] Hu, F.B.; Willett, W.C. Optimal diets for prevention of coronary heart disease. JAMA 2002, 288, 2569–2578. [CrossRef]

[13] Astuti, R.I.; Listyowati, S.; Wahyuni, W.T. Life span extension of model yeast Saccharomyces cerevisiae upon ethanol derived-clover bud extract treatment. IOP Conf. Ser. Earth Environ. Sci. 2019, 299, 012059. [CrossRef]

[14] Prashar A, Locke IC, Evans CS. 2006. Cytotoxicity of clove (Syzygium aromaticum) oil and its major components to human skin cells. Cell Prolif 39: 241–248.

[15] Pawar VC, Thaker VS. 2006. In vitro efficacy of 75 essential oils against Aspergillus niger. Mycoses 49: 316 –323

[16] Lee KG, Shibamoto T. 2002. Antioxidant property of aroma extract isolated from clove buds (Syzygium aromaticum (L.) Merr. Et Perry). Food Chem 74: 443–448.

[17] Khalil AA, Rahman UU, Khan MR, Sahar A, Mehmood T, Khan M. Essential oil eugenol: sources, extraction techniques and nutraceutical perspectives. RSC Adv. (2017) 7:32669–81. doi: 10.1039/C7RA04803C

[18] Ratri PJ, Ayurini M, Khumaini K, Rohbiya A. Clove oil extraction by steam distillation and utilization of clove buds waste as potential candidate for eco-friendly packaging. J Bahan Alam Terbarukan. (2020) 9:47–54. doi: 10.15294/jbat.v9i1.24935

[19] Soares MCP, Machado PR, Guinosa RE. Supercritical extraction of essential oils from dry clove: a technical and economic viability study of a simulated industrial plant. Environ Sci Proc. (2022) 13:11. doi: 10.3390/IECF2021-10778

[20] Liu Z, Chen Z, Han F, Kang X, Gu H, Yang L. Microwave-assisted method for simultaneous hydrolysis and extraction in obtaining ellagic acid, gallic acid and essential oil from Eucalyptus globulus leaves using Brönsted acidic ionic liquid [HO3S(CH2)4mim]HSO4. Ind Crops Prod. (2016) 81:152– 61. doi: 10.1016/j.indcrop.2015.11.074

[21] Tigrine-Kordjani N, Meklati BY, Chemat F. Microwave 'dry' distillation as an useful tool for extraction of edible essential oils. Int J Aromather. (2006) 16:141–7. doi: 10.1016/j.ijat.2006.09.007

[22] Chemat F, Boutekedjiret C. Extraction//steam distillation?. In: Reference Module in Chemistry, Molecular Sciences and Chemical Engineering Amsterdam (2015).

[23] Sui X, Liu T, Ma C, Yang L, Zu Y, Zhang L, et al. Microwave irradiation to pretreat rosemary (Rosmarinus officinalis L.) for maintaining antioxidant content during storage and to extract essential oil simultaneously. Food Chemistry. (2012) 131:1399–405. doi: 10.1016/j.foodchem.2011.10.007

[24] Lambert, M. M., Campos, D. R., Borges, D. A., de Avelar, B. R., Ferreira, T. P., Cid, Y. P., Boylan, F., Scott, F. B., Chaves, D. S. A., Coumendouros, K. 2020. Activity of Syzygium aromaticum essential oil and its main constituent eugenol in the inhibition of the development of Ctenocephalides felis felis and the control of adults. Veterinary Parasitology. 282: 109126.

[25] Yadav, S. K. (2016). Physicochemical Properties of Essential Oils and Applications. In Essential Oils - Advances in Extractions and Biological Applications a. https://www. intechopen.com/books/advanced-biometric-technologies/liveness-detection inbiometrics%0Afile:///D:/Google Drive/Organized Folder/2016/Kerkeni et al/We are IntechOpen , the world ' s leading publisher of Open Access books Built by scientists.

[26] T.K.T. Do, F. Hadji-Minaglou, S. Antoniotti, X. Fernandez, Authenticity of essential oils. TrAC -, Trends Anal. Chem. 66 (October 2017) (2015) 146–157,

[27] Fokou, J. B. H., Dongmo, P. M. J., & Boyom, F. F. (2012). Essential Oil's Chemical Composition and Pharmacological Properties. In Essential Oils - Oils of Nature Biotic. IntechOpen.

[28] Tisserand, R., & Young, R. (2014). Essential oil safety a guide for health care professionals (2nd ed.). Churchill Livingston.

[29] Sonia, M. (2019). Essential oils. In M. Sonia (Ed.), Essential oil research trends in biosynthesis, analytics, industrial applications and biotechnological production (pp. 3–17), Springer.

[30] Başer, K. H. C., & Buchbauer, G. (2016). Chemistry of essential oils. In C. Sell (Ed.), Handbook of essential oils science technology, and applications, (2nd ed.) (pp. 165–195). CRC Press Taylor & Francis Group NW

[31] Cortés-Rojas DF, de Souza CRF, Oliveira WP. Clove (Syzygium aromaticum): a precious spice. Asian Pac J Trop Biomed. (2014) 4:90–6. doi: 10.1016/S2221-1691(14)60215-X

[32] Hussein G, Miyashiro H, Nakamura N, Hattori M, Kakiuchi N, Shimotohno K. 2000. Inhibitory effects of Sudanese medical plant extracts on hepatitis C virus (HCV) protease. Phytother Res 14: 510–516

[33] Kurokawa M, Hozumi T, Basnet P et al. 1998. Purification and characterization of eugeniin as an anti-herpesvirus compound from Geum japonicum and Syzygium aromaticum. J Pharmacol Exp Ther 284: 728–735

[34] Kim B, Kim J, Kim H, Heo M. 1997. Biological screening of 100 plants for cosmetic use. II.

Antioxidative activity and free radical scavenging activity. Int J Cosmet Sci 19: 299– 307.

[35] Ogata M, Hoshi M, Urano S, Endo T. 2000. Antioxidant activity of eugenol and related monomeric and dimeric compounds. Chem Pharm Bull 48: 1467–1469

[36] Mihara S, Shibamoto T. 1982. Photochemical reactions of eugenol and related compounds: Synthesis of new flavor chemicals. J Agric Food Chem 30: 1215–1218

[37] Atsumi T, Iwakura I, Fujisawa S, Ueha T. 2001. Reactive oxygen species generation and photo-cytotoxicity of eugenol in solutions of various pH. Biomaterials 22: 1459–1466.

[38] Jirovetz L, Buchbauer G, Stoilova I, Stoyanova A, Krastanov A, Schmidt E. 2006. Chemical composition and antioxidant properties of clove leaf essential oil. J Agric Food Chem 54: 6303–6307.

[39] Gülçin Ì, Güngör Ì, Beydemir SS, Elmasta9 M, Küfrevioglu I. 2004. Comparison of antioxidant activity of clove (Eugenia caryophylata Thunb) buds and lavender (Lavandula stoechas L.). Food Chem 87: 393–400.

[40] Markowitz K, Moynihan M, Liu M, Kim S. 1992. Biologic properties of eugenol and zinc oxide-eugenol. A clinically oriented review. Oral Surg Oral Med Oral Pathol 73: 729– 737.

[41] Keene JL, Noakes DLG, Moccia RD, Soto CG. 1998. The efficacy of clove oil as an anaesthetic for rainbow trout, Oncorhynchus mykiss (Walbaum). Aquacult Res 29: 89–101.

[42] Wagner E, Arndt R, Hilton B. 2002. Physiological stress responses, egg survival and sperm motility of rainbow trout broodstock anesthetized with clove oil, tricaine methanesulfonate or carbon dioxide. Aquaculture 211: 353– 366.

[43] Anderson GW, McKinley SR, Colavecchia M. 1997. The use of clove oil as an anaesthetic for rainbow trout and its effects on swimming performance. North Am J Fish Management 17: 301–307.

[44] Waterstrat PR. 1999. Induction and recovery from anaesthesia in channel catfish Ictalurus punctatus fingerlings exposed to clove oil. J World Aquacult Soc 30: 250–255.

[45] Roubach R, Gomes LC, Leao Fonseca FA, LuizVal A. 2005. Eugenol as an efficacious anaesthetic for tambaqui, Colossoma macropomum (Cuvier). Aquacult Res 36: 1056–1061.

[46] Marmouzi I, Karym EM, Alami R, El Jemli M, Kharbach M, Mamouch F, et al. Modulatory effect of Syzygium aromaticum and pelargonium graveolens on oxidative and sodium nitroprusside stress and inflammation. Orient Pharm Exp Med. (2019) 19:201–10. doi: 10.1007/s13596-018-0335-9

[47] Banerjee K, Madhyastha H, Sandur VR, Manikandanath NT, Thiagarajan N, Thiagarajan P. Anti-inflammatory and wound healing potential of a clove oil emulsion. Colloids Surf B Biointerfaces. (2020) 193:111102. doi: 10.1016/j.colsurfb.2020.111102

[48] Taher YA. Antinociceptive activity of Mentha piperita leaf aqueous extract in mice. Libyan J Med. 2012; 7: 16205,

[49] Valarmathi R, Rajendran A, Akilandeswari S, Senthamarai R. Study on antipyretic activity of a Mollugo pentaphylla Linn in albino mce. Inter J Pharm Tech Res. 2010; 2: 238890

[50] Ren, Z., L. Chen, J. Li and Y. Li (2016). Inhibition of Streptococcus mutans polysaccharide synthesis by molecules targeting glycosyltransferase activity. J Oral Microbiol., 20: 8:31095