# Camphor laurel tree (*Cinnamomum camphora*). A review of chemical composition and biological activities

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## Abstract

This review is focused on the chemical composition of extracts from *Cinnamomum camphora* and their potential biological activities. Many of these species synthesize aromatic volatile oils, depending on the nature of the chemical composition with a wide range of variations in samples obtained from distinct countries. Reports on chemical analysis of *Cinnamomum* species essential oils and extracts have disclosed that most oils are rich in camphor, linalool, 1.8-cineol, d-borneol and safrole. There are different chemotypes observed worldwide for *Cinnamomum camphora* essential oils that have proven their effectiveness as repellent agents against stored product pests, with antifungal and antibacterial properties, as well as anthelmintic, anticandidial, anticonvulsant, neuroprotective, anti-inflammatory, anti-depressant and antioxidant activities.

**Keywords:** *Cinnamomum camphora*, chemical composition, biological activities. POOR keywords!

## Introduction

The *Lauraceae* family consists about of 70 genera and circa 250 species [1] distributed in tropical and subtropical regions of America, Central America, Asia, Oceania and Australasia [2]. *Cinnamomum camphora* has a long history of medicinal herbal use. *Camphora* is not only used for ornamental purposes, but also as a preservative in pharmaceuticals, cosmetics and perfumery because it has commercially important compounds of terpenoids [3]. However, despite these positive properties and popularity in many countries, the Australian Land Protection Act of 2001 considers the introduction of camphor trees to be undesirable within agricultural, native, and urban environments [4], and in Florida the species is designated as a

category I invasive plant [5]. Annually, a single camphor tree can produce >100,000 seeds [4].

## 1. Medicinal properties of *Cinnamomum camphora*

Camphor tree is used in aromatherapy for its beneficial effects. Different of his parts have several applications, this relates to stem bark, twigs, leaves and flowers. Camphor has several chemical varieties, each with different essential oil compositions [12]. The leaf contains camphor, as the main component along with cineol, linalool, eugenol, limonene, safrole, α-pinene, β-pinene, β-myrecene, α-humulene, p-cymene, nerolidol borneol, camphene and some other components [12-15]. Camphor has been used for centuries and throughout the world in many pharmaceutical applications such as topical analgesic, antiseptic, antispasmodic, anti-pruritc, antiinflammatory, anti-infective, rubefacient, contraceptive, mild expectorant, nasal decongestant, cough suppressant…etc. [13] [16]. This component is easily absorbed through the skin and can also be administrated by injection, inhalation and ingestion [16].

## 2. Essential oil composition of *Cinnamomum camphora*

The cinnamon essential oil composition varies depending on the geographical origin of the spice and the processing conditions [17] (Table: 1). Numerous studies of *Cinnamomum camphora* essential oil composition have been published, usually most studies have dealt with components of the tree that are simple to sample, such as leaves, twigs, tiny branches, bark, and whole young plants. *Cinnamomum camphora* (L.) *Sieb. var. linaloolifera* essential oil leaves from ~~Vietnan~~ Vietnam was analyzed by the combination of capillary GC and CG-MS. There were 17 components found, which the major components are: linalool (91.1%), camphor (2.3%) and a-terpineol (l.8%) (Figure 3) [18].

The analysis of the oils extracts of different aerial organs of *Cinnamomum camphora* Nees & Ebermaier from Ivory Cost showed that the main components in essential oil leaves were camphor (84.1%), spathulenol (2.6%), bicyclogermacrene (2.0%), a-terpineol (2.0%), α-humulene (1.5%), terpinen-4-ol (1.2%), 1,8-cineol (1.0%) and borneol (1.0%). The essential oil from bark contained camphor (59.2%), 1,8-cineol (6.8%), α-terpineol (4.8%), safrole (4.5%), α-santalene (4.2%), terpinen-4-ol (3.6%), β-santalene (2.5%), cis-α-bergamotene (2.2%), δ-terpineol (1.5%) and the analysis of stem showed that the major components: camphor (69.6%), 1,8-cineol (8.2%), α-humulene (3.6%), α-terpineol (3.5%), β-cadinene (1.7%), terpinen-4-ol (1.7%), limonene (1.4%), β-caryophyllene (1.2%) [19].

The leaf oil from Cuba was investigated by GC/MS which the major components identified were camphor (71.2%), limonene (5.0%), α-fenchene (4.6%), camphene (3.7%), β-pinene (1.7%), β-caryophyllene (1.7%), bicyclogermacrene (1.5%), germacrene (1.5%), α-terpineol (1.2%) [20].

The composition of two varieties Hon-Sho and Ho-Sho of essential oil from Brazil camphor tree identified using GC, GC/MS showed that the major components in Hon-Sho variety were camphor (68.03%), linalool (8.92%), limonene (3.59%), α-pinene (3.15%), β-myrcene (1.90%), camphene (1.83%), β-pinene (1.16%) and in Ho-Sho variety linalool (95.29%), (E)-β-ocymene (0.48%), camphor (0.40%) [21].

The oil of *Cinnamomum camphora* from Madagascar analyzed by gas chromatography contained: 1.8-cineol (63.7%), sabinene (14.0%), α-terpineol (8.3%), α-pinene (4.6%), β-pinene (3.3%), terpinen-4-ol (2.4%) [22].

In previous chemical investigations of two chemo types of *Cinnamomum camphora* from Eastern Australia cineol type with 1.8-cineol (49.8%), sabinene (16.6%), α-pinene (4.5%), α-myrcene (3.2%), citronellol (9.3%), and camphor type which the major chemicals are camphor (65.8%), α-pinene (4.5%), camphene (2.6%), limonene (3.9%), alloaromadendrene (2.7%) [23].

The volatile components from flowers, leaves and branches of *Cinnamomum camphora var Borneol* in China were studied by GC-MS and gas chromatography with flame ionization detector GC/FID. Volatile oil from flowers contained d-borneol (43.4%), α-pinene (31.5%), camphene (8.4%), 1.8-cineol (7.4%), limonene (3.4%). d- borneol was the main component in leaves essential oil with (66.8%), α-pinene (8.3%), limonene (4.6%), 1.8-cineol (4.1%). On other wise in branch volatile oil the major component is also d-borneol (49.4%), 1.8-cineol (16.1%), camphor (12.7%), limonene (4.3%), α-pinene (3.2%), and camphene (1.7%) [24].

The leaves essential oils obtained from Nepal was dominated by camphor (36.5%), camphene (11.7%), limonene (9.0%), sabinene (6.3%) and α-pinene (6.3%) [25].

In another research, GC-MS analyzes showed that the main parts of *Cinnamomum camphora* xylem methanol extract were linalool (2.9%), 4-terpeneol (2.0%), camphor (14.3%), α-Terpineol (9.9%), translinalool oxide (furanoid) (7.7%), g-cadinene (5.5%) [8].

The results analysis by GC-MS for bark *Cinnamomum camphora* essential oil were D-camphor (51.3%), 1.8-cineol (4.3%), α -terpineol (3.8%), and 3-methyl-2-butenoic acid, oct-3-en-2-yl ester (3.1%), while in fruits were safrole (29.0%), D-camphor (28.1%), linalool (12.8%), and 1,8-cineol (5.3%) were D-camphor (40.5%), linalool (22.9%), 1.8-cineol (11.3%), 3,7,11-Trimethyl-3-hydroxy-6,10-dodecadien-1-yl acetate (4.5%), p-Menth-1-en-8-

ol (2.3%), Caryophyllene (2.2%), α-pinene (2.1%), 2-Thujene (2.0%), sabinene (1.8%) were the main constituents of its leaves [26].

The chemical compound of Chinese *Cinnamomum camphora* was identified by the GC-GC-TOFMS [27]. In the leaf essential oil of *Cinnamomum camphora* the major compounds were camphor (18.48%), 1.8-cineol (16.46%), linalool (11.58%) and 3,7-dimethyl-1,3,7-octatriene (11.07%). From *Cinnamomum camphora* twigs the main compounds were 1,8-cineol (17.21%), camphor (13.17%) and 3,7-dimethyl-1,3,7-octatriene (11.47%), while in seed eucalyptol (20.90%), methyleugenol (19.98%), linalool (14.66%) and camphor (5.5%) [27].

**Table 1.** Summary of denominations, chemotypes and producer organs found in the essential oils from the camphor tree

| Countries | Authors | Organs | Chemotype |
|---|---|---|---|
| Vietnam | Dung, 1993 [18] | Leaf | Linalool |
| Ivory Coast | Pélissier, 1995 [19] | Leaf | Camphor |
| | | Bark | Camphor |
| | | Stem | Camphor |
| Cuba | Pino, 1998 [20] | Leaf | Camphor |
| Brazil | Frizzo, 1999 [12] | Leaf | Camphor |
| Madagascar | Chalcha & Valade, 2000 [22] | Leaf | 1.8-Cineol |
| Australia | Stubbs & Specht, 2004 [23] | Leaf | 1.8-Cineol; Camphor |
| China | Shi, 2013 [24]<br>Guo, 2016 [26]<br>Jiang, 2016 [27] | Flower | D-Borneol |
| | | Leaf | D-Borneol; D-Camphor |
| | | Branch | D-Borneol |
| | | Bark | D-Camphor |
| | | Fruits | Safrole |
| | | Twigs | 1.8-Cineol |
| Nepal | Li, 2013 [08] | Leaf | Camphor |

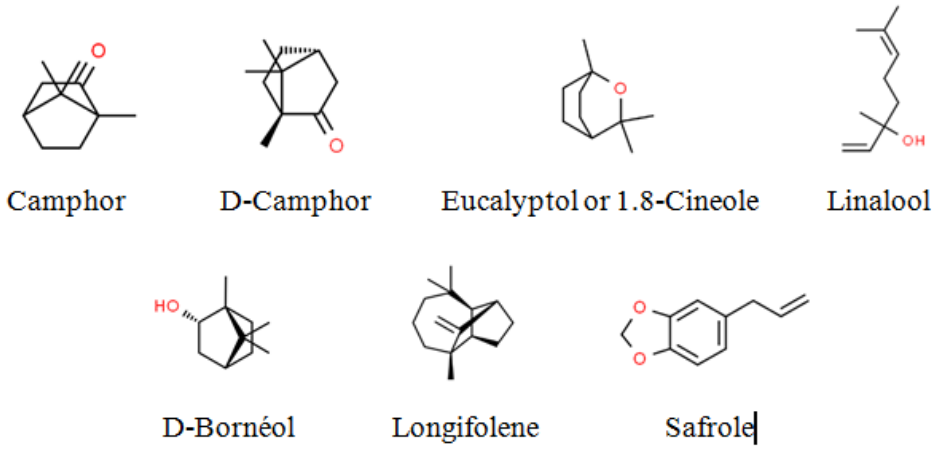


**Figure 3.** Molecular structure of major oil constituent of *Cinnamomum camphora*

## 6. Biological activity of *Cinnamomum* species

Researchers from several research organizations around the world have focused their attention in recent years on the biological activities of essential oils and their constituents of different chemotypes of *Cinnamomum camphora*. The activity of essential oils of different *Cinnamomum* camphora chemotypes against plant fungal pathogens and stored product insects, their mechanism and post-harvest applications and pharmacological activity was evaluated [28].

### 6.1. Antifungal activity of essential oils

~~A~~ Research examined *Cinnamomum camphora* essential oil's antifungal, anti-aflatoxin and antioxidant effectiveness against 14 mold species isolated from wheat and chickpea plants. *Aspergillus niger, Aspergillus terreus, Aspergillus nidulans, Aspergillus candidus, Aspergillus fumigatus, Alternaria alternata, Curvularia lunata, Cladosporium cladosporioides, Fusarium oxysporum, Fusarium nivale, Penicillium italicum, Penicillium citrinum* and *Mycelia sterilia* along with toxigenic strain of *A. flavus* (LHP-10). The antifungal activity of test EOs against the 14 storage mold species was recorded in terms of minimum inhibitory concentration MIC [28]. The EO *Cinnamomum camphora* (leaves) exhibited pronounced efficacy against test mold species (MIC 5.0 µL/mL) inhibited aflatoxin secretion at 1.0 µL/mL, which showed significant inhibition of sporulation in fungal mycelia on increasing concentration up to the MIC, which could also be a reason for its enhanced anti-aflatoxin activity below the MIC. EO's antioxidant activity was discovered to be higher than some commercially available EO-based parts in terms of $IC_{50}$ value (31.85 µL/mL) [28]. Other study investigates the antioxidant capacity from peel and seed of *Cinnamomum camphora* by DPPH, metal chelating and ABTS assays. The results showed that the extracts from seed didn't have antioxidant activity by compression and n-hexane extraction. These results indicated that the antioxidant activity comes mainly from the peel. Water or n-butanol fraction of peel displayed the higher inhibitor activity than ethyl acetate fraction [29].

Recently, essential oils have been introduced for their fungicidal activity to prevent agricultural pathogenic fungi and shown that probing efficiency in the treatment of *Choanephora* and other fungi. Furthermore, Nepal's leaf oil had important antifungal activity against *Aspergillus niger* [30]. Extract of leaf *Cinnamomum camphora* that used by Himalayan people, were investigated against *Alternaria alternata* and *Curvularia lunata* using bioautography. *Cinnamomum Camphora* developed an inhibition zone of 12 mm in diameter against *Curvularia*. *Lunata* and a diameter of 9 mm against *Alternaria alternata* [31].

### 6.2. *Cinnamomum* essential oil as an Antibacterial agent

Recently, various studies have been carried out on the pharmacological activity of essential oil *Cinnamomum Camphora*. Studies have been conducted on Gram-positive and Gram-negative bacteria [32-33]. In another research, antimicrobial characteristics were assessed by five food-related bacteria, including *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, *Salmonella enterica* ATCC 14028, *Staphylococcus aureus* ATCC 25925 and *Bacillus subtilis* ATCC 6633, using both the agar disk diffusion technique and the broth dilution process [34]. The inhibition zone diameter (DIZ) values for all tested bacterial strains were within the range of 16.33 ± 1.70 mm and 18.33 ± 0.47 mm, while the minimum inhibitory (MIC) and minimum bactericidal (MBC) values for tested bacterial strains were within the range of 3.9-31.25 mg / mL and 7.8-62.5 mg / mL respectively [34].

### 6.3. Anticandidal activity of *Cinnamomum camphora* essential oil

*Candida albicans* is the most popular species of *Candida* in the world that can cause any clinical mycoses [35]. While prescribed antifungals may be necessary for the treatment of invasive or chronic infections, natural remedies may provide a safer alternative for less severe infections. Cinnamaldehyde tends to occur in the bark of Cinnamon trees, as well as different types of *Cinnamomum* family, such as camphor and cassia. Cinnamaldehyde is convincing to restrain the development of microscopic organisms, more like yeast, filamentous molds. Nevertheless, for yeasts, cinnamaldehyde MIC is high ranging from 100 mg / ml to 450 mg / ml [36].

*Cinnamomum camphora* was teste to establish the anticandidal activity with two standard antibiotics, miconazole (1000 µg/ ml) and clotrimazole (1000 µg /ml) against *Candida albicans*. The oil and antibiotics antimycotic activity were determined by testing the inhibition zone (IZ). The essential oil was more effective than the two synthetic antibiotics with zone of inhibition (10.67 mm), and Minimum inhibitory concentration (3180 µg/ ml). The two referred antibiotics miconazole and clotrimazole showed lowest ZI 1.44 and 1.39 mm, respectively, in comparison with the oil [35].

### 6.4. Insecticide and repellent activity of *Cinnamomum camphora* essential oil

Recently the essential oil activity continues to be a subject of interest in agricultural crops pests. The pesticide activity against cotton aphids of tree essential oils was investigated by contact toxicity assay [26]. Researches showed higher contact toxicity of essential oil from

seeds ($LC_{50}$ 146, 78 mg/L) more than leaves ($LC_{50}$ 245, 79 mg/L) and twigs ($LC_{50}$ 274, 99 mg/L) compared with the commercial insecticide imidacloprid ($LC_{50}$ 3.58 mg/L). Repellent assay of seeds essential oil was more effective at the concentration of 20 µL/ml after 24h of treatment. In another study against two stored product pests conducted by Shanshan Guo *et al*. (2016), showed that the essential oil and the individual compounds D-camphor, 1.8-cineol exhibits a high efficacy against red flour beetle (*Tribolium castaneum*) and the cigarette beetle (*Lasioderma serricorne*) by contact activity with $LD_{50}$ values of 19.0 and 10.1 ug/adult, respectively [26].

*Solenopsis invicta* Buren, imported red fire ant (RIFA), causes severe damage to humans and animals as well as to the environment. Chemical treatment is the main strategy of RIFA, which may also be poisonous to the environment. In recent years, several studies have shown that essential oils (EOs) obtained from plants are toxic to different pests. The insecticidal activity of Camphor EO was evaluated by fumigant toxicity to workers of RIFA. Results of the fumigant toxicity test showed that the deadly dose of the EO ($LC_{50}$) was 1.67 and 4.28µg /ml for both minor and major workers at 24 h, respectively; knockdown time (KT50) was 10.82 and 14.73 h. The ants' lowest average mortality at 2.55 g / ml after 72 h was 84.89%. Camphor EO has shown fumigant toxicity to minor and major employees as demonstrated by the effects on behaviors that attack, feed and climb [37]. Strong fumigant toxicity with $LC_{50}$ value of 2.50 mg/L was found in another research against *Lasioderma serricorne*, *Cinnamomum camphora* leaves essential oil. There was also powerful fumigant toxicity against L in the isolated compounds D-camphor and linalool. Serricorne adults with 2.36 and 18.04mg / L $LC_{50}$ values, respectively. *Cinnamomum camphora* leaves essential oil also showed strong toxicity to adults with $LD_{50}$ of 21.25 µg / adult to *Lasioderma serricorne* relative to beneficial control pyrethrins of 0.24 µg / adult $LD_{50}$. Camphor EO's fumigant toxicity stated that this substance could be a prospective option for developing environmentally friendly pest control products [38].

Mosquitoes can spread various infectious diseases, in Southeast Asia *Anopheles stephensi* is the main malaria vector. The unreasonable long-term use of Chemical insecticides begun to lead to the destruction of the ecological balance which make the need of for new environmentally sustainable initiatives and mosquito control strategies is an urgent need [39]. Plant extracts containing camphor can be also developed as larvicides against pests. In the study that investigate the larvicidal activity of the essential oil from leaf of C. camphora (L.) against *Anopheles stephensi*. The results showed an efficiency larvicidal potential with The

LC50 and LC95 determined as 0.146% and 1.057% at 1 h, 0.031% and 0.237% at 12 h, 0.026% and 0.128% at 24 h, respectively [39]. In another study that investigate larvicidal activities against Anopheles sinensis larvae, showed that essential oils from *Cinnamomum camphora* may be effective with LC50 (109.40 μg/mL) [40].

### 6.5. Protective effect of *Cinnamomum camphora* leaves extract against atrazine induced genotoxicity and biochemical changes on mice

Triazine herbicides are one of the world's largest herbicide groups. Specific *in vitro* and *in vivo* studies have shown AT's ability to cause serious health risks. *Cinnamomum camphora* has been used in traditional medicine for a long time [41]. This study was conducted to investigate the protective effect of *Cinnamomum Camphora* Leaves Extract (CLE) against genotoxicity caused by AT and biochemical changes in mice. The findings showed a significant decrease in the percentage of micronuclei, chromosomal aberrations and DNA damage in all tissues examined relative with mice treated with AT. It also regulates enzymes such as glutathione and lipid peroxidase. These results clearly demonstrated CLE's protective effect in mitigating genotoxicity and biochemical changes induced by AT [41].

### 6.6. The algicidal properties of *Cinnamomum camphora* extracts

Due to the release of secondary metabolites including volatile organic compounds (VOCs) and algal contaminants, algal blooms cause several ecological problems and reduce water quality. Developing a new generation of algaecides that should be efficient, economical and environmentally friendly in controlling unwanted algae is important. Plants can prevent algal growth effectively and degrade in nature, which are considerate the possible origin of new algaecides. The inhibitory effects of *Cinnamomum camphora* fresh leaves extracts was studies on the growth of standard cyanobacteria *Microcystis aeruginosa* and green algae *Chlamydomonas reinhardtii* species [42]. *Cinnamomum camphora* fresh leaf water extracts showed inhibitory effects on *Microcystis aeruginosa* cells growth. The methanol extracts from *Cinnamomum camphora* leaf also had inhibitory effects on *Microcystis aeruginosa* cells, and the inhibitory effect at the same concentration was greater than that of water extracts. In the same way as *Microcystis aeruginosa, Chlamydomonas reinhardtii* also had greatly inhibited the growth of *Chlamydomonas reinhardtii* cells. Extracts of water and methanol from *Cinnamomum camphora* and extracts of methanol demonstrated stronger inhibitory effects compared to water extracts at the same concentration. Meanwhile, all *Chlamydomonas reinhardtii* were destroy by the methanol extracts at 15 mg $ml^{-1}$ [42].

### 6.7. Acaricidal activity of compounds from *Cinnamomum camphora* against the carmine spidermite, *Tetranychus cinnabarinus*

Between arthropod pests, the carmine spider mite, *Tetranychus cinnabarinus* (Boisduval), is considerate one of the most common, highly polyphagous pests of a wide range of fields and greenhouse crops worldwide. This mite control still mainly based on the use of synthetic chemical pesticides [43]. A slide-dip bioassay evaluated the acaricidal activity of both the *Camphora* extract and the compounds obtained from the active fractions, 2,4-di-tert-butylphenol and ethyl oleate. The results showed potential acaricidal activity against *Tetranychus cinnabarinus* with *Cinnamomum camphora* extract and its two active components. The $LC_{50}$ levels of 2,4-di-tert-butylphenol and ethyl oleate were found to be 1850.94 and 2481.65 $mg.kg^{-1}$ at 7 days after treatment in a potted seedling study [43].

### 6.8. Study the nematicidal efficiency of *Cinnamomum camphora* extracted saponins and their formulations on root-knot nematodes *Meloidogyne spp*

Plant parasitic nematodes constitute one of the most important pest groups of the economic crops, Nematode root-knot diseases are regulated effectively and mainly by synthetic nematicides. But it has been reported that artificial nematicides are a source of water, nutrition and environmental pollution. The screening of naturally occurring plant secondary compounds for enough nematicidal behavior was an option [44]. Total saponin was extracted from *Cinnamomum camphora*, the nematicidal efficacy was tested by dipping and migration techniques against second-stage larvae under laboratory conditions. In green house conditions, the effect of the tested saponins on the penetration of second stage larvae into egg-plant roots was also studied. The results showed that the saponins derived from *Cinnamomum camphora* do not have any nematic efficacy on root-knot nematode [44].

### 6.9. Anti-inflammatory properties of *Cinnamomum camphora*

Camphor tree, *Cinnamomum camphora* it is the source of natural camphor, used commonly in medicine in various application: the treatment of muscular strains, rheumatic conditions, inflammations and as antiseptic [45-48]. To know *Cinnamomum camphora* anti-inflammatory action in investigating the camphor's modulatory impact on macrophage-mediated inflammatory events such as cytokine production, nitric oxide (NO) release, prostaglandin E2 (PGE2) release adhesion molecules and oxidative stress functional activation. The findings have an important immunomodulatory impact on different inflammatory conditions. In

addition, there is a strong potential for nutritional polyphenols from *Cinnamomum* to become the next generation of nutritional variables that have inflammatory health impacts beyond synthetic drugs [2].

### 6.10. *Cinnamomum camphora* extracts are beneficial against oxidative stress, ~~and~~ inflammation and lipid metabolism disturbances in diet‑induced obese rats

Obesity epidemic can lead to diverse diseases including type 2 diabetes, hypertension and various cancers. Thus, obesity is also considered as a status of chronic oxidative stress. The results shown that *Cinnamomum camphora* seed kernel oil (CCSKO) may promote the mobilization and decomposition of fat and decrease fat accumulation in adipose tissue and improve lipid metabolism. However, other mechanisms by which CCKSO improve hepatocellular injury, and have anti-inflammatory effect in high fat diet (HFD)-induced obese rats. These may partly account for the improvement of CCSKO in amelioration of oxidative stress [49]. In traditional medicine *Cinnamomum camphora* has been prescribed for the treatment of various inflammatory diseases. Methanol extract and its fractions obtained by solvent partition with hexane and ethyl acetate prepared under non-cytotoxic (less than 100 µg/ml) conditions to investigate the potential anti-inflammatory mechanisms [50]. The results obtained shown that ethyl acetate and n-butanol extracts showed a strong anti-oxidative activity with IC50 values of 14 and 15µM, severally, once tested by the 1,1-diphenyl-2-picrylhydrazyl (DPPH) and xanthine oxide (XO) assays. Consider these results the anti-inflammatory activity of *Cinnamomum camphora* may be attributable to the regulation of cytokine, nitric oxide (NO) and prostaglandin E2 (PGE2) development and oxidative stress, and to the subfractions examined, the ethyl acetate extract may be further studied to isolate the active anti-inflammatory principles [50].

### 6.11. Effects of *Cinnamomum camphora* on male rats' sexual behaviors

Camphor has been used both as an aphrodisiac and as an anti-aphrodisiac in the folk medicine of Iran. The finding research on the impact of camphor injection of ICV on concentration of GnRH, LH, FSH and testerone showed minor change in GnRH and sexual hormones. Subcutaneous camphor injection for 5 days also caused a slight decline in GnRH, LH, and FSH. The camphor's effect on sexual performance requires more studies [51-52].

### 6.13. An investigation of anti-depressant activity of *Cinnamomum camphora* oil in experimental mice

*Cinnamomum camphora* oil (CCO) has been referred for multiple disease therapy in the Indian traditional medicine scheme, including its antidepressant activity. Antidepressant activity assessment was performed in experimental animals using different depression models using 3 doses of *Cinnamomum camphora* oil, 250 mg / kg, 500 mg / kg, and 750 mg / kg [54]. The results indicate that in the Forced Swim Test (FST) & Tail Suspension Test (TST), which was important compared to control, animals treated with 3 doses of CCO showed a reduction in their immobility times. The essential oil of *Cinnamomum camphora* may have an antidepressant like effect [54].

### 6.15. Anthelmintic activity of *Cinnamomum Camphor* leaves

For the evaluation of anthelmintic activity in vitro, adult earthworms *(Pheretima posthuma*), roundworms (*Ascaridia galli*) and tapeworms (*Raillietina spiralis*) were used. Different levels (10-70 mg / ml) of *Cinnamomum camphora* leaves aqueous extract have been evaluated in the bioassay [56]. Piperazine citrate (10 mg / ml) has been used as a normal reference drug while distilled water has been used as control. It was noted that the worms were determined when paralysis and death occurred. Extract showed significant anthelmintic activity at a concentration of 50 mg / ml [56]. The result shows that aqueous extract has vermicidal activity and is found to be effective as an anthelmintic. Therefore, the aqueous extract of *Cinnamomum camphora* leaves' anthelmintic activity has been recorded [56].

### 6.16. Anticonvulsant and neuroprotective effects of methanolic extract of *Cinnamomum camphora* leaves in rat brain

Epilepsy is one of the most prevalent chronic neurological disorders, characterized by repeated excessive, uncontrolled exercise of either portion or all the central nervous system called epileptic seizures. A seizure is the physical outcome or behavioral changes following an episode of abnormal electrical activity in the brain [57-59]. Medicinal plant records have been improved over the past two centuries and the research of different medicinal products obtained from plants has resulted in the discovery of some clinically useful drugs that have played a vital role in human disease treatment. *Cinnamomum* methanolic extract's anticonvulsant and neuroprotective effects to further explore Camphora's potential activity on the central nervous system. *Cinnamomum camphora* leaves (MECC) were studied for seizures and acetylcholinesterase (AChE)-induced peak electroshock seizures (MES) and pentylenetetrazol (PTZ) activity. Results showed that MECC (50 and 100 mg / kg b.w., p.o.) showed anticonvulsant conduct as shown by a significant reduction ($P < 0.05$, $P < 0.01$) in

the length of the hind limb tonic extender in the MES seizure model and a significant boost ($P < 0.05$, $P < 0.01$) in the clonic seizure; decreased seizure duration, enhanced protection proportion and percentage boost ($P < 0.05$, $P < 0.01$). MECC at 50 and 100 mg / kg b.w., p.o., also showed dose-dependent neuroprotective activity as indicated by significant reduction in MDA levels, AChE activity and increased GSH levels. These results show that MECC may have anticonvulsant and neuroprotective effects that may be related to increased levels of GABA, AChE inhibition, and brain inflammation and antioxidant activity [60-61].

## Conclusion

*Cinnamomum* belongs to the *Lauraceae* family. Many of these species yield aromatic volatile oils, depending on the nature of the chemical composition. Camphor has a long history of medicinal herbal use in many different cultures. The compiled analysis showed that various species of the *Cinnamomum* genius possessed essential oils with a wide range of variations in their chemical composition in samples obtained from distinct countries. The major components reported in the essential oils of the *Cinnamomum camphora* were camphor, linalool, 1.8-cineol, d-borneol currently, there are different chemotypes observed worldwide for *Cinnamomum camphora* oils have proven their effectiveness as repellent agent against stored product pests, an antifungal and antibacterial propriety, as well the pharmacological activity as anthelmintic activity, anticandidial, anticonvulsant and neuroprotective, anti-inflammatory, anti-depressant and antioxidant activities. For external applications, it is used against headaches and pain.

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## References

[01]. Mabberley D.J. 2008. Mabberley's Plant-Book, 3rd Ed. Cambridge University Press, UK.

[02]. Gunawardena D., Govindaraghavan S. and Munch G. 2014. Anti-Inflammatory Properties of Cinnamon Polyphenols and their Monomeric Precursors. Polyphenols in

Human Health and Disease, 409-427. https://doi.org/10.1016/B978-0-12-398456-2.00030-X

[03]. Miyazawa M., Hashimoto Y., Taniguchi Y., Kubota K. 2006. Headspace Constituents of The Tree Remain of *Cinnamomum Camphora*. Natural Product Letters, 63-69. https://doi.org/10.1080/10575630108041259

[04]. Department of Natural Resources, Mines and Energy, 2001. DNRME facts pest series, Land Protection. State of Queensland, Australia. Available: http://www.dnrme.qld.gov.au (Accessed: January 9, 2020).

[05]. Florida Exotic Pest Plant Council. 2001. List of Invasive Species. Florida Exotic Pest Plant Council, Florida EPPC Newsletter, Vol 11, Number 1, pp. 3-4. Available: http://www.fleppc.org (Accessed: January 9, 2020).

[06]. Donald G. 2009. Cinnamon (*Cinnamomum* Species). Barceloux, MD. pp. 327-335. doi: 10.1016/j.disamonth.2009.03.003

[07]. Güenther, E. 1950. The Essential Oils. 3rd Edition. D. Van Nostrand, New York.

[08]. Li X, Li J, Van der Werff H. 2013. *Cinnamomum camphora*. Flora of China. Missouri Botanical Garden, St. Louis, MO & Harvard University Herbaria, Cambridge, MA.

[09]. Babu K.N, Sajina A, Minoo D., John C.Z., Mini P.M., Tushar K.V., Rema J., Ravindran P.N. 2003. Micropropagation of camphor tree (*Cinnamomum camphora*). Plant Cell Tissue Organ Cult. 74: 179–183. https://doi.org/10.1023/A:1023988110064

[10]. Rich Singh, Talha Jawaid. (2012). *Cinnamomum camphora* (Kapur): Review. Pharmacognosy Journal. Vol 4, 1-5. https://doi.org/10.5530/pj.2012.28.1

[11]. Hsieh T.J., Chen C.H., Lo W.L., Chen C.Y. 2006. Lignans from the stem of *Cinnamomum camphora.* Natural Product Communications, 1(1): 21-25. https://doi.org/10.1177/1934578X0600100104

[12]. Frizzo C.D., Santos A.C., Paroul N., Serafini L.A., Dellacassa E., Lorenzo D. 2000. Essential Oils of Camphor Tree (*Cinnamomum Camphora* Nees & Eberm) Cultivated in Southern Brazil. Brazilian Archives of Biology and Technology. 43(3). https://doi.org/10.1590/S1516-89132000000300011

[13]. Chelliah Abiya D. 2008. Biological Activity Prediction of an Ethno Medicinal Plant *Cinnamomum Camphora* Through Bio-informatics. Ethnobotanical Leaflets.12:181-189. http://www.ethnoleaflets.com/leaflets/cinna2.htm

[14]. Ho C.L., Wang E.I.C., Su Y.C. 2009. Essential Oil Compositions and Bioactivities of the Various Parts of *Cinnamomum Camphora* Sieb.Var. Linaloolifera Fujuta. 31(2):77-96. https://doi.org/10.29898/SHBQ.200906.0006

[15]. Joshi S.C., Padalia R.C., Bisht D.S., Mathela C.S. 2009. Terpenoid Diversity in the Leaf Essential Oils of Himalayan Lauraceae Species. Chemistry& Biodiversity. 6(9):1364-373. https://doi.org/10.1002/cbdv.200800181

[16]. Zuccarini P. 2009. Camphor: Risks and Benefits of a Widely Used Natural Product. J. Appl. Sci. Environ. Manage. 13(2):69-74. http://www.bioline.org.br/pdf?ja09027

[17]. Gabriel A. Cardoso-Ugarte. 2016. Essential Oils in Food Preservation, Flavor and Safety. 930p. https://doi.org/10.1016/C2012-0-06581-7

[18]. Dung N.X., Van Khien P., Trung Chien H., Leclercq P.A. 1993. The Essential Oil of *Cinnamomum camphora* (L.) Sieb. var. linaloolqera from Vietnam. Journal of Essential Oil Research, 451-453. https://doi.org/10.1080/10412905.1993.9698258

[19]. Pélissier Y., Marion C. and Prunac S. 1995. Volatile components of leaves, stems and bark of *Cinnamonum camphora* Nees et Ebermaier. Journal of Essential Oil research, 7(3): 313-315. https://doi.org/10.1080/10412905.1995.9698525

[20]. Pino J.A., Fuentes V. 1998. Leaf Oil of *Cinnamomum camphora* (L.) J. Presl.from Cuba. Journal of Essential Oil Research, 10(5): 531-532. https://doi.org/10.1080/10412905.1998.9700962

[21]. Caren D.F., Ana C.S., Natalia P., Luciana A.S., Eduardo D., Daniel L. 1999. Essential Oils of Camphor Tree (*Cinnamomum camphora* Nees & Eberm) Cultivated in Southern Brazil. Braz. arch. biol. technol. 43(3). https://doi.org/10.1590/S1516-89132000000300011

[22]. Chalcha J.C., Valade I. 2000. Chemical Composition of Leaf Oils of *Cinnamomum* from Madagascar: C. zeylanicum Blume, C. camphora L., C. fragrans Baillon and C. angustifolium. Journal of Essential Oil Research, 12(5): 537-540. https://doi.org/10.1080/10412905.2000.9712153

[23]. Stubbs B.J. and Specht A. 2004. The Essential Oil of *Cinnamomum camphora* (L.) Nees and Eberm. Variation in Oil Composition Throughout the Tree in Two Chemotypes from Eastern Australia. Journal of Essential Oil Research, 16(3): 200-205. https://doi.org/10.1080/10412905.2004.9698697

[24]. Shujiang Shi, Qiduan Wu, Jiyan Su, Chuwen Li, Xiaoning Zhao, Jianhui Xie, Shuhua Gui, Ziren Su & Huifang Zeng. 2013. Composition analysis of volatile oils from flowers, leaves and branches of *Cinnamomum camphora* chvar. Borneol in China. Journal of Essential Oil Research, 25(5): 394–400. http://dx.doi.org/10.1080/10412905.2013.809323

459 [25]. Prabodh Satyala, Prajwal Paudel, Ambika Poudel 2013. Bioactivities and
460 Compositional Analyses of *Cinnamomum* Essential Oils from Nepal: *C. camphora*, *C.*
461 *tamala*, and *C. glaucescens*. Natural Product Communications, 8(12): 1777-1784.
462 https://doi.org/10.1177/1934578X1300801232
463 [26]. Shanshan Guo, Zhufeng Geng, Wenjuan Zhang 2016. The Chemical Composition of
464 Essential Oils from *Cinnamomum camphora* and Their Insecticidal Activity against
465 the Stored Product Pests. International Journal of Molecular Sciences. 17(11): 1836.
466 http://dx.doi.org/10.3390/ijms17111836
467 [27]. Hao Jiang, Jin Wang, Li Song 2016. GCxGC-TOFMS Analysis of Essential
468 OilsComposition from Leaves, Twigs and Seeds of *Cinnamomum camphora* L. Presl
469 and Their Insecticidal and Repellent Activities. Molecules. 21(4): 423.
470 http://dx.doi.org/10.3390/molecules21040423
471 [28]. Bhanu P., Akash K., Aakankcha S., Shashi Y., Arti S., Amrita Yadav D. 2016.
472 Antifungal, antiaflatoxin and antioxidant activity of plant essential oils and their *in*
473 *vivo* efficacy in protection of chickpea seeds. Journal of Food Quality, 39(1): 36-44.
474 https://doi.org/10.1111/jfq.12168
475 [29]. Chi-Ming Liu, Mei-Hui Perng, Chung-Yi Chen. 2018. Antioxidant activities of crude
476 extracts from peel and seed of *Cinnamomum camphora*. Biomedical Research. 29(13):
477 2854-2858.
478 [30]. Pragadheesha V.S, Arvind Saroj, Anju Yadav 2013. Chemical characterization and
479 antifungal activity of *Cinnamomum camphora* essential oil. Industrial Crops and
480 Products, 49: 628- 633. http://dx.doi.org/10.1016/j.indcrop.2013.06.023
481 [31]. Sanjay Guleria, Ashok Kumar. 2006. Antifungal activity of some Himalayan
482 medicinal plants using direct bioautography. Journal of Cell and Molecular Biology.
483 5: 95-98.
484 [32]. Uehara Iwao, Kuramoto Masatoshi, Takeuchi Hiroe, Tanaka Megumi. 2013.
485 Antibacterial effects of volatile fragrance and distilled water of *Cinnamomum*
486 *camphora* leaves.. Chubu Forest Research 61: 171-174.
487 [33]. Neerja Gupta and Goldy Saxena 2010. Antimicrobial Activity of Constituents
488 Identified In Essential Oils from *Mentha* and *Cinnamomum* through GC-MS.
489 International Journal of Pharma and Bio Sciences, 1(4): 715-720.
490 https://ijpbs.net/abstract.php?article=MTQ4

[34]. Haixu Zhou, Jiali Ren, Zhonghai Li. 2017. Antibacterial activity and mechanism of pinoresinol from *Cinnamomum camphora* leaves against food-related bacteria. Food Control, 79: 192-199. http://dx.doi.org/10.1016/j.foodcont.2017.03.041

[35]. Dutta B.K., Karmakar S., Naglot A., Aich J.C. and Begam M. 2007. Anticandidial activity of some essential oils of a mega biodiversity hotspot in India. Journal Compilation, 50(2): 121-124. https://doi.org/10.1111/j.1439-0507.2006.01332.x

[36]. Sheikh Shreaz, Rayees A. Sheikh, Bhatia Rimple, Athar Adil Hashmi. 2010. Anticandidal activity of cinnamaldehyde, its ligand and Ni(II) complex: Effect of increase in ring and side chain. Journal Microbial Pathogenesis. 49: 75-82. https://doi.org/10.1016/j.micpath.2010.03.013

[37]. Fu J.T., Tang L., Li W.S., Wang K., Cheng D.M., Zhang X.Z. 2015. Fumigant Toxicity and Repellence Activity of Camphor Essential Oil from *Cinnamonum camphora* Siebold against *Solenopsis invicta* Workers (Hymenoptera: Formicidae). Journal of Insect Science. 15(1): 129. https://dx.doi.org/10.1093/jisesa/iev112

[38]. Hai Ping Chen, Kai Yang, Chun Xue You. 2014. Chemical Constituents and Insecticidal Activities of the Essential Oil of *Cinnamomum camphora* Leaves against Lasioderma serricorne. Journal of Chemistry. http://dx.doi.org/10.1155/2014/963729

[39]. Yite Xu, Jie Qin, Pan Wang, Qiuxia Li, Shasha Yu, Yanling Zhang, Ying Wang. 2019. Chemical composition and larvicidal activities of essential oil of *Cinnamomum camphora* (L.) leaf against *Anopheles stephensi*. Journal of the Brazilian Society of Tropical Medicine. 53: 01-05. http://dx.doi.org/10.1590/0037-8682-0211-2019.

[40]. Jingjing Zhang, Ting Huang, Jing Zhang, Zongpan Shi, Zhengbo He. 2018. Chemical Composition of Leaf Essential Oils of Four *Cinnamomum* Species and Their Larvicidal Activity Against *Anophelus sinensis* (Diptera: Culicidae). Journal of Essential Oil Bearing Plants. 21(5): 1284-1294. http://dx.doi.org/10.1080/0972060X.2018.1552205

[41]. Asmaa S.S., Ayman A.F., Souria M.D., Fawzia S. 2012. Protective Effect of *Cinnamomum Camphora* Leaves Extract against Atrazine Induced Genotoxicity and Biochemical Effect on Mice. Journal of American Science, 8(1): 190-196.

[42]. Silan Chena, Tiefeng Zheng, Chaolin Ye, Wulan Huannixi, Zumulati Yakefu, Yiyu Meng, Xin Peng, Zhengfeng Tian, Junhao Wang, Yuandan Ma, Youyou Yang, Zhongqing Ma, Zhaojiang Zuo. 2018. Algicidal properties of extracts from *Cinnamomum camphora* fresh leaves and their main compounds. Ecotoxicology and Environmental Safety, 163: 594–603. https://doi.org/10.1016/j.ecoenv.2018.07.115

[43]. Yijuan Chen, Guanghui Dai. 2015. Acaricidal activity of compounds from *Cinnamomum camphora* (L.) Presl against the carmine spidermite, *Tetranychus cinnabarinus*. Pest Management Science. 71(11): 1561-1571. https://doi.org/10.1002/ps.3961

[44]. Hala S.I., Hamouda S.E.S., El-kady A.M.A., Abd-Alla H.I. 2014. Study the Nematicidal Efficiency of *Corchorus olitorius*, *Cinnamomum camphora*, *Portulace oleraceae* and *Lantana camara* Extracted Saponins and Their Formulations on Root-Knot Nematodes *Meloidogyne Spp*. Nature and Science. 12(11): 40-45.

[45]. The Wealth of India: A Dictionary of Indian Raw Materials and Industrial Products (Industrial Products—Part I). *Ind Med Gaz*. 1949;84(10):476-477.

[46]. Bailey L.H., Bailey E.Z. 1976. Hortus Third, a concise history of plants cultivated in the United States and Canada. Macmillan Publishing Co. Inc, New York.

[47]. Grieve M. 1979. A Modern Herbal. In: Leyel CF (ed) A Modern Herbal. Jonathan Cape, Thirty Bedford Square, London. 155–156

[48]. Nirmal Babu K, Sajina A, Minoo D., John C.Z., Mini P.M., Tushar K.V., Rema J. & Ravindran P.N.. 2003. Micropropagation of camphor tree (*Cinnamomum camphora*. Plant Cell, Tissue and Organ Culture, 74: 179–183. https://doi.org/10.1023/A:1023988110064

[49]. Jing Fu, Cheng Zeng, Zheling Zeng, Baogui Wang, and Deming Gong. 2016. *Cinnamomum camphora* Seed Kernel Oil Ameliorates Oxidative Stress and Inflammation in Diet-Induced Obese Rats. Journal of Food Science. 81(5): H1295-H1300. https://doi.org/10.1111/1750-3841.13271

[50]. Hye Ja Lee, Eun-A Hyun, Weon Jong Yoon, Byung Hun Kim, Man Hee Rhee, Hee Kyoung Kang, Jae Youl Cho, Eun Sook Yoo. 2006. *In vitro* anti-inflammatory and anti-oxidative effects of *Cinnamomum camphora* extracts. Journal of Ethnopharmacology. 103(2): 208–216. https://doi.org/10.1016/j.jep.2005.08.009

[51]. Akram J., Javad S., Ali Akbar N., Fateme T., Gholam-Hossein O. 2006. Effects of camphor on sexual behaviors in male rats. Iranian Journal of Pharmaceutical Sciences, 2(4): 209-214. http://www.ijps.ir/mobile/article_1949.html

[52]. Shahabi S., Jorsaraei S.J.A., Moghadamnia A.A., Zabihi E., Aghajanpour S.M., Kani S.N.M., Pourbagher R., Hosseini S.A., Esmaili M., Yoonesi A.A., Zarghami A. and Alinezhad F., 2012. Central Effects of Camphor on GnRH and Sexual Hormones in Male Rat. Int J Mol Cell Med, 1(4): 191-196. https://www.ncbi.nlm.nih.gov/pubmed/24551777

559 [53]. Qing Wu, Qingdong Huang, Zhuomei Chen. 2019. Effects of *Cinnamomum*
560 *Camphora* Forest Environment on Elderly Patients with Hypertension: Implications
561 for Adjunctive Therapy. Advances in Social Science, Education and Humanities
562 Research, 268: 203-209. https://dx.doi.org/10.2991/sohe-19.2019.34
563 [54]. Jay Rabadia, Satish.S, Ramanjaneyulu J, Narayanaswamy VB. 2013. An Investigation
564 of Anti-Depressant Activity of *Cinnamomum Camphora* Oil in Experimental Mice.
565 Asian Journal of Biomedical and Pharmaceutical Sciences, 3(20): 44-48.
566 [55]. Gorji, A. 2003. Pharmacological treatment of headache using traditional Persian
567 medicine. Trends in Pharmacological Sciences, 24(7): 331-334.
568 https://doi.org/10.1016/S0165-6147(03)00164-0
569 [56]. Haque Rabiul, Mondal Subhasish, Ghosh Parag. 2011. Investigation of in Vitro
570 Anthelmintic activity of *Cinnamomum camphor* Leaves. International Journal of Drug
571 Development & Research, 3(1): 295-300.
572 [57]. Loscher W. 1998. New visions in the pharmacology of anticonvulsion. Eur J
573 Pharmacol 342:01-13. https://doi.org/10.1016/S0014-2999
574 [58]. Fisher RS., van Emde BW., Blume W., Elger C., Genton P., Lee P., Engel J Jr. 2005.
575 Epileptic seizures and epilepsy: definitions proposed by the International League
576 against Epilepsy (ILAE) and the International Bureau for Epilepsy (IBE). Epilepsia
577 46: 470–472. https://doi.org/10.1111/j.0013-9580.2005.66104.x
578 [59]. Shakya AK., Kamal M., Balaramnavar VM., Bardaweel SK., Naik RR., Saxena AK.,
579 Siddiqui HH. 2016. Design, synthesis and evaluation of benzofuran-acetamide
580 scaffold as potential anticonvulsant agent. Acta Pharm 66(3): 353–372.
581 https://doi.org/10.1515/acph-2016-0023
582 [60]. Talha J., Mehnaz K., Richa S. 2018. Anticonvulsant and neuroprotective effects of
583 methanolic extract of *Cinnamomum camphora* leaves in rat brain. Oriental Pharmacy
584 and Experimental Medicine. 18: 237-246. https://doi.org/10.1007/s13596-018-0306-1
585 [61]. Siti Y.M. Subki, Jamia A. Jamal, Khairana Husain, Nurhuda Manshoor 2013.
586 Characterisation of leaf essential oils of three *Cinnamomum* species from Malaysia by
587 gas chromatography and multivariate data analysis. Pharmacognosy Journal, 5(1): 22-
588 29. https://doi.org/10.1016/j.phcgj.2012.12.004