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Original article

Antimicrobial potential of Indian *Cinnamomum* species

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ABSTRACT

Cinnamomum is the largest genus of Lauraceae family and has been used as spices, food, and food additives by the people. Total 15 Cinnamomum species are distributed in different parts of Indian subcontinent. Different parts (leaves, stem bark, stem wood, roots, flowers, and fruits) of these species were shade-dried and used for the determination of essential oils. A total of 19 essential oils were identified and quantified from the different parts of (leaf, stem bark, stem wood, root, flower, and fruit) of 15 Cinnamomum species. The stem bark of C. altissimum was rich in the presence of essential oils (52.2 %) whereas minimum levels of essential oils were recorded in roots (17.9 %). The γ-terpinene (11.1 %) was reported as the major component essential oil in C. subavenium flowers. Methanol extract of C. camphora stem wood showed stronger lowest minimum inhibitory concentration against S. aureus (25 ± 0.01 μg/ml), H. pylori (29 ± 0.05 μg/ml), B. subtilis (31 ± 0.03 μg/ml), E. faecalis (33 ± 0.01 μg/ml), C. albicans (38 ± 0.03 μg/ml) when compared to amoxycillin (S. aureus 56 ± 0.05 μg/ml; B. subtilis 27 ± 0.04 μg/ml, E. faecalis 22 ± 0.01 μg/ml), streptomycin (H. pylori 38 ± 0.02 μg/ml) and fluconazole (C. albicans 56 ± 0.01 μg/ml). Methanolic extract of C. camphora stem wood demonstrated maximum antimicrobial activity against S. aureus, H. pylori, B. subtilis, E. faecalis and C. albicans. The essential oil of C. altissimum stem bark displayed significant lowest MIC against S. aureus (21 ± 0.03 μg/ml), E. coli (22 ± 0.03 μg/ml), E. cloacae (37 ± 0.06 μg/ml), L. monocytogenes (47 ± 0.08 μg/ml), and P. chrysogenum (101 ± 0.07 μg/ml) when compared to amoxycillin (E. coli 18 ± 0.01 μg/ml, E. cloacae 21 ± 0.05 μg/ml, L. monocytogenes 31 ± 0.03 μg/ml), and fluconazole (P. chrysogenum 101 ± 0.07 μg/ml). The essential oil of C. altissimum stem bark displayed maximum antimicrobial activity against S. aureus, E. coli, E. cloacae, L. monocytogenes, and P. chrysogenum. Cinnamomum essential oils may be used as an alternative source of antibacterial and antifungal compounds in the treatment of various types of infections.

1. Introduction

India is known for its rich biodiversity of medicinal plants as well as for ancient traditional system of medicine. As per ancient literature, the Ayurvedic system of medicine was established in between 2500 and 500 BCE in India (Subhose et al. 2005). Medicinal plants are widely used in the treatment of fever, asthma, gastrointestinal problems, skin, respiratory and urinary complaints, inflammations, rheumatism, hepatic, and cardiovascular disorders (Tian et al. 2014). The biosynthesis of phytoconstituents in medicinal plants are widely depending on the type of plant species, soils and on their interaction with microorganisms (Zhao et al. 2011; Morsy 2014). More than 200 species of *Cinnamomum* genus are naturalized in Asia, South and Central America, China, and Australia (Cardoso-Ugarte et al. 2016).

C. altissimum Kosterm is a large size tree and grows up to 30 m high. The stem girth is about 1.5 m. It is native to Peninsular Malaysia, India as well as in lowland and hill forests of Sumatra (Kochummen 1989; Abdelwahab et al. 2017). The different parts (leaves, stem bark and stem wood) of this species are used in the healing of wounds (Salleh et al. 2015). *C. bejolghota* (Buch.-Ham.) Sweet [syn. *C. obtusifolium* (Roxb.) Nees] is an evergreen tree with smooth stem bark and is naturalized in India (Gogoi et al. 2014, 2021), Bangladesh, Myanmar, Nepal, Thailand, and Vietnam (Wu and Raven 1996), China, Sri Lanka, Madagascar, and East of Thailand (Li et al. 2013). *C. bejolghota* is useful in the treatment of

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cough, cold, toothache, and liver complaints (Choudhury et al. 1998; Liu et al. 2020). Its leaves are used in the treatment of diarrhea (Chopra et al. 1956) and bark is useful in fever (Sajem et al. 2008). *C. burmannii* is a shrub and/or a small tree and is distributed in Southeast Asia, India, Indonesia, and Philippines (Tan 2005). The stem bark powder is used in the treatment of nausea, flatulent dyspepsia, coughs, chest complaints, diarrhea, and malaria (Chopra et al. 1956; Rovira 2008; Nunes et al. 2022).

C. camphora (L.) Siebold is an evergreen tree with wide branching. The leaves are green and broad. The flowers are white in color. The plant species is distributed in China, India, Korea, Japan, and Vietnam. It is useful in cough, cold, toothache, diarrhea, dysentery, skin infections and vomiting (Nishida et al. 2006; Hsieh et al. 2006). *C. cassia* (L.) J.Presl is a small perennial and evergreen tree, grows with thick and aromatic bark (Sharifi-Rad et al. 2021). It is naturalized in China, India, Vietnam, and Indonesia (Wang et al. 2013, 2020). In Chinese and Indian traditional medicine, it is used in the treatment of arthritis, bellyaches, dysmenorrhea, nephropathy, dysmenorrhea, menoxenia and diabetes (Chinese Pharmacopoeia Commission 2015; Zhang et al. 2019). *C. cassia* possesses antitumor, anti-inflammatory, analgesic, anti-diabetic, anti-obesity, antibacterial, antiviral, cardiovascular protective, cytoprotective, neuroprotective, and anti-tyrosinase activities (Kwon et al. 2006; Hong et al. 2012). *C. glaucescens* (Nees) Hand. -Mazz. is a perennial tree with rough bark and is distributed in Himalayan range of Nepal and India (Baruah and Nath 2006; Chinh et al. 2017). It has been used as an analgesic, antiseptic, astringent, and carminative agent. Its seeds are used in the treatment of cold, cough, and toothache (Chopra et al. 1956; Sthapit and Tuladhar 1993). Seed paste is externally applied in curing muscular pain and swellings (Prakash et al. 2013). In Manipuri medicine (India), its bark powder is used to treat kidney complaints (Mikawlrawng and Kuma 2014). Essential oils of *C. glaucescens* demonstrated antibacterial effects against *Escherichia coli*, *Staphylococcus aureus* and *Klebsiella pneumoniae* (Gyawali et al. 2013).

C. insularimontanum Hayata is an evergreen tree with broad leaves (Chung et al. 2003). It is distributed in different regions of Taiwan, Bangladesh, Myanmar, and India and useful in the treatment of inflammations, gastric ulcers, and rheumatic diseases (Lin et al. 2003). *C. javanicum* Blume is a medium size tree and grows up to 30–35 m high. It is naturalized in southern China to Peninsular Malaysia, Sumatra, Java, India, and Borneo (Wuu-Kuang 2011). Stem crude extract of *C. javanicum* showed significant antimicrobial activity against *Listeria monocytogenes* (Yuan et al. 2017; Ardhany et al. 2021). *C. kanehirae (Hayata) Hayata* (syn. *C. micranthum* (Hayata) Hayata; syn. *C. xanthophyllum* H.W. Li) is a perennial tree and grows up to 8–10 m high. It is native to Taiwan (Wu et al. 2017) but, naturalized in tropical and subtropical regions of eastern Asia (India, and Myanmar), Australia, and the Pacific Islands (Liao et al. 2010). As per Chinese traditional medicine, it is used in the treatment of lung infections and nervous depressions. Its essential oils possess antimicrobial (Yeh et al. 2009), and hepato-protective activities (Zisman et al. 2002; Lin et al. 2018). *C. kotoense* is an evergreen tree and grows up to 45 feet high (Chen et al. 2006). It is used in the treatment of headache and boosting of blood circulation in people (Li et al. 2006; Yuan et al. 2020).

C. osmophloeum Kaneh is a perennial tree and is distributed in Taiwan, India, South and Southeast Asia. Its essential oils are used in the treatment of bacterial and fungal infections (Kurniawati et al. 2017; Chen et al. 2021). *C. subavenium* Miq is a perennial tree and grows up to 18–27 m high (Wuu-Kuang 2011). It is distributed in China, Malaysia, Cambodia, Indonesia, India, and Burma (Lin et al. 2008). Its fruit peel, fruits, and leaves are used in the treatment of abdominal and chest pain, hernia, vomiting, nausea, and diarrhea (Liu et al. 2011; Hao et al. 2015). *C. tamala* (Buch. -Ham.) T.Nees & Eberm. is an evergreen tree, 20 m high and with soft wrinkled bark (Singh and Singh 1992). It is naturalized in tropical and subtropical regions of Australia, South America, and the Himalayan region of Asia (Ahmed et al. 2000), India, Nepal, Bhutan, and China (Rema et al. 2005). The plant species possesses antidiarrheal, antibacterial, and immunomodulatory properties (Kumar et al. 2012). In Nepalese traditional medicine, *C. tamala* stem bark is used to treat intestinal diseases, nausea, and diarrhea (Kunwar and Adhikari 2005). The leaves are useful in bladder diseases, ulcers, mouth dryness, coryza, diarrhea, and nausea (Kapoor 2000; Tiwari and Talreja, 2020).

C. verum J.Presl (syn. *C. iners* Reinw. ex Blume; *C. zeylanicum* Blume;) is an erect tree and is found in Sri Lanka, China, Sumatra, Eastern Islands, Brazil, Mauritius, India, and Jamaica (Mehrpouri et al. 2020; Pathak and Sharma, 2021). It possesses stomachic, antirheumatic and carminative properties. Its stem bark paste is mixed with lemon juice and externally applied for the treatment of pimples (Premakumara and Abeysekera 2021; Abeysinghe et al. 2021). *C. walaiwarense* is an evergreen tree with a large and dense crown, and grows up to 40–70 feet high. The straight, and cylindrical bole (30 – 80 cm in diameter) has been used in traditional system of medicine in India (Kostermans 1983; Sriramavaratharajan and Murugan, 2018). The essential oils-rich extract (cinnamaldehyde, eugenol, caryophyllene, cinnamyl acetate and cinnamic acid) possesses antimicrobial (Vigila et al. 2018), antidiabetic, wound healing, and antidepressant activities (Wariyapperuma et al. 2020; Singh et al. 2021). However, the volatile constituents of several *Cinnamomum* species grown in different countries have been characterized but, we report the distribution of essential oils in different parts (leaf, stem bark, stem wood, root, flower, fruit) of 15 Indian *Cinnamomum* species. We have also assessed the antimicrobial activities of essential oil from 15 species against selected microorganisms.

2. Materials and methods

2.1. Collection and identification plant materials

Fresh leaves, stem bark, stem wood, roots, flowers, and fruits of 15 *Cinnamomum* (Fam. - Lauraceae) species [*C. altissimum* (Thiruvananthapuram, Kerala, September 2019; Herbarium sheet number RUBL 32115), *C. bejolghota* (Dibrugarh, Assam, August 2019; Herbarium sheet number RUBL 32116), *C. burmannii* (Changlang, Arunachal Pradesh, August 2019; Herbarium sheet number RUBL 32117), *C. camphora* (Madurai, Tamil Nadu, September 2019; Herbarium sheet number RUBL 32118), *C. cassia* (Kochi, Kerala, September 2019; Herbarium sheet number RUBL 32119), *C. glaucescens* (Khasi Hills, Shillong, Meghalaya, August 2019; Herbarium sheet number RUBL 32120), *C. insularimontanum* (Haridwar, Uttrakhand, March 2019; Herbarium sheet number RUBL 32121), *C. javanicum* (Mysore Plateau, Karnataka, September 2019; Herbarium sheet number RUBL 32122), *C. kanehirai* (Warangal, Telangana, September 2019; Herbarium sheet number RUBL 32123), *C. kotoense* (Idukki, Kerala, September 2019; Herbarium sheet number RUBL 32124), *C. osmophloeum* (Darjeeling, West Bengal, August 2019; Herbarium sheet number RUBL 32125), *C. subavenium* (Chhindwara, Madhya Pradesh, July 2019; Herbarium sheet number RUBL 32126), *C. tamala* (Srinagar Garhwal, Uttarakhand, March 2019; Herbarium sheet number RUBL 32127), *C. verum* (Nainital, Uttarakhand, March 2019; Herbarium sheet number RUBL 32128) and *C. Walaiwarense* (Tirunelveli, Tamil Nadu, September 2019; Herbarium sheet number RUBL 32129) were collected from the different states of India. Collected plant materials were identified by Professor (Dr.) R. S. Mishra, Department of Botany, University of Rajasthan, Jaipur. The voucher specimens have been

deposited in the Herbarium, Department of Botany, University of Rajasthan, Jaipur.

2.2. Extraction of plant materials

The shade-dried parts (leaves, stem bark, stem wood, roots, flowers, and fruits) of 15 *Cinnamomum* species (500 g) were powdered, percolated with methanol for 48 h, and filtered. The filtrates of each part of each species were concentrated *in vacuo* at room temperature (yield 39.89 g, w/w). The methanolic extracts of different parts of each species were stored separately in a refrigerator at 4 °C and were used for the evaluation of antimicrobial activities.

Similarly, dried parts of 15 *Cinnamomum* species were weighed (200 g) and subjected to the extraction process by means of water distillation using Clevenger apparatus (Borosil 3451029, Borosil, India) for 5 h. The essential oils of different parts of each species were concentrated by anhydrous sodium sulfate and yields were determined by using the following formula:

$$\text{Essentialoilyield} : \frac{\text{Essential oil mass obtained in grams}}{\text{Plant material mass in grams}} \times 100$$

2.3. Isolation of essential oil from Cinnamomum species

The essential oils of different parts were stored in dark bottles at 4 °C and used for the determination of antimicrobial activities. The yields of essential oils were calculated based on weight percent [w/w, *C. altissimum* (10.61 %), *C. bejolghota* (2.87 %), *C. burmannii* (7.72 %), *C. camphora* (5.32 %), *C. cassia* (4.31 %), *C. glaucescens* (6.12 %), *C. insularimontanum* (6.88 %), *C. javanicum* (9.12 %), *C. kanehirai* (3.46 %), *C. kotoense* (5.51 %), *C. osmophloeum* (7.22 %), *C. subavenium* (8.48 %), *C. tamala* (7.31 %), *C. verum* (6.15 %) and *C. Walaiwarense* (6.19 %) and the process was repeated for three times (Ghavam et al. 2020).

2.4. Gas Chromatography-mass spectrometric (GC–MS) and gas chromatography and flame ionization detector (GC-FID) analysis

For the determination of essential oils components from different parts of 15 *Cinnamomum* species, the following GC–MS conditions were used: Agilent 5975 GC–MSD system (Agilent Technologies, Santa Clara, California) with an 19091 N-136I-HP-INNOWax FSC column [60 m (length) × 0.25 mm (ID), 0.25 μm (film thickness)]; helium as a carrier gas (0.8 ml/min); GC oven temperature adjusted at 60 °C for 10 min and computed to 220 °C at a rate of 4 °C/min. The split ratio was maintained at 40:1 and injector temperature adjusted at 250 °C. The mass spectra were recorded at 70 eV. The mass spectrum range was adjusted in between *m*/*z* 35 to 450. The essential oils of different parts were identified based on comparison of their relative retention times with those of standard compounds. Similarly, the identity of essential oils was also confirmed by computer matching against commercial (Wiley GC/MS Library, MassFinder 3 Library, McLafferty, F.W.; Joulain et al., 2004) and MS mass fragmentation patterns reported in literature NIST05.LIB and NIST05s.LIB (NIST, USA; Phutdhawong et al., 2007). The analysis of essential oils was evaluated in an Agilent 7890A gas chromatogram fitted with a HP-5 capillary column (30 m × 0.32 mm × 0.25 μm; 5 % phenyl – 95 % methylpolysiloxane; carrier gas – hydrogen, 1.5 ml/min; oven temperature 60–240 °C at 3 °C/min). Essential oil solution (1 %), dissolved in dichloromethane, was injected at 250 °C in split mode (1:20). Results of study are expressed as normalized with relative area, calculated from a FID (280 °C) signal.

2.5. Sources of microorganisms

Pure cultures of *Escherichia coli* (ATCC-5922; Gram (-)ve), *Eterobacter cloacae* (ATCC-25924; Gram (-)ve), *Listeria monocytogenes* (ATCC-19111; Gram (+)ve), *Staphylococcus aureus* (ATCC-25923; Gram (+)ve), *Bacillus subtilis* (ATCC-10031; Gram(+)ve), *Streptococcus pneumoniae* (ATCC-10032; Gram (+)ve), *Helicobacter pylori* (ATCC-43504; Gram (-)ve), and *Enterococcus faecalis* (ATCC-11700; Gram (+)ve) (obtained from SMS Medical College, Jaipur, India) were grown on nutrient agar and brain heart infusion medium at 37 °C for 24 h. Fungal organisms viz, *Aspergillus niger* (ATCC 6275), *A. flavus* (ATCC 204304), *Rhizoctonia phaseoli* (ATCC 14016), *Penicillium chrysogenum* (QM 6851; obtained from the Department of Plant Pathology, Agricultural Research Station, SKN University, Jobner, Jaipur, India) were cultured in potato dextrose broth medium (incubated at 27 °C) for 48 h. Similarly, the pure cultures of *Candida albicans* (ATCC 14053; obtained from SMS Medical College, Jaipur, India) were cultured in Sabouraud dextrose broth medium. The pure cultures were cultivated at 30 °C for 5 days. The brain heart infusion agar (Difco Laboratories, MI) medium was used for culturing *H. pylori*. The culture medium was supplemented with horse serum (5 %, Invitrogen, NY), IsoVitale X (0.4 %), trimethoprim (5 μg/ml), vancomycin (8 μg/ml), and polymixin B (10 μg/ml). The cultures were incubated at 37 °C in microaerophilic conditions for 5 days. Similarly, the MRS agar medium was used for cultivation of pure cultures of *E. faecalis* (CLSI, 2002, 2006, 2007; Singh and Sharma, 2013).

2.6. Minimum inhibitory concentration (MIC)

The minimum inhibitory concentration of methanolic extracts, essential oils and standard compounds was determined by using microdilution method. Methanolic extracts (50 μg/ml initial concentration), essential oils (10 μg/ml) from different parts of 15 *Cinnamomum* species and reference compounds (amoxicillin, streptomycin – 5 μg/ml initial concentration) were dissolved in dimethyl sulfoxide (5 %; Merck KGaA, Germany) for the initial stock solutions. The dilution series of methanolic extracts and essential oils were prepared in 96-well microtiter plates (Microplate Manager 4.0; Bio-Rad Laboratories, Hercules, California, USA). Each bacterial suspension containing 10^7 CFU/ml of the bacterial cells (100 μl) were added to each well. Amoxicillin and streptomycin (Sigma-Aldrich, St. Louis, MO, USA) were used as antibacterial positive controls. Similarly, the last rows consisting of medium with selected microbes were used as negative controls. After 24 h incubation at 37 °C, the staining of viable microorganisms was conducted by mixing 20 μl resazurin solution (0.01 %) into the plates. The minimum inhibitory concentration (MIC, μg/ml) was evaluated as the lowest sample concentration, in which no microbial growth was visible. The optical densities of test samples were recorded at 655 nm and compared with blank. The MIC values of methanolic extracts of different parts of 15 *Cinnamomum* species were recorded in the range of 23 ± 0.01–336 ± 0.06 μg/ml against tested bacterial strains. Similarly, the MIC values of essential oils of different parts of all species were reported in between 21 ± 0.03–690 ± 0.04 μg/ml against tested bacterial species. During this study, the MIC values of standard antibacterial compounds (amoxicillin and streptomycin-18 ± 0.01–58 ± 0.06 μg/ml; positive control) were measured in different ranges. Dimethyl sulfoxide (5 %) solution was used as negative control.

The antifungal activity of methanolic extract (50 μg/ml) and essential oils (10 μg/ml) of different parts (leaf, stem bark, stem wood, root, flower, and fruit) of 15 *Cinnamomum* species and fluconazole (5 μg/ml) were tested against selected fungal species by using serial dilution method (*A. niger*, *A. flavus*, *R. phaseoli*, *P. chrysogenum*, and *C. albicans*). MIC values of tested samples were

evaluated by serial dilution method using 96-well microtiter plates. Each fungal suspension containing 10^7 CFU/ml of the fungal spores (100 µl) were added to each well. The fungal spores were cultivated in potato dextrose broth medium and stored at 4 °C during this study. The methanolic extracts and essential oils of different parts of 15 *Cinnamomum* species and fluconazole were dissolved in 5 % dimethyl sulfoxide solution, consisting of polysorbate-80 (0.1 %; 1 mg/ml), and added to a potato dextrose broth medium with spore inoculum. The microtiter plates were incubated in a rotary shaker (160 rpm) for 72 h at 27 °C. The minimum concentrations without conspicuous microbial growth were defined as the minimum inhibitory concentrations that completely suppressed the fungal spore growth. Similarly, *C. albicans* suspension was prepared according to CLSI methods (CLSI 2002, 2007, 2012), where fluconazole (Sigma-Aldrich, St. Louis, MO, USA) was used as a standard antifungal agent. MIC values of methanolic extracts of different parts of all species were recorded in between 23 ± 0.01 to 444 ± 0.01 µg/ml against tested bacterial species. During this study, the MIC values of standard antifungal compound (fluconazole) were also recorded in different ranges (30 ± 0.01–7 6 ± 0.01 µg/ml) against selected fungal spores. Dimethyl sulfoxide (5 %) solution was used as negative control.

2.7. Minimum bacterial concentrations (MBCs) and minimum fungicidal concentrations (MFCs)

For the determination of minimum bactericidal concentration of test samples, the same serial dilution method was used. The minimum concentration without visible microbial growth defined as MBC, revealing the death of bacterial inoculum (99.5 %). The optical densities (OD) for each well were determined at 655 nm wavelength and compared to a blank. The amoxicillin (27 ± 0.02 to 77 ± 0.04 µg/ml), and streptomycin (25 ± 0.06 to 90 ± 0.06 µg/ml) were used as positive controls for bacterial cultures. Dimethyl sulfoxide (5 %) solution was used as negative control. The minimum fungicidal concentration (MFC) of methanolic extracts and essential oils of different parts of *Cinnamomum* species was evaluated in a potato dextrose broth medium and inoculated in microtiter plates containing 100 µl of broth per well. The cultures were incubated at 28 °C for 72 h. The lowest concentration without visible growth was defined as MFC revealing the death of 99.5 %. The commercial antifungal agent (fluconazole – 30 ± 0.01–94 ± 0.03 µg/ml) was used as positive control against tested microorganisms. Similarly, dimethyl sulfoxide (5 %) solution was used as negative control.

2.8. Statistical analysis

Statistical analysis was conducted by using SPSS software. The statistical variables normality was assessed by using a Kolmogorov–Smirnov test. After ensuring the data normality, the variance was analyzed by using one-way analysis of variance (ANOVA). Comparison of the means (mean values ± standard deviations) was analyzed using a Duncan test with a probability level of 5 % error. $P < 0.05$ was used to define statistical significance.

3. Results

3.1. Determination of essential oils components

The shade-dried parts of 15 *Cinnamomum* species were subjected to the determination of components of essential oils and their respective percentage (yield %) were calculated by using standard protocols. The determined quantities of the components of 19 essential oils (leaves, stem bark, stem wood, roots, flowers, and fruits) of 15 *Cinnamomum* species are presented in Table 1. Analytical studies revealed that stem bark of *C. altissimum* was rich in the presence of components of essential oils (total yield 52.2 %) while minimum levels of components of essential oils were recorded in roots (total yield 17.9 %). *C. insularimontanum* (total yield 36.3 %) and *C. osmophloem* stem (total yield 40.1 %) barks were also rich in the presence of components of essential oils. In the case of *C. bejolghota,* maximum percentage of components of essential oil was observed in flowers (total yield 49.4 %) only. Similarly, *C. mercadoi* (total yield 44.4 %) and *C. subavenium* flowers (total yield 45.7 %) were also rich in the presence of components of essential oils. The leaves of *C. burmanii,* (total yield 33.5 %), *C. javanicum* (total yield 40.4 %), *C. tamala* (total yield 42.3 %), *C. verum* (total yield 44.0 %) also contain significant quantities of components of essential oil. The fruits of *C. walaiwarense* (total yield 32 %), *C. camphora* (total yield 37 %), and *C. glaucescens* (total yield 36.2 %) were also found to be rich in the presence of components of essential oils but, *C. kaneherai* and *C. kotoense* stem woods contain moderate quantities of essential oil (total yield 45.1 and 40.2 %). The γ-terpinene (11.1 %), α-pinene (10.2 %), α-phellandrene (9.9 %), isoeugenol (9.0 %), camphene (7.9 %), α-terpenene (7.8 %), isoborneole (7.2 %), β-pinene (6.6 %), and elemol (5.1 %) were reported as major components of essential oils in different parts of 15 *Cinnamomum* species (Table 1). The identities of components of essential oils were confirmed by comparing with standard essential oils (Supplementary Table 2; Figs. 1-3; Fig. S4 - S6).

3.2. Antimicrobial activity of methanolic extracts of different parts (leaves, stem bark, stem wood, roots, fruits, and flowers)

The antimicrobial activity of methanolic extracts of different parts (leaves, stem bark, stem wood, roots, fruits, and flowers) of 15 *Cinnamomum* species were assayed against selected bacterial and fungal species. The ANOVA results displayed a significant difference between the mean suppression halos achieved on treating tested microbes with the methanolic extracts of different parts and standard compounds (Table 2; $p < 0.05$). Methanolic extract of *C. camphora* stem wood presented maximum antibacterial activity against *S. aureus* (MIC 25 ± 0.01 µg/ml), *H. pylori* (MIC 29 ± 0.05 µg/ml), *B. subtilis* (MIC 31 ± 0.03 µg/ml), *E. faecalis* (MIC 33 ± 0.01 µg/ml) and *C. albicans* (MIC 38 ± 0.03 µg/ml). Similarly, its root extract also displayed strong activity to *H. pylori* (MIC 26 ± 0.01 µg/ml), *B. subtilis* (MIC 29 ± 0.02 µg/ml), *S. pneumoniae* (MIC 31 ± 0.07 µg/ml), *E. faecalis* (MIC 32 ± 0.03 µg/ml), *A. niger* (MIC 23 ± 0.01 µg/ml), and *R. phaseoli* (MIC 30 ± 0.09 µg/ml). The methanolic extract of *C. altissimum* stem bark displayed stronger antibacterial effects against *S. aureus* (MIC 26 ± 0.04 µg/ml), *E. coli* (MIC 33 ± 0.01 µg/ml) and *A. flavus* (MIC 81 ± 0.05 µg/ml). Methanolic extract of *C. bejolghota* stem bark also showed strong antibacterial activity against *E. cloacae* (MIC 32 ± 0.01 µg/ml) and its stem wood extract presented antibacterial effect to *S. aureus* (MIC 41 ± 0.01 µg/ml). Amoxicillin showed maximum antibacterial activity (in terms of MIC) in the range of 18 ± 0.01 to 51 ± 0.08 µg/ml while streptomycin presented activity in the range of 15 ± 0.05 to 58 ± 0.06 µg/ml (Fig. S7). Similarly, fluconazole demonstrated antifungal activity in the range of 30 ± 0.01 to 76 ± 0.01 µg/ml (MIC; Fig. S8). Maximum MIC (444 ± 0.01 µg/ml) was reported for *P. chrysogenum*, which showed a high resistance to methanolic extract of *C. glaucescens* stem bark.

The MBC and MFC values of methanolic extract of *C. camphora* stem wood were varied against *S. aureus* (MBC 43 ± 0.05 µg/ml), *H. pylori* (MBC 49 ± 0.04 µg/ml), *B. subtilis* (MBC 55 ± 0.04 µg/ml) and *R. phaseoli* (MFC 56 ± 0.03 µg/ml). Similarly, its root extract also displayed potent activity against *S. aureus* (MBC 49 ± 0.04), *B. subtilis* (MBC 50 ± 0.01), *H. pylori* (MBC 52 ± 0.05 µg/ml), *S. pneumoniae* (MBC 53 ± 0.03 µg/ml), *A. niger* (MFC 44 ± 0.04 µg/ml) and

Table 1
Essential oil composition (%) in leaves, stem bark, stem wood, flowers, and fruits of Cinnamomum species.

Plant species/parts	Essential oils (%)																		
	I	II	III	1 V	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
C. altissimum parts																			
Leaf	4.1	1.1	6.4	tr	1.3	1.2	5.2	1.7	4.8	tr	3.5	tr	3.9	4.2	3.4	tr	1.8	tr	2.1
Stem bark	2.2	4.9	tr	5.8	tr	2.4	1.7	tr	tr	4.2	6.8	5.7	4.4	–	–	tr	1.1	tr	–
Stem wood	3.1	4.1	tr	tr	3.3	tr	2.7	tr	–	tr	5.6	tr	4.9	2.0	tr	5.5	tr	1.0	3.7
Root	4.7	tr	2.1	2.2	tr	tr	tr	2.7	2.9	tr	tr	tr	–	tr	tr	3.3	–	tr	tr
Flower	3.1	–	tr	–	7.3	–	5.4	tr	2.4	6.7	4.2	tr	tr	3.2	2.3	4.0	–	2.6	tr
Fruit	5.0	tr	3.0	6.3	4.4	tr	5.6	tr	5.1	tr	3.9	tr	3.1	3.0	4.7	2.1	tr	2.5	–
C. bejolghota parts																			
Leaf	2.2	1.6	4.0	–	3.1	tr	5.9	5.4	–	tr	6.1	4.2	tr	4.9	tr	tr	tr	tr	tr
Stem bark	3.0	2.9	3.4	–	4.8	3.8	tr	–	–	tr	2.0	4.5	1.3	4.8	2.1	–	tr	2.1	–
Stem wood	tr	3.6	tr	6.1	3.7	tr	–	tr	3.9	4.5	–	–	1.2	tr	–	1.1	tr	5.5	–
Root	tr	4.4	–	4.0	tr	tr	4.1	tr	3.1	2.2	tr	3.2	tr	4.5	–	3.3	tr	2.5	tr
Flower	3.3	tr	2.2	3.9	4.7	2.1	3.2	2.0	6.1	4.4	1.8	9.0	1.1	tr	5.6	tr	tr	–	tr
Fruit	4.2	1.8	3.7	–	tr	4.0	–	tr	5.5	–	tr	6.6	tr	2.1	5.5	–	5.8	tr	–
C. burmanii parts																			
Leaf	3.1	1.2	2.1	3.2	tr	4.5	–	tr	4.9	–	2.6	–	4.4	tr	1.6	tr	–	2.9	3.0
Stem bark	2.1	5.4	2.2	tr	1.4	tr	–	tr	tr	1.0	–	tr	4.3	2.2	1.2	–	+	tr	–
Stem wood	5.7	2.1	4.0	6.1	–	tr	tr	–	2.8	tr	2.9	4.7	tr	tr	–	–	–	tr	tr
Root	tr	tr	tr	3.8	2.6	3.8	2.5	tr	tr	3.9	2.8	5.0	6.6	tr	4.2	4.0	–	4.9	3.1
Flower	tr	5.9	3.4	5.7	tr	–	3.3	5.1	tr	–	tr	tr	–	–	5.0	6.9	tr	5.6	4.6
Fruit	4.1	tr	3.3	4.8	–	3.3	3.9	–	–	4.2	tr	4.7	3.2	–	tr	5.7	tr	4.0	–
C. camphora parts																			
Leaf	tr	–	tr	3.5	3.6	tr	tr	tr	tr	tr	4.1	tr	–	tr	1.6	1.4	5.1	tr	1.4
Stem bark	tr	2.2	3.1	–	tr	3.3	1.6	3.2	tr	–	5.7	tr	3.2	tr	2.0	tr	3.1	1.5	tr
Stem wood	tr	tr	4.4	4.2	5.6	tr	–	tr	3.3	tr	tr	1.3	2.1	tr	2.1	–	tr	–	2.0
Root	tr	2.7	tr	tr	3.1	tr	3.3	3.3	2.6	2.4	2.1	1.7	tr	tr	–	tr	2.9	tr	tr
Flower	4.4	tr	tr	1.1	–	1.4	tr	2.0	tr	–	tr	1.5	3.2	3.2	4.5	–	1.4	2.1	–
Fruit	5.1	tr	tr	1.1	tr	–	8.2	–	4.9	3.0	6.4	tr	1.7	–	tr	1.9	tr	3.1	1.6
C. cassia parts																			
Leaf	1.4	tr	tr	4.3	3.8	–	1.8	tr	3.0	tr	–	tr	tr	3.3	2.9	tr	4.1	–	2.7
Stem bark	tr	3.0	tr	–	tr	tr	3.9	–	tr	5.5	2.1	3.3	4.1	tr	4.1	1.5	2.1	1.2	tr
Stem wood	4.5	tr	tr	2.0	–	4.3	6.0	–	tr	3.2	tr	4.1	1.8	3.2	tr	–	4.1	tr	–
Root	2.4	tr	1.3	–	tr	4.4	tr	tr	1.7	2.8	tr	4.1	–	tr	5.5	–	4.1	tr	tr
Flower	tr	4.5	–	3.9	4.8	tr	tr	2.1	tr	4.6	5.1	2.9	1.2	1.0	5.2	tr	5.0	–	4.1
Fruit	–	1.5	–	tr	5.2	tr	3.6	–	2.1	3.1	–	5.7	–	tr	–	4.3	4.0	3.3	tr
C. glaucescens parts																			
Leaf	5.1	tr	4.1	tr	–	1.8	3.1	tr	tr	3.1	–	tr	4.1	tr	–	1.9	2.6	1.1	3.1
Stem bark	4.1	2.7	tr	–	3.1	tr	tr	–	3.5	4.7	4.1	3.1	–	tr	3.9	tr	tr	–	2.1
Stem wood	4.2	2.1	–	tr	–	tr	–	4.5	–	tr	tr	2.0	tr	tr	–	tr	1.4	tr	4.5
Root	3.0	4.9	tr	tr	5.2	3.3	–	tr	tr	3.1	2.1	–	4.1	5.7	tr	2.0	3.7	–	tr
Flower	–	tr	9.1	1.1	–	tr	–	4.1	3.0	1.2	1.5	tr	tr	4.2	4.1	3.2	tr	tr	4.7
Fruit	tr	–	5.7	–	3.8	6.6	–	tr	tr	1.1	–	tr	–	tr	2.1	tr	–	2.1	1.8
C. insularimontanum parts																			
Leaf	tr	–	–	2.2	3.3	tr	4.2	1.5	–	3.0	2.5	1.1	tr	–	3.1	2.6	tr	3.1	tr
Stem bark	2.1	3.6	5.5	4.6	1.4	–	tr	tr	1.9	2.8	2.1	tr	tr	tr	2.8	tr	2.5	–	–
Stem wood	tr	–	4.2	1.4	3.2	tr	–	tr	tr	4.0	3.0	–	3.9	3.5	tr	–	4.0	tr	–
Root	3.1	–	1.4	4.1	tr	1.6	–	1.9	2.7	2.1	3.6	5.2	tr	2.1	1.6	–	tr	3.5	–
Flower	–	3.1	tr	–	5.0	4.1	tr	1.8	tr	–	tr	tr	–	tr	–	4.6	–	3.0	tr
Fruit	1.2	tr	–	tr	2.7	–	tr	3.1	4.1	4.0	–	tr	3.1	4.9	tr	–	3.1	tr	–
C. javanicum parts																			
Leaf	3.1	tr	3.1	4.3	tr	tr	6.3	–	2.0	2.4	–	6.1	1.3	tr	3.7	3.6	tr	2.2	2.4
Stem bark	tr	tr	–	tr	–	1.2	4.8	1.1	–	3.2	tr	3.1	2.9	4.4	tr	2.1	–	tr	tr
Stem wood	–	2.7	tr	–	1.1	2.5	4.1	tr	3.1	2.7	tr	–	3.7	tr	tr	1.7	3.2	tr	–
Root	4.8	tr	3.2	tr	2.2	–	tr	–	–	tr	3.1	1.7	–	2.6	tr	1.1	1.3	3.5	tr
Flower	1.9	5.6	tr	tr	3.9	2.6	tr	4.4	tr	–	tr	3.2	tr	4.1	5.1	4.0	tr	tr	–
Fruit	3.1	tr	–	3.3	tr	tr	4.7	4.8	–	3.1	1.4	+	1.1	tr	–	3.0	1.2	tr	tr
C. kaneherai parts																			
Leaf	2.1	–	tr	3.2	2.0	1.5	tr	3.4	1.8	2.1	tr	4.8	tr	–	tr	6.1	tr	tr	5.5
Stem bark	tr	tr	2.1	5.5	3.0	2.2	4.1	–	–	tr	–	5.3	4.1	1.4	3.1	tr	tr	tr	–
Stem wood	–	3.0	4.8	4.1	–	tr	2.9	5.1	tr	4.0	tr	4.1	–	4.1	1.5	tr	–	5.5	–
Root	tr	tr	tr	5.0	–	tr	1.1	–	5.1	1.5	3.1	2.2	–	tr	3.0	1.7	4.2	–	4.1
Flower	–	–	tr	3.9	tr	4.1	5.1	3.5	2.7	–	tr	1.2	2.4	2.2	tr	–	tr	1.0	5.3
Fruit	tr	tr	6.9	4.2	tr	5.3	1.8	3.2	tr	–	tr	5.1	1.5	–	4.4	–	tr	3.1	1.7
C. kotoense parts																			
Leaf	1.1	2.0	–	tr	tr	2.1	4.1	–	3.2	–	5.6	tr	1.7	5.2	tr	tr	–	tr	2.2
Stem bark	3.1	3.8	tr	tr	tr	–	tr	2.8	3.3	tr	tr	4.9	tr	3.7	tr	–	3.6	tr	–
Stem wood	tr	–	tr	3.9	tr	–	tr	5.2	tr	3.1	4.7	5.0	tr	tr	–	1.6	1.4	4.1	6.2
Root	–	tr	–	tr	5.2	tr	2.1	3.1	–	tr	5.5	tr	4.0	5.1	tr	5.0	tr	3.0	tr
Flower	tr	5.0	–	4.3	4.4	4.0	tr	5.2	–	tr	tr	4.9	tr	tr	5.1	tr	–	tr	tr
Fruit	1.0	–	tr	–	1.4	4.0	6.1	3.1	2.3	tr	–	tr	–	6.3	4.1	tr	tr	2.2	–
C. osmophloem parts																			
Leaf	tr	4.0	1.9	4.8	2.1	–	tr	tr	–	tr	4.0	3.1	1.5	–	2.3	tr	tr	–	2.3
Stem bark	4.9	–	4.1	tr	–	4.7	3.1	3.1	5.5	4.6	2.9	tr	–	7.2	tr	–	tr	tr	–

(*continued on next page*)

Table 1 (*continued*)

Plant species/parts	Essential oils (%)																		
	I	II	III	1 V	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
Stem wood	tr	2.1	3.7	2.1	3.8	tr	2.9	–	tr	3.1	1.7	3.2	tr	–	2.9	3.2	3.3	2.8	tr
Root	–	–	6.2	1.6	1.4	–	tr	tr	4.0	2.6	–	tr	4.4	3.2	2.1	tr	2.8	–	3.1
Flower	3.1	–	tr	tr	–	2.8	tr	3.2	2.2	tr	3.1	–	4.9	3.1	–	3.1	4.1	2.1	4.0
Fruit	2.1	–	tr	3.2	tr	tr	2.1	4.1	2.0	1.5	2.1	tr	2.1	tr	4.0	tr	–	3.5	tr
C. subavenium parts																			
Leaf	1.8	tr	–	3.4	tr	3.1	–	4.0	tr	3.1	tr	–	5.1	–	4.7	tr	1.1	tr	–
Stem bark	1.1	2.3	–	tr	4.6	–	tr	1.4	1.6	3.1	–	tr	6.0	5.4	tr	–	tr	1.1	3.1
Stem wood	1.5	2.1	1.8	–	3.0	tr	3.9	tr	2.1	2.6	–	1.4	tr	4.6	2.2	tr	–	2.1	–
Root	6.7	4.8	7.9	2.5	8.9	2.8	2.2	tr	tr	1.3	–	1.2	1.1	tr	–	–	tr	3.4	4.2
Flower	–	–	tr	3.9	tr	–	11.1	4.1	3.5	1.5	4.1	2.1	2.1	–	tr	3.3	tr	–	–
Fruit	2.0	1.0	4.5	4.8	2.1	1.8	tr	–	2.1	tr	6.6	2.1	tr	1.7	–	6.1	2.2	–	tr
C. tamala parts																			
Leaf	tr	–	4.7	5.8	1.2	2.1	3.0	6.6	–	4.8	3.8	tr	3.9	–	tr	1.3	2.1	tr	–
Stem bark	–	5.5	tr	2.6	–	tr	–	–	3.1	tr	3.2	tr	2.4	tr	3.2	–	1.6	–	tr
Stem wood	1.1	–	tr	2.5	3.0	1.6	4.2	tr	2.1	1.6	tr	–	3.6	–	1.5	3.4	3.1	1.4	4.2
Root	1.6	1.4	1.9	–	3.3	tr	1.9	tr	4.1	tr	2.1	–	tr	2.0	3.1	–	1.5	tr	2.1
Flower	3.4	1.9	2.8	2.5	2.1	3.1	3.3	2.9	2.2	–	tr	5.5	–	tr	2.1	1.5	tr	–	tr
Fruit	2.1	1.3	–	tr	–	tr	3.8	2.0	–	1.6	1.6	2.1	2.6	2.2	–	tr	1.1	–	1.5
C. verum parts																			
Leaf	3.8	tr	4.3	1.2	5.7	tr	5.1	4.4	tr	2.3	tr	–	4.3	4.4	3.9	2.6	tr	–	tr
Stem bark	tr	1.5	–	tr	–	tr	2.4	3.5	tr	4.0	tr	–	4.1	3.3	tr	3.2	2.9	4.3	–
Stem wood	1.4	1.0	1.9	–	tr	2.1	2.3	1.2	tr	–	2.1	tr	1.7	tr	3.2	4.1	1.1	tr	3.0
Root	2.7	tr	4.1	–	1.8	3.6	6.7	4.4	1.1	tr	tr	1.6	tr	–	tr	3.1	2.1	1.7	tr
Flower	1.8	–	2.5	4.0	3.1	tr	–	3.2	3.4	1.2	tr	1.5	2.3	6.6	1.0	–	tr	tr	–
Fruit	tr	2.2	–	tr	3.2	1.1	tr	–	1.4	tr	2.1	tr	4.0	–	9.3	–	tr	–	6.9
C. walaiwarense parts																			
Leaf	3.0	1.3	3.9	4.0	tr	–	4.3	tr	tr	tr	–	tr	4.3	3.1	tr	tr	–	tr	2.6
Stem bark	3.8	–	tr	2.8	1.3	tr	tr	–	4.6	3.0	tr	5.1	tr	tr	1.2	1.4	tr	–	3.1
Stem wood	2.5	2.1	tr	3.4	tr	2.1	–	tr	3.2	1.8	3.9	3.1	tr	2.0	tr	3.4	–	tr	1.5
Root	tr	tr	3.2	tr	4.6	2.6	–	2.2	tr	2.8	–	tr	3.3	2.6	tr	tr	tr	3.2	4.4
Flower	–	tr	tr	3.1	–	2.3	4.7	4.2	tr	–	tr	2.9	tr	tr	1.1	4.0	tr	tr	tr
Fruit	2.1	–	3.1	–	5.7	tr	3.4	tr	2.7	3.2	1.8	tr	tr	tr	tr	4.6	2.9	–	2.5

Percentage of essential oils calculated from flame ionization detection data. Identified essential oils: I, α-Pinene; II, β-Pinene; III, Camphene; IV, α-Phellandrene; V, *p*-Cymene; VI, α-Terpinene; VII, γ-Terpinene; VIII, Isoborneole; IX, Terpinolene; X, Cinnamaldehyde; XI, Eugenol; XII, Isoeugenol; XIII, β-Caryophyllene; XIV, Safrole; XV, Elemol; XVI, β-Farnesene; XVII, Methyl eugenol; XVIII, 1,8-Cineole; XIX, Linalool. - = Not detected; tr = Trace (less than 1.0 %).

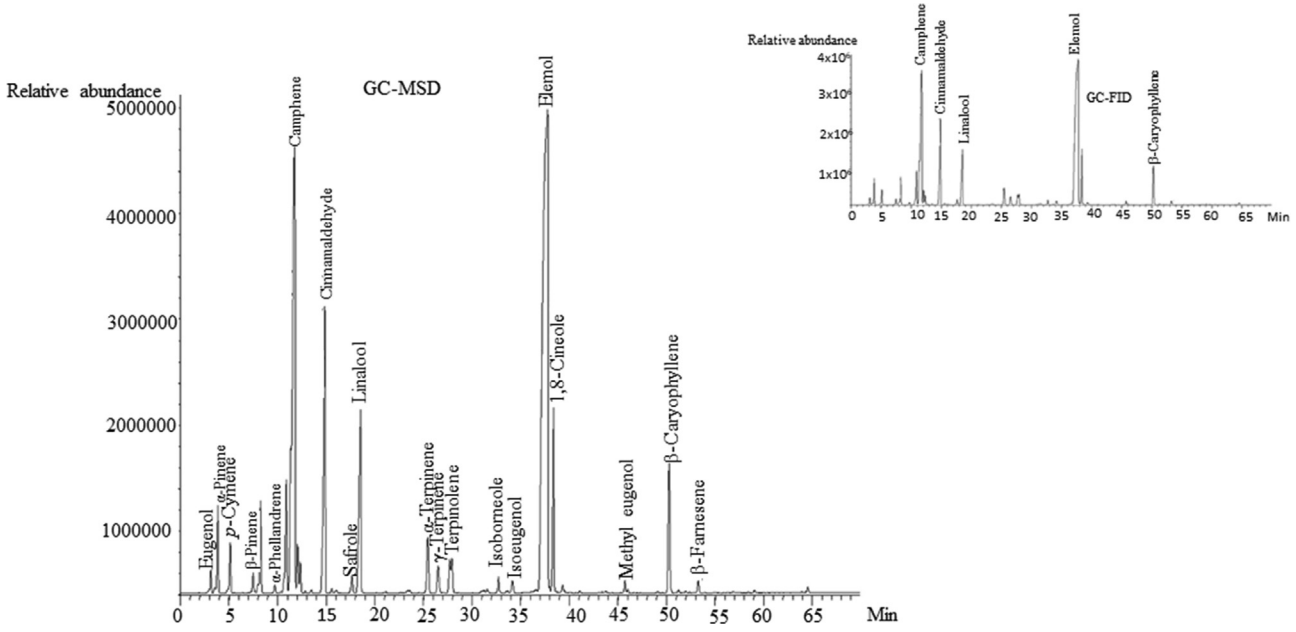

Fig. 1. The GC MSD and GC FID(insert) Chromastograms of C altistimum leaf oil.

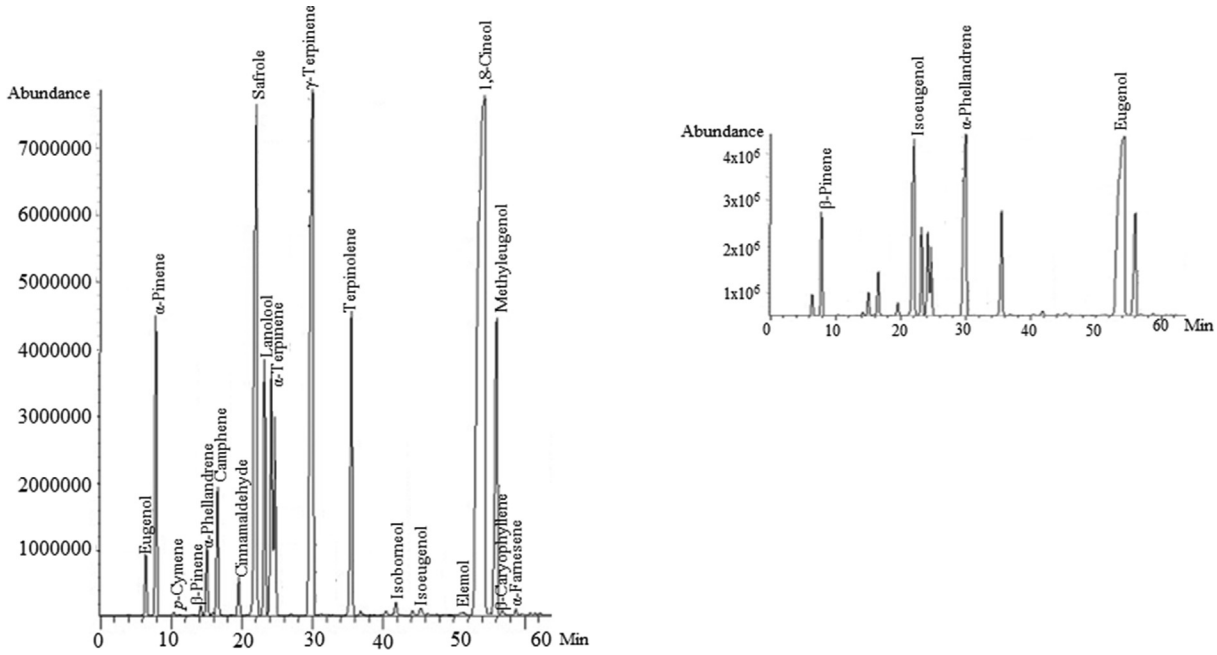

Fig. 2. The GC MSD and GC FID(insert) chromatograms of C altissimum stem bark oil.

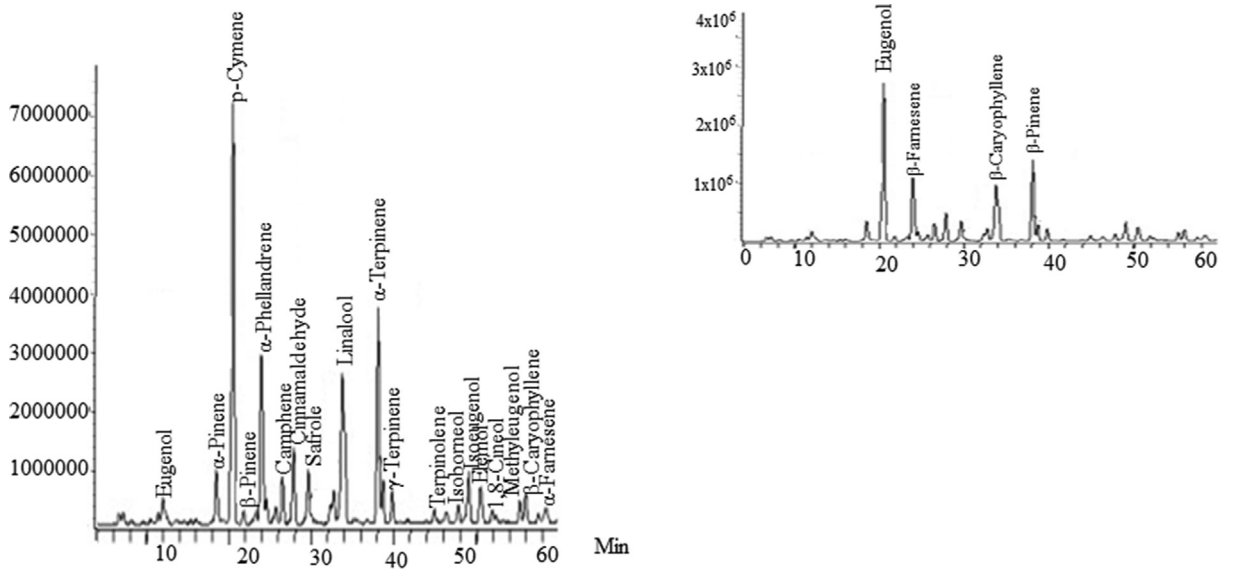

Fig. 3. The GC MSD and GC-FID (insert) chromatograms of C altissimum stem wood oil.

R. phaseoli (MFC 47 ± 0.09 μg/ml). The MBC and MFC values exhibited by the methanolic extract of different parts of 15 *Cinnamomum* species were varied against tested microbes (Supplementary Table 4). The MBC values provided by methanolic extracts of different parts of all species were higher than MIC values of tested microbes.

3.3. Antimicrobial effect of essential oils of different parts

Essential oil of *C. altissimum* stem bark demonstrated maximum antimicrobial activity against *S. aureus* (MIC 21 ± 0.03 μg/ml), *E. coli* (MIC 26 ± 0.03 μg/ml), *E. cloacae* (MIC 37 ± 0.06 μg/ml), *L. monocytogenes* (MIC 47 ± 0.08 μg/ml), and *P. chrysogenum* (MIC 101 ± 0.07 μg/ml). Essential oil of *C. altissimum* stem wood presented potent antibacterial activity against *H. pylori* (MIC 49 ± 0.04 μg/ml). MIC values of the essential oil of different parts varied in the range of 21 ± 0.03 μg/ml to 690 μg/ml whereas the standard compounds (amoxicillin and streptomycin) displayed activity in the range of 18 ± 0.01 to 58 ± 0.06 μg/ml (Table 3). MBC and MFC values of isolated essential oils from different parts are presented in Supplementary Table 6. The essential oils of *C. altissimum* stem bark demonstrated potent bactericidal effect against *S. aureus* (39 ± 0.03 μg/ml) and *E. coli* (45 ± 0.05 μg/ml). The rate of mortality was observed higher on *S. aureus* (Gram-positive) than *E. coli* (Gram-negative).

4. Discussion

The biosynthesis of secondary metabolites depends on defense mechanisms against plant pathogens; the quantity produced together with quality may vary as a function of habitat, climatic conditions, and the organ where they synthesized (Zargoosh

Table 2
Minimum inhibitory concentrations (MICs) of methanolic extract of leaves, stem bark, stem wood, flowers, and fruits of different *Cinnamomum* species against selected bacteria and fungi.

Standard compound/ plant parts	MIC (μg/ml)												
	Ec	Ecl	Lm	Sa	Bs	Sp	Hp	Ef	Ca	An	Af	Rp	*Pc*
Standard compounds													
Amoxicillin	18 ± 0.01[a]	21 ± 0.05[a]	31 ± 0.03[a]	36 ± 0.08[b]	27 ± 0.04[a]	45 ± 0.07[b]	51 ± 0.08[b]	22 ± 0.01 [a]	–	–	–	–	–
Streptomycin	26 ± 0.04[a]	36 ± 0.06[a]	41 ± 0.09[b]	58 ± 0.06[b]	43 ± 0.02[b]	15 ± 0.05[a]	38 ± 0.02[a]	57 ± 0.04[b]	–	–	–	- -	–
Fluconazole	–	–	–	–	–	–	–	–	56 ± 0.05[b]	76 ± 0.01[b]	40 ± 0.02[a]	30 ± 0.01[a]	51 ± 0.03[a]
C. altissimum parts													
Leaf	94 ± 0.05[b]	112 ± 0.01[b]	134 ± 0.08[b]	64 ± 0.01[a]	68 ± 0.06[a]	116 ± 0.05[b]	101 ± 0.04[b]	78 ± 0.01[a]	157 ± 0.08[b]	145 ± 0.01[a]	122 ± 0.06[a]	140 ± 0.02[a]	125 ± 0.03[a]
Stem bark	33 ± 0.01[a]	45 ± 0.04[a]	36 ± 0.05[a]	26 ± 0.04[a]	87 ± 0.01[a]	92 ± 0.01[a]	114 ± 0.02[b]	121 ± 0.01[b]	146 ± 0.02[a]	136 ± 0.03[a]	81 ± 0.05[a]	99 ± 0.02[a]	113 ± 0.01[a]
Stem wood	67 ± 0.07[a]	66 ± 0.06[a]	54 ± 0.01[a]	48 ± 0.01[a]	92 ± 0.01[a]	77 ± 0.08[a]	55 ± 0.05[a]	111 ± 0.05[b]	142 ± 0.03[a]	157 ± 0.07[b]	127 ± 0.04[a]	144 ± 0.01[a]	123 ± 0.04[a]
Root	55 ± 0.04[a]	78 ± 0.01[a]	61 ± 0.04[a]	52 ± 0.04[a]	65 ± 0.05[a]	101 ± 0.01[a]	87 ± 0.01[a]	36 ± 0.05[a]	65 ± 0.03[a]	49 ± 0.01[a]	87 ± 0.01[a]	115 ± 0.07[a]	130 ± 0.01[a]
Flower	58 ± 0.05[b]	82 ± 0.01[a]	69 ± 0.05[a]	39 ± 0.01[a]	62 ± 0.04[a]	45 ± 0.00 [a]	66 ± 0.07[a]	78 ± 0.02[a]	94 ± 0.01[a]	88 ± 0.06[a]	102 ± 0.05[a]	98 ± 0.01[a]	103 ± 0.07[a]
Fruit	68 ± 0.01[a]	77 ± 0.07[a]	63 ± 0.05[a]	58 ± 0.05[a]	78 ± 0.07[a]	112 ± 0.02[b]	43 ± 0.01[a]	90 ± 0.05[a]	99 ± 0.04[a]	113 ± 0.01[a]	125 ± 0.05[a]	100 ± 0.06[a]	112 ± 0.04[a]
C. bejolghota parts													
Leaf	67 ± 0.02[a]	85 ± 0.01[b]	64 ± 0.04[a]	98 ± 0.01[a]	109 ± 0.02[a]	121 ± 0.06[a]	87 ± 0.01[a]	82 ± 0.05[a]	35 ± 0.02[a]	110 ± 0.01[a]	88 ± 0.05[a]	55 ± 0.01[a]	120 ± 0.05[a]
Stem bark	43 ± 0.04[a]	32 ± 0.01[a]	50 ± 0.05[a]	76 ± 0.07[a]	100 ± 0.01[a]	54 ± 0.07[a]	73 ± 0.01[a]	91 ± 0.08[a]	42 ± 0.01[a]	49 ± 0.06[a]	53 ± 0.01[a]	63 ± 0.02[a]	110 ± 0.04[a]
Stem wood	77 ± 0.01[a]	65 ± 0.05[a]	52 ± 0.01[a]	41 ± 0.01[a]	68 ± 0.01[b]	44 ± 0.01[a]	55 ± 0.02[b]	87 ± 0.05[a]	48 ± 0.06[a]	74 ± 0.02 [a]	66 ± 0.05[a]	99 ± 0.01[a]	117 ± 0.01[a]
Root	119 ± 0.02[b]	115 ± 0.01[b]	73 ± 0.06[a]	89 ± 0.09[b]	42 ± 0.04[a]	52 ± 0.02[a]	77 ± 0.06[a]	138 ± 0.01[a]	132 ± 0.05[a]	128 ± 0.01[a]	123 ± 0.08[a]	88 ± 0.06[a]	126 ± 0.04[a]
Flower	134 ± 0.07[a]	136 ± 0.05[a]	88 ± 0.02[a]	126 ± 0.01[a]	159 ± 0.01[a]	145 ± 0.01[b]	89 ± 0.01[a]	144 ± 0.07[b]	134 ± 0.04[a]	152 ± 0.06[b]	132 ± 0.02[a]	65 ± 0.054[a]	66 ± 0.05[a]
Fruit	113 ± 0.05[b]	97 ± 0.04[a]	83 ± 0.01[b]	95 ± 0.01[b]	103 ± 0.05[a]	99 ± 0.01[a]	75 ± 0.02[a]	136 ± 0.01[b]	141 ± 0.04[a]	117 ± 0.05[a]	101 ± 0.01[a]	128 ± 0.04[a]	90 ± 0.02[a]
C. burmanii parts													
Leaf	55 ± 0.02[b]	44 ± 0.06[a]	51 ± 0.03[a]	52 ± 0.01[a]	66 ± 0.01[a]	49 ± 0.07[a]	38 ± 0.01[a]	74 ± 0.08[a]	88 ± 0.06 [a]	94 ± 0.02[a]	75 ± 0.03[a]	66 ± 0.06[a]	58 ± 0.01[a]
Stem bark	136 ± 0.01[b]	91 ± 0.08 [a]	83 ± 0.01[b]	101 ± 0.07[a]	118 ± 0.01[a]	123 ± 0.08[b]	121 ± 0.03[b]	98 ± 0.09[a]	85 ± 0.01[a]	90 ± 0.03[a]	86 ± 0.01[a]	100 ± 0.07[a]	80 ± 0.03[a]
Stem wood	131 ± 0.08[b]	118 ± 0.07[a]	117 ± 0.03[a]	95 ± 0.01[a]	117 ± 0.07[a]	120 ± 0.01[a]	128 ± 0.02[b]	112 ± 0.01[b]	116 ± 0.09[a]	69 ± 0.08[a]	104 ± 0.08[a]	111 ± 0.06[a]	81 ± 0.06[a]
Root	142 ± 0.02[b]	126 ± 0.02[b]	121 ± 0.01[b]	142 ± 0.02[b]	131 ± 0.01[b]	119 ± 0.08[a]	101 ± 0.06[a]	97 ± 0.08[a]	119 ± 0.06[a]	78 ± 0.07[a]	100 ± 0.02[a]	161 ± 0.01[a]	83 ± 0.02[a]
Flower	101 ± 0.07[a]	98 ± 0.09[a]	111 ± 0.03[a]	100 ± 0.07[a]	89 ± 0.09[a]	98 ± 0.01[a]	99 ± 0.01[a]	126 ± 0.06[b]	128 ± 0.07[a]	65 ± 0.03[a]	123 ± 0.03[a]	149 ± 0.00[a]	76 ± 0.07[a]
Fruit	87 ± 0.02[a]	91 ± 0.03[a]	82 ± 0.01[a]	88 ± 0.06[a]	78 ± 0.08[a]	71 ± 0.08[a]	80 ± 0.07[a]	73 ± 0.02[a]	67 ± 0.01[a]	59 ± 0.01[a]	61 ± 0.06[a]	84 ± 0.02[a]	65 ± 0.06[a]
C. camphora parts													
Leaf	52 ± 0.05[a]	91 ± 0.01[a]	71 ± 0.02[a]	42 ± 0.07[a]	36 ± 0.01[a]	29 ± 0.01[a]	42 ± 0.08[a]	60 ± 0.02[a]	56 ± 0.01[a]	45 ± 0.01[a]	59 ± 0.03[a]	43 ± 0.02[a]	69 ± 0.01[a]
Stem bark	45 ± 0.09[a]	53 ± 0.02[a]	62 ± 0.05[a]	40 ± 0.02[a]	52 ± 0.05[a]	34 ± 0.06[a]	48 ± 0.03[a]	76 ± 0.06[a]	48 ± 0.02[a]	52 ± 0.02[a]	63 ± 0.08[a]	42 ± 0.05[a]	61 ± 0.03[a]
Stem wood	40 ± 0.03[a]	87 ± 0.02[a]	88 ± 0.01[a]	25 ± 0.01[a]	31 ± 0.03[a]	42 ± 0.08[a]	29 ± 0.05[a]	33 ± 0.01[a]	38 ± 0.03[a]	46 ± 0.06[a]	52 ± 0.05[a]	49 ± 0.06[a]	50 ± 0.02[a]
Root	42 ± 0.07[a]	39 ± 0.01[a]	67 ± 0.03[a]	36 ± 0.06[a]	29 ± 0.02[a]	31 ± 0.07[a]	26 ± 0.01[a]	32 ± 0.03[a]	39 ± 0.05[a]	23 ± 0.01[a]	41 ± 0.03[a]	30 ± 0.09[a]	50 ± 0.05[a]
Flower	102 ± 0.05[a]	95 ± 0.03[a]	61 ± 0.09[a]	47 ± 0.01[a]	32 ± 0.09[a]	42 ± 0.06[a]	31 ± 0.03[a]	43 ± 0.02[a]	53 ± 0.01[a]	42 ± 0.02[a]	47 ± 0.07[a]	29 ± 0.05[a]	57 ± 0.07[b]
Fruit	30 ± 0.06[a]	37 ± 0.02[a]	45 ± 0.06[a]	35 ± 0.08[a]	41 ± 0.01[a]	28 ± 0.09[a]	54 ± 0.02[a]	51 ± 0.05[a]	66 ± 0.07[a]	48 ± 0.03[a]	56 ± 0.01[a]	42 ± 0.02[a]	69 ± 0.03[a]
C. cassia parts													
Leaf	114 ± 0.02[a]	131 ± 0.01[b]	122 ± 0.03[a]	99 ± 0.03[a]	132 ± 0.03[b]	111 ± 0.02[a]	76 ± 0.01 [a]	88 ± 0.03[a]	57 ± 0.01 [a]	44 ± 0.01[a]	53 ± 0.01[a]	45 ± 0.03[a]	44 ± 0.02[a]
Stem bark	213 ± 0.05[b]	221 ± 0.04[b]	233 ± 0.01[b]	198 ± 0.01[b]	128 ± 0.01[b]	128 ± 0.03[b]	163 ± 0.02[b]	123 ± 0.04[b]	84 ± 0.02 [a]	166 ± 0.04[b]	145 ± 0.02[a]	66 ± 0.04[a]	54 ± 0.04[a]
Stem wood	146 ± 0.03[b]	124 ± 0.02[b]	156 ± 0.04[b]	125 ± 0.04[a]	142 ± 0.01[b]	127 ± 0.01[b]	166 ± 0.01[b]	78 ± 0.02[a]	126 ± 0.05[a]	78 ± 0.03[a]	166 ± 0.01[b]	88 ± 0.02[a]	62 ± 0.03[a]
Root	234 ± 0.02[b]	251 ± 0.01[b]	234 ± 0.01[b]	261 ± 0.03[b]	244 ± 0.02[b]	256 ± 0.05[b]	265 ± 0.04[b]	244 ± 0.01[b]	243 ± 0.04[b]	271 ± 0.01[b]	216 ± 0.03[b]	198 ± 0.05[b]	133 ± 0.08[a]
Flower	156 ± 0.04[b]	176 ± 0.03[b]	168 ± 0.03[b]	173 ± 0.01[b]	165 ± 0.00[b]	123 ± 0.01[a]	112 ± 0.03[a]	118 ± 0.03[a]	155 ± 0.02[a]	166 ± 0.04[b]	144 ± 0.02[a]	112 ± 0.04[a]	99 ± 0.02[a]
Fruit	124 ± 0.02[a]	131 ± 0.01[a]	122 ± 0.02[a]	102 ± 0.06[a]	124 ± 0.02[b]	99 ± 0.08[a]	88 ± 0.02[a]	78 ± 0.00[a]	68 ± 0.02[a]	78 ± 0.01[a]	60 ± 0.08[a]	65 ± 0.01[a]	77 ± 0.03[a]
C. glaucescens parts													
Leaf	105 ± 0.03[b]	255 ± 0.07[b]	149 ± 0.06[b]	115 ± 0.04[a]	111 ± 0.01[a]	215 ± 0.02[b]	336 ± 0.06[b]	311 ± 0.05[b]	241 ± 0.09[b]	349 ± 0.01[b]	136 ± 0.02	236 ± 0.05[b]	219 ± 0.06[b]
Stem bark	98 ± 0.03[a]	215 ± 0.06[b]	223 ± 0.08[b]	205 ± 0.06[b]	279 ± 0.09[b]	111 ± 0.04[a]	331 ± 0.06[b]	258 ± 0.03[b]	318 ± 0.07[b]	319 ± 0.05[b]	411 ± 0.08[b]	230 ± 0.02[b]	444 ± 0.01[b]
Stem wood	134 ± 0.04[b]	198 ± 0.06[b]	334 ± 0.02[b]	276 ± 0.01[b]	315 ± 0.06[b]	184 ± 0.08[b]	265 ± 0.09[b]	189 ± 0.06[b]	412 ± 0.07[b]	273 ± 0.04[b]	367 ± 0.07[b]	234 ± 0.08[b]	418 ± 0.09[b]
Root	145 ± 0.06[b]	113 ± 0.03[a]	141 ± 0.01[b]	300 ± 0.03[b]	213 ± 0.09[b]	167 ± 0.07[b]	213 ± 0.08[b]	173 ± 0.06[b]	313 ± 0.06[b]	200 ± 0.08[b]	288 ± 0.04[b]	223 ± 0.03[b]	347 ± 0.06[b]
Flower	225 ± 0.03[b]	345 ± 0.04[b]	335 ± 0.07[b]	321 ± 0.06[b]	245 ± 0.05[b]	182 ± 0.03[b]	265 ± 0.01[b]	242 ± 0.02[b]	337 ± 0.06[b]	274 ± 0.08[b]	267 ± 0.09[b]	225 ± 0.06[b]	312 ± 0.07[b]
Fruit	255 ± 0.02[b]	241 ± 0.01[b]	441 ± 0.05[b]	332 ± 0.06[b]	195 ± 0.07	285 ± 0.06[b]	285 ± 0.09[b]	234 ± 0.08[b]	229 ± 0.02[b]	410 ± 0.01[b]	285 ± 0.03[b]	341 ± 0.08[b]	311 ± 0.09[b]
C. insularimontanum parts													
Leaf	145 ± 0.01[b]	168 ± 0.04[b]	176 ± 0.03[b]	121 ± 0.01[a]	176 ± 0.00[b]	154 ± 0.01[b]	167 ± 0.01[b]	154 ± 0.01[b]	189 ± 0.0[b]	179 ± 0.01[a]	164 ± 0.01[b]	99 ± 0.08[a]	119 ± 0.01[a]
Stem bark	121 ± 0.02[a]	132 ± 0.01[a]	113 ± 0.05[a]	102 ± 0.02[a]	123 ± 0.01[a]	101 ± 0.02[a]	99 ± 0.01[a]	112 ± 0.02[a]	123 ± 0.03[a]	119 ± 0.00[a]	124 ± 0.03[a]	131 ± 0.01[a]	164 ± 0.02[b]
Stem wood	154 ± 0.05[b]	143 ± 0.04[b]	131 ± 0.02[b]	121 ± 0.08[b]	118 ± 0.03[a]	97 ± 0.05[b]	111 ± 0.01[a]	126 ± 0.05[a]	68 ± 0.01[a]	54 ± 0.01[a]	63 ± 0.05[a]	43 ± 0.02[a]	55 ± 0.05[a]
Root	161 ± 0.03[b]	179 ± 0.01[b]	182 ± 0.04[b]	129 ± 0.02[a]	176 ± 0.02[b]	162 ± 0.01[b]	181 ± 0.01[b]	187 ± 0.08[b]	172 ± 0.05[b]	161 ± 0.09[b]	183 ± 0.01[b]	98 ± 0.01[a]	112 ± 0.03[a]

Table 2 (*continued*)

Standard compound/ plant parts	MIC (μg/ml)												
	Ec	Ecl	Lm	Sa	Bs	Sp	Hp	Ef	Ca	An	Af	Rp	*Pc*
Flower	67 ± 0.04^{a}	49 ± 0.05^{a}	61 ± 0.01 ^{a}	62 ± 0.05^{b}	89 ± 0.01^{a}	71 ± 0.05^{a}	61 ± 0.03^{a}	73 ± 0.01^{a}	81 ± 0.01^{a}	62 ± 0.01^{a}	56 ± 0.01^{a}	72 ± 0.03^{a}	81 ± 0.05^{a}
Fruit	145 ± 0.03^{b}	167 ± 0.01^{b}	158 ± 0.05^{b}	152 ± 0.02^{b}	86 ± 0.04^{a}	92 ± 0.05^{a}	76 ± 0.01^{a}	119 ± 0.01^{a}	123 ± 0.01^{a}	142 ± 0.08^{a}	137 ± 0.05^{a}	147 ± 0.02^{a}	163 ± 0.02^{b}
C. javanicum parts													
Leaf	201 ± 0.01^{b}	212 ± 0.01^{b}	198 ± 0.03^{b}	215 ± 0.01^{b}	176 ± 0.00^{b}	169 ± 0.04^{b}	162 ± 0.01^{b}	189 ± 0.05^{b}	198 ± 0.03^{b}	169 ± 0.01^{b}	170 ± 0.05^{b}	97 ± 0.05^{a}	84 ± 0.03^{a}
Stem bark	179 ± 0.03^{b}	158 ± 0.02^{b}	149 ± 0.02^{b}	158 ± 0.04^{b}	164 ± 0.02^{b}	129 ± 0.03^{b}	180 ± 0.01^{b}	211 ± 0.08^{b}	178 ± 0.02^{b}	148 ± 0.01^{a}	184 ± 0.04^{b}	211 ± 0.03^{b}	200 ± 0.08^{b}
Stem wood	112 ± 0.04^{a}	134 ± 0.05^{b}	125 ± 0.01^{a}	152 ± 0.03^{b}	142 ± 0.01^{b}	136 ± 0.02^{b}	178 ± 0.03^{b}	162 ± 0.01^{b}	144 ± 0.01^{a}	128 ± 0.03^{a}	179 ± 0.01^{b}	163 ± 0.01^{b}	182 ± 0.02^{b}
Root	218 ± 0.05^{b}	229 ± 0.03^{b}	267 ± 0.01^{b}	212 ± 0.05^{b}	235 ± 0.03^{b}	245 ± 0.01^{b}	241 ± 0.01^{b}	258 ± 0.05^{b}	278 ± 0.05^{b}	148 ± 0.01^{a}	222 ± 0.01^{b}	210 ± 0.03^{b}	201 ± 0.05^{a}
Flower	167 ± 0.02^{b}	152 ± 0.02^{b}	123 ± 0.04^{a}	145 ± 0.05^{b}	139 ± 0.02^{b}	156 ± 0.03^{b}	143 ± 0.04^{b}	152 ± 0.01^{b}	147 ± 0.04^{a}	112 ± 0.02^{a}	124 ± 0.05^{a}	130 ± 0.01^{a}	146 ± 0.04^{a}
Fruit	210 ± 0.03^{b}	213 ± 0.01^{b}	224 ± 0.03^{b}	231 ± 0.02^{b}	179 ± 0.01^{b}	200 ± 0.05^{b}	187 ± 0.01^{b}	189 ± 0.02^{b}	202 ± 0.03^{b}	187 ± 0.01^{b}	165 ± 0.01^{b}	162 ± 0.01^{b}	142 ± 0.03^{a}
C. kaneherai parts													
Leaf	145 ± 0.04^{b}	156 ± 0.01^{b}	166 ± 0.00^{b}	124 ± 0.01^{a}	167 ± 0.01^{b}	187 ± 0.05^{b}	167 ± 0.02^{b}	132 ± 0.02^{b}	118 ± 0.01^{a}	128 ± 0.05^{b}	143 ± 0.01^{a}	126 ± 0.01^{a}	115 ± 0.02^{a}
Stem bark	214 ± 0.02^{b}	228 ± 0.05^{b}	234 ± 0.04^{b}	241 ± 0.02^{b}	243 ± 0.01^{b}	223 ± 0.04^{b}	160 ± 0.01^{b}	211 ± 0.03^{b}	143 ± 0.05^{a}	219 ± 0.02^{b}	221 ± 0.05^{b}	198 ± 0.02^{b}	219 ± 0.04^{b}
Stem wood	164 ± 0.04^{b}	156 ± 0.03^{b}	123 ± 0.04^{a}	152 ± 0.01^{b}	124 ± 0.05^{a}	144 ± 0.01^{b}	122 ± 0.02^{a}	126 ± 0.05^{b}	112 ± 0.01^{a}	126 ± 0.00^{a}	110 ± 0.01^{a}	87 ± 0.03^{a}	98 ± 0.05^{a}
Root	211 ± 0.01^{b}	158 ± 0.01^{b}	201 ± 0.05^{b}	211 ± 0.01^{b}	187 ± 0.04^{b}	167 ± 0.03^{b}	143 ± 0.01^{b}	147 ± 0.04^{b}	183 ± 0.04^{b}	148 ± 0.03^{a}	155 ± 0.05^{b}	122 ± 0.04^{a}	111 ± 0.02^{a}
Flower	123 ± 0.02^{a}	134 ± 0.03^{a}	99 ± 0.04^{a}	111 ± 0.02^{a}	124 ± 0.01^{a}	141 ± 0.01^{b}	166 ± 0.02^{b}	152 ± 0.01^{b}	123 ± 0.01^{a}	126 ± 0.02^{a}	167 ± 0.02^{b}	85 ± 0.01^{a}	102 ± 0.05^{a}
Fruit	111 ± 0.04^{a}	74 ± 0.04 ^{a}	66 ± 0.01^{a}	52 ± 0.03^{a}	57 ± 0.01^{a}	62 ± 0.01^{a}	122 ± 0.01^{a}	114 ± 0.04^{a}	134 ± 0.05^{b}	121 ± 0.04^{a}	131 ± 0.01^{a}	112 ± 0.01^{a}	100 ± 0.03^{a}
C. kotoense parts													
Leaf	213 ± 0.02^{b}	234 ± 0.01^{b}	216 ± 0.04^{b}	256 ± 0.01^{b}	243 ± 0.00^{b}	159 ± 0.02^{b}	165 ± 0.06^{b}	168 ± 0.01^{b}	213 ± 0.04^{b}	200 ± 0.01^{b}	187 ± 0.00^{b}	155 ± 0.04^{b}	164 ± 0.05^{b}
Stem bark	222 ± 0.04^{b}	245 ± 0.03^{b}	226 ± 0.08^{b}	248 ± 0.02^{b}	288 ± 0.03^{b}	167 ± 0.01^{b}	159 ± 0.04^{b}	178 ± 0.02^{b}	169 ± 0.01^{b}	204 ± 0.02^{b}	155 ± 0.03^{b}	168 ± 0.03^{b}	137 ± 0.02^{a}
Stem wood	144 ± 0.06^{b}	163 ± 0.05^{b}	188 ± 0.03^{b}	165 ± 0.01^{b}	177 ± 0.01^{b}	134 ± 0.06^{b}	162 ± 0.03^{b}	152 ± 0.01^{b}	132 ± 0.04^{a}	99 ± 0.03^{a}	119 ± 0.06^{a}	122 ± 0.01^{a}	143 ± 0.03^{a}
Root	154 ± 0.02^{b}	167 ± 0.01^{b}	176 ± 0.02^{b}	169 ± 0.06^{b}	165 ± 0.04^{b}	154 ± 0.02^{b}	157 ± 0.00^{b}	82 ± 0.03^{a}	100 ± 0.01^{a}	80 ± 0.01^{a}	78 ± 0.02^{a}	121 ± 0.03^{a}	109 ± 0.04^{a}
Flower	82 ± 0.01^{a}	88 ± 0.02^{a}	115 ± 0.08^{a}	162 ± 0.01^{a}	155 ± 0.01^{b}	162 ± 0.04^{b}	158 ± 0.06^{b}	151 ± 0.04^{b}	116 ± 0.08^{a}	164 ± 0.04^{b}	72 ± 0.01^{a}	64 ± 0.01^{a}	85 ± 0.02^{a}
Fruit	112 ± 0.04^{a}	126 ± 0.01^{a}	78 ± 0.00^{a}	64 ± 0.03^{a}	88 ± 0.03^{a}	112 ± 0.08^{a}	101 ± 0.03^{a}	211 ± 0.01^{b}	124 ± 0.02^{a}	123 ± 0.01^{a}	111 ± 0.03^{a}	67 ± 0.02^{a}	77 ± 0.03^{a}
C. osmophloem parts													
Leaf	145 ± 0.03^{b}	168 ± 0.01^{b}	144 ± 0.02^{b}	126 ± 0.01^{a}	116 ± 0.05^{a}	121 ± 0.08^{a}	158 ± 0.02^{b}	167 ± 0.01^{b}	148 ± 0.02^{a}	132 ± 0.01^{a}	113 ± 0.02^{a}	124 ± 0.03^{a}	116 ± 0.02^{a}
Stem bark	117 ± 0.05^{a}	90 ± 0.03^{b}	87 ± 0.03^{a}	77 ± 0.01^{a}	58 ± 0.03^{a}	64 ± 0.02^{a}	45 ± 0.01^{a}	52 ± 0.03^{b}	56 ± 0.03^{a}	49 ± 0.04^{b}	45 ± 0.03^{a}	52 ± 0.07^{a}	66 ± 0.05^{a}
Stem wood	189 ± 0.02^{b}	194 ± 0.01^{b}	164 ± 0.08^{b}	212 ± 0.03^{b}	213 ± 0.04^{b}	200 ± 0.01^{b}	168 ± 0.04^{b}	146 ± 0.01^{b}	159 ± 0.05^{b}	152 ± 0.02^{a}	161 ± 0.05^{b}	134 ± 0.02^{a}	123 ± 0.04^{a}
Root	128 ± 0.05^{a}	151 ± 0.02^{b}	142 ± 0.02^{b}	154 ± 0.01^{b}	176 ± 0.03^{b}	155 ± 0.01^{b}	142 ± 0.03^{b}	166 ± 0.03^{b}	187 ± 0.02^{b}	168 ± 0.01^{b}	189 ± 0.04^{b}	150 ± 0.01^{a}	144 ± 0.02^{a}
Flower	111 ± 0.04^{a}	132 ± 0.01^{b}	118 ± 0.04^{a}	142 ± 0.03^{b}	154 ± 0.02^{b}	140 ± 0.02^{b}	118 ± 0.01^{a}	99 ± 0.01^{a}	116 ± 0.04^{a}	98 ± 0.01^{b}	101 ± 0.02^{a}	110 ± 0.01^{a}	124 ± 0.03^{a}
Fruit	79 ± 0.02^{a}	67 ± 0.03 ^{a}	54 ± 0.02^{a}	43 ± 0.08^{b}	76 ± 0.01^{a}	80 ± 0.03^{a}	87 ± 0.05^{a}	66 ± 0.02^{a}	55 ± 0.03^{a}	41 ± 0.04^{a}	67 ± 0.01^{b}	52 ± 0.01^{a}	87 ± 0.02^{a}
C. subavenium parts													
Leaf	121 ± 0.02^{a}	101 ± 0.02^{a}	92 ± 0.01^{a}	124 ± 0.00^{b}	133 ± 0.02^{b}	88 ± 0.03^{a}	68 ± 0.05^{a}	49 ± 0.03^{a}	52 ± 0.09 ^{a}	65 ± 0.01^{a}	63 ± 0.01^{a}	58 ± 0.01^{a}	68 ± 0.09^{a}
Stem bark	200 ± 0.04^{b}	231 ± 0.03^{b}	241 ± 0.04^{b}	222 ± 0.03^{b}	212 ± 0.01^{b}	241 ± 0.04^{b}	219 ± 0.01^{b}	187 ± 0.01^{b}	166 ± 0.02^{b}	123 ± 0.03^{a}	142 ± 0.02^{a}	150 ± 0.03^{a}	169 ± 0.04^{b}
Stem wood	167 ± 0.02^{b}	156 ± 0.01^{b}	178 ± 0.01^{b}	210 ± 0.02^{b}	133 ± 0.07^{b}	187 ± 0.00^{b}	138 ± 0.02^{b}	173 ± 0.04^{b}	164 ± 0.05^{b}	221 ± 0.04^{b}	129 ± 0.05^{a}	178 ± 0.06^{b}	160 ± 0.02^{b}
Root	202 ± 0.05^{b}	211 ± 0.01^{b}	186 ± 0.03^{b}	190 ± 0.01^{b}	210 ± 0.02^{b}	222 ± 0.08^{b}	170 ± 0.05^{b}	184 ± 0.03^{b}	159 ± 0.07^{b}	150 ± 0.08^{a}	166 ± 0.01^{a}	139 ± 0.04^{a}	180 ± 0.03^{b}
Flower	111 ± 0.03^{a}	132 ± 0.02^{b}	102 ± 0.02^{a}	97 ± 0.05^{a}	121 ± 0.01^{a}	182 ± 0.03^{b}	174 ± 0.02^{b}	148 ± 0.01^{b}	139 ± 0.02^{a}	142 ± 0.03^{a}	121 ± 0.01^{a}	123 ± 0.02^{a}	164 ± 0.01^{b}
Fruit	140 ± 0.02^{b}	152 ± 0.03^{b}	163 ± 0.01^{b}	178 ± 0.02^{b}	192 ± 0.01^{b}	201 ± 0.03^{b}	211 ± 0.01^{b}	189 ± 0.06^{b}	184 ± 0.05^{b}	155 ± 0.07^{b}	114 ± 0.00^{a}	116 ± 0.09^{a}	153 ± 0.00^{a}
C. tamala parts													
Leaf	113 ± 0.03^{a}	155 ± 0.01^{b}	212 ± 0.01^{b}	112 ± 0.01^{a}	168 ± 0.01^{b}	177 ± 0.01^{b}	202 ± 0.08^{b}	154 ± 0.01^{b}	134 ± 0.09^{a}	187 ± 0.02^{b}	163 ± 0.08^{b}	158 ± 0.04^{b}	188 ± 0.00^{b}
Stem bark	123 ± 0.01^{a}	143 ± 0.08^{b}	188 ± 0.02^{b}	99 ± 0.01^{a}	155 ± 0.02^{b}	127 ± 0.02^{a}	188 ± 0.09^{b}	166 ± 0.08^{b}	180 ± 0.01^{b}	123 ± 0.00^{a}	132 ± 0.01^{a}	140 ± 0.07^{a}	159 ± 0.02^{b}
Stem wood	156 ± 0.02^{b}	110 ± 0.01^{a}	221 ± 0.01^{b}	167 ± 0.01^{b}	142 ± 0.01^{b}	166 ± 0.01^{b}	176 ± 0.01^{b}	189 ± 0.02^{b}	202 ± 0.01^{b}	181 ± 0.01^{b}	139 ± 0.01^{a}	148 ± 0.00^{a}	150 ± 0.01^{a}
Root	176 ± 0.01^{b}	142 ± 0.00^{b}	165 ± 0.08^{a}	156 ± 0.01^{b}	131 ± 0.00^{a}	144 ± 0.08^{b}	166 ± 0.03^{b}	141 ± 0.01^{b}	211 ± 0.04^{b}	190 ± 0.02^{b}	216 ± 0.04^{b}	189 ± 0.02^{b}	170 ± 0.08^{b}
Flower	144 ± 0.01^{b}	123 ± 0.04^{a}	111 ± 0.01^{a}	133 ± 0.02^{a}	121 ± 0.01^{a}	174 ± 0.01^{b}	177 ± 0.01^{b}	133 ± 0.08^{b}	142 ± 0.00^{a}	132 ± 0.08^{a}	111 ± 0.09^{a}	123 ± 0.01^{a}	154 ± 0.02^{b}
Fruit	128 ± 0.02^{b}	110 ± 0.01^{a}	98 ± 0.09 ^{a}	122 ± 0.08^{a}	111 ± 0.09^{a}	118 ± 0.02^{a}	143 ± 0.01^{b}	112 ± 0.02^{a}	122 ± 0.04^{a}	135 ± 0.01^{a}	144 ± 0.01^{a}	132 ± 0.02^{a}	143 ± 0.09^{a}
C. verum parts													
Leaf	178 ± 0.06^{b}	169 ± 0.00^{b}	110 ± 0.07^{a}	134 ± 0.02^{b}	172 ± 0.01^{b}	133 ± 0.01^{b}	147 ± 0.01^{b}	155 ± 0.01^{b}	148 ± 0.05^{a}	165 ± 0.01^{b}	173 ± 0.07^{b}	158 ± 0.09^{b}	148 ± 0.00^{a}
Stem bark	167 ± 0.00^{b}	211 ± 0.02^{b}	199 ± 0.01^{b}	168 ± 0.01^{b}	143 ± 0.02^{b}	132 ± 0.07^{b}	168 ± 0.04^{b}	160 ± 0.02^{b}	144 ± 0.02^{a}	153 ± 0.05^{b}	132 ± 0.01^{a}	140 ± 0.03^{a}	149 ± 0.02^{a}
Stem wood	187 ± 0.02^{b}	142 ± 0.05^{b}	187 ± 0.05^{b}	130 ± 0.07^{b}	124 ± 0.05^{a}	144 ± 0.01^{b}	186 ± 0.02^{b}	155 ± 0.01^{b}	172 ± 0.01^{b}	121 ± 0.01^{a}	139 ± 0.02^{a}	148 ± 0.01^{a}	150 ± 0.04^{a}
Root	210 ± 0.06^{b}	123 ± 0.01^{a}	132 ± 0.02^{b}	156 ± 0.02^{b}	140 ± 0.01^{b}	139 ± 0.05^{b}	177 ± 0.01^{b}	121 ± 0.05^{a}	152 ± 0.00^{b}	130 ± 0.01^{a}	146 ± 0.05^{a}	129 ± 0.00^{a}	120 ± 0.07^{a}
Flower	112 ± 0.01^{a}	102 ± 0.01^{a}	117 ± 0.01^{a}	111 ± 0.01^{a}	128 ± 0.09^{a}	148 ± 0.06^{b}	162 ± 0.00^{b}	142 ± 0.00^{b}	166 ± 0.02^{b}	162 ± 0.07^{b}	141 ± 0.01^{a}	123 ± 0.02^{a}	114 ± 0.09^{a}
Fruit	156 ± 0.02^{b}	145 ± 0.09^{b}	123 ± 0.01^{a}	138 ± 0.02^{b}	119 ± 0.02^{a}	121 ± 0.07^{a}	101 ± 0.05^{a}	132 ± 0.07^{b}	142 ± 0.01^{a}	115 ± 0.01^{a}	134 ± 0.00^{a}	156 ± 0.06^{b}	163 ± 0.02^{b}

(*continued on next page*)

Table 2 (*continued*)

Standard compound/ plant parts	MIC (µg/ml)												
	Ec	Ecl	Lm	Sa	Bs	Sp	Hp	Ef	Ca	An	Af	Rp	*Pc*
C. walaiwarense parts													
Leaf	121 ± 0.02^{a}	139 ± 0.01^{b}	145 ± 0.01^{b}	98 ± 0.01^{a}	112 ± 0.05^{a}	102 ± 0.01^{a}	89 ± 0.05^{a}	129 ± 0.07^{b}	138 ± 0.01^{a}	119 ± 0.05^{a}	156 ± 0.01^{b}	148 ± 0.05^{a}	132 ± 0.02^{a}
Stem bark	151 ± 0.06^{b}	162 ± 0.02^{b}	161 ± 0.06^{b}	151 ± 0.03^{b}	140 ± 0.01^{b}	139 ± 0.02^{b}	93 ± 0.09^{a}	146 ± 0.03^{b}	152 ± 0.02^{b}	162 ± 0.03^{b}	171 ± 0.01^{b}	149 ± 0.03^{a}	166 ± 0.01^{b}
Stem wood	145 ± 0.03^{b}	128 ± 0.07^{a}	165 ± 0.02^{b}	168 ± 0.05^{b}	130 ± 0.09^{b}	138 ± 0.08^{b}	125 ± 0.03^{a}	131 ± 0.08^{b}	153 ± 0.05^{b}	170 ± 0.01^{b}	165 ± 0.06^{b}	156 ± 0.01^{b}	112 ± 0.03^{a}
Root	167 ± 0.08^{b}	134 ± 0.09^{b}	156 ± 0.08^{b}	145 ± 0.02^{b}	152 ± 0.03^{b}	162 ± 0.03^{b}	122 ± 0.05^{a}	143 ± 0.06^{b}	167 ± 0.07^{b}	161 ± 0.06^{b}	152 ± 0.02^{b}	163 ± 0.08^{b}	176 ± 0.05^{b}
Flower	146 ± 0.07^{b}	132 ± 0.03^{b}	158 ± 0.06^{b}	142 ± 0.01^{b}	129 ± 0.06^{b}	102 ± 0.07^{a}	128 ± 0.01^{a}	138 ± 0.06^{b}	181 ± 0.03^{b}	138 ± 0.01^{a}	157 ± 0.00^{b}	161 ± 0.06^{b}	163 ± 0.02^{b}
Fruit	90 ± 0.06^{a}	75 ± 0.01^{a}	61 ± 0.01^{a}	49 ± 0.07^{b}	61 ± 0.05^{a}	48 ± 0.01^{a}	87 ± 0.01^{a}	72 ± 0.01^{a}	127 ± 0.05^{a}	118 ± 0.08^{a}	121 ± 0.07^{a}	86 ± 0.03^{a}	54 ± 0.07^{a}

Used microorganisms: Ec = *Escherichia coli*; Ecl = *Enterobacter cloacae*; Lm = *Listeria monocytogenes*; Sa = *Staphylococcus aureus*; Bs = *Bacillus subtilis*; Sp = *Streptococcus pneumoniae*; Hp = *Helicobacter pylori*; Ef = *Enterococcus faecalis*; Ca = *Candida albicans*; An = *Aspergillus niger*; Af = *Aspergillus flavus*; Rp = *Rhizoctonia phaseoli*, *Pc* = *Penicillium chrysogenum*. The values of MIC (mean values ± standard deviations) as presented are of triplicate readings for each bacterial and fungal species. Values with different letters are statistically different (Duncan, $p < 0.05$).

et al. 2019; Moradi et al. 2020). Moreover, habitat and climatic factors can affect the composition of the essential oils, growth and growth phases, and genetic properties of plants (Millauskas et al. 2004). The differences in quantities of essential oils are most likely due to differences in species, as well as their interaction with environmental conditions (Yavari et al. 2010; Sriramavaratharajan et al. 2017; Ghavam et al. 2020). The levels of essential oils of *C. altissimum* stem bark agree with the quantities of essential oils reported in previous studies (Paranagama et al. 2001; Shahina et al. 2018). γ-Terpinene (11.1 %) was reported in abundant quantity and the quantity agreed with the reports of other authors (1.2 %, Ananthakrishnan et al. 2018; 0.9 %, Sriramavaratharajan and Murugan 2018). γ-Terpinene is generally used in the production of therapeutic and cosmetic products. Due to its physical and chemical characteristics, it is proposed to become one of the important phytochemicals used as an alternative biofuel in the future (Qi et al. 2018). α-Pinene (10.2 %) was the second major bioactive compound in this essential oil, as reported previously by other researchers, with some variations in the quantity identified: 3.34 % (Paranagama et al. 2001), 3.36 % (Anandakrishnan et al. 2018). α-Pinene inhibits inflammatory signaling pathways in immune cells. Preclinical studies have suggested neuroprotective activity of α-pinene in models of multiple neurological complaints (Khoshnazar et al. 2019). Earlier findings have shown that essential oils obtained from different parts (stem, leaves and bark) of *Cinnamomum* plants differ in their chemical compositions (Wang et al. 2009).

Surprisingly, the MIC (MIC 25 ± 0.01 µg/ml) of methanolic extract of *C. camphora* stem wood against *S. aureus*, which is the main endocarditis, osteomyelitis, influenza-causing agent in humans, was significantly greater in comparison with the corresponding methanolic extracts of other parts of other *Cinnamomum* species. The other species of *Cinnamomum* showed different levels of antimicrobial effects against tested microorganisms. Previous studies have revealed the potent antimicrobial effect of methanol extract against *P. aeuroginosa* (Hassan et al. 2016), *L. monocytogenes* (Kačániová et al. 2012), *S. aureus, B. cereus, E. coli,* and *P. aeruginosa* (Mazimba et al. 2015), *Klebsiella pneumoniae* and *C. albicans* (Sree Satya et al. 2012), *A. niger* and *C. albicans* (Varalakshmi et al. 2014; Sharifi-Rad et al. 2021). To the best of our knowledge, the MFC values of methanolic extracts of different parts of 15 *Cinnamomum* species have been evaluated for the first time in this work, therefore no comparison could be made with previous studies.

In the traditional system of medicine, plant essential oils have been used as an antimicrobial agent and in natural therapies. Various researchers are showing their interest in the formulation of novel pharmaceutical products from medicinal plants (Valdivieso-Ugarte et al. 2019; Baptista-Silva et al. 2020). Several authors have evaluated the antimicrobial activities of essential oils (Lang and Buchbauer 2012; Raut and Karuppayil 2014) against various microbial strains. Due to increasing multidrug resistance (Cleveland et al. 2015), essential oils can be considered as a natural source of antibacterial and antifungal agents. It has been proven from various studies that the synergistic actions of different essential oils are useful in the treatment of various infections (Mourey and Canillac 2002). The antimicrobial effect of essential oil, that of recovered from stem bark, appears to be mainly attributed to the presence of monoterpenes: α-pinene and β-pinene. α-phellandrene, α-terpinene, cinnamaldehyde, eugenol, and isoeugenol. The monoterpenes are widely used in producing of pesticides, cosmetic products, and antiseptic agents. Moreover, α-pinene and β-pinene have anti-inflammatory (Kim et al. 2015), antibacterial (Dhar et al. 2014), and anticancer (Chen et al., 2015) properties. A similar type (essential oils) of antibacterial effects against *S. aureus* (inhibition zone 27.4 mm; MIC 2.5 mg/ml; MBC

Table 3
Minimum inhibitory concentrations (MICs) of essential oil of leaves, stem bark, stem wood, flowers and fruits of different *Cinnamomum* species against selected bacteria and fungi.

Standard compound/ plant parts	MIC (μg/ml)												
	Ec	Ecl	Lm	Sa	Bs	Sp	Hp	Ef	Ca	An	Af	Rp	*Pc*
Standard compounds													
Amoxicillin	18 ± 0.01[a]	21 ± 0.05[a]	31 ± 0.03b	36 ± 0.08[b]	27 ± 0.04[a]	45 ± 0.07[b]	51 ± 0.08[b]	22 ± 0.01[a]	–	–	–	–	–
Streptomycin	26 ± 0.04[a]	36 ± 0.06[a]	41 ± 0.09[b]	58 ± 0.06[b]	43 ± 0.02[b]	15 ± 0.05[a]	38 ± 0.02[a]	57 ± 0.04[b]	–	–	–	- -	–
Fluconazole	–	–	–	–	–	–	–	–	56 ± 0.05[b]	76 ± 0.01[b]	40 ± 0.02[a]	30 ± 0.01[a]	51 ± 0.03[b]
C. altissimum parts													
Leaf	65 ± 0.04[a]	98 ± 0.06[a]	113 ± 0.09[a]	76 ± 0.08[a]	78 ± 0.06[a]	121 ± 0.03[a]	84 ± 0.04[a]	67 ± 0.08[a]	178 ± 0.05[a]	121 ± 0.07[a]	102 ± 0.05[a]	154 ± 0.08[a]	123 ± 0.09[a]
Stem bark	22 ± 0.03[a]	37 ± 0.06[a]	47 ± 0.08[a]	21 ± 0.03[a]	99 ± 0.06[a]	81 ± 0.04[a]	101 ± 0.02[a]	92 ± 0.06[a]	138 ± 0.03[a]	139 ± 0.08[a]	112 ± 0.06[a]	113 ± 0.07[a]	101 ± 0.07[a]
Stem wood	117 ± 0.07[a]	98 ± 0.04[a]	79 ± 0.03[a]	79 ± 0.05[a]	123 ± 0.03[a]	99 ± 0.04[a]	49 ± 0.04[a]	167 ± 0.08[b]	173 ± 0.05[a]	160 ± 0.02[a]	101 ± 0.03[a]	133 ± 0.06[a]	111 ± 0.03[a]
Root	223 ± 0.06[b]	117 ± 0.01[a]	256 ± 0.07[b]	213 ± 0.06[a]	124 ± 0.06[a]	267 ± 0.07[a]	334 ± 0.01[b]	278 ± 0.06[b]	231 ± 0.06[a]	210 ± 0.06[a]	187 ± 0.05[a]	156 ± 0.07[a]	235 ± 0.06[a]
Flower	39 ± 0.02[a]	113 ± 0.05[a]	145 ± 0.05[a]	29 ± 0.06[a]	98 ± 0.07[a]	112 ± 0.08[a]	126 ± 0.08[a]	65 ± 0.06[a]	119 ± 0.07[a]	156 ± 0.07[a]	198 ± 0.03[a]	201 ± 0.07[a]	228 ± 0.05[a]
Fruit	59 ± 0.04[a]	67 ± 0.05[a]	45 ± 0.04[b]	49 ± 0.04[a]	117 ± 0.06[a]	92 ± 0.02[a]	44 ± 0.03[a]	111 ± 0.04[a]	88 ± 0.07[a]	123 ± 0.05[a]	224 ± 0.02[a]	223 ± 0.03[a]	331 ± 0.07[a]
C. bejolghota parts													
Leaf	165 ± 0.06[b]	166 ± 0.08[b]	122 ± 0.07[a]	160 ± 0.07[b]	289 ± 0.07[b]	287 ± 0.04[b]	333 ± 0.08[b]	290 ± 0.08[b]	234 ± 0.09[a]	222 ± 0.05[a]	187 ± 0.03[a]	123 ± 0.06[a]	245 ± 0.08[a]
Stem bark	190 ± 0.05[b]	99 ± 0.05[a]	88 ± 0.06[a]	168 ± 0.03[b]	123 ± 0.05[a]	314 ± 0.07[b]	124 ± 0.06[a]	187 ± 0.06[b]	123 ± 0.06[a]	97 ± 0.05[a]	127 ± 0.08[a]	126 ± 0.05[a]	231 ± 0.05[a]
Stem wood	89 ± 0.08[a]	66 ± 0.08[a]	127 ± 0.06[a]	80 ± 0.08[a]	238 ± 0.07[b]	159 ± 0.03[b]	166 ± 0.04[b]	218 ± 0.04[b]	99 ± 0.09[b]	143 ± 0.07[a]	145 ± 0.07[a]	200 ± 0.07[a]	345 ± 0.06[b]
Root	236 ± 0.07[b]	217 ± 0.07[b]	155 ± 0.04[b]	238 ± 0.07[b]	253 ± 0.08[b]	112 ± 0.06[a]	154 ± 0.03[b]	334 ± 0.07[b]	266 ± 0.04[b]	209 ± 0.07[a]	268 ± 0.06[b]	288 ± 0.05[b]	239 ± 0.08[a]
Flower	311 ± 0.07[b]	187 ± 0.06[b]	180 ± 0.01[b]	268 ± 0.06[b]	333 ± 0.05[b]	288 ± 0.06[b]	239 ± 0.07[b]	336 ± 0.09[b]	312 ± 0.03[b]	269 ± 0.05[b]	268 ± 0.04[b]	135 ± 0.07[a]	145 ± 0.03[a]
Fruit	222 ± 0.06[b]	77 ± 0.06[a]	168 ± 0.07[b]	178 ± 0.06[b]	347 ± 0.06[b]	199 ± 0.07[b]	156 ± 0.04[b]	280 ± 0.07[b]	456 ± 0.06[b]	247 ± 0.03[a]	207 ± 0.08[a]	265 ± 0.09[b]	178 ± 0.05[a]
C. burmanii parts													
Leaf	162 ± 0.07[b]	187 ± 0.07[b]	112 ± 0.06[a]	120 ± 0.06[a]	122 ± 0.07[a]	138 ± 0.05[a]	211 ± 0.04[b]	134 ± 0.05[a]	221 ± 0.08[a]	212 ± 0.01[a]	154 ± 0.06[a]	211 ± 0.08[a]	119 ± 0.08[a]
Stem bark	256 ± 0.01[b]	177 ± 0.06[b]	212 ± 0.07[b]	269 ± 0.08[b]	244 ± 0.06[a]	255 ± 0.09[b]	246 ± 0.08[b]	211 ± 0.07[b]	152 ± 0.06[a]	166 ± 0.06[a]	184 ± 0.07[a]	200 ± 0.04[a]	145 ± 0.08[a]
Stem wood	277 ± 0.02[b]	367 ± 0.04[b]	258 ± 0.02[b]	190 ± 0.06[b]	266 ± 0.03[a]	259 ± 0.01[b]	277 ± 0.06[b]	249 ± 0.06[b]	234 ± 0.05[a]	136 ± 0.04[a]	211 ± 0.06[a]	324 ± 0.07[b]	165 ± 0.07[a]
Root	321 ± 0.02[b]	233 ± 0.02[b]	257 ± 0.05[b]	356 ± 0.05[b]	276 ± 0.03[b]	257 ± 0.06[b]	321 ± 0.05[b]	199 ± 0.06[b]	345 ± 0.05[b]	247 ± 0.03[a]	222 ± 0.06[a]	321 ± 0.07[b]	168 ± 0.04[a]
Flower	100 ± 0.04[a]	244 ± 0.02[b]	340 ± 0.04[b]	199 ± 0.06[b]	189 ± 0.05[b]	196 ± 0.04[b]	211 ± 0.06[b]	261 ± 0.08[b]	348 ± 0.06[b]	211 ± 0.04[a]	277 ± 0.02[b]	300 ± 0.00[b]	245 ± 0.05[a]
Fruit	431 ± 0.05[b]	277 ± 0.05[b]	168 ± 0.06[b]	281 ± 0.06[b]	158 ± 0.04[b]	233 ± 0.04[b]	166 ± 0.06[b]	148 ± 0.08[a]	268 ± 0.05[b]	118 ± 0.08[a]	225 ± 0.05[a]	190 ± 0.03[a]	226 ± 0.04[a]
C. camphora parts													
Leaf	111 ± 0.04[a]	187 ± 0.04[b]	167 ± 0.06[b]	421 ± 0.06[b]	342 ± 0.05[b]	239 ± 0.05[b]	258 ± 0.05[b]	259 ± 0.01[b]	450 ± 0.06[b]	328 ± 0.08[b]	509 ± 0.07[b]	403 ± 0.07[b]	541 ± 0.09[b]
Stem bark	424 ± 0.08[b]	523 ± 0.03[b]	312 ± 0.06[b]	404 ± 0.03[b]	502 ± 0.03[b]	304 ± 0.08[b]	453 ± 0.04[b]	520 ± 0.03[b]	408 ± 0.02[b]	502 ± 0.07[b]	506 ± 0.03[b]	451 ± 0.06[b]	462 ± 0.06[b]
Stem wood	467 ± 0.05[b]	327 ± 0.06[b]	286 ± 0.07[b]	256 ± 0.02[b]	319 ± 0.04[b]	429 ± 0.06[b]	299 ± 0.06[b]	318 ± 0.08[b]	386 ± 0.03[b]	469 ± 0.06[b]	527 ± 0.04[b]	328 ± 0.04[b]	505 ± 0.06[b]
Root	429 ± 0.04[b]	395 ± 0.06[b]	279 ± 0.03[b]	265 ± 0.03[b]	296 ± 0.03[b]	331 ± 0.05[b]	267 ± 0.04[b]	328 ± 0.04[b]	359 ± 0.04[b]	239 ± 0.07[a]	416 ± 0.06[b]	310 ± 0.06[b]	509 ± 0.08[b]
Flower	328 ± 0.04[b]	359 ± 0.04[b]	219 ± 0.06[b]	278 ± 0.04[b]	328 ± 0.04[b]	426 ± 0.04[b]	319 ± 0.04[b]	434 ± 0.06[b]	538 ± 0.08[b]	429 ± 0.04[b]	417 ± 0.06[b]	206 ± 0.04[a]	507 ± 0.05[b]
Fruit	305 ± 0.05[b]	267 ± 0.01[b]	415 ± 0.04[b]	342 ± 0.04[b]	401 ± 0.05[b]	248 ± 0.03[b]	544 ± 0.03[b]	510 ± 0.04[b]	516 ± 0.05[b]	408 ± 0.04[b]	516 ± 0.04[b]	432 ± 0.04[b]	619 ± 0.05[b]
C. cassia parts													
Leaf	314 ± 0.03[b]	431 ± 0.07[b]	222 ± 0.05[b]	299 ± 0.01[b]	432 ± 0.02[b]	211 ± 0.04[b]	276 ± 0.05[b]	288 ± 0.07[b]	357 ± 0.05[b]	344 ± 0.06[b]	433 ± 0.05[b]	331 ± 0.07[b]	444 ± 0.06[b]
Stem bark	313 ± 0.07[b]	421 ± 0.05[b]	333 ± 0.03[b]	498 ± 0.03[b]	328 ± 0.04[b]	228 ± 0.04[b]	363 ± 0.05[b]	323 ± 0.06[b]	284 ± 0.07[b]	266 ± 0.03[b]	345 ± 0.04[b]	266 ± 0.07[b]	354 ± 0.06[b]
Stem wood	346 ± 0.06[b]	424 ± 0.08[b]	356 ± 0.07[b]	425 ± 0.05[b]	342 ± 0.04[b]	327 ± 0.03[b]	466 ± 0.02[b]	378 ± 0.03[b]	426 ± 0.04[b]	378 ± 0.05[b]	366 ± 0.06[b]	288 ± 0.06[b]	262 ± 0.07[b]
Root	334 ± 0.05[b]	451 ± 0.08[b]	334 ± 0.07[b]	461 ± 0.04[b]	344 ± 0.03[b]	456 ± 0.05[b]	565 ± 0.03[b]	444 ± 0.04[b]	243 ± 0.05[a]	471 ± 0.04[b]	316 ± 0.05[b]	498 ± 0.06[b]	533 ± 0.07[b]
Flower	356 ± 0.06[b]	476 ± 0.06[b]	368 ± 0.05[b]	473 ± 0.02[b]	365 ± 0.05[b]	223 ± 0.09[b]	312 ± 0.08[b]	418 ± 0.06[b]	355 ± 0.04[b]	466 ± 0.05[b]	344 ± 0.07[b]	312 ± 0.06[b]	399 ± 0.06[b]
Fruit	224 ± 0.07[b]	431 ± 0.06[b]	322 ± 0.08[b]	502 ± 0.09[b]	524 ± 0.07[b]	499 ± 0.06[b]	388 ± 0.04[b]	378 ± 0.08[b]	468 ± 0.07[b]	478 ± 0.06[b]	360 ± 0.06[b]	365 ± 0.05[b]	277 ± 0.04[b]
C. glaucescens parts													
Leaf	406 ± 0.04[b]	487 ± 0.06[b]	392 ± 0.05[b]	565 ± 0.06[b]	560 ± 0.06[b]	448 ± 0.07[b]	364 ± 0.06[b]	456 ± 0.06[b]	453 ± 0.04[b]	362 ± 0.02[b]	467 ± 0.04[b]	470 ± 0.03[b]	579 ± 0.04[b]
Stem bark	312 ± 0.05[b]	402 ± 0.05[b]	393 ± 0.06[b]	387 ± 0.05[b]	158 ± 0.02[b]	429 ± 0.03[b]	311 ± 0.05[b]	567 ± 0.04[b]	549 ± 0.02[b]	469 ± 0.04[b]	382 ± 0.03[b]	489 ± 0.06[b]	398 ± 0.05[b]
Stem wood	245 ± 0.04[b]	327 ± 0.05[b]	293 ± 0.03[b]	266 ± 0.08[b]	271 ± 0.04[b]	274 ± 0.06[b]	241 ± 0.06[b]	228 ± 0.07[b]	189 ± 0.03[a]	326 ± 0.07[b]	242 ± 0.05[a]	199 ± 0.08[a]	163 ± 0.05[a]
Root	245 ± 0.06[b]	365 ± 0.05[b]	558 ± 0.04[b]	367 ± 0.04[b]	462 ± 0.02[b]	257 ± 0.04[b]	352 ± 0.02[b]	365 ± 0.06[b]	235 ± 0.03[a]	141 ± 0.05[a]	148 ± 0.07[a]	221 ± 0.05[a]	288 ± 0.03[b]
Flower	345 ± 0.03[b]	367 ± 0.06[b]	357 ± 0.05[b]	372 ± 0.018[b]	271 ± 0.06[b]	210 ± 0.07[b]	262 ± 0.04[b]	278 ± 0.07[b]	379 ± 0.06[b]	252 ± 0.07[b]	270 ± 0.05[b]	253 ± 0.02[b]	347 ± 0.08[b]
Fruit	298 ± 0.07[b]	282 ± 0.08[b]	178 ± 0.04[b]	172 ± 0.09[b]	168 ± 0.06[b]	253 ± 0.04[b]	462 ± 0.05[b]	287 ± 0.09[b]	303 ± 0.05[b]	356 ± 0.05[b]	204 ± 0.06[a]	398 ± 0.03[b]	456 ± 0.09[b]
C. insularimontanum parts													
Leaf	245 ± 0.03[b]	268 ± 0.07[b]	276 ± 0.06[b]	211 ± 0.01[b]	156 ± 0.00[b]	164 ± 0.04[b]	187 ± 0.08[b]	134 ± 0.02[a]	182 ± 0.03[a]	139 ± 0.04[a]	104 ± 0.03[a]	199 ± 0.05[a]	109 ± 0.09[a]
Stem bark	191 ± 0.08[b]	152 ± 0.07[a]	173 ± 0.07[b]	182 ± 0.03[b]	223 ± 0.07[b]	141 ± 0.08[a]	199 ± 0.06[b]	118 ± 0.05[a]	127 ± 0.04[a]	112 ± 0.00[a]	104 ± 0.09[a]	121 ± 0.05[a]	164 ± 0.04[a]
Stem wood	254 ± 0.08[b]	243 ± 0.06[b]	231 ± 0.07[b]	321 ± 0.07[b]	218 ± 0.08[b]	197 ± 0.06[b]	141 ± 0.06[a]	156 ± 0.07[b]	268 ± 0.08[b]	154 ± 0.07[a]	163 ± 0.07[a]	143 ± 0.07[a]	155 ± 0.08[a]

(*continued on next page*)

Table 3 (*continued*)

Standard compound/ plant parts	MIC (μg/ml)												
	Ec	Ecl	Lm	Sa	Bs	Sp	Hp	Ef	Ca	An	Af	Rp	*Pc*
Root	261 ± 0.03[b]	379 ± 0.08[b]	282 ± 0.06[b]	229 ± 0.07[b]	276 ± 0.06[b]	262 ± 0.04[b]	281 ± 0.06[b]	387 ± 0.06[b]	272 ± 0.07[b]	261 ± 0.06[b]	283 ± 0.06[b]	198 ± 0.06[a]	152 ± 0.07[a]
Flower	167 ± 0.06[b]	149 ± 0.05[a]	161 ± 0.08[b]	362 ± 0.05[b]	289 ± 0.08[b]	171 ± 0.07[b]	161 ± 0.06[b]	173 ± 0.06[b]	281 ± 0.06[b]	262 ± 0.07[b]	256 ± 0.06[b]	272 ± 0.06[b]	281 ± 0.06[b]
Fruit	245 ± 0.07[b]	267 ± 0.07[b]	258 ± 0.06[b]	252 ± 0.05[b]	186 ± 0.06[b]	192 ± 0.06[b]	176 ± 0.05[b]	319 ± 0.05[b]	323 ± 0.05[b]	242 ± 0.04[a]	237 ± 0.02[a]	347 ± 0.04[b]	263 ± 0.07[b]
C. javanicum parts													
Leaf	221 ± 0.01[b]	232 ± 0.06[b]	298 ± 0.04[b]	115 ± 0.09[b]	186 ± 0.00[b]	269 ± 0.04[b]	362 ± 0.05[b]	389 ± 0.04[b]	398 ± 0.07[b]	369 ± 0.06[b]	270 ± 0.07[b]	197 ± 0.08[a]	184 ± 0.03[a]
Stem bark	179 ± 0.03[b]	158 ± 0.02[b]	149 ± 0.02[a]	158 ± 0.04[b]	164 ± 0.02[b]	129 ± 0.03[a]	180 ± 0.01[b]	311 ± 0.06[b]	328 ± 0.08[b]	148 ± 0.07[a]	184 ± 0.08[a]	201 ± 0.09[a]	120 ± 0.06[a]
Stem wood	212 ± 0.06[b]	234 ± 0.06[b]	225 ± 0.05[b]	352 ± 0.03[b]	242 ± 0.04[b]	336 ± 0.05[b]	478 ± 0.06[b]	362 ± 0.06[b]	344 ± 0.04[b]	228 ± 0.02[a]	279 ± 0.06[b]	263 ± 0.03[b]	382 ± 0.03[b]
Root	318 ± 0.06[b]	329 ± 0.05[b]	467 ± 0.07[b]	412 ± 0.06[b]	335 ± 0.09[b]	343 ± 0.06[b]	441 ± 0.06[b]	458 ± 0.06[b]	478 ± 0.07[b]	248 ± 0.08[a]	322 ± 0.01[b]	410 ± 0.08[b]	231 ± 0.06[a]
Flower	367 ± 0.05[b]	452 ± 0.03[b]	323 ± 0.06[b]	445 ± 0.06[b]	539 ± 0.05[b]	456 ± 0.02[b]	243 ± 0.03[b]	352 ± 0.05[b]	347 ± 0.06[b]	212 ± 0.08[a]	324 ± 0.02[b]	430 ± 0.05[b]	346 ± 0.05[b]
Fruit	410 ± 0.07[b]	313 ± 0.01[b]	424 ± 0.05[b]	131 ± 0.02[a]	379 ± 0.08[b]	260 ± 0.06[b]	387 ± 0.07[b]	489 ± 0.07[b]	302 ± 0.07[b]	487 ± 0.05[b]	465 ± 0.08[b]	362 ± 0.06[b]	342 ± 0.05[b]
C. kaneherai parts													
Leaf	245 ± 0.06[b]	356 ± 0.06[b]	366 ± 0.07[b]	324 ± 0.06[b]	367 ± 0.08[b]	287 ± 0.07[b]	467 ± 0.07[b]	332 ± 0.08[b]	218 ± 0.06[a]	328 ± 0.06[b]	343 ± 0.08[b]	326 ± 0.07[b]	215 ± 0.05[a]
Stem bark	314 ± 0.06[b]	428 ± 0.01[b]	534 ± 0.02[b]	141 ± 0.05[a]	343 ± 0.08[b]	323 ± 0.07[b]	460 ± 0.06[b]	311 ± 0.04[b]	443 ± 0.07[b]	319 ± 0.05[b]	321 ± 0.04[b]	398 ± 0.06[b]	419 ± 0.08[b]
Stem wood	464 ± 0.01[b]	356 ± 0.01[b]	223 ± 0.02[b]	252 ± 0.07[b]	324 ± 0.06[b]	244 ± 0.04[b]	222 ± 0.03[b]	326 ± 0.07[b]	312 ± 0.05[b]	226 ± 0.06[a]	410 ± 0.04[b]	287 ± 0.03[b]	298 ± 0.07[b]
Root	311 ± 0.02[b]	458 ± 0.04[b]	301 ± 0.04[b]	311 ± 0.07[b]	287 ± 0.08[b]	367 ± 0.07[b]	243 ± 0.05[b]	347 ± 0.06[b]	283 ± 0.05[b]	248 ± 0.03[a]	255 ± 0.07[b]	322 ± 0.08[b]	311 ± 0.09[b]
Flower	223 ± 0.02[b]	334 ± 0.04[b]	299 ± 0.05[b]	211 ± 0.06[b]	324 ± 0.06[b]	241 ± 0.07[b]	266 ± 0.08[b]	352 ± 0.09[b]	323 ± 0.07[b]	226 ± 0.06[a]	367 ± 0.05[b]	285 ± 0.04[b]	302 ± 0.03[b]
Fruit	311 ± 0.01[b]	274 ± 0.02[b]	266 ± 0.07[b]	252 ± 0.07[b]	257 ± 0.09[b]	362 ± 0.06[b]	322 ± 0.05[b]	414 ± 0.01[b]	334 ± 0.08[b]	421 ± 0.05[b]	331 ± 0.04[b]	212 ± 0.05[a]	300 ± 0.08[b]
C. kotoense parts													
Leaf	313 ± 0.08[b]	134 ± 0.02[a]	316 ± 0.07[b]	356 ± 0.07[b]	343 ± 0.05[b]	459 ± 0.04[b]	465 ± 0.06[b]	368 ± 0.08[b]	313 ± 0.05[b]	400 ± 0.05[b]	287 ± 0.07[b]	355 ± 0.05[b]	364 ± 0.05[b]
Stem bark	342 ± 0.05[b]	365 ± 0.02[b]	426 ± 0.05[b]	378 ± 0.07[b]	478 ± 0.04[b]	467 ± 0.04[b]	359 ± 0.05[b]	378 ± 0.05[b]	369 ± 0.08[b]	414 ± 0.07[b]	355 ± 0.04[b]	368 ± 0.05[b]	337 ± 0.09[b]
Stem wood	344 ± 0.07[b]	263 ± 0.04[b]	288 ± 0.07[b]	365 ± 0.04[b]	377 ± 0.07[b]	234 ± 0.04[b]	262 ± 0.07[b]	352 ± 0.04[b]	232 ± 0.06[a]	299 ± 0.07[b]	319 ± 0.04[b]	322 ± 0.07[b]	443 ± 0.06[b]
Root	254 ± 0.08[b]	367 ± 0.03[b]	376 ± 0.01[b]	269 ± 0.03[b]	365 ± 0.02[b]	454 ± 0.03[b]	357 ± 0.05[b]	482 ± 0.02[b]	400 ± 0.05[b]	280 ± 0.06[b]	278 ± 0.07[b]	421 ± 0.08[b]	309 ± 0.07[b]
Flower	182 ± 0.05[b]	188 ± 0.01[b]	215 ± 0.02[b]	262 ± 0.04[b]	255 ± 0.05[b]	262 ± 0.07[b]	358 ± 0.06[b]	351 ± 0.06[b]	316 ± 0.06[b]	364 ± 0.05[b]	272 ± 0.04[b]	264 ± 0.06[b]	285 ± 0.05[b]
Fruit	312 ± 0.02[b]	226 ± 0.06[b]	278 ± 0.07[b]	464 ± 0.07[b]	288 ± 0.04[b]	412 ± 0.07[b]	201 ± 0.06[b]	311 ± 0.05[b]	424 ± 0.04[b]	223 ± 0.04[a]	411 ± 0.03[b]	367 ± 0.04[b]	277 ± 0.05[b]
C. osmophloem parts													
Leaf	345 ± 0.05[b]	468 ± 0.04[b]	544 ± 0.03[b]	526 ± 0.06[b]	416 ± 0.07[b]	421 ± 0.04[b]	358 ± 0.05[b]	367 ± 0.04[b]	548 ± 0.05[b]	432 ± 0.08[b]	513 ± 0.07[b]	424 ± 0.08[b]	416 ± 0.09[b]
Stem bark	417 ± 0.07[b]	490 ± 0.07[b]	587 ± 0.06[b]	477 ± 0.03[b]	358 ± 0.05[b]	364 ± 0.06[b]	445 ± 0.08[b]	452 ± 0.09[b]	356 ± 0.08[b]	549 ± 0.04[b]	445 ± 0.05[b]	352 ± 0.06[b]	366 ± 0.08[b]
Stem wood	389 ± 0.08[b]	494 ± 0.06[b]	464 ± 0.05[b]	312 ± 0.08[b]	413 ± 0.07[b]	400 ± 0.06[b]	368 ± 0.03[b]	246 ± 0.05[b]	359 ± 0.07[b]	552 ± 0.06[b]	461 ± 0.04[b]	434 ± 0.07[b]	523 ± 0.08[b]
Root	328 ± 0.07[b]	451 ± 0.08[b]	442 ± 0.07[b]	354 ± 0.06[b]	476 ± 0.04[b]	555 ± 0.04[b]	342 ± 0.07[b]	466 ± 0.05[b]	587 ± 0.03[b]	368 ± 0.06[b]	589 ± 0.05[b]	350 ± 0.07[b]	244 ± 0.06[a]
Flower	311 ± 0.03[b]	432 ± 0.06[b]	318 ± 0.07[b]	542 ± 0.06[b]	454 ± 0.08[b]	540 ± 0.04[b]	618 ± 0.05[b]	499 ± 0.04[b]	516 ± 0.08[b]	498 ± 0.07[b]	501 ± 0.07[b]	510 ± 0.05[b]	424 ± 0.07[b]
Fruit	279 ± 0.08[b]	367 ± 0.08[b]	254 ± 0.07[b]	343 ± 0.06[b]	376 ± 0.04[b]	280 ± 0.08[b]	487 ± 0.06[b]	466 ± 0.08[b]	255 ± 0.06[b]	341 ± 0.07[b]	367 ± 0.05[b]	452 ± 0.08[b]	387 ± 0.07[b]
C. subavenium parts													
Leaf	321 ± 0.07[a]	401 ± 0.01[b]	492 ± 0.03[b]	324 ± 0.05[b]	433 ± 0.04[b]	388 ± 0.08[b]	468 ± 0.07[b]	449 ± 0.06[b]	352 ± 0.06[b]	265 ± 0.04[b]	263 ± 0.08[b]	358 ± 0.07[b]	468 ± 0.06[b]
Stem bark	100 ± 0.01[a]	131 ± 0.03[b]	341 ± 0.07[b]	322 ± 0.06[b]	412 ± 0.03[b]	541 ± 0.04[b]	319 ± 0.05[b]	287 ± 0.04[b]	366 ± 0.05[b]	323 ± 0.06[b]	442 ± 0.07[b]	450 ± 0.08[b]	569 ± 0.07[b]
Stem wood	367 ± 0.08[b]	456 ± 0.09[b]	378 ± 0.07[b]	220 ± 0.06[b]	333 ± 0.05[b]	387 ± 0.02[b]	438 ± 0.08[b]	473 ± 0.07[b]	564 ± 0.05[b]	521 ± 0.04[b]	429 ± 0.05[b]	378 ± 0.07[b]	460 ± 0.06[b]
Root	302 ± 0.08[b]	411 ± 0.05[b]	486 ± 0.06[b]	590 ± 0.02[b]	310 ± 0.09[b]	422 ± 0.08[b]	370 ± 0.06[b]	484 ± 0.02[b]	559 ± 0.03[b]	250 ± 0.03[b]	366 ± 0.05[b]	539 ± 0.06[b]	480 ± 0.07[b]
Flower	411 ± 0.02[b]	532 ± 0.03[b]	402 ± 0.08[b]	397 ± 0.06[b]	421 ± 0.08[b]	482 ± 0.02[b]	374 ± 0.06[b]	348 ± 0.06[b]	439 ± 0.02[b]	542 ± 0.05[b]	421 ± 0.06[b]	423 ± 0.06[b]	564 ± 0.05[b]
Fruit	240 ± 0.08[b]	352 ± 0.07[b]	263 ± 0.07[b]	478 ± 0.06[b]	492 ± 0.06[b]	501 ± 0.02[b]	311 ± 0.04[b]	489 ± 0.07[b]	684 ± 0.03[b]	555 ± 0.07[b]	414 ± 0.04[b]	416 ± 0.07[b]	553 ± 0.05[b]
C. tamala parts													
Leaf	313 ± 0.07[b]	355 ± 0.04[b]	412 ± 0.06[b]	312 ± 0.02[b]	467 ± 0.03[b]	477 ± 0.03[b]	502 ± 0.06[b]	454 ± 0.04[b]	634 ± 0.06[b]	587 ± 0.06[b]	463 ± 0.04[b]	358 ± 0.05[b]	388 ± 0.06[b]
Stem bark	323 ± 0.06[b]	443 ± 0.06[b]	488 ± 0.03[b]	399 ± 0.05[b]	455 ± 0.05[b]	327 ± 0.04[b]	488 ± 0.07[b]	366 ± 0.06[b]	480 ± 0.03[b]	523 ± 0.05[b]	432 ± 0.05[b]	540 ± 0.03[b]	559 ± 0.06[b]
Stem wood	556 ± 0.03[b]	510 ± 0.07[b]	421 ± 0.06[b]	367 ± 0.05[b]	442 ± 0.03[b]	366 ± 0.05[b]	476 ± 0.03[b]	389 ± 0.05[b]	402 ± 0.04[b]	381 ± 0.07[b]	439 ± 0.05[b]	548 ± 0.05[b]	550 ± 0.08[b]
Root	476 ± 0.04[b]	542 ± 0.08[b]	465 ± 0.06[b]	556 ± 0.05[b]	431 ± 0.02[b]	544 ± 0.05[b]	466 ± 0.04[b]	341 ± 0.02[b]	411 ± 0.03[b]	690 ± 0.04[b]	516 ± 0.05[b]	589 ± 0.06[b]	670 ± 0.07[b]
Flower	344 ± 0.08[b]	423 ± 0.07[b]	511 ± 0.05[b]	433 ± 0.03[b]	521 ± 0.02[b]	674 ± 0.03[b]	577 ± 0.05[b]	533 ± 0.04[b]	542 ± 0.05[b]	532 ± 0.06[b]	511 ± 0.07[b]	523 ± 0.08[b]	654 ± 0.09[b]
Fruit	428 ± 0.03[b]	510 ± 0.06[b]	598 ± 0.03[b]	422 ± 0.03[b]	511 ± 0.06[b]	318 ± 0.08[b]	343 ± 0.07[b]	212 ± 0.05[b]	422 ± 0.03[b]	335 ± 0.05[b]	444 ± 0.07[b]	332 ± 0.06[b]	443 ± 0.06[b]
C. verum parts													
Leaf	378 ± 0.03[b]	469 ± 0.04[b]	510 ± 0.05[b]	534 ± 0.07[b]	572 ± 0.04[b]	433 ± 0.03[b]	347 ± 0.04[b]	355 ± 0.07[b]	448 ± 0.06[a]	565 ± 0.04[a]	473 ± 0.08[a]	458 ± 0.07[a]	548 ± 0.06[b]
Stem bark	467 ± 0.07[b]	511 ± 0.04[b]	499 ± 0.05[b]	568 ± 0.06[b]	443 ± 0.01[b]	332 ± 0.02[b]	568 ± 0.03[b]	460 ± 0.04[b]	544 ± 0.06[a]	453 ± 0.04[a]	332 ± 0.05[a]	540 ± 0.07[a]	549 ± 0.06[b]
Stem wood	487 ± 0.03[b]	542 ± 0.04[b]	487 ± 0.05[b]	330 ± 0.05[b]	324 ± 0.06[b]	544 ± 0.07[b]	486 ± 0.08[b]	355 ± 0.07[b]	572 ± 0.06[a]	421 ± 0.05[a]	339 ± 0.04[a]	448 ± 0.05[a]	550 ± 0.07[b]
Root	410 ± 0.04[b]	523 ± 0.03[b]	332 ± 0.04[b]	356 ± 0.05[b]	540 ± 0.06[b]	439 ± 0.07[b]	577 ± 0.06[b]	421 ± 0.04[b]	452 ± 0.06[a]	430 ± 0.04[a]	546 ± 0.06[a]	529 ± 0.05[a]	320 ± 0.06[b]
Flower	412 ± 0.02[b]	502 ± 0.04[b]	517 ± 0.05[b]	611 ± 0.04[b]	528 ± 0.05[b]	548 ± 0.07[b]	362 ± 0.02[b]	542 ± 0.04[b]	466 ± 0.04[a]	562 ± 0.05[a]	341 ± 0.06[a]	523 ± 0.08[a]	414 ± 0.07[b]
Fruit	356 ± 0.01[b]	445 ± 0.03[b]	523 ± 0.06[b]	538 ± 0.05[b]	619 ± 0.06[b]	421 ± 0.07[b]	501 ± 0.08[b]	632 ± 0.09[b]	642 ± 0.07[a]	515 ± 0.06[a]	634 ± 0.03[a]	556 ± 0.05[a]	563 ± 0.06[b]

Table 3 (*continued*)

Standard compound/ plant parts	MIC (μg/ml)												
	Ec	Ecl	Lm	Sa	Bs	Sp	Hp	Ef	Ca	An	Af	Rp	*Pc*
C. walaiwarense parts													
Leaf	411 ± 0.06^{b}	456 ± 0.06^{b}	289 ± 0.05^{b}	194 ± 0.03^{b}	266 ± 0.05^{b}	246 ± 0.05^{b}	378 ± 0.04^{b}	299 ± 0.06^{b}	367 ± 0.06^{b}	412 ± 0.06^{b}	337 ± 0.06^{b}	355 ± 0.05^{b}	421 ± 0.08^{b}
Stem bark	300 ± 0.04^{b}	336 ± 0.04^{b}	345 ± 0.04^{b}	305 ± 0.03^{b}	270 ± 0.04^{b}	306 ± 0.05^{b}	325 ± 0.04^{b}	288 ± 0.04^{b}	335 ± 0.06^{b}	355 ± 0.06^{b}	376 ± 0.05^{b}	455 ± 0.06^{b}	444 ± 0.05^{b}
Stem wood	316 ± 0.04^{b}	269 ± 0.06^{b}	344 ± 0.06^{b}	421 ± 0.04^{b}	265 ± 0.06^{b}	304 ± 0.05^{b}	256 ± 0.08^{b}	256 ± 0.03^{b}	312 ± 0.07^{b}	400 ± 0.05^{b}	426 ± 0.07^{b}	477 ± 0.05^{b}	145 ± 0.06^{a}
Root	412 ± 0.05^{b}	280 ± 0.04^{b}	341 ± 0.06^{b}	321 ± 0.04^{b}	308 ± 0.03^{b}	336 ± 0.06^{b}	321 ± 0.06^{b}	338 ± 0.05^{b}	458 ± 0.08^{b}	421 ± 0.04^{b}	568 ± 0.02^{b}	421 ± 0.06^{b}	352 ± 0.03^{b}
Flower	298 ± 0.07^{b}	313 ± 0.04^{b}	350 ± 0.08^{b}	335 ± 0.04^{b}	236 ± 0.06^{b}	201 ± 0.03^{b}	368 ± 0.08^{b}	268 ± 0.02^{b}	456 ± 0.02^{b}	489 ± 0.02^{b}	450 ± 0.04^{b}	341 ± 0.03^{b}	412 ± 0.04^{b}
Fruit	194 ± 0.04^{b}	167 ± 0.05^{b}	168 ± 0.04^{b}	100 ± 0.05^{a}	121 ± 0.06^{b}	102 ± 0.05^{b}	225 ± 0.01^{b}	219 ± 0.09^{b}	439 ± 0.06^{b}	459 ± 0.04^{b}	317 ± 0.05^{b}	191 ± 0.07^{a}	118 ± 0.05^{a}

Used microorganisms: Ec = *Escherichia coli*; Ecl = *Enterobacter cloacae*; Lm = *Listeria monocytogenes*; Sa = *Staphylococcus aureus*; Bs = *Bacillus subtilis*; Sp = *Streptococcus pneumoniae*; Hp = *Helicobacter pylori*; Ef = *Enterococcus faecalis*; Ca = *Candida albicans*; An = *Aspergillus niger*; Af = *Aspergillus flavus*; Rp = *Rhizoctonia phaseoli*, *Pc* = *Penicillium chrysogenum*. The values of MIC (mean values ± standard deviations) as presented are of triplicate readings for each bacterial and fungal species. Values with different letters are statistically different (Duncan, $p < 0.05$).

5.0 mg/ml) were also reported by other researchers (Huang et al., 2014).

The essential oils of *C. altissimum* stem bark demonstrated potent bactericidal effect against *S. aureus* (39 ± 0.03 μg/ml) and *E. coli* (45 ± 0.05 μg/ml). The rate of mortality was higher on *S. aureus* (Gram-positive) than *E. coli* (Gram-negative). Several researchers have revealed that Gram-negative bacteria are higher sensitive to essential oils than Gram-positive strains (Ravikumar et al. 2012; Chaudhry and Tariq 2008) but our results are not in agreement with the previously reported results. Similarly, the essential oil of *C. altissimum* fruits showed potent mortality on *C. albicans* (156 ± 0.04 μg/ml) also.

5. Conclusions

Methanolic extract of *C. camphora* stem wood demonstrated moderate antimicrobial effects against *S. aureus* (MIC 25 ± 0.01 μg/ml), *H. pylori* (MIC 29 ± 0.05 μg/ml), *B. subtilis* (MIC 31 ± 0.03 μg/ml), *E. faecalis* (MIC 33 ± 0.01 μg/ml), and *C. albicans* (MIC 38 ± 0.03 μg/ml). Similarly, its root extract also displayed strong activity to *H. pylori* (MIC 26 ± 0.01 μg/ml), *B. subtilis* (MIC 29 ± 0.02 μg/ml), *S. pneumoniae* (MIC 31 ± 0.07 μg/ml), *E. faecalis* (MIC 32 ± 0.03 μg/ml), *A. niger* (MIC 23 ± 0.01 μg/ml), and *R. phaseoli* (MIC 30 ± 0.09 μg/ml). The essential oil of *C. altissimum* stem bark displayed potent antimicrobial effects against *S. aureus*, *E. coli*, *E. cloacae*, *L. monocytogenes*, and *P. chrysogenum* therefore, essential oils of *Cinnamomum* species may be used as an alternative source of antimicrobial compounds in the treatment of various types of infections.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

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