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ESSENTIAL OILS FROM FAMILY ZINGIBERACEAE FOR ANTIMICROBIAL ACTIVITY- A REVIEW

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ABSTRACT

Multi drug resistant pathogenic bacteria are posing a serious problem for the current world. Thus in the search for novel antibiotics traditional plants have been proved to be potent source for antimicrobial agents. Zingiberaceae family constitutes a vital group of rhizomatous medicinal and aromatic plants characterised by the presence of volatile oils and oleoresins of export value. Since the middle ages, essential oils have been widely used for bactericidal, fungicidal, medicinal and cosmetic applications. The aim of this review article is to elucidate major constituents present in essential oils of some medicinally important plants of Zingiberaceae family and to explain their antimicrobial activities.

KEYWORDS: Zingiberceae, aromatic plants, essential oils, antimicrobial.

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INTRODUNTION

A large portion of the world population, especially in developing countries depends upon the traditional system of medicine for a variety of diseases. Several hundred genera of plants are used as vital sources for potent and powerful drugs [1]. In herbal medicine, crude plant extracts in the form of herbal extracts are used by the population for the treatment of diseases, including infectious diseases. Although their efficacy and mechanism of action have not been tested scientifically in most cases, these simple medicinal preparations often mediate beneficial responses due to their active chemical constituents [2]. Plant- derived products contain a great diversity of phytochemicals and secondary metabolites which possess numerous health- related effects such as antibacterial, antimutagenic, anticarcinogenic, antithrombotic, and vasodilatory activities [3]. During the recent years, infectious diseases have increased to a great extent and antibiotic resistances have become an ever increasing therapeutic problem [4]. Increasing bacterial resistance is prompting resurgence in research towards explaining the antimicrobial role of herbs against resistant strains [5]. Considering the vast potentiality of plants as sources for antimicrobial drugs with reference to antibacterial and antifungal agents, a systematic investigation was undertaken to screen the local flora for antibacterial and antifungal activities from different medicinal plants of Zingiberaceae family. The Zingiberaceae family has held a place of importance for hundreds of years because the infusion and the tinctures of numerous aromatic species have been used and are still used as components of herbal treatments for a variety of ailments [5]. Economically many members of Zingiberaceae are of outstanding importance since their volatile oils form indispensable ingredient of perfumery, flavour, fragrance and pharmaceutical industries [6]. The family is of great ethanobotanical value being employed in many indigenous medical systems. The important genera coming under Zingiberaceae are *Curcuma, Alpinia, Zingiber, Hedychium, Kaempferia, Elletaria, Amomum and Costus.* In the gnus *Alpinia*, *Alpinia galanga* is the most important one which finds varying uses in ayurvedic preparations such as "Rasnadi Powder". In *Curcuma, Curcuma longa* is the most popular one, which has been studied in depth and has enormous medicinal values. *C. aromatica* is used in the treatment of skin diseases and is extremely used in vanishing creams. *Kaempferia galanga* has become very popular and is identified to have treatmandous effects in curing bronchial and gastric diseases. Of late, it has been used in preparations of mouth washes and oral deodorants. *Kaempferia rotunda* is another related plant under this genus which has potential for great exploitation on commercial basis [7].

As things stand now, knowledge on the chemistry of essential oils of Zingiberaceae and allied taxa are very uneven and inadequate for a serious comparative discussion. Thus owing to the richness of this family in vegetation of India, the knowledge of its essential oil constituents and their significance may lead to the better understanding of these plants. Thus the aims of the present review are to assess the components determined to be present in the volatile oils and assess the antimicrobial activities of the test volatile oils and compare these to the effect of the antibiotics upon bacterial growth. To use these data to deduce which components are likely to contribute to the activities of the whole oils and to determine any structural relationships between the components and their antibacterial activity.

Essential Oils

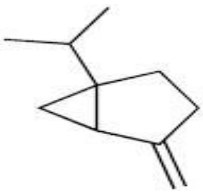
Essential oils are made from a very complex mixture of volatile molecules that are produced by the secondary metabolism of aromatic and medicinal plants and can be obtained by different methods, including the use of low or high pressure distillation of different parts of plants or the employment of liquid carbon dioxide or microwaves. Several factors influence the quality and quantity of the extracted product, in particular the soil composition, plant organ, vegetative cycle phase and climate [8, 9]. Essential oils are stored in plants in special brittle secretory structures, such as glands, secretory hairs, secretory ducts or resin ducts [10, 11]. In Zingiberaceae family, many members are aromatic due to the due to the presence of

essential oils that are located in highly specialized secretory structures. Essential oils are very complex natural mixtures which can contain about 20–60 components at quite different concentrations. They are characterized by two or three major components at fairly high concentrations (20–70%) compared to others components present in trace amounts. Detailed compositional analysis is achieved by gas chromatography and mass spectrometry of essential oils from rhizome and leaves. The data of major essential oils constituents of the species of the family Zingiberaceae are presented here (Table 1).

Table 1
Major Chemical Constituents of some Plants of Zingiberaceae Family.

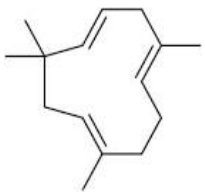
S.No.	Taxa investigated	Part Used	% composition	Major Components	Reference
1.	*Zingiber officinale*	Rhizome	15.92	α-Zinigiberene	[12, 13]
			11.75	β-sesquiphellandrene	
			11.12	ar-Curcumene	
		Leaves	22.65	β-caryophyllene	
			11.26	Geraniol	
			9.51	Caryophyllene oxide	
2.	*Z. zerumbet*	Rhizome	36.93	Zerumbone	[14, 15]
			16.53	α-Caryophyllene	
			14.4	Curzerenone	
			9.21	Camphene	
		Leaves	46.83	Zerumbone	
			19.00	α-terpineol	
3.	*Z. cassumunar*	Rhizome	60.33	2,6,9,9-tetramethyl-2,6,	[16, 17, 18]
				10-cycloundecatrien-1-one	
			50. 5	Terpinen-4-ol	
			23.92	α-caryophyllene	
		Leaves	14.99	Sabinene	
			14.32	β-pinene	
			13.85	Caryophyllene oxide	
4.	*Z.purpureum*	Rhizome	24.76	Sabinene	[19]
			20.06	Terpineol	
5.	*Curcuma longa*	Rhizome	31.7	ar-turmerone	[20, 21]
			12.9	α-turmerone	
			12.0	β-turmerone	
			11. 2	1, 8- cineole	
			11.1	α-turmerone	
		Leaves	9.9	α-phellandrene	
			7.3	1, 8-cineole	
6.	*C. amada*	Rhizome	88.84	Myrcene	[22, 23]
			3.74	β-pinene	
			2.61	(E)-β-ocimene	
		Leaves	17.7	1.8-cineole	
			10.5	Curzerenone	
			7.8	furanogermenone	
7.	*C. aeruginosa*	Rhizome	35.29	Cycloisolongifolene, 8,9-	[16, 24]
				dehydroformyl	
			22.51	dihydrocostunolide	
		Leaves	17.7	1, 8- cineole	
			10.5	curzerenone	
			7.8	furanogermenone	
8.	*C. zedoaria*	Rhizome	22.3	curzerenone	[25, 26]
			15.9	1, 8-cineole	
			9.0	germacrone	

		Leaves	8.4	α-terpinylacetate	
			9	dehydrocurdiane	
			7	isoborneol	
9.	*Hedychium spicatum*	Rhizome	44.3	1, 8-cineole	[27]
		Leaves	40.9	β-pinene	
			9.6	α-pinene	
10.	*H. coronarium*	Rhizome	34.8	1, 8-cineole	[28, 29]
			16.7	β-pinene	
			13.1	α-terpineol	
		Leaves	43.0	β-caryophyllene	
			12.1	caryophyllene oxide	
			11.6	β-pinene	
11.	*H. gardenarium*	Rhizome	48.7	1, 8-cineole	[30]
			43.6	β-pinene	
12.	*Alpinia galanga*	Rhizome	33.3	1,8-cineole	[31, 32]
			12.7	α-fenchyl acetate	
			9.3	α-terpineol	
		Leaves	34.4	1, 8-cineole	
			21.5	β-pinene	
13.	*A. nigra*	Rhizome	13.1	α-fenchyl acetate	[33]
			9.6	α-terpineol	
		Leaves	15.3	Camphor	
			15	β-pinene	
14.	*A.calcarata*	Rhizome	51.34	fenchyl acetate	[34]
			11.44	borneol	
		Leaves	28.48	1,8-cineole	
			29.4	Camphor	
15.	*A. smithiae*	Rhizome	14.44	Myrcene	[35]
			9.28	Sabinene	
			10.36	1, 8-cineole	
16.	*Elettaria cardamomum*	Rhizome	29.97	1, 8-cineol	[36, 37]
			26.1	α-terpinyl acetate	
17.	*Kaempferia galangal*	Rhizome	39.9	Ethyl-trans-p-methoxy cinnamate	[38, 39, 40]
			18.83	Ethyl trans- cinnamate	
		Leaves	21.42	Linoleoyl Chloride	
			11.75	Caryophyllene Oxide	
18.	*Kaempferia rotunda*	Rhizome	25.4	Pentadecane	[41]
			24.9	Bornyl acetate	
			15.3	Benzyl benzoate	
			12.1	Camphor	

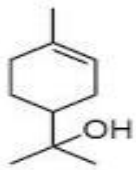


1. Sabinene

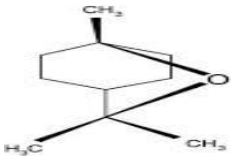
2. Zingiberene



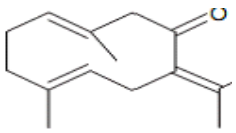
3.Humulene



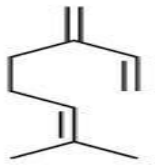
4. Terpineol

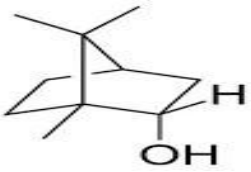

5. 1, 8- Cineole

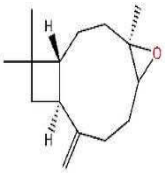

6. Curzerenone


7. Germacrone


8. Camphene


9. Myrcene


10. Borneol


11. Carophyllene oxide

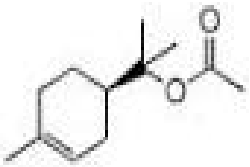

12. -Terpinyl acetate

Figure.1
Chemical structures of selected components of essential oils.

Major Oil Components Identified in Zingiberaceae Family

The major essential oil components identified in various plants of Zingiberaceae broadly belong to monoterpenes, sesquiterpenes and few phenols. The rhizome oil of *Z.officinale* contained mainly monoterpenoids and major sesquiterpenoids hydrocarbons viz alpha-zingiberene, alpha-curcumene, β-bisabolene, β-sesquiphellandrene, which is in accordance with most of the reports [12, 13]. The essential oil from rhizome and leaf of *Z.officinale* displays considerable compositional diversity. The essential oil of leaves contains beta-caryophyllene as a major component [42]. *Z. zerumbet* (L.) Smith showed high content of monocyclic sesquiterpene ketone zerumbone which is an oxygenated humulene derivative [14, 15]. The isolation of new sesquiterpenoids (e.g., humulene epoxide-I, humulene epoxide-II, humulenol-II, dihydro-*ψ*-photo-zerumbone and *ψ*-photozerumbone) and sesquiterpene alcohols (humulenol-I and humulenol-III) from the sesquiterpene fractions of essential oil of *Z. zerumbet* (L.) Smith have been reported[43, 44]. Curzerenone was also reported as major constituent in *Z. zerumbet* rhizome oil [15]. In *Z. zerumbet* var. darcyi zerumbone content was found to be highest which is about 69.9% [45]. The essential oils from leaf and rhizome of *Z. casumunar* were dominated by sesquiterpenes [16]. Some report also shows high percent of monoterpene alcohol, terpinen 4-ol as a major constituent in rhizome oil [17, 18] while leaf essential oil were rich in l(10),4-furanodien-6-one (27.3%), curzerenone (25.7%) and β-sesquiphellandrene (5.7%) [18]. In *Z. purpureum* the monoterpene hydrocarbon sabinene and monoterpene tertiary alcohol terpinen-4-ol are major components identified [19]. All the species studied under genus curcuma showed variation in their chemical constituents. In *C.longa* major component identified was tuemerone a sesquiterpene, sabinene and 1, 8-cineole were the major monoterpenes while in leaves of *C.longa* cyclic monoterpene alpha-phellandrene is major constituent [20, 21]. Some diterpenes and triterpenoids were also identified in turmeric, diterpenoid (*E,E,E*)-3,7,11,15-tetramethylhexadeca-1,3,6,10,14-pentaene, 2,6,11,15-tetramethyl-hexadeca-2,6,8,10,14-pentaene and 1,6,10,14-hexadecatetraen-3-ol, 3,7,11,15-tetramethyl-, (E,E)- [16c] and triterpenoids hopenone I, hop-17(21)-en-3β-ol and hop-17(21)-en-3β-yl-acetate were reported [46]. Acyclic monoterpene

Myrcene, the single major constituent of rhizome oil, along with β-pinene and (*E*)-β-ocimene, seem to be responsible for the characteristic mango aroma of *C. amada* [22, 23]. The essential oil from leaves of *C. amada* was mainly composed of furanosesquiterpenoids, namely *epi*-curzerenone, curzerenone, curzerene and furanogermenone. Camphor, isoborneol, camphene, borneol and camphene hydrate were the major constituents of 36.79% of the monoterpenoids fraction of leaf essential oil composition. Conversely, the rhizome essential oil of *C. amada* was mainly dominated by monoterpenoids. Comparison of the volatile constituents of leaves and rhizome essential oil of *C. amada* revealed sharp qualitative and quantitative variations. Furanosesquiterpenoids, isoborneol and borneol were the exclusive constituents of leaf essential oil, and were not noticed in rhizome oil of *C. amada* [22]. In *C. zedoria* sesquiterpene like germacrone and curzeronene were major components in rhizome oil while in leaves essnetial oils oxygenated monoterpenes have major contribution [25, 26]. Sesquiterpenes dominated the chemical composition of *C. aeruginosa* while rest of oil composition comprised of oxygenated monoterpene like eucalyptol, L-camphor and isoborneol [16, 24]. Rhizome oil of *C. aeruginosa* from Thailand contain high amount of Curerenone (41.93%) and Eucalyptol (9.64%) [47]. *C.aeruginosa* rhizome oil from Indonesia and India was found to have high content of Curcumanolides (11.41%) and curcumenol (9.9%) [47].Monoterpene ethers such as 1, 8- cineole is major constituent of essential oils of Hedychium family which shows that oil is rich in monoterpene [27, 28, 29, 30]. *H. spicatum* leaves were found to be rich in bicyclic monoterpenes and β pinene [27] whereas *H. coronarium* leaves have a high content of sesquiterpenes [28, 29]. The percentages of sesquiterpenes were the highest in the rhizome oil of *H. venustum* (24.0%) followed by *H. spicatum* var. *acuminatum* (22.2%), *H. flavescens* (0.6%) and *H. coronarium* (0.5%) [27]. The essential oil from the rhizomes of *Hedychium gardnerianum* ('Kahili ginger', grown at Mungpoo, Darjeeling, India) contained pinenes (46%), other monoterpenes, and about 30% sesquiterpenes, mainly cadinane derivatives. The new sesquiterpenes such as α-corocalene epoxide; 1,10;7,10-bisepoxy-1,10-*seco*-calamenene; 6,7;7,10-bisepoxy-6,7-*seco*-calamenene; 7-*epi*-*trans*- and 7-*epi*-*cis*-sesquisabinene hydrate; 10-*epi*-cubenol, and *ar*-curcumen-1,10-diol were identified from their NMR and MS data [30].*Alpinia galanga* rhizome oil was rich in o-fenchyl aceate and monoterpene ether, 1,8-cineole, was less in percent in rhizome oil of *A.galanga* but was more in amount in leaves [31, 32]. *A. nigra* showed high amount of monocyclic monoterpene alcohol alpha- terpineol and alpha fenchyl acetate [33]. Alcohol acyclic monoterpenes like geraniol, monocyclic alpha-terpineol and bicyclic borneol are important costituents in essential oil of *alpinia calcarata.* Bicyclic borneol is an important constituent in essential oils of *alpinia calcarata* [34]. The presence of endo-fenchyl acetate, exo-fenchyl acetate, and endo-fenchol were the unique feature of rhizome essential oils of *A. galanga, A. calcarata,* and *A. Speciosa* [32]. *A. officinarum* have phenol rich compound eugenol as major constituents in its oil [35]. In the current study the two main components of *Elettaria cardamomum* was found to be 1, 8-cineole and alpha terpineol acetate, hence the oil is rich source of monoterpenes [36, 37]. *Kaempeferia galangal* essential oil was dominated by cinnamate derivatives [38, 39] and these cinnamate derivates are responsible for the aromatic spicy odour [40, 48]. Whereas *K. rotunda* essential oil was dominated by bicyclic ester monoterpene bornyl acetate, benzoate and bicyclic monoterpene ketone camphor [41].

Mechanism of Action of Essential Oils

The antimicrobial properties of essential oils and their components have been reviewed in the past and the mechanism of action has not been studied in great detail [49]. Because of the great number of constituents, essential oils seem to have no specific cellular targets. As typical lipophiles, they pass through the cell wall and cytoplasmic membrane, disrupt the structure of their different layers of polysaccharides, fatty acids and phospholipids and permeabilize them. Cytotoxicity appears to include such membrane damage [50]. In bacteria, the permeabilization of the membranes is associated with loss of ions and reduction of membrane potential, collapse of the proton pump and depletion of the ATP pool [51, 52, 53, 54]. Essential oils can coagulate the cytoplasm [55] and damage lipids and proteins

[56]. Damage to the cell wall and membrane can lead to the leakage of macromolecules and to lysis [57, 58, 59]. In eukaryotic cells, essential oils can provoke depolarisation of the mitochondrial membranes by decreasing the membrane potential, affect ionic Ca^{++} cycling and other ionic channels and reduce the pH gradient, affecting (as in bacteria) the proton pump and ATP pool. They change the fluidity of membranes, which become abnormally permeable resulting in leakage of radicals, cytochrome C, calcium ions and proteins, as in case of oxidative stress and bioenergetic failure [60, 61]. Permeabilization of outer and inner membrane leads to cell death by apoptosis and necrosis [62]. Cytotoxic effects were observed in vitro in most of pathogenic gram positive and gram negative bacteria by agar diffusion method using a filter paper disc or by the dilution method using agar or liquid broth cultures. The cytotoxic effects of essential oils are attributed to the presence of alcohols, phenols, and aldehyde [63, 64, 65]. The locations or mechanisms in the bacterial cell can be classified into one or more of the following groups (Figure 2)

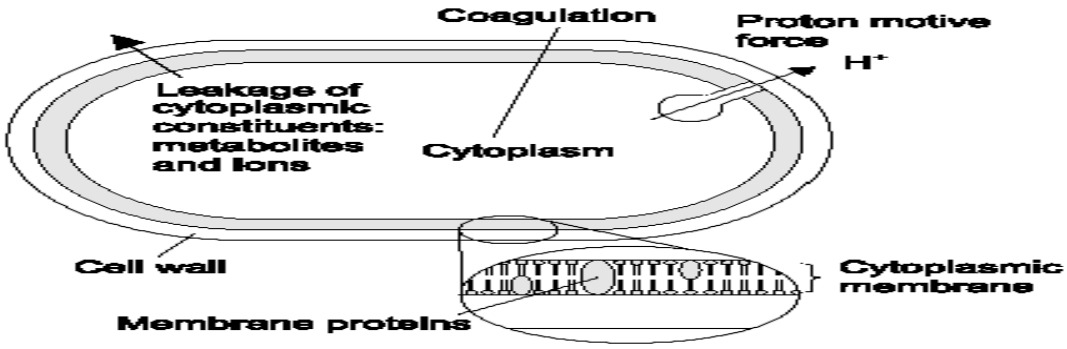


Figure 2

Locations and mechanisms in the bacterial cell thought to be sites of action for essential oil components: degradation of the cell wall; damage to cytoplasmic membrane; damage to membrane proteins; leakage of cell contents; coagulation of cytoplasm and depletion of the proton motive force (Burt, 2004).

The active components are commonly found in the essential oil fractions and it is well established that most of them have a wide spectrum of antimicrobial activity, against food-borne pathogens and spoilage bacteria [66]. The antimicrobial activity of plant essential oils is due to their chemical structure, in particular to the presence of hydrophilic functional groups, such as hydroxyl groups of phenolic components and/or lipophilicity of some essential oil components [67]. The antimicrobial activity of the essential oils derived from different plant species of Zingiberaceae family are shown in the Table (2) below.

Table 2
Antibacterial Activities of Some Plants belonging to Family Zingiberceae

Taxa Investigate	Solvent	Organism Tested	Zone of Inhibition(in mn)	Reference
Zingiber officinale	DMSO	*Escherichia coli*	8.7	[68]
		Bacillus subtilis	9.0	
		Staphylococcus aureus	9.3	
		Pseudomonas aeruginosa	7.7	
		Proteus vulgaris	8.3	
		Candida albicans	12.2	
Z. zerumbet	Ethanol	*Escherichia coli*	9	[69, 70]
		Pseudomonas aeruginosa	9	
		Bacillus subtilis	9	
		Bacillus cereus	9	
		Staphylococcus typhi	9	
		Candida albicans	9	
Z.cassumunar	DCM	*acillus cereus*	8.5	[71]
		Pseudomonas aeruginosa	7.5	
Curcuma longa	Methanol	*Escherichia coli*	20	[72, 73]
		Salmonella typhi	9	
		Pseudomonas aeruginosa	8	
		Staphylococcus aureus	10	
C. amada	DCM	*Escherichia coli*	13	[74]
		Staphylococcus aureus	15	
		Bacillus subtilis	26	
C. aeruginosa	DCM	*Bacillus cereus*	9.3	[16]
		Staphylococcus aureus	7	
		Pseudomona aeruginosa	7.5	
		Candida albicans	7.0	
C. zedoaria	DCM	*Escherichia coli*	9	[75]
		Staphylococcus aureus	11	
		Bacillus subtilis	8	
Alpinia galanga	Ethanol	*Bacillus cereus*	11.0	[76,77]
		Staphylococcus aureus	19.67	
		Staphylococcus cerevisiae	21.67	
Alpinia calcarat	Aqueous	*Bacillus cereus*	11	[77]
		Staphylococcus aureus	9	
		Escherichia coli	10	
		ethanol*Staphylococcus aureus*	12	
		Escherichia coli	13	
H. coronarium	Methanol	*Staphylococcus aureus*	11	[78]
		Bacillus subtilis	15	
		Escherichia coli	13	
		Pseudomonas aeruginosa	14	
		Salmonella typhi	16	
E.cardamomum	Ethanol	*Escherichia coli*	10.77	[79, 80]
		Staphylococcus aureus	14.08	
		Bacillus subtilis	10.53	
		Bacillus cereus	9.87	
		Candida albicans	13.31	
		Aqueous *Escherichia coli*	14.67	
		Salmonella typhi	12.27	
		Staphylococcus aureus	20.63	
		Bacillus subtilis	11.5	
		Bacillus cereus	11.3	

Antimicrobial Activity of Essential Oils

The main features of all essential oils besides the fragrance are their antimicrobial properties and almost all essential oils studied have been proved to possess both antibacterial and antifungal activities, although some are more active than others. The effectiveness differs depending on the oil and is strictly linked with its chemical composition, but it is always dose dependent. Almost all the plants mentioned above are multi resistant against a number of bacterial pathogens and may have the potentiality for broad range of clinical practices. Relatively high levels of activity (MIC of 12.5 – 6.25 µg/ml) was found to be for *Z.officinale.* The MIC values indicated that ginger oil from hydrodistillation is more efficient [81] and Ginger Oil was found to have higher activity towards *Aspergillus niger*, *Candida albicans* [68]. *Z. cassumunar* oil was found to be inactive against *E.coli* and *C.albicans* [71] but *Z.cassumunar* oil was found to be slightly inhibitory towards *P.aeruginosa* and moderate activity was reported for *S.aureus* [16]. *Z. zerumbet* showed potent antimicrobial activity and recent studies have revealed the presence of a sesquiterpene, Zederone, phenolic saponins and terpenoids in ethanol extract which are responsible for antibacterial activity [69, 70, 82]. Various evidences reveal that *C.longa* oil can inhibit the growth of number of bacteria namely *E.coli, P.aeruginosa, S.aureus* and *Shigella* etc [72, 73, 83]. *C. longa* posses low activity against *P.aeruginosa* and some mycobacterium species [83]. *C. longa* oil also shows antifungal activity against *Aspergillus flavus* and *Penicillium digitalum*. The antibacterial activity of Oleoresins from all species showed promising antibacterial activity against *Staphylococcus aureus*, *Bacillus subtilis* and *E. coli* at a concentration of 1 mg and the highest antibacterial activity was present in *C.amada* oleoresin. Among the three bacteria, *B. subtilis* was the most sensitive one. *Curcuma* oleoresins were highly active against *B. subtilis*. In spite of the lower phenol content, *C. amada* showed highest antibacterial activity against all three test micro organisms [74]. The maximum activity of *C.amada* was found to be for *Cryptococcus neoformas* which had lowest MIC (Minimum inhibitory concentration) value and is about to be 0.1 gm/ml minimum activity was observed for *Bacillus cereus* with MIC of 11 gm/ml. *C.aeruginosa* showed moderate activity against pathogens [16]. The essential oil of rhizome with high content of 1, 8-cineole was responsible for its antibacterial activity [76]. 1, 8-cineole has been reported to have high antibacterial activity against *Staphylococcus aureus* [77]. Essential oils had shown significant antibacterial activity against *S. aureus, B. cereus, P. aeruginosa* and *E. coli* [84]. The anti bactericidal action of *A. galanga* oil was extremely rapid. Results of scanning electron microscopy suggested that *A. galanga* oil had antibacterial action probably as a result of its modification of the bacterial cell membrane, disrupting the membrane's permeability [85]. It has been found that the presence of diterpenes and sesquiterpenes in crude extract plays an important role for producing antibacterial activity. Since the rhizomes of H*edychium coronarium* contained diterpenes and sesquiterpenes in its plant extracts so they show antibacterial activity [78, 86]. *E.cardamomum* showed inhibitory activity against *S.mutans, S.aureus, C.albicans* and *S.cerevisiae* with the mean of the highest zone of inhibition being 20.96 mm and MIC of 1.25mg/ml shown by acetonic extract of *E.cardamomum* against *S.aureus* [79, 80]. Ethyl-*p*-methoxycinnamate isolated from extracts of *Kaempferia galangal* has considerable activity against *Mycobactrium tuberculosis* and *Candida albicans* [87]. Data on antibacterial activity from a large number of genera are lacking. Extensive research in this area is needed as they can enrich the area of medicinal chemistry by providing valuable drugs with better efficacy.

CONCLUSION

Essential oils from family Zingiberaceae are found to be rich source of terpenes monoterpenes and sesquiterpenes and phenols. The relation between terpenes as antimicrobials are well established and studies have demonstrated optimal potential of these essential oils for antimicrobial activity. Therefore, these natural products have a considerable potential as antimicrobial agents. Extensive research is needed on isolation and characterization of pure chemical constituents from these plants and their successful clinical applications in curing various infectious diseases.

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CONFLICT OF INTEREST

Conflict of interest declared none

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