



Natural, chemical and pharmacological properties of *Zingiber officinale*: An Overview

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ABSTRACT

Zingiber officinale (family: *Zingiberaceae*) is a flowering plant, which is prevalent throughout India and in South East Asia. Ginger originated in the lush tropical jungles of Southern Asia. Many reports have appeared in mainstream scientific journals describing its nutritional and medicinal properties. While much of this recent enthusiasm indeed appears to be justified, it is critical to separate rigorous scientific evidences from anecdote. The present review provides the available information for *Zingiber officinale* as its botanical descriptions, vernacular names, biological activity of plant parts, ethanomedicinal uses, and current status of research with scope of *Zingiber officinale* for future research. The structures of one hundred forty identified compounds from different parts of *Zingiber officinale* with molecular formula, formula weight, have been reported in this study.

Keywords: Overview, Chemical compounds, Natural, Recent research, *Zingiber officinale*

INTRODUCTION

Ginger (*Zingiber officinale* Roscoe.) is a flowering plant of the family *Zingiberaceae* which is a widely used herb and food-flavouring agent. Gingers are an important part of the tropical flora and exceptionally important component in the tropical forests of Southeast Asia. Its nutraceutical properties have long been of interest to the food processing and pharmaceutical industries [1]. The rhizome of ginger has also been used as traditional herbal medicine for treatment of symptoms such as common cold, digestive disorder, rheumatism, neuralgia, colic and motion sickness [2]. Jideani et al. (2001) observed that ginger was the most important single spice in the production of a staple food (Fura) for the Fulanis and Hausas of northern Nigeria. Ginger is extremely valuable in dyspepsia, flatulence, colic, spasms and other painful affection of stomach [3]. It stimulates blood circulation throughout the body by powerful stimulatory effect on the heart muscle and by diluting blood [4]. The improved circulation is believed to increase the cellular metabolic activity; thus, contributing to the relief in cramps and tension [5]. It has a long history of medicinal use dating back 2500 years in

China and India for conditions such as nausea and vomiting, diarrhoea, dyspepsia, rheumatism, and colds [6].

The present review intend to describe three different aspects of *Zingiber officinale*: (a) critical evaluation of the published scientific evidences on *Zingiber officinale*, (b) highlighting claims from the traditional and tribal medicinal uses and from non-peer reviewed sources that would benefit from further, rigorous scientific evaluation, and (c) suggesting directions for future clinical research that could be carried out by local investigators in developing regions.

Importance of *Zingiberaceae* family: The family *Zingiberaceae* is well-known for its medicinal values and it is distributed widely throughout the tropics, particularly in Southeast Asia [7]. The members of *Zingiberaceae* are annual or perennial rhizomatous herbs. The rhizome is sympodially branched and composed of distinct segments [9]. The rhizomes are varying colored ranging from pale yellow, deep yellow, greenish blue, pink or combinations of these in different species. The young rhizomes and auxiliary buds are protected by

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scale leaves. Leafy shoots are generally unbranched and true aerial stem is present in some genera and absent in others. True stem is very short as in *Kaempferia* or pseudostem with clasping leaf sheaths as in *Curcuma*. The leaves are distichous and they exhibit morphological variations in structure, shape, size, texture and venation [10]. Leaves distichously arranged transverse or parallel to rhizome, aromatic oil cells present. Labellum small or large, showy. Lateral staminodes mostly present. Filament narrow, long, exerted.

Epigynous glands usually two, linear, or rarely absent. Ovary unilocular or trilocular. The important genera having medicinal uses coming under *Zingiberaceae* are *Alpinia*, *Amomum*, *Curcuma*, *Elettaria*, *Hedychium*, *Kaempferia* and *Zingiber* [11]. The plants are characterized by the presence of volatile oils and oleoresins of export value. In general, the rhizomes and fruits are aromatic, tonic and stimulant. Some are used as food as they contain starch in large quantities while others yield an astringent and diaphoretic juice.

TAXONOMICAL CLASSIFICATION:

Kingdom	: <i>Plantae</i> – Plants
Subkingdom	: <i>Tracheobionta</i> – Vascular plants
Superdivision	: <i>Spermatophyta</i> – Seed plants
Division	: <i>Magnoliophyta</i> – Flowering plants
Class	: <i>Liliopsida</i> – <i>Monocotyledons</i>
Subclass	: <i>Zingiberidae</i>
Order	: <i>Zingiberales</i>
Family	: <i>Zingiberaceae</i> – Ginger family
Genus	: <i>Zingiber</i> Mill. – ginger P
Species	: <i>Zingiber officinale</i> Roscoe – garden ginger

BOTANICAL DESCRIPTION:

Underground parts: Ginger has a distinctive thickened, branched rhizome (underground stem) which sometimes looks somewhat like a swollen hand. The rhizome has a brown corky outer layer (usually removed before use) and a pale yellow centre with a spicy lemon-like scent.

Leaves: Shoots (pseudostems), up to 1.2 m tall, arise annually from buds on the rhizome. These pseudostems are formed from a series of leaf bases (sheaths) wrapped tightly around one another with long (up to 7 cm), narrow (up to 1.9 cm wide), mid-green leaf blades arranged alternately.

Flowers: The flowering heads, borne on separate shorter stems, are cone-shaped spikes and composed of a series of greenish to yellowish leaf-like bracts. Protruding just beyond the outer edge of the bracts, the flowers are pale yellow in colour with a purplish lip that has yellowish dots and striations. Flowering stems are rarely, if ever, produced in cultivated plants.

GEOGRAPHICAL DISTRIBUTION:

Zingiber officinale is possibly native to India. It is widely grown as a commercial crop in south and southeast Asia, tropical Africa (especially Sierra Leone and Nigeria), Latin America, the Caribbean (especially Jamaica) and Australia. (<http://www.kew.org/science-conservation/plants-fungi/zingiber-officinale-ginger>)

SYNONYMS: Different synonyms of *Zingiber officinale*, were described according to the catalogue of life, 3rd January 2011 (<http://www.gbif.org/species/2757280/synonyms>). *Amomum zingiber* L. species, *Amomum zinziba* Hill species, **Zingiber cholmondeleyi** (F.M.Bailey) K. Schum. Species, *Zingiber missionis* Wall. Species, *Zingiber officinale* f. macrorhizonum form, *Zingiber officinale* f. rubens form, *Zingiber officinale* var. cholmondeleyi variety, *Zingiber officinale* var. macrorhizonum variety, *Zingiber officinale* var. rubens variety, *Zingiber officinale* var. rubrum variety, *Zingiber officinale* var. sichuanense variety, *Zingiber sichuanense* Z.Y. Zhu, S.L. Zhang & S.X. Chen species, *Zingiber zingiber* (L.) H. Karst. Species.

VERNACULAR NAMES:

There are many vernacular names of *Z. officinale* in different languages according to distribution of ecozone known by different local names in several parts of the world and in India, Such as: **Arabic:** Skînzhbîr (Morocco), Zanjabil; **Assamese:** Aadaa; **Bengali:** Aadaa (plant), Adrak; **Bosnian:** Crni ingver, Đumbir, Gingibar, Isiot, Isnot, Mrki ingver, Pravi ingver, Vručá trava, Zindefil; **Bulgarian:** Dzhindzhifil; **Burmese:** Gyin. **Chinese:** Qiang jiang, Zi jiang; **Croatian:** Cencer, Crni ingver, Đumber, Gingibar, Ingver, Isjet, Mrki ingver, Pravi ingver, Zenzer; **Czech:** Dumbír, Zázvor, Zázvor kofen; **Danish:** Ingefaer. **Dutch:** Gember; **Estonian:** Harilik ingver; **Finnish:** Inkivääri; **French:** Gingembre, Gingembre commun, Gingembre officinal, Gingembre traditionnel;

German: Inbwer, Ingwer; **Greek:** Tzintzer, Piperoriza, Ziggiveris; **Hebrew:** Zangvil; **Hindi:** Adarak, Sonth; **Hungarian:** Gyömbér; **Italian:** Zenzero, Zenzevero, Pepe zenzero; **Japanese:** Jinjaa, Shouga; **Kannada:** Alla; **Khmer:** Khnehey, Khnhei phlung; **Korean:** Saeng gang; **Laotian:** Khing; **Malay:** Halia, Haliya, Haliya merah, Kunyit terus, Aliah, Jae, Jahe, Jahya, Lahya; **Malayalam:** Inchi, Chuku; **Nepalese:** Aduvaa, Sutho; **Norwegian:** Ingefær; **Portuguese:** Gengibre, Ingever; **Punjabi:** Adrak, Sund; **Russian:** Imbir', Imbir' lekarstvennyi; **Sinhalese:** Inguru; **Spanish:** Anchoas, Jengibre; **Swedish:** Ingefära, Ingefoera; **Thai:** Khing, Khing daeng, Khing klaeng, Khing phueak, Sae; **Vietnamese:** Cây gừng, Gừng, Sinh khương.

ETHANOMEDICINAL USES OF *ZINGIBER OFFICINALE*:

Medicinal plants play an important role in traditional health care systems for curing many diseases. The medicinal value of these plants lie in certain chemical substances that produce a definite physiological action on human body. Ginger is an important plant with several medicinal, ethno medicinal and nutritional values [12]. Ginger is the underground rhizome of the ginger plant with a firm, striated texture. *Zingiber officinale* Roscoe, commonly known as ginger belongs to family *Zingiberaceae*. The cultivation of ginger is known to originate in China which then spread to India, South East Asia, West Africa and the Caribbean [13, 14]. India is the biggest producer of ginger in the world. In India, it is cultivated in almost all the states. Some reports suggest that climatic conditions of Orissa, West Bengal, North Eastern states and Kerala are more suitable for the growth of ginger in India [15]. The medicinal use of ginger is well known in India and its neighboring countries for more than 2000 years making it as one of the most versatile medicinal plant. Ginger is been used both as Ayurvedic and Chinese medicine for curing heart problems, treat stomach upset, diarrhea, and nausea [16].

It is also used so as to disguise the taste of medicines; promotes the release of bile from the gall bladder [17,18], decreases joint pain from arthritis, useful for the treatment of heart diseases and lungs diseases [19], relief from cough and cold, throat infection etc [20]. Besides these, it is also used as curry powder, hot drinks like ginger beer, ginger wine and ginger tea. Ginger has been identified as an herbal medicinal product with pharmacological effects. Ginger plays an important role in traditional Indian Ayurvedic medicine. It is also used as an ingredient in traditional Indian drinks. Fresh ginger is one of the main spices used

for making dishes, both vegetarian and non-vegetarian based foods. Indian traditional medicinal remedies especially for cough and asthma uses of juice of fresh ginger with juice of fresh garlic mixed with honey. It is also suggested that 1-2 tea spoons of ginger juice with honey is a potent cough suppressant. Besides these, ginger is very often used to cure many illness such as indigestion, tastelessness, loss of appetite, flatulence, intestinal, nausea, vomiting, allergic reactions, acute and chronic cough, common cold, fever, allergic rhinitis, sinusitis, acute chronic bronchitis, respiratory troubles, pain, headache, backache or any kind of muscular catch, painful tooth and swelled gum etc [21].

PREVIOUSLY ISOLATED COMPOUNDS:

The *Zingiber officinale* contains number of compounds which are reported in table no 1 mentioning general name and different physical properties of compounds. The constituents of ginger are numerous and vary depending on the place of origin and whether the rhizomes are fresh or dry. It is our intention in this review to summarize the reported components that have been implicated in the volatile oil, the yield of which varies from 1% to 3%. Over 50 components of the oil have been characterized and these are mainly monoterpenoids [b-phellandrene, (+)-camphene, cineole, geraniol, curcumene, citral, terpineol, borneol] and sesquiterpenoids [a-zingiberene (30–70%), b-sesquiphellandrene (15–20%), b-bisabolene (10–15%), (E-E)-a farnesene, arcurcumene, zingiberol][98], but there is still lack of knowledge regarding details of chemical constituents present in different parts (region-wise) of *Zingiber officinale*.

CURRENT STATUS OF RESEARCH ON *ZINGIBER OFFICINALE*:

There are more than seventy biological studies on rhizome of *Zingiber officinale*, have been reported which are described in Table 2. The studies on antioxidant activities have been carried out in rhizome but it is still not clear that which part of the plant have highest antioxidant activity (in vitro and in vivo). Hence studies are required to report this most important aspect that which part of the plant (region wise) possess highest antioxidant activity in different antioxidant bioassays.

The antimicrobial activity has been investigated on essential oil and leaf. Immuno-pharmacological profiling, anti-ulcerogenic effect, antiulcer, immuno-modulatory and gastroprotective studies have been reported in the rhizome. Current studies show that researchers are taking interest on

isolation of bioactive compounds of *Zingiber officinale* due to their important therapeutic uses. However, there is still lack of knowledge on details of chemical constituents which are responsible for different biological activities.

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Table 1. List of previously reported compounds from different part *Zingiber officinale* Roscoe

Compound Name	Mol. For.	Mol. Wt.	Structure no		Ref.
Adenine	C ₅ H ₅ N ₅	135.13	-	LXXVII	93,94
α -zingiberene	C ₁₅ H ₂₄	204.35	-	XXIII	93,94
Zinziberol	C ₁₆ H ₂₈ O	236.39	-	XXIV	93,94
Zingerone	C ₁₁ H ₁₄	194.22	-	XXV	93,94
Zingiberenol	C ₁₅ H ₂₆ O	222.36	-	XXVI	93,94
Hexanal	C ₆ H ₁₂ O	100.15	-	XXVII	93,94
1-Hexanol	C ₆ H ₁₄ O	102.17	-	XXVIII	93,94
o-Xylene	C ₈ H ₁₀	106.16	-	XXIX	93,94
Amyl acetate	C ₇ H ₁₄ O	130.18	-	XXX	93,94
β -bisabolene	C ₁₅ H ₂₄	204.35	-	LXXVIII	93,94
Camphene	C ₁₀ H ₁₆	136.23	-	XXXII	93,94
Citral	C ₁₀ H ₁₆ O	152.23	-	LXXIX	93,94
Curcumene	C ₁₅ H ₂₂	202.33	-	LXXX	93,94
1-dehydrogingerdiones	C ₁₇ H ₂₂ O ₄	289	-	LXXXI	93,94
β -sitosterol palmitate	C ₄₅ H ₈₀ O ₂	653.11	-	LXXXII	93,94
Geraniol	C ₁₀ H ₁₈ O	154.24	-	LXXXIII	93,94
Geranyl acetate	C ₁₂ H ₂₀ O ₂	196.28	-	LXXXIV	93,94
[6]-gingerdiones	C ₁₇ H ₂₄ O ₄	292.37	-	LXXXV	93,94
[8]-gingerdiones	C ₁₉ H ₂₈ O ₄	320.42	-	LXXXVI	93,94
[10]-gingerdiones	C ₂₁ H ₃₂ O ₄	348.47	-	LXXXVII	93,94
[12]-gingerdiones	C ₂₃ H ₃₆ O ₄	376.52	-	LXXXVIII	93,94
Glycol monopalmitate	C ₁₈ H ₃₆ O ₃	300.48	-	LXXXIX	93,94
Hexacosanoic acid 2,3-dihydroxypropyl ester	C ₂₉ H ₅₈ O ₄	470.76	-	XC	93,94
[4]-Isogingerol	C ₁₅ H ₂₂ O ₄	266.33	-	I	93,94
p-Hydroxybenzaldehyde	C ₇ H ₆ O ₂	122.12	-	II	93,94
Isovanillin	C ₈ H ₈ O ₃	152.14	-	III	93,94
Limonene	C ₁₀ H ₁₆	136.23	-	IV	93,94
β -phellandrene	C ₁₀ H ₁₆	136.23	-	V	93,94
Gingerdiol	C ₁₇ H ₂₈	296.40	-	VI	93,94
[6]-Paradol	C ₁₇ H ₂₆ O ₃	278.38	n = 6, R = H	VII	94,95,96
[7]-Paradol	C ₁₈ H ₂₈ O ₃	292.41	n = 7, R = H		94,95,96
[8]-Paradol	C ₁₉ H ₃₀ O ₃	306.44	n = 8, R = H		94,95,96
[9]-Paradol	C ₂₀ H ₃₂ O ₃	320.23	n = 9, R = H		94,95,96
[10]-Paradol	C ₂₁ H ₃₄ O ₃	334.49	n = 10, R = H		94,95,96
[11]-Paradol	C ₂₂ H ₃₆ O ₃	348.7	n = 11, R = H		94,95,96
[13]-Paradol	C ₂₄ H ₄₀ O ₃	376	n = 13, R = H		94,95,96
Methyl -[6]-Paradol	C ₁₈ H ₂₈ O ₃	292.41	n = 6, R = Me		94,95,96

Compound Name	Mol. For.	Mol. Wt	Structure no		Ref
Limonene	C ₁₀ H ₁₆	136.23	-	XXXVI	93,94
E)-β-ocimene	C ₁₀ H ₁₆	136.23	-	XL	93,94
γ- Terpinene	C ₁₀ H ₁₆	136.23	-	XLI	93,94
Trans-Linalool oxide(furanoid)	C ₁₀ H ₁₈ O ₂	170.24	-	XLII	93,94
Undecane	C ₁₁ H ₂₄	156.30	-	XLIV	93,94
Camphor	C ₁₀ H ₁₆ O	152.23	-	XLIII	93,94
Menthone	C ₁₀ H ₁₈ O	154.24	-	XLV	93,94
Borneol	C ₁₀ H ₁₈ O	154.24	-	XLVI	93,94
Terpinen-4-ol	C ₁₀ H ₁₈ O	154.24	-	XLVII	93,94
Menthol	C ₁₀ H ₂₀ O	156.26	-	XLVIII	93,94
α-Terpinol	C ₁₀ H ₁₈ O	154.24	-	XXII	93,94
Decanal	C ₁₀ H ₂₀ O	156.26	-	L	93,94
Nerol	C ₁₀ H ₁₈ O	154.24	-	LI	93,94
Neral	C ₁₀ H ₁₆ O	152.23	-	LII	93,94
Geraniol	C ₁₀ H ₁₈ O	154.24	-	LIII	93,94
Geranial	C ₁₀ H ₁₆ O	152.23	-	LIV	93,94
Trans-carvone oxide	C ₁₀ H ₁₄ O ₂	166.21	-	LV	93,94
Bornyl acetate	C ₁₂ H ₂₀ O ₂	196.28	-	LVI	93,94
2-Undecanone	C ₁₁ H ₂₂ O	170.29	-	LVII	93,94
Undecanal	C ₁₁ H ₂₂ O	170.29	-	LVIII	93,94
β-Cubebene	C ₁₅ H ₂₄	204.35	-	LX	93,94
Geranyl acetate	C ₁₂ H ₂₀ O ₂	196.28	-	LXII	93,94
δ-elemene	C ₁₅ H ₂₄	204.36	-	LXI	93,94
β-elemene	C ₁₅ H ₂₄	204.35	-	LIX	93,94
α-bergamotene	C ₁₅ H ₂₄	204.35	-	LXIV	93,94
Germacrene-D	C ₁₅ H ₂₄	204.35	-	LXIII	93,94
γ-muurolene	C ₁₅ H ₂₄	204.35	-	LXV	93,94
α-curcumene	C ₁₅ H ₂₂	202.33	-	LXVI	93,94
β-fanesener	C ₁₅ H ₂₄	204.35	-	XLIX	93,94
β-Thujene	C ₁₀ H ₁₆	136.23	-	LXVII	93,94
n-octa-3,5-dien-2-ol	C ₈ H ₁₄ O	126.19	-	LXIX	93,94
Linalool	C ₁₀ H ₁₈ O	154.24	-	LXVIII	93,94
α - Terpinolene	C ₁₀ H ₁₆	136.23	-	XCII	93,94
Verbenol	C ₁₀ H ₁₆ O	152.23	-	LXX	93,94
4- Terpineol	C ₁₀ H ₁₈ O	154.24	-	XCI	93,94
Cis-p-Mentha-2-en-1-ol	C ₁₀ H ₁₈ O	154	-	LXXIII	93,94
Citronellal	C ₁₀ H ₁₈ O	154.24	-	LXXIV	93,94
Terpinolene	C ₁₀ H ₁₆	136.23	-	LXXV	93,94
[4]-Gingerol	C ₁₅ H ₂₂ O ₄	266	n=2, R= H	VIII	94,95,96
[6]- Gingerol	C ₁₇ H ₂₆ O ₄	294	n=4, R= H		94,95,96
[8]- Gingerol	C ₁₉ H ₃₀ O ₄	322	n=6, R= H		94,95,96
[10]- Gingerol	C ₂₁ H ₃₄ O ₄	350	n=8, R= H		94,95,96
[12]- Gingerol	C ₂₃ H ₃₈ O ₄	378	n=10, R= H		94,95,96
Methyl- [4]-gingerol	C ₁₆ H ₂₄ O ₄	280	n=2, R= Me	VIII	94,95,96
Methyl- [6]-gingerol	C ₁₈ H ₂₈ O ₄	308	n=4, R= Me		94,95,96
Methyl- [8]-gingerol	C ₂₀ H ₃₂ O ₄	336	n=6, R= Me		94,95,96
Methyl- [10]-gingerol	C ₂₂ H ₃₆ O ₄	364	n=8, R= Me		94,95,96
[4]-Shagaol	C ₁₅ H ₂₀ O ₃	248	n=2, R= H	IX	94,95,96
[6]-Shagaol	C ₁₇ H ₂₄ O ₃	276.76	n=4, R= H		94,95,96
[8]-Shagaol	C ₁₉ H ₂₈ O ₃	304	n=6, R= H		94,95,96
[10]-Shagaol	C ₂₁ H ₃₂ O ₃	332	n=8, R= H		94,95,96

Compound Name	Mol. For.	Mol. Wt	Structure no	Ref		
[12]-Shagaol	C ₂₃ H ₃₆ O ₃	360	n=10, R= H	94,95,96		
Methyl-[6]-Shagaol	C ₁₈ H ₂₆ O ₃	290.39	n=4, R= Me			
Methyl- [8]-Shagaol	C ₂₀ H ₃₀ O ₃	318.21	n=6, R= Me			
1-Dehydro-[3]-gingerdione	C ₁₅ H ₂₀ O ₄	264.32	n=1, R= H	XI	94,95,96	
1-Dehydro-[6]-gingerdione	C ₁₇ H ₂₂ O ₄	290	n=4, R= H		94,95,96	
1-Dehydro-[8]-gingerdione	C ₁₉ H ₂₆ O ₄	318	n=6, R= H		94,95,96	
1-Dehydro-[10]-gingerdione	C ₂₁ H ₃₀ O ₄	346	n=8, R= H		94,95,96	
1-Dehydro-[12]-gingerdione	C ₂₃ H ₃₄ O ₄	374	n=10, R= H		94,95,96	
5-Acetoxy-[4]-gingerol	C ₁₇ H ₂₆ O ₅	310	n=2, R= H	X	94,95,96	
5-Acetoxy-[6]-gingerol	C ₁₉ H ₃₀ O ₅	338	n=4, R= H		94,95,96	
5-Acetoxy-[8]-gingerol	C ₂₃ H ₃₈ O ₅	394	n=6, R= H		94,95,96	
5-Acetoxy-[10]-gingerol	C ₂₅ H ₄₂ O ₅	422	n=8, R= H		94,95,96	
Methyl -5-acetoxy-[4]-gingerol	C ₁₈ H ₂₈ O ₅	324	n=2, R= Me		94,95,96	
Methyl -5-acetoxy-[6]-gingerol	C ₂₀ H ₃₂ O ₅	352	n=4, R= Me		94,95,96	
5-Acetoxy-[4]-gingerdiol	C ₁₇ H ₂₆ O ₅	310.17	n=2, R= H	XV	94,95,96	
5-Acetoxy-[6]-gingerdiol	C ₁₉ H ₃₀ O ₅	338.20	n=4, R= H		94,95,96	
5-Acetoxy-[7]-gingerdiol	C ₂₀ H ₃₂ O ₅	352.22	n=5, R= H		94,95,96	
Methyl -5-diacetoxy-[4]-gingerdiol	C ₁₈ H ₂₈ O ₅	324.19	n=2, R= Me		94,95,96	
Methyl -5-diacetoxy-[6]-gingerdiol	C ₂₀ H ₃₂ O ₅	352.22	n=4, R= Me		94,95,96	
Methyl-5-diacetoxy -[10]-gingerdiol	C ₂₄ H ₄₀ O ₅	408	n=8, R= Me		94,95,96	
[4]-gingerdiol	C ₁₅ H ₂₄ O ₄	268.16	n=2, R= H	XII	94,95,96	
[6]-gingerdiol	C ₁₇ H ₂₈ O ₄	296.19	n=4, R= H		94,95,96	
[8]-gingerdiol	C ₁₉ H ₃₂ O ₄	324.23	n=6, R= H		94,95,96	
[10]-gingerdiol	C ₂₁ H ₃₆ O ₄	352.26	n=8, R= H		94,95,96	
Diacetoxy-[4]-gingerdiol	C ₁₉ H ₂₈ O ₆	352	n=2, R= H	XIII	94,95,96	
Diacetoxy-[6]-gingerdiol	C ₂₁ H ₃₂ O ₆	380	n=4, R= H		94,95,96	
Diacetoxy-[8]-gingerdiol	C ₂₃ H ₃₆ O ₆	408	n=6, R= H		94,95,96	
Diacetoxy-[10]-gingerdiol	C ₂₅ H ₄₀ O ₆	436	n=8, R= H		94,95,96	
Methyl diacetoxy-[4]-gingerdiol	C ₂₀ H ₃₀ O ₆	366	n=2, R= Me		94,95,96	
Methyl diacetoxy-[6]-gingerdiol	C ₂₂ H ₃₄ O ₆	394	n=4, R= Me		94,95,96	
Methyl diacetoxy-[8]-gingerdiol	C ₂₄ H ₃₈ O ₆	422	n=6, R= Me		94,95,96	
Methyl diacetoxy-[10]-gingerdiol	C ₂₆ H ₄₂ O ₆	450	n=8, R= Me		94,95,96	
3-Dihydro-[6]-demethoxyshagaol	C ₁₆ H ₂₄ O ₂	248	n= 4, R=R		XIV	94,95,96
5- Methoxy-[6]- gingerol	C ₁₈ H ₂₈ O ₄	308	n= 4, R=H		XVI	94,95,96
1,7-bis(4'-Hydroxy-3' - Methoxy-phenyl)-4-heptene-3-One	C ₂₁ H ₂₄ O ₅	356	-	XVII	94,95,96	
1,7-bis-(4'-Hydroxy-3' - Methoxy-phenyl)-3,5-heptadione	C ₂₁ H ₂₄ O ₆	372	-	XVIII	94,95,96	
1-Dehydro-3-dihydro-[10]-gingerdione	C ₂₁ H ₃₂ O ₄	348	n=8	XIX	94,95,96	
6-Dihydroparadol	C ₁₇ H ₂₈ O ₃	280	n= 6, R=H	XX	94,95,96	
Acetoxy-6-dihydroparadol	C ₁₉ H ₃₀ O ₄	322	n= 6, R=Ac		94,95,96	
1-(4'-Hydroxy-3' - Methoxy-phenyl)-7-octaen-3-One)	C ₁₅ H ₂₀ O ₃	248	R=H	XXI	94,95,96	
1-(4'-Hydroxy-3' - Methoxy-phenyl)-7-decen-3-One)	C ₁₇ H ₂₄ O ₃	276	R=CH ₂ Me		94,95,96	
1-(4'-Hydroxy-3' - Methoxy-phenyl)-7-dodecen-3-One)	C ₁₈ H ₂₆ O ₃	290	R=(CH ₂) ₃ Me		94,95,96	

Compound Name	Mol. For.	Mol. Wt	Structure no	Ref
Heptanol	C ₇ H ₁₆ O	116.20	XXXIII	93, 94
Sabinene	C ₁₀ H ₁₆	136.23	-	XXXIV
β-pinene	C ₁₀ H ₁₆	136.23	-	XXXV
α-pinene	C ₁₀ H ₁₆	136.23	-	XXXI
Myrcene	C ₁₀ H ₁₆	136.23	-	XXXVII
6-Methyl-5-hepten-2-one	C ₈ H ₁₄ O	126.19	-	XXXVIII
1,8 – cineole	C ₁₀ H ₁₈ O	154.24	-	XXXIX
n-Octanoic acid	C ₈ H ₁₆ O ₂	144.21	-	LXXI
Limonene-1,2-epoxide	C ₁₀ H ₁₆ O	152.23	-	LXXII
Trans- pinocarveol	C ₁₀ H ₁₆ O	152.23	-	LXXVI

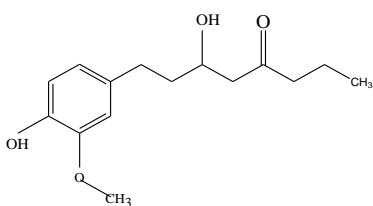
Table 2. Record of previously reported biological properties of *Zingiber officinale* Roscoe

Functional Properties/other studies	Part of plant	Solvent Extracts /other	Model	Ref
Anti oxidant activity	Dry ginger	SC-CO ₂ extract	<i>In vitro</i>	1
	Fresh ginger	Microwave-assisted extraction (MAE)	<i>In vitro</i>	22
	Dry rhizome	Methanol (95% v/v)	<i>In vivo</i>	23
	Fresh rhizomes	Various treatment	<i>In vitro</i>	24
	Dried ginger (DG)	Aqueous, Ethanol and freeze-dried.	<i>In vitro</i>	25
	Rhizome	Ethanol	<i>In vivo</i>	26
Anti-trypanosomal effect	Ginger	Methanol extract	<i>In vivo</i>	27
Histopathologic effect	Rhizomes	90% ethyl alcohol	<i>In vivo</i>	28
Alcohol toxicity	Rhizomes	95% ethanol	<i>In vivo</i>	29
Methyl parathion intoxication	Fresh ginger	Baked at 60 degree	<i>In vivo</i>	30
Hypolipidaemic activity	Ginger	Aqueous extract	<i>In vivo</i>	31
Antiatherogenic activity	Ginger	Aqueous extract	<i>In vivo</i>	31
Aluminium toxicity	Ginger	Powder	<i>In vivo</i>	32
Liver enzyme activities	Dried rhizome	Cold water	<i>In vivo</i>	97
Beneficial degree of sexual behavior	Ginger	Powder	<i>In vivo</i>	33
Enzyme inhibitory activity	Fresh ginger	Aqueous	<i>In vitro</i>	34
Efficient natural growth promoter activity	Ginger	Diet	<i>In animal model</i>	35
Inhibitory activity toward nitric oxide (NO) production	Ginger	Powder	<i>In vivo</i>	36
Cytotoxicity, Toxicity and Anti cancer activity	Rhizome	Ethanol	Cell line	38
Anti-ulcerogenic effect	Rhizome	Hydroalcoholic extract	<i>In vivo</i>	37
Proteolytic enzyme	Rhizome	Homogenate	<i>In vitro</i>	39
Metiram-inhibited spermatogenesis and induced apoptosis	Rhizome	Aqueous extract	<i>In vivo</i>	40
Aceclofenac induced oxidative stress	Rhizome	Homogenized	Rat liver	41
Chemopreventive effects	Rhizome	Water extract	<i>In vivo</i>	42
Effect of marinated of ginger extract on Duck meat (anti oxidant activity)	Rhizome	Water base	<i>In vitro</i>	43

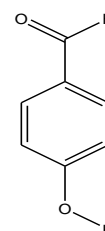
Pregnancy outcome and postnatal development	Rhizome	Powdered	<i>In vivo</i>	44
Efficacy against the treatment of osteoarthritis.	Rhizome	Powdered	Human	45
Cloning and characterization of a novel full-length mannose-binding lectin cDNA from <i>Z. officinale</i>	Rhizome	Trizol reagent	<i>In vitro</i>	46
Antimicrobial Activity	Rhizome	Essential oil	<i>In vitro</i>	47
Anti-Ulcerogenic Effect	Rhizome	Hydro alcoholic	<i>In vivo</i>	48
Antioxidants and Hypolipidemic Effects	Root	Aqueous, Ethanol	<i>In vivo</i>	49
Ameliorative Effect	Rhizome	Aqueous	<i>In Vivo</i>	50
Phenolic profile, antioxidant and anticancer potential	Rhizome	Ethanol	<i>In vitro</i> and cell line	51
Anti-cancer activity	Leaves	Methanol, petroleum ether and ethyl acetate	Cancer cells	52
Trionase inhibitory and superoxide inhibitory activity	Rhizome	Methanol	<i>In vitro</i>	53
Antiglycation and Hypolipidemic Effects	Rhizome	80 % acetone	<i>In vivo</i>	54
Histological and immunohisto-chemical study	Rhizome	Powder as oral	<i>In vivo</i>	55
Antimicrobial effect and enzymatic activity	Rhizome	Juice/ Aqueous and ethyl glycol extract	<i>In vitro</i>	56
Antibacterial Activity	Rhizome	Aquatic extract (fresh ginger, powder ginger), Apple vinegar extract (fresh Ginger) and Crude oil of Ginger	<i>In vitro</i>	57
Antimicrobial effect	Rhizome	Aqueous and ethanol	<i>In vitro</i>	58
Pharmacological and Clinical Effectiveness (reduce postoperative pain in patients with osteoarthritis)	Rhizome	Powder	Human	59
Antimicrobial activity	Rhizome	Essential oils	<i>In vitro</i>	60
Genetic diversity detection	Leaf tissue	DNA isolation	<i>In vitro</i>	61
Anti-inflammatory effects	Rhizome	Chloroform, ethanol and water	Cell line	62
Meiotic chromosome Behavior activity	Rhizome knobs	-	Plant	63
Antibacterial Activity	Rhizome	Aqueous , Methanol	<i>In vitro</i>	64
Metabolic fingerprinting	Leaves	Essential oil fractionation (methanol and chloroform)	<i>In vitro</i>	65
Hypoglycemic effect	Rhizome	Raw and cooked	<i>In vivo</i>	66
Antibacterial and antioxidant activities	Leaf and rhizome	Essential oils	<i>In vitro</i>	67
Antioxidant potential and free radical scavenging activity	Rhizome	Aqueous and ethanol	<i>In vitro</i>	68
Anti-Inflammatory (Pro-inflammatory cytokines) Effects	Rhizome	Tablets	In patients	69
Antibacterial activity	Fresh rhizome	Volatile oil	<i>In vitro</i>	70
Xenobiotic detoxification	Rhizome	Fine powder	<i>In vivo</i>	71

Total phenolic contents, anti-oxidant and anti-inflammatory potential	Young rhizome	Water	<i>In vitro</i>	72
Spermatogenesis	Rhizome	Powder dose	<i>In vivo</i>	73
Effect on plasma pro-inflammatory cytokine	Rhizome	Placebo capsules contained toast powder	Well-trained endurance runners (male)	74
Antimicrobial activity	Rhizomes	Methanol and n-hexane	<i>In vitro</i>	75
Physiological and pharmaceutical effects	Ginger	Aqueous	<i>In vivo</i>	76
Immuno-pharmacological Profiling	Rhizome	Aqueous	<i>In vivo</i>	77
Anti-ulcerogenic effect	Ginger root	Aqueous	<i>In vivo</i>	78
Effects on growth performance, carcass characteristics, serum lipids and serum cholesterol profiles	Rhizome	Extraction of oleoresin using ethanol	<i>In vivo</i>	79
Effects on the haematological and immunological parameters	Rhizome	Powdered	<i>In vivo</i>	80
Histological Effect	Root	Ethanol	<i>In vivo</i>	81
Anti- Alzheimer effect	Rhizome	Methanol	<i>In vitro</i>	82
Antibacterial and Anti-biofilm Activity	Rhizome	Ethanol	<i>In vitro</i>	83
Effects of on Reproductive Functions	Rhizome	Aqueous	<i>In vivo</i>	84
Antifungal activities	Rhizome	Essential oil	<i>In vitro</i>	85
Chemo preventative effects	Ginger root	Methanol	<i>In vivo</i>	86
Effect on intestinal motility	Rhizome	Alcoholic	<i>In vivo</i>	87
Cytotoxicity, Toxicity, and Anticancer Activity	Rhizome	Ethanol	<i>In vivo</i>	88
Alter Pancreatic Amylase Activity	Rhizome	Cooked ginger	<i>In vivo</i>	89
Effect against Ulcerative colitis	Rhizome	Volatile oils	<i>In vivo</i>	90
Anti-diabetic effects	Rhizome	Aqueous extracts	<i>In vitro</i>	91
Immune-modulatory effects	Compounds	Ethanol, chloroform	<i>In vitro</i>	92

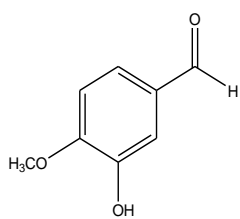
FIGURES OF THE LISTED COMPOUNDS:



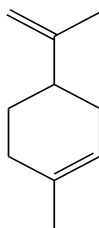
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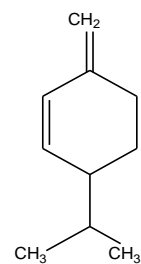
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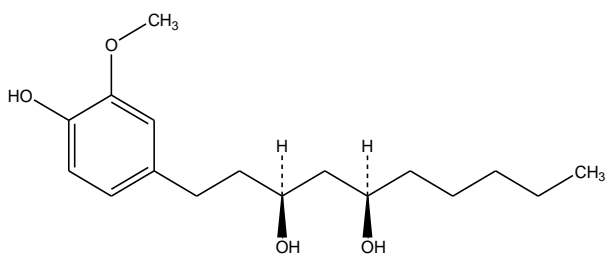
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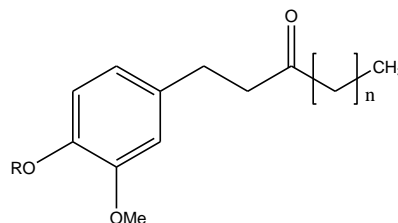
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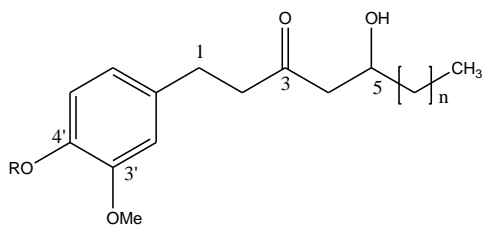
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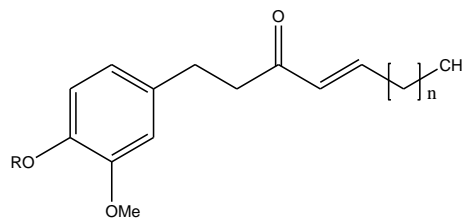
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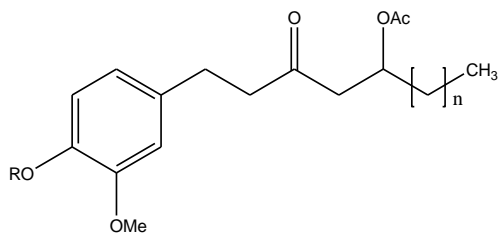
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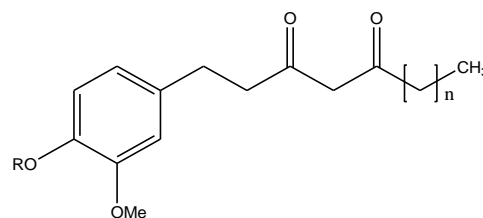
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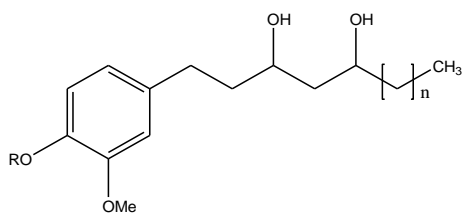
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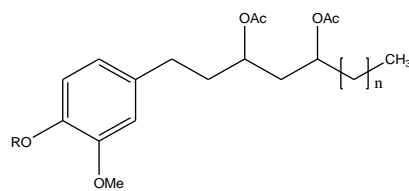
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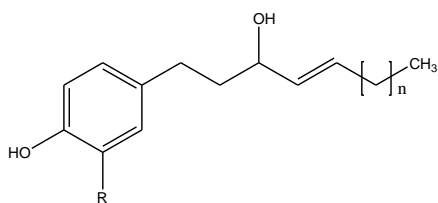
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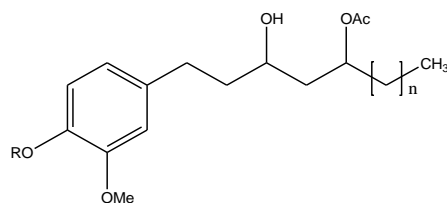
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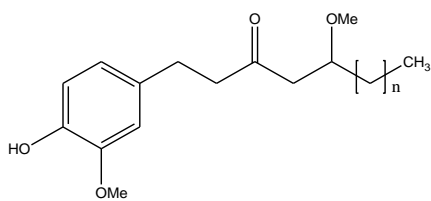
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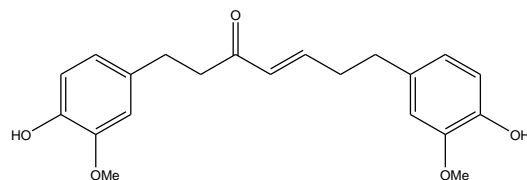
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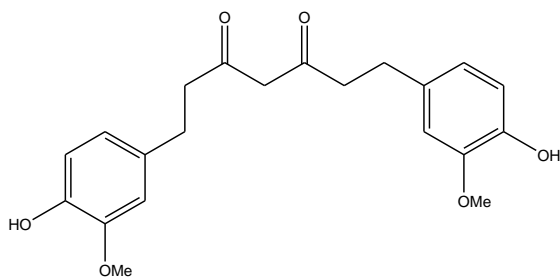
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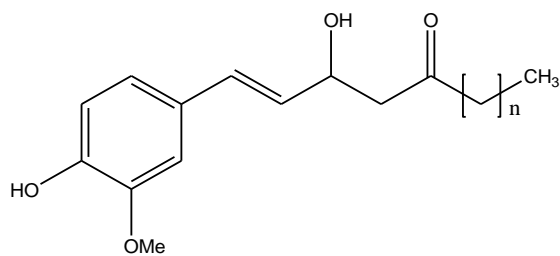
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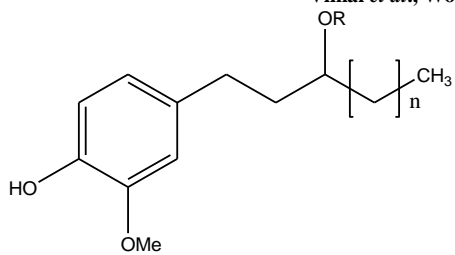
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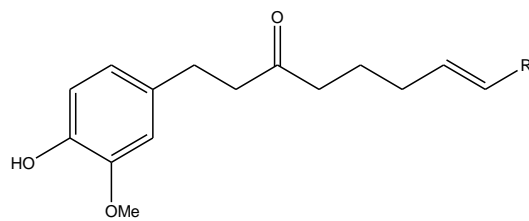
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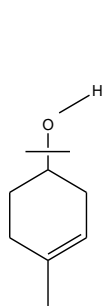
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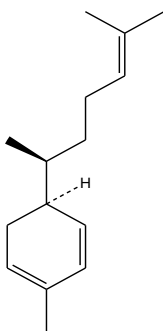
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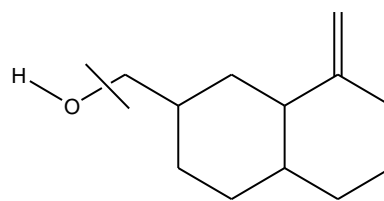
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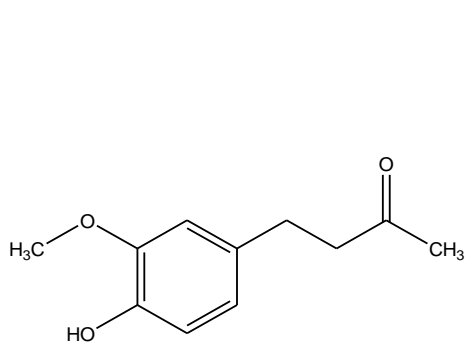
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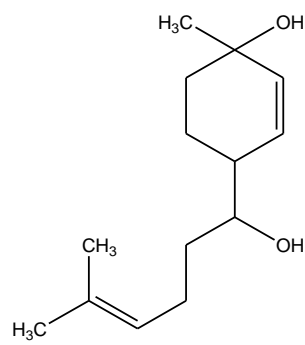
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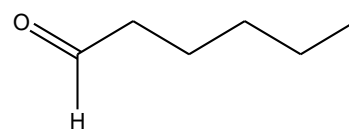
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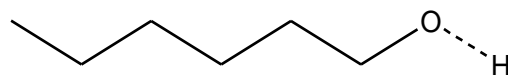
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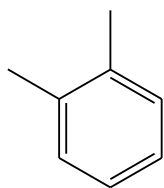
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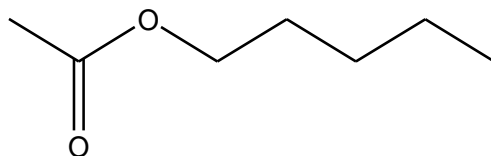
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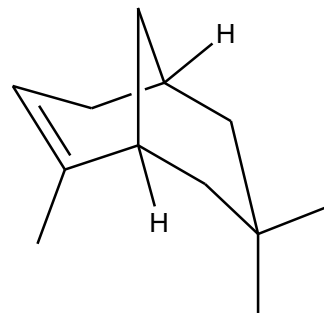
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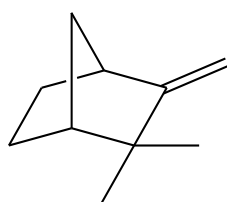
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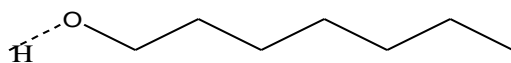
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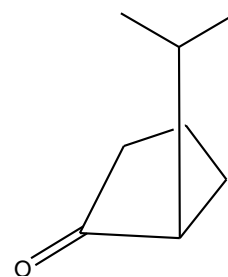
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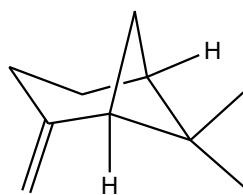
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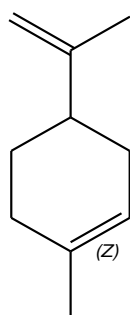
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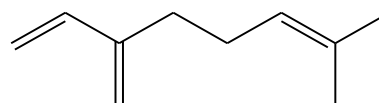
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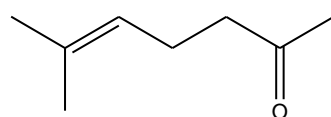
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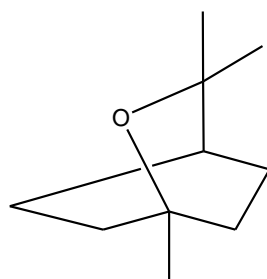
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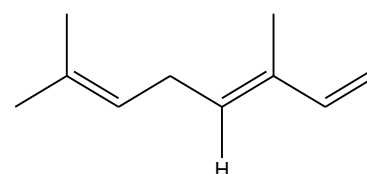
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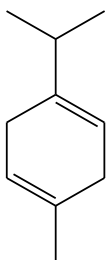
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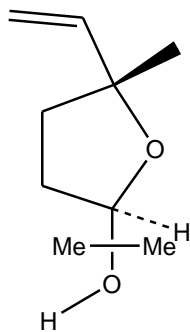
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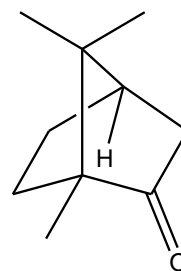
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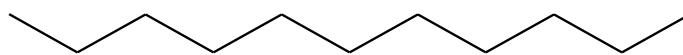
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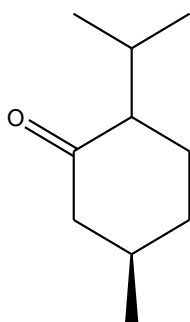
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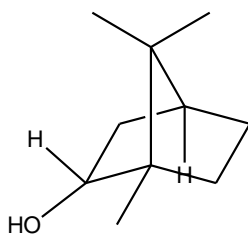
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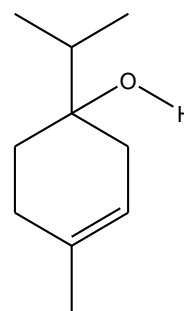
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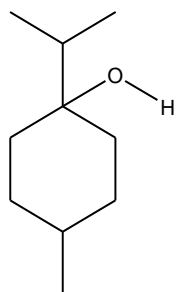
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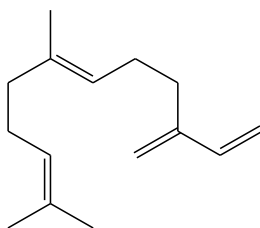
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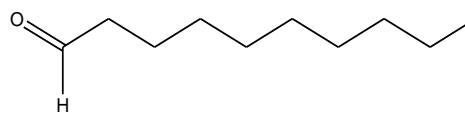
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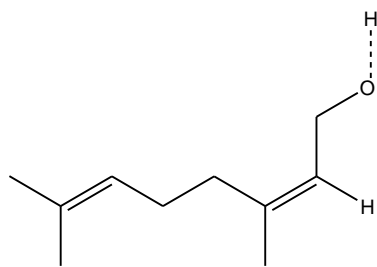
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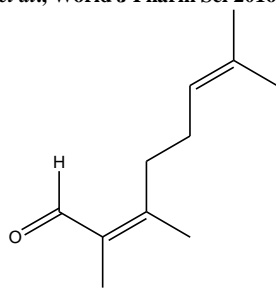
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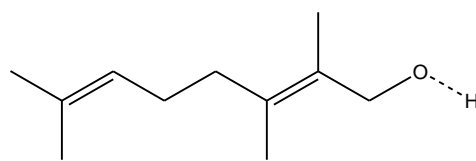
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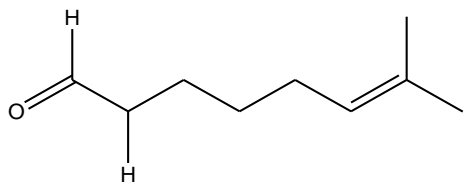
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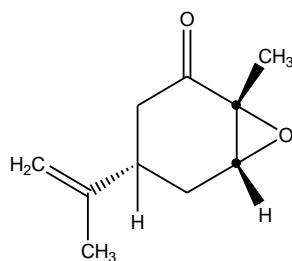
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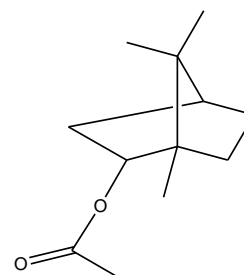
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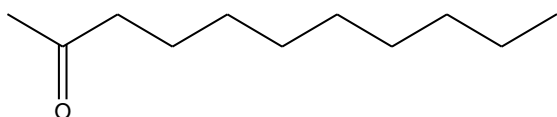
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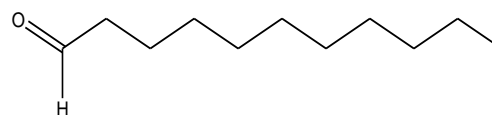
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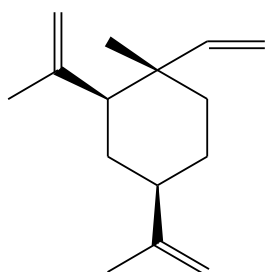
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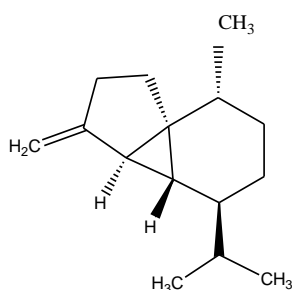
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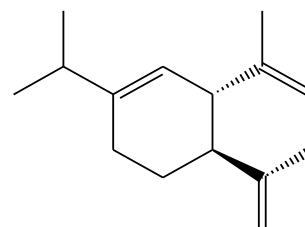
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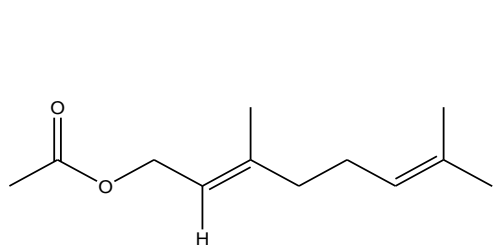
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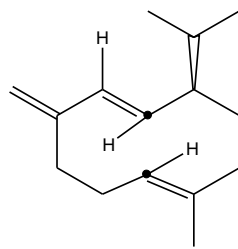
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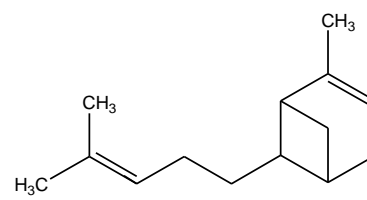
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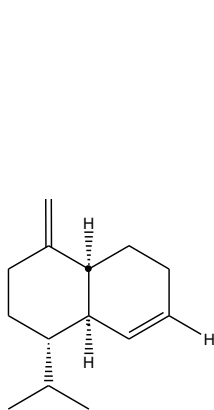
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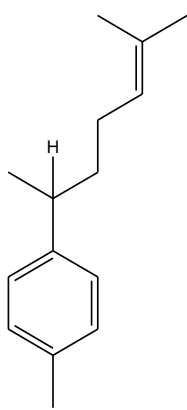
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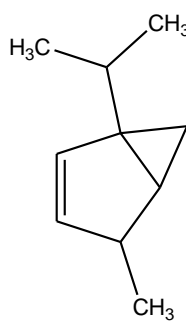
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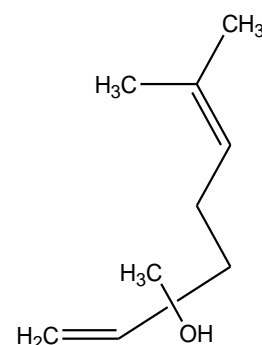
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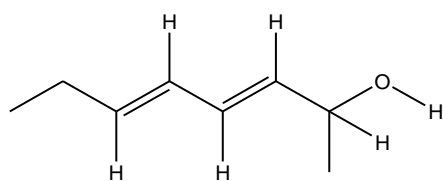
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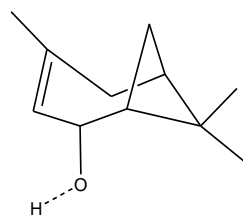
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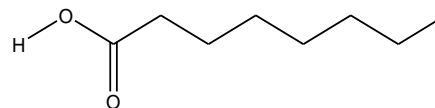
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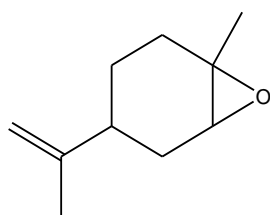
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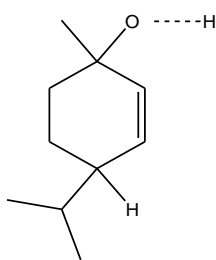
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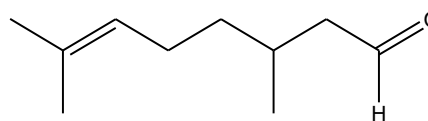
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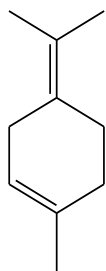
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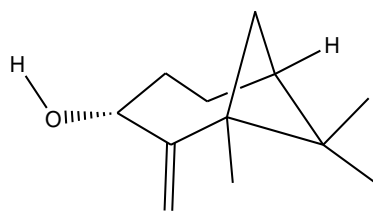
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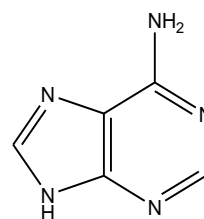
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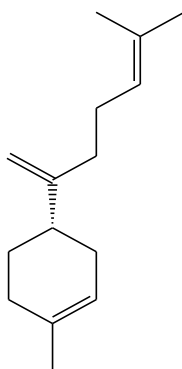
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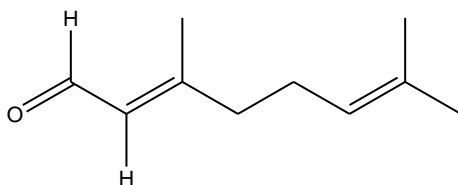
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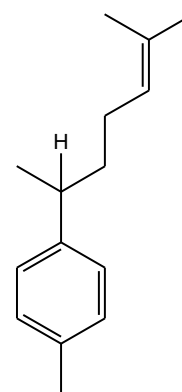
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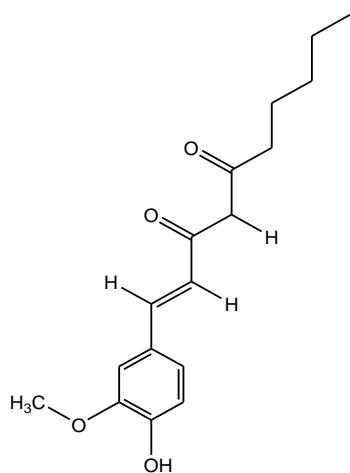
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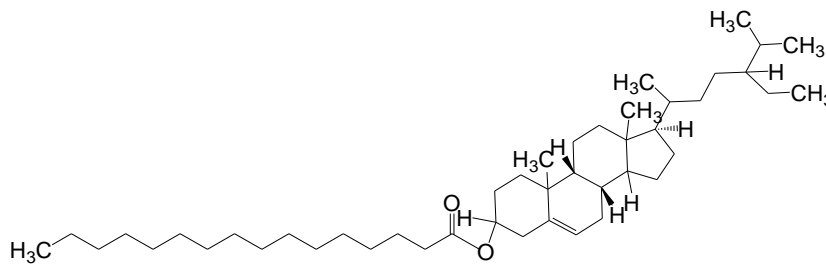
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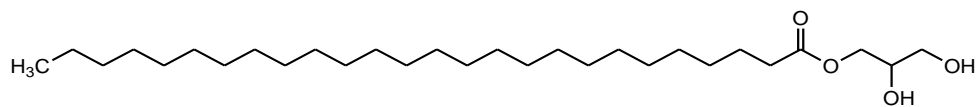
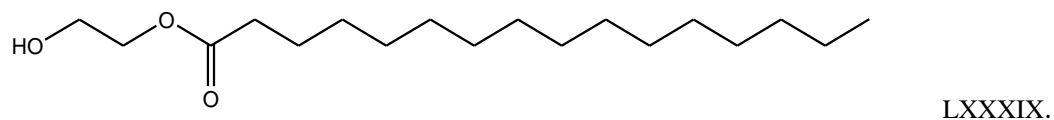
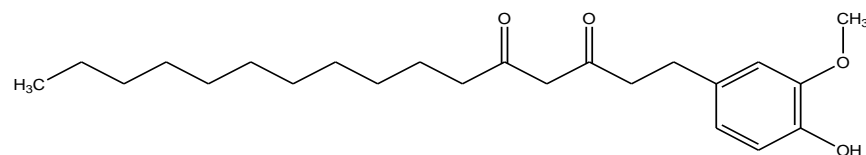
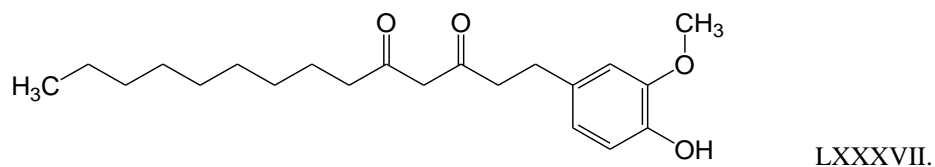
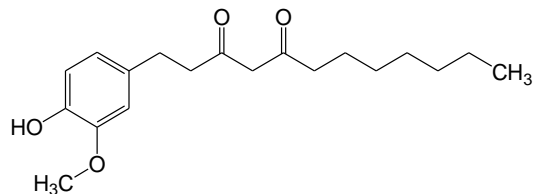
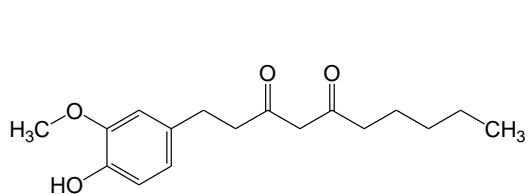
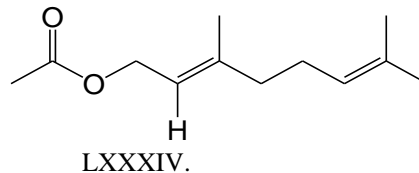
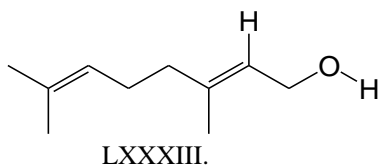
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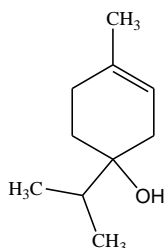


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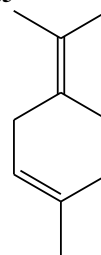


LXXXII.





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