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Chemical composition, antimicrobial, antioxidant, and toxicity of essential oils as food preservatives

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ABSTRACT: Owing to the toxicity of chemical food preservatives, essential oils have gained significant attention in the food industry. Because they can be toxic at certain concentrations, their toxicity must be carefully considered. This study is a systematic review based on 312 references to ensure accuracy .The databases WOS, PubMed, Embase, Scopus, and Google Scholar are utilized to gather relevant information. Various combinations of the following keywords are employed: essential oil, food preservative, antimicrobial, toxicity, and MIC. The inclusion and exclusion criteria and quality assessment of the included studies led to the formation of a search strategy flowchart. Data were tabulated showing the names of the plants containing volatile oil, the major ingredients of essential oils, their antimicrobial, antioxidant, and anti-aflatoxin effects, oral toxicity, and Minimum Inhibitory Concentration (MIC) of volatile oils against pathogens. The acute, sub-acute, and chronic toxicities of volatile oils are also discussed and investigated. In addition, the toxicity of the essential oils and their MIC were compared. Additionally, the MIC of the effective antibiotics against pathogenic microorganisms were compared with those of the volatile oils. Several figures have been prepared that show the relative frequencies of the data obtained from the tables. These results suggest that essential oils have great potential for use in the food industry. However, only a few studies have been conducted to determine their toxicity. Thus, further investigation is required.

KEYWORDS: Essential oil; food preservative; antimicrobial; toxicity; MIC.

1. INTRODUCTION

Food safety is a vital factor in determining the quality of food and nutrients. It should be carefully considered during food preparation, distribution, and consumption. Contaminated foods are reservoirs of various diseases and infections, leading to diminished food quality and harm to human health.[1,2] Food spoilage occurs due to diverse factors, including food characteristics, storage methods and conditions, environmental factors (light, temperature, and pH), and microbial activities. Bacteria, yeasts, molds, and fungi play an important role in contamination. [1,2] Several preservation methods, including canning, drying, freezing, smoking, pasteurizing, and antimicrobial peptides (AMPs), have been utilized to prolong shelf life and maintain food quality. [1-3]

Preservatives are pivotal in preventing microbial growth and maintaining food durability and stability. Preservatives are divided into three main classes: antimicrobials, antioxidants, and anti-enzymatic. Preservatives can be used either separately or simultaneously. While traditional preservatives, as indicated in Table 1, such as organic acids, nitrates, nitrites, sulfites (sodium and potassium), SO_2, and several polypeptides such as Natamycin and Nisin [4,5] are effective, but they still pose a concern about potential adverse health effects and toxicity, including allergic reactions, headaches, and gastrointestinal issues (e.g., gastric cancer).

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Table 1. Some compounds used as food preservatives

Preservatives	Usage and function
Organic acids (such as acetic acid, benzoic acid, etc.)	Preparing foods with low pH
Nitrates and Nitrites	Inhibition of bacterial proliferation in raw meat
SO_2 and Sulfites	Preventing the growth of microorganisms inside dried fruits
Natamycin and Nisin	Inhibition of bacterial growth in meat and dairy products

Many people may not consider chemical preservatives disadvantageous; however, some are toxic, and others can indirectly lead to health-threatening harm. For instance, sulfite preservatives may cause headaches, heart palpitations, and allergies, whereas nitrates or nitrites play a fundamental role in the development of gastric cancer. Asthma, Dermatitis, and Hypertension are other diseases caused by chemical preservation. Therefore, chemical types are no longer considered safe for food preparation. Consequently, it is better to examine the application of safer compounds with fewer side effects. An appropriate option is to use pure herbal compounds, extracts, and essential oils as preservatives.[5-7]

Herbal essential oils can be used alone or in combination with other materials as preservatives in the food industry. These essential oils contain various compounds, including monoterpenes and sesquiterpenes. Owing to these compounds and their mutual effects, they exhibit antioxidant, antifungal, and antibacterial properties. Like other preservatives besides their benefits, other preservatives also have side effects. For instance, at high concentrations, they can cause changes in the organoleptic properties of foods.[8,9] Numerous studies have reported that the improper use of essential oils could lead to toxicity. When used at high concentrations, phenolic compounds of essential oils, such as Morin and Cinnamic acid, may cause skin inflammation and dermatitis. The monoterpenes present in essential oils have various biological and health activities. However, further studies have uncovered their neurotoxic, allergenic, and genotoxic effects, as well as their vast fetotoxic effects in pregnancy. These compounds can also disturb the membrane function, DNA structure, and enzyme function.[10,11]

Although volatile oils are widely used in various industries, such as the food industry, their toxicity is underestimated. To the best of our knowledge, no study has explored the toxicity of essential oils as food preservatives. Thus, this study aimed to investigate the main essential oils that have the potential to be used in the food industry. The second aim of this study was to identify the dominant phytochemicals in essential oils. Third, the biological activities of essential oils, including antimicrobial, MIC, antioxidant, and anti-aflatoxin effects, were investigated. Fourth, the oral toxicities of the volatile oils were tabulated.

2. RESULTS

Our primary objective was to identify essential oils with significant antimicrobial activity and understand their chemical composition. To achieve this, we extensively researched the plant sources of these oils and their chemical makeup, as detailed in the Table 2.

Table 2. Essential oils' major effective compounds and their biological effect

Plant name (Effective part)	Common name	Family of the plant	Major effective compounds	Biological effect	R*
Acorus calamus (Rhizomes)	Sweet flag	Acoraceae	β-Aasarone (82.42 %)	Antimicrobial Antioxidant Antifungal Antiaflatoxigenic	[12,13]
Ageratum conyzoides (Flowers and stems)	Billygoat weed	Asteraceae	Precocene I (flower: 58.8%, stem: 76.5%), β-Caryophyllene (flower: 15.2%, stem: 8.1%)	Antibacterial Antioxidant Antifungal	[14,15]
Allium sativum (Bulbs)	Garlic	Alliaceae	Diallyl trisulfide (16.8%-33.4%), Diallyl disulfide (20.8%-27.9%), Allyl methyl trisulfide (19.2%)	Antibacterial Antifungal	[16,17]
Alpinia galanga (Rhizomes)	Siamese ginger	Zingiberaceae	Ethyl cinnamate (37.559 %), Methyl cinnamate (19.993 %), n-Pentadecane (14.614 %)	Antibacterial Antioxidant	[18]

Alpinia zerumbet *(Leaves)*	Shell ginger	Zingiberaceae	γ-Terpinene (14.5%), Cineole (13.8%), p-Cymene (13.5%), Sabinene (12.5%),	Antimicrobial Antioxidant	[19,20] [21]
Anethum graveolens *(Fruits)*	Dill	Apiaceae	Carvone (58%), D-Limonene (37%)	Antimicrobial Antioxidant Antifungal	[22,23]
Artemisia absinthium *(Aerial parts)*	Wormwood	Asteraceae	Sabinene (30.1%), Myrcene (38.9%), 1,8-Cineole (18%)	Antibacterial Antifungal	[24,25]
Artemisia campestris *(Aerial parts)*	Field wormwood	Asteraceae	α-Pinene (18.65%), β-Pinene (16.78%), β-Myrcene (17.34%), Germacrene D (10.34%)	Antimicrobial Antioxidant Antifungal	[26,27]
Artemisia herba-alba *(Aerial parts)*	White wormwood	Asteraceae	*α/β*-thujone (57%), Camphor (24%)	Antimicrobial Antioxidant	[22,28]
Boswellia papyrifera *(Leaves)*	Sudanese frankincense	Bruceraceae	Octyl acetate (49.5%-81.0%), Diterpenoids (6.6%-32.7%) Octanol (6.5%-13.7%),	Antimicrobial Antifungal	[29,30]
Bunium persicum *(Aerial parts)*	Black Cumin	Apiaceae	Caryophyllene (27.81%), γ-Terpinene (15.19%), Cuminyl acetate (14.67%)	Antimicrobial Antioxidant	[31,32]
Calendula officinalis *(Flowers and leaves)*	Pot marigold	Asteraceae	α-Cadinol (32.3%), δ-Cadinene (11.8%), τ -Muurolol (8.5%)	Antimicrobial Antioxidant Antifungal	[33]
Carum carvi *(Seeds)*	Meridian fennel, Persian cumin	Apiaceae	γ-Terpinene (31.03%), β-Pinene (18.77%), p-Cymene (17.16%), Carvone (12.20%)	Antimicrobial Antioxidant Antifungal Antiaflatoxigenic	[34,35]
Cedrus deodara *(Leaves and peels)*	Deodar cedar	Pinaceae	α-terpineol (30.2%), linalool (24.47%), limonene (17.01%), Anethole (14.57%)	Antimicrobial Antioxidant	[36]
Chenopodium ambrosioides *(Leaves, flowers, and stems)*	Mexican tea	Amaranthaceae	α-Terpinene (51.3%), p-Cymene (23.4%), p-Mentha-1,8-diène (15.3%)	Antimicrobial Antioxidant Antifungal	[37,38]
Cinnamomum camphora *(Leaves)*	Camphor tree	Lauraceae	Camphor (93.1%)	Antimicrobial Antifungal	[39]
Cinnamomum cassia *(Bark)*	Chinese cinnamon	Lauraceae	cis-2-Methoxycinnamic acid (43.06%), Cinnamaldehyde (42.37%)	Antimicrobial Antioxidant Antiaflatoxigenic	[40,41] [42]
Citrus aurantifolia *(Leaves)*	Lime	Rutaceae	Limonene (77.5 %), Linalool (20.1 %), Citronellal (14.5 %)	Antioxidant Antifungal Antibacterial Antiparasitic	[43,44] [45]
Citrus aurantium *(Flowers)*	Sour orange	Rutaceae	Limonene (27.5%), (E)-Nerolidol (17.5%), *α*-Terpineol (14.0%) *α* -Terpinol acetate (11.7%)	Antimicrobial Antioxidant	[46]
Citrus grandis *(Peels)*	Pomelo	Rutaceae	Limonene (63.7%), *β*-pinene (6.09%)	Antimicrobial Antioxidant Antifungal	[47,48]

Citrus hystrix (*Peels and leaves*)	Kaffir lime	Rutaceae	Citronellol (10.7%), Limonene (7.3%)	Antibacterial Antioxidant Antiaflatoxigenic	[17,49,
Citrus reticulata (*Peels and leaves*)	Mandarin orange	Rutaceae	Limonene (83.67%), γ -Terpinene (6.09%)	Antimicrobial Antioxidant Antifungal	[47,51]
Citrus sinensis (*Fruits*)	Sweet orange	Rutaceae	Limonene (77.37%), β-pinene (3.45%)	Antimicrobial Antioxidant Antifungal Antiaflatoxigenic	[47,52] [53]
Clausena lansium (*Leaves*)	Wampee	Rutaceae	α-Santalol (31.7%), α-Santalane (19.5%)	Antimicrobial Antioxidant Antifungal	[54,55]
Cleistocalyx operculatus (*Leaves*)	Voi, Shui weng	Myrtaceae	Myrcene (69.7%), (E)-β-Ocimene (12.24%)	Antimicrobial Antioxidant	[56,57]
Coriandrum sativum (*Leaves and seeds*)	Cilantro	Apiaceae	Linalool (76.41%), γ-terpinene (5.35%)	Antimicrobial Antioxidant Antifungal Antiaflatoxigenic	[34,58] [35]
Croton argyrophylloides (*Leaves*)	Croton	Euphorbiaceae	Spathulenol (26.7%), Caryophyllene oxide (13.1%), β-Elemene (12.2%)	Antibacterial Antioxidant Antifungal	[19,59,
Croton zehntneri (*Leaves*)	–	Euphorbiaceae	Estragole (46%), trans-Anethole (42.1%)	Antimicrobial Antifungal Cytotoxic	[19,60,
Cuminum cyminum (*Seeds*)	Cumin	Apiaceae	Cumin aldehyde (29%), α-Terpinen-7-al (20.7%), γ-Terpinene (12.9%),	Antibacterial Antifungal Antiaflatoxigenic	[17,62]
Curcuma longa (*Leaves*)	Turmeric	Zingiberaceae	Terpinolene (52.88%), α-Phellandrene (21.13%)	Antimicrobial Antioxidant	[63,64]
Cymbopogon citratus (*Leaves*)	Lemongrass	Poaceae	Geranial (55.2%), Neral (44.7 %)	Antibacterial Antifungal Antioxidant Antiaflatoxigenic	[65,66]
Cymbopogon giganteus (*Leaves*)	–	Poaceae	cis-p-Mentha-1(7),8-dien-2-ol (19.4%), trans-p-Mentha-2,8-dien-1-ol (16.4%), Limonene (13.7%).	Antimicrobial, Antifungal	[67]
Cymbopogon martini (*Leaves*)	Ginger grass	Poaceae	Geraniol (40.89%), Cyclofenchene (13.91%), Myrcene (9.34%)	Antimicrobial Antioxidant Antifungal	[68,69] [70,71]
Cymbopogon schoenanthus (*Aerial parts*)	Camel grass	Poaceae	Piperitone (63.35%), β-Eudesmol (9.305%)	Antimicrobial Antioxidant Antifungal Antiaflatoxigenic	[66,72]
Cymbopogon winterianus (*Leaves and stems*)	Java citronella	Poaceae	Citronellal (27.00%), trans.-Geraniol (22.78%), Citronellol (10.09%)	Antibacterial Antioxidant	[73,74]
Cyperus rotundus (*Tubers*)	Purple nutsedge	Cyperaceae	Cyperene (16.9%), Caryophyllene oxide (8.9%), α-Longipinane (8.4%)	Antibacterial Antioxidant	[75]
Daucus carota (*Seeds and leaves*)	Wild carrot	Apiaceae	α-Pinene (27.44%), Sabinene (25.34 %), Germacrene D (16.33 %)	Antimicrobial Antioxidant	[76,77]
Eucalyptus camaldulensis	River red	Myrtaceae	1,8-cineole (16.2%),	Antimicrobial	[78,79]

(Leaves)	gum		α-pinene (15.6%), α-phellandrene (10.0%)	Antifungal	
Eucalyptus globulus (Leaves)	Tasmanian bluegum	Myrtaceae	1,8-Cineole (55.29%), Spathulenol (7.44%)	Antimicrobial Antioxidant	[80]
Eugenia florida (Leaves)	Rainforest cherry	Myrtaceae	seline-3,11-dien-6-α-ol (12.93%), Eremoligenol (11%), γ-Elemene (10.70%)	Antibacterial Antioxidant Antifungal	[81,82]
Eupatorium adenophorum (Inflorescences and roots)	Crofton weed	Asteraceae	γ-Cadinene (18.4 %), γ-muurolene (11.7 %)	Antimicrobial Antioxidant	[83,84]
Ferula assa-foetida (Oleo-gum-resins)	Devil's dung	Umbelliferae	(E)-1-Propenyl sec-butyl disulf (23.9%), 10-epi-γ-Eudesmol (15.1%)	Antimicrobial Antioxidant Antifungal	[85]
Ferula macrecolea (Aerial parts)	–	Apiaceae	Terpinolene (77.72%), n-Nonanal (4.47%), Linalool (4.35%),	Antibacterial Antifungal	[86]
Foeniculum vulgare (Seeds)	Fennel	Apiaceae	trans-Anethole (75.8%), Estragole (4.6%)	Antimicrobial Antioxidant Antiaflatoxigenic	[19,87] [88]
Gnaphalium affine (Aerial parts)	Cotton weed	Asteraceae	Eugenol (18.2%), Linalool (10.6%)	Antimicrobial Antioxidant	[17,89]
Hedychium spicatum (Rhizomes)	Spiked ginger lily	Zingiberaceae	Curzerene (14.7 %), Coronarin E (13.3 %), Curdione (10.2 %)	Antimicrobial Antioxidant Antifungal	[90]
Heracleum sphondylium (Aerial parts)	Common hogweed	Apiaceae	Curcumene (13.42%), β-Sesquiphellandrene (11.91%), β-Bisabolene (10.11%)	Antimicrobial Antioxidant	[91]
Hyptis suaveolens (Leaves)	Pignut	Lamiaceae	Sabinene (7.3-31.3%), Eeucalyptol (14.0-24.6%), β-Caryophyllene (6.9-12.7%), 1, 8-Cineole (11.5%), β-Phellandrene (10.2%)	Antimicrobial Antioxidant Antiaflatoxigenic	[92,93] [94]
Juniperus communis (Cones and leaves)	Common juniper	Cupressaceae	α-Pinene (51.4%), Myrcene (8.3%)	Antimicrobial Antioxidant Antifungal	[95,96] [97]
Lavandula angustifolia (Leaves and flowers)	English lavender	Lamiaceae	Eucalyptol (52.36%), Camphor (11.91%), *δ*-Terpinene (8.775%)	Antimicrobial Antifungal	[98,99]
Lippia gracilis (Leaves)	–	Verbenaceae	Thymol (70.3%), p-Cymene (9.2%)	Antimicrobial Antioxidant Antifungal	[100,10
Lippia origanoides (Stems)	Mexican oregano	Verbenaceae	Carvacrol (29.00%), o-Cymene (25.57%), Thymol methyl ether (11.50%)	Antimicrobial Antioxidant	[102,10
Litsea elliptica (Leaves)	Medang, Perawas	Lauraceae	α-Terpineol (34.54%), 9-Decen-2-ol (25.09%), p-Menthan-8-ol, (18.57%), 7-Decen-2-one (10.62%)	Antimicrobial Antioxidant	[104,10
Matricaria chamomilla (Flowers)	Chamomile	Asteraceae	β-Farnesene (29.8 %), α-Bisabolol (15.7 %)	Antimicrobial Antioxidant	[106]
Melaleuca alternifolia (Leaves)	Tea tree	Myrtaceae	Terpinen-4-ol (38.6%), γ-Terpinene (21.7%)	Antifungal Antimicrobial	[107,10
Melaleuca leucadendron (Leaves)	Weeping paperbark	Myrtaceae	Eugenol methyl ether (95.4%)	Antimicrobial Antioxidant	[109]

				Antifungal	
Melissa officinalis (*Leaves*)	lemon balm	Lamiaceae	Ggeranial (44.20 %), Neral (30.20 %) Citronellal (6.30 %)	Antimicrobial Antioxidant Antiaflatoxigenic	[110,11
Mentha longifolia (*Flowers, leaves, and stems*)	Menthol	Lamiaceae	Piperitenone oxide (70.0%), Piperitenone (18.7%)	Antimicrobial Antioxidant Antiaflatoxigenic	[17,112 [113]
Mentha mozaffarianii (*Leaves and fruits*)	Pooneh koohi	Lamiaceae	Piperitenone (59.5 %), cis-Iiperitenone epoxide (14.9 %), Pulegone (8.5 %)	Antimicrobial Antifungal	[114]
Mentha piperita (*Leaves*)	Peppermint	Lamiaceae	Menthone (30.63 %), Menthol (25.16 %)	Antimicrobial Antimicrobial Antiaflatoxigenic	[107,11 [116]
Mentha pulegium (*Aerial parts*)	Pennyroyal	Lamiaceae	Menthone (35.9%), Pulegone (23.2%),	Antimicrobial Antioxidant	[117]
Monarda citriodora (*Flowers*)	Lemon mint	Lamiaceae	Thymol (79.7%), p-Cymene (7.7%)	Antimicrobial Antioxidant Antifungal Antiaflatoxigenic	[118,11
Monodora myristica (*Seeds*)	Calabash nutmeg	Annonaceae	p-Cymene (50.58%), α-Phellandrene (32.09%)	Antibacterial Antioxidant	[120]
Myrtus communis (*Aerial parts*)	Myrtle	Myrtaceae	1,8-cineole (13.5–19.6%), linalool (7.7–15.8%)	Antimicrobial Antioxidant	[121]
Nardostachys jatamansi (*Roots*)	Indian spikenard	Caprifoliaceae	Guaia-6,9-diene (11.96 %), Calarene (10.44 %)	Antimicrobial Antioxidant	[122]
Nepeta faassenii (*Flowers, leaves, and stems*)	Catmint	Lamiaceae	4a alpha,7alpha,7a alpha-Nepetalactone (34.12%), Elemol (23.23%), spiro (5,6) Dodecane (13.73%)	Antimicrobial Antioxidant	[123]
Nepeta sintenisii (*Aerial parts*)	–	Lamiaceae	4aα,7α,7aβ-Nepetalactone (51.74%), β-Farnesene (12.26%)	Antimicrobial Antioxidant	[124]
Ocimum basilicum (*Aerial parts*)	Common basil	Lamiaceae	Estragole (80%), Linalool (16.12%)	Antimicrobial Antioxidant Antifungal	[125,12
Ocimum gratissimum (*Leaves*)	Basil, Basil-clove, Alfavaca	Lamiaceae	Eugenol (68.8%), Methyl eugenol (13.21%), cis-Ocimene (7.47%)	Antimicrobial Antifungal	[127,12
Origanum compactum (*Leaves*)	Oregano	Lamiaceae	Carvacrol (36.5%), Thymol (29.7%), p-Cymene (24.3%)	Antibacterial Antioxidant	[17]
Origanum vulgare (*Leaves*)	Oregano	Lamiaceae	Carvacrol (58.30%), Linalool (9.09%),	Antibacterial Antioxidant Antiaflatoxigenic	[9] [129,13 [131]
Rosa damascena (*Petals*)	Damask rose	Rosaceae	β-citronellol (14.5-47.5%), Nonadecane (10.5-40.5%), Geraniol (5.5-18%)	Antibacterial Antifungal	[25,132
Rosmarinus officinalis (*Leaves*)	Rosemary	Lamiaceae	1,8-Cineole (eucalyptol, 52.2%), Camphor (15.2%), α-Pinene (12.4%)	Antibacterial Antioxidant Cytotoxic Antiaflatoxigenic	[133] [134]
Satureja hortensis (*Flowers and leaves*)	Summer savory	Lamiaceae	Thymol (41.28%), γ-Terpinene (37.63%), p-Cymene (12.2%)	Antimicrobial Antioxidant Antifungal	[135,13 [137]

				Antiaflatoxigenic	
Satureja khuzestanica (Aerial parts)	Marzeh khuzestani	Lamiaceae	Carvacrol (64.4%)	Antimicrobial Antioxidant	[138,13
Satureja montana (Aerial parts)	Savory	Lamiaceae	Thymol (24.69%), linalool (15.38%)	Antimicrobial Antioxidant	[140]
Syzygium aromaticum (Flowers)	Clove	Myrtaceae	β-Caryophyllene (5-14%), Eugenol (75-88%), Eugenol acetate (4-15%)	Antimicrobial Antioxidant Antifungal	[107,14
Tagetes elliptica (Leaves)	Chincho	Asteraceae	cis-Tagetenone (37.27%), trans-Tagetenone (18.84%), Dihydrotagetone (14.38%),	Antibacterial Antioxidant	[142]
Tagetes erecta (Leaves and flowers)	African Marigold	Asteraceae	Piperitone (35.9%), Terpinolene (22.2%)	Antimicrobial Antioxidant	[143,14
Tanacetum parthenium (Flowers and leaves)	Feverfew	Asteraceae	Camphor (45.47%), trans-Chrisantenyl acetate (21.65%), Camphene (9.48%)	Antimicrobial Antioxidant Antifungal	[145]
Thymus schimperi (Flowers and leaves)	Tosign	Lamiaceae	Thymol (49.6 %), Carvacrol (36.3%)	Antimicrobial Antioxidant Antifungal	[146,14
Thymus vulgaris (Leaves and flowers)	Thyme	Lamiaceae	Thymol (47.59%), γ-Terpinene (30.90%), p-Cymene (8.41%)	Antibacterial Antifungal Antiviral Antioxidant Antiaflatoxigenic	[148,14 [150]
Trachyspermum ammi (Fruits)	Ajwain	Apiaceae	Thymol (67.4%), p-Cymene (17.9%), γ-Terpinene (11.3%)	Antimicrobial Antioxidant Antifungal	[151]
Vitex agnus (Leaves)	Chaste tree	Lamiaceae	α-Pinene (14.83%), Limonene (10.29%), β-Caryophyllene (6.9%)	Antimicrobial Antioxidant Antifungal	[152,15
Vitex negundo (Leaves)	Chinese chaste tree	Lamiaceae	2R–acetoxymethyl-1,3,3-trimethyl-4T-(3-methyl-2-buten-1-yl)-1tcyclohexano (27.198%), Nerolidol (14.61%), β-Caryophyllene (11.949%),	Antimicrobial Antioxidant	[154]
Zingiber officinale (Rhizomes)	Common ginger	Zingiberaceae	Citral (17.25%), δ-Citral (10.25%), Camphene (9.55%)	Antimicrobial Antioxidant Antifungal Antiaflatoxigenic	[155,15 [157]

*References

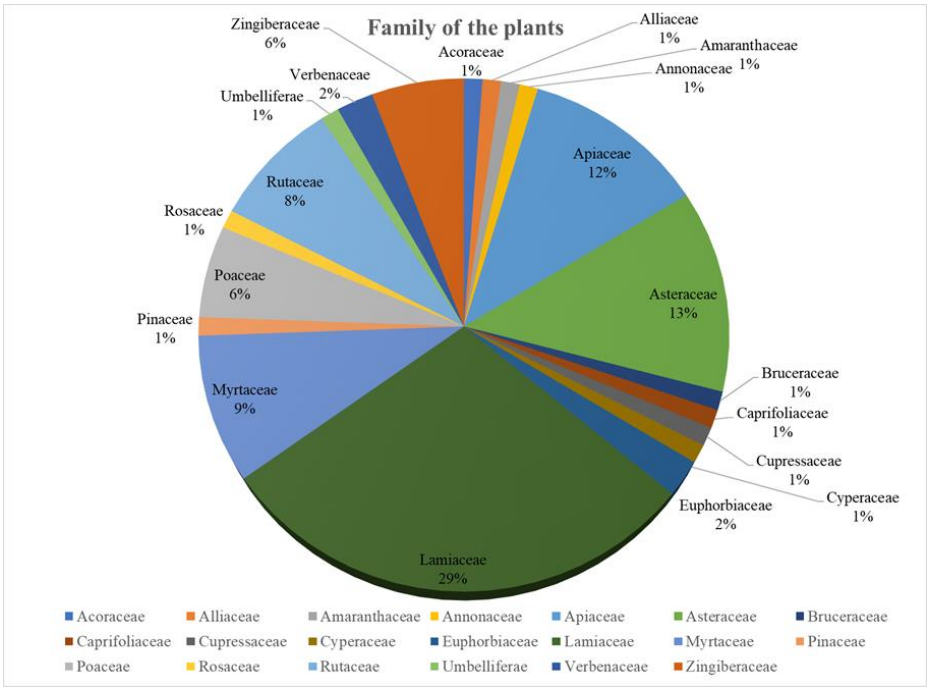

Figure 1. Dominant families tabulated in Table 2

Based on the information gathered in Table 2, the top five most frequently mentioned families were Lamiaceae 25 times, Asteraceae 11 times, Apiaceae 10 times, Myrtaceae 8 times, and Rutaceae 7 times. Figure 1 illustrates the leading plant families. Out of the 107 chemical compositions listed in Table 2, the most mentioned chemicals were limonene 10 times, p-cymene 10 times, gamma-terpinene 10 times, linalool 9 times, thymol 9 times, caryophyllene 8 times, 1,8-cineole 7 times, eugenol 6 times, alpha-pinene 6 times, camphor, carvacrol, myrcene, and piperitenone 5 times each; the abundance of chemical compounds is shown in Figure 2. Different parts of plants show biological effects, such as leaves, stems, and flowers. Figure 3 shows the abundance of the biologically active plant parts.

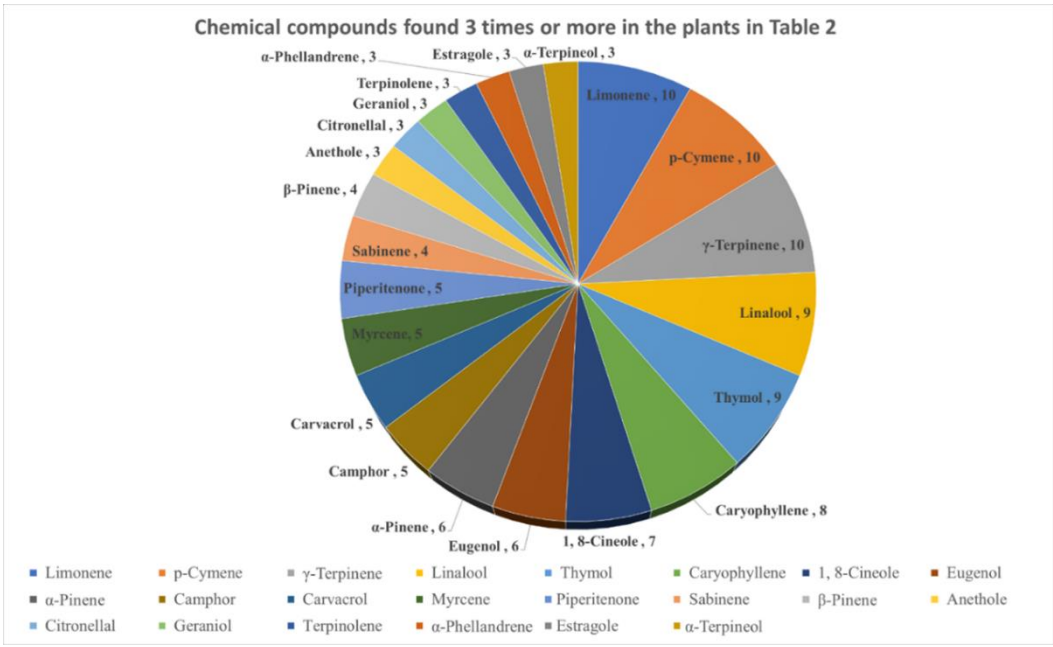

Figure 2. Chemical compounds found 3 times or more in the plants in Table 2

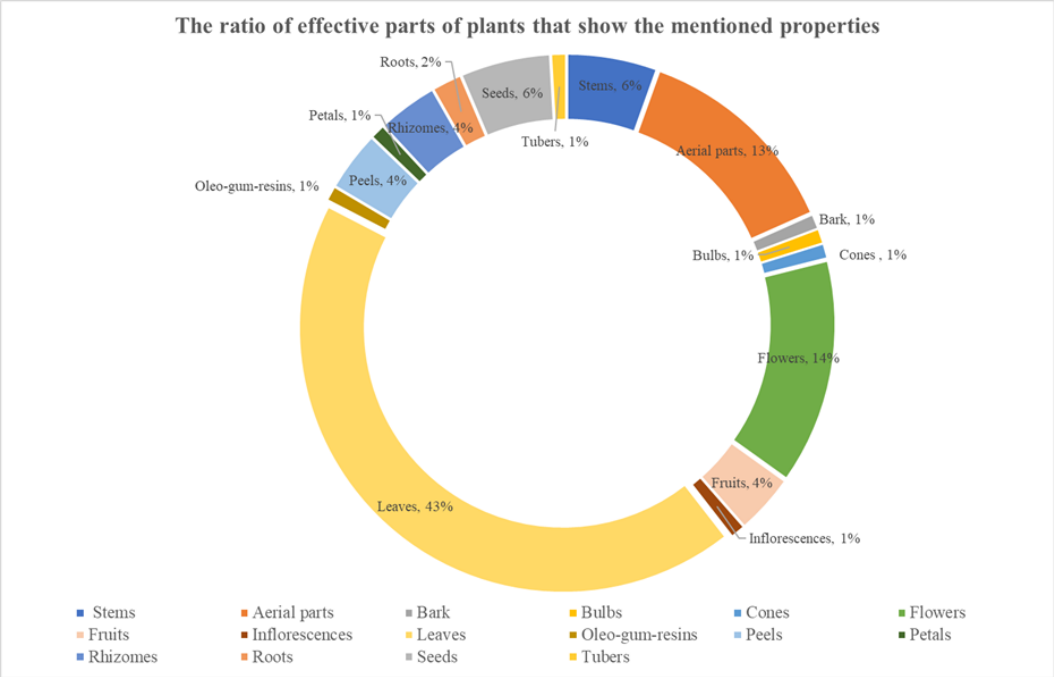

Figure 3. The ratio of effective parts of plants that show the mentioned properties

One of the factors investigated was the anti-aflatoxin activity. *Acorus calamus, Carum carvi, Cinnamomum cassia, Citrus hystrix, Citrus sinensis, Coriandrum sativum, Cuminum cyminum, Cymbopogon citratus, Cymbopogon schoenanthus, Foeniculum vulgare, Hyptis suaveolens, Melissa officinalis, Mentha longifolia, Mentha piperita, Monarda citriodora, Origanum vulgare, Rosmarinus officinalis, Satureja hortensis, Thymus vulgaris,* and *Thymus vulgaris* have shown this property. Subsequently, we conducted a rigorous evaluation of the antimicrobial activity of the essential oils. Assessing antimicrobial activity involved determining the MIC against various microorganisms. Similarly, we meticulously assessed the toxicity, including acute, sub-acute, and chronic, and compiled the data in Table 3.

Table 3. Acute,sub-acute,chronic oral toxicity and MIC of essential oils

Plant name (Effective part)	Acute toxicity (LD_{50})	Sub-acute toxicity	Chronic toxicity	MIC*	R**
Acorus calamus (Rhizomes)	350 mg/kg (rats)	-	-	*P. aeruginosa, S. aureus, B. subtilis* (0.25 mg/ml) *E. coli* (0.5 mg/ml)	[158,159]
Ageratum conyzoides (Flowers and leaves)	Female: 1247.88 mg/kg Male: 1674.57 mg/kg (mice)	100 mg/kg: Decrease in kidney and heart weight, increase in creatinine, decrease erythrocyte, haemoglob and haematocrit (mice - 28days)	-	*S. aureus* (64 $\mu g/ml$ *E. faecalis* (256 $\mu g/ml$) *S. aureus* (256 $\mu g/ml$) *E. coli* (256 $\mu g/ml$) *E. aerogenes* (512 $\mu g/ml$)	[14,160]
Allium sativum (Bulbs)	4472 mg/kg (mice)	15,25 mg/kg: No significant changes 50 mg/kg: Mild changes in glucose level (mice - 28days)	-	*C. albicans (470–940 µg/ml) E. coli (15–15000 µg/mL or 3.95% v/v) L. monocytogenes (8.8% v/v) Salmonella typhi (7% v/v) S. aureus (12–15000 µg/mL or 5% v/v)*	[17,161] [162]
Alpinia galanga (Rhizomes)	-	-	-	*E. coli (15 µl/ml) P. vulgaris (20 µl/ml) S. entertidis (10 µl/ml) B. subtilis (2.5 µl/ml) S. aureus (2.5 µl/ml)*	[163]

				S. feacalis (5 µl/ml) *S. cerevisae (15 µl/ml)*	
Alpinia zerumbet (Leaves)	2500 mg/kg (rats)	-	-	-	[164]
Anethum graveolens (Seeds)	-	-	-	*S.aureus (0.62 mg/ml)* *V.cholerae (0.7 mg/ml)*	[165]
Artemisia absinthium (Leaves)	5700 mg/kg (mice)	-	-	*Streptococcus mutans (250 µg/ml)* *Streptococcus mitis (62.5 µg/ml)*	[166,167]
Artemisia campestris (Leaves)	>2 g/kg (mice)	-	-	*Fusarium graminearum (1.25 µl/ml)* *F. moniliforme, F. culmorum, P. expansum, A. flavus, A. ochraceus, and, A. parasitcus (2.5 µl/ml)* *P. viridicatum and, A. niger (10 µl/ml)*	[27,168]
Artemisia herba-alba (Aerial parts)	2000 mg/kg (rats)	50, 100, 200 mg/kg: No significant changes (rats - 28days)	-	*Klebsiella oxytoca (5-10 mg/ml)* *Acinetobacter baumannnii (10–20 mg/ml)*	[28,169]
Boswellia papyrifera (Branches)	-	-	-	*Bacillus cereus (4 µg/ml)* *Enterococcus faecalis (2 µg/ml)* *Escherichia coli (4 µg/ml)* *Listeria innocua (4 µg/ml)* *Proteus mirabilis (16 µg/ml)* *Salmonella enterica (4 µg/ml)* *Shigella dysenteria (8 µg/ml)* *Staphylococcus aureus (4 µg/ml)* *Staphylococcus camorum (4 µg/ml)*	[170]
Bunium persicum (Seeds)	>4000 mg/kg (rats)	250,500,1000 mg/kg: Changes in the blood parameters happen, attenuated histopathological changes in lung, liver, kidney, testes and spleen tissues (rats - 14days)	-	*E.aerogenes (0.125 µg/ml)* *S.enterica (0.125 µg/ml)* *B.cereus (0.5 µg/ml)* *S.aureus (0.25 µg/ml)*	[171,172]
Calendula officinalis (Flowers)	20 ml/kg (rats)	-	2.5, 5, 10 ml/kg: nontoxic behaviours were observed (rats - 90days)	-	[173]
Carum carvi (Seeds)	2.62 ml/kg (mice)	-	-	*Bacillus cereus (0.5 µl/ml)* *Escherichia coli (2 µl/ml)* *Micrococcus luteus (1 µl/ml)* *Proteus mirabilis (2 µl/ml)* *Pseudomonas tolaasii (4 µl/ml)* *Salmonella enteritidis (0.25 µl/ml)* *Staphylococcus aureus (0.1 µl/ml)*	[174,175]
Cedrus deodara (Leaves and peels)	34.4 mg/kg (rats)	-	-	*E. coli (1.56 µg/ml)* *S. aureus (0.78 µg/ml)* *B. subtilis (0.39 µg/ml)* *B. cereus (0.78 µg/ml)* *S. cerevisiae (0.39 µg/ml)* *A. niger (0.78 µg/ml)* *P. citrinum (0.39 µg/ml)* *R. oryzae (0.20 µg/ml)* *A. flavus (0.20 µg/ml)*	[36,176]
Chenopodium ambrosioides	100 mg/kg (mice)	3,7,10,25,40 mg/kg: Increase in liver index, a	-	*C. albicans (1 mg/ml)* *C. albicans (2 mg/ml)*	[38,177] [178]

(Aerial parts)		serum AST and ALT levels, and also induced distinct morphological changes in liver, heart, and kidney (mice - 27days)		*C. albicans (1 mg/ml)* *C. glabrata (0.25 mg/ml)* *C. guilliermondi (0.25 mg/ml)* *C. krusei (1 mg/ml)* *C. lusitaneae (1 mg/ml)*	
Cinnamomum camphora (Leaves)	2749 mg/kg (mice)	-	-	*Bacillus cereus (625 µg/ml)* *Propionibacterium acnes (312.5 µg/ml)* *Pseudomonas aeruginosa (625 µg/ml)* *Serratia marcescens (625 µg/ml)* *Staphylococcus aureus (1250 µg/ml)* *Streptococcus pyogenes (625 µg/ml)*	[39,179]
Cinnamomum cassia (Bark)	-	-	-	*B. cereus (339 µg/ml)* *E. coli (2640 µg/ml)* *L. monocytogenes (2640 µg/ml)* *S. infantis (2640 µg/ml)* *S. aureus (1320 µg/ml)*	[17]
Citrus aurantifolia (Peels of ripe fruits)	-	100-500 mg/kg: Mild hepatotoxic and nephrotoxic 4 deaths of 60 subjects (rats - 60 days)	-	*A. flavus (560 µg/mL)* *A. parasiticus (1130 µg/mL)*	[17,180]
Citrus aurantium (Zest of fruits and leaves)	4360 mg/kg (mice)	-	-	*S. aureus (leaves :1 v/v%)* *B. subtilis (leaves: 1 v/v% zest: 2 v/v%)* *E. coli (leaves: 2 v/v%)*	[181,182]
Citrus grandis (Peels)	-	-	-	*B. subtilis (9.38 µl/ml)* *S. aureus (9.38 µl/ml)* *E. coli (37.50 µl/ml)* *P. chrysogenum (4.69 µl/ml)*	[183]
Citrus hystrix (Peels and leaves)	-	-	-	*P. gingivalis (1.06 mg/ml)* *S. sanguinis (2.12 mg/ml)* *S. mutans (1.06 mg/ml)*	[184]
Citrus reticulata (Peels and leaves)	4520 mg/kg (mice)	-	-	-	[182]
Citrus sinensis (Peels)	4040 mg/kg (mice)	-	-	*S. aureus, Penicillium chrysogenum, B. subtilis,E. coli, and S .cerevisiae (4.66-18.75 µl/ml)*	[182,185]
Clausena lansium (Leaves)	-	-	-	*S. aureus (312.5 µg/ml)* *low antifungal activities in Candida spp.*	[55,186]
Cleistocalyx operculatus (Leaves)	-	-	-	*B. cereus (1250 µg/ml)* *S. aureus (625 µg/ml)* *A. niger (625 µg/ml)* *C. albicans (2500 µg/ml)*	[187]
Coriandrum sativum (Leaves and fruits)	1.53 ml/kg (mice)	-	-	*Candida spp. (0.05–0.4% v/v)* *L. monocytogenes (0.018–0.074% v/v)*	[17,188]
Croton argyrophylloides (Leaves)	9.84 mg/kg (rats)	-	-	*M. tuberculosis (97 µg/ml)* *C.albicans (no inhibition)* *C.tropicalis (no inhibition)* *M.canis (9 µg/ml)*	[60,189] [190,191]
Croton zehntneri (Leaves)	2500 mg/kg (rats)	-	250 mg/kg: No death but some changes (rats – 10 weeks)	*C albicans (>5000 µg/ml)* *C.tropicalis (>2500 µg/ml)* *M.canis (620 µg/ml)*	[60,192] [193]

Cuminum cyminum (Seeds)	0.44 ml/kg (mice)	250,500 mg/kg: No significant changes were observed 1000 mg/kg: Increase of in ALT (rats - 23 and 45days)	-	*B. cereus (0.05 µl/ml)* *B. subtilis (0.05 µl/ml or 1000 µg/ml)*	[17,194] [188]
Curcuma longa (Rhizomes and stems)	> 5000 mg/kg (rats)	1000 mg/kg: No significant changes (rats - 28days)	500 mg/kg: No significant changes were observed (rats-13weeks)	*Microsporum gypseum (459,6 µg/ml)* *Epidermophyton flocosum (229,8 µg/ml)* *Trichophyton mentagrophytes (114.9 µg/ml)* *Trichophyton rubrum (459.6 µg/ml)*	[195,196]
Cymbopogon citratus (Leaves and stalks)	>2000 mg/kg (mice)	2000 mg/kg: Only changes body weights and a few changes in AlT and GI serum activity of GOT w lower (mice-21days)	-	*Bacillus subtilis (163.25 µl/ml)* *Enterococcus faecalis (136.25 µl/ml)* *Micrococcus luteus (142.11 µl/ml)* *Staphylococcus aureus (135.42 µl/ml)* *Pseudomonas aeruginosa (174.18 µl/ml)* *Yersinia enterocolitica (156.24 µl/ml)* *Serratia marcescens (181.37 µl/ml)* *Candida albicans (245.18 µl/ml)* *Candida krusei (211.36 µl/ml)* *Candida glabrata (221.32 µl/ml)* *Candida tropicalis (226.25 µl/ml)* *Salmonella enteritidis (112.36 µl/ml)* *Salmonella enteritidis (181.25 µl/ml)*	[197]
Cymbopogon giganteus (Leaves)	>2000 mg/kg (rats)	50,500 mg/kg: No toxic effects were observed (rats - 28days)	-	*E. faecalis (6.7 mg/ml)* *S. aureus (2.1 mg/ml)* *L. monocytogenes (13.3 mg/ml)* *E. aerogenes (12 mg/ml)* *E. coli (6.3 mg/ml)* *P. aeruginosa (70 mg/ml)* *S. enterica (10 mg/ml)* *S. typhimurium (8.3 mg/ml)* *S. dysenteria (25 mg/ml)*	[198,199]
Cymbopogon martini (Leaves)	>5000 mg/kg (mice)	500,1000 mg/kg: No toxicity or mortality (mice-28days)	-	*Staphylococcus aureus (250 µg/ml)* *Bacillus subtilis (250 µg/ml)* *Staphylococcus epidermidis (125 µg/ml)* *Streptococcus mutans (500 µg/ml)* *Klebsiella pneumoniae (250 µg/ml)* *Escherichia coli (500 µg/ml)* *Salmonella typhimurium (250 µg/ml)*	[68,200]
Cymbopogon schoenanthus (Aerial parts)	>2000 mg/kg (mice)	10, 100, and 200 mg/kg: Some changes in liver weight Significant changes in urea, glucose, and potassium, at high dos some changes happen the liver and kidney (mice – 28days)	-	*Staphylococcus aureus (2.63 mg/ml)* *Escherichia coli (2.63 mg/ml)*	[67,201]
Cymbopogon winterianus	5.81 g/kg (male mice)	-	-	*Bacillus cereus (2 µl/ml)* *Escherichia coli (6 µl/ml)*	[174,202]

(Leaves)	17.42 g/kg (female mice)			*Micrococcus luteus (2 µl/ml)* *Proteus mirabilis (6 µl/ml)* *Salmonella enteritidis (4 µl/ml)* *Staphylococcus aureus (2 µl/ml)*	
Cyperus rotundus (Rhizomes)	5000 mg/kg (mice)	-	-	*S. aureus (10 mg/ml)* *S. epidermidis (20 mg/ml)* *B. subtilis (10 mg/ml)* *S. yphimurium (40 mg/ml)* *E. coli (>40 mg/ml)* *S. ysenteriae (40 mg/ml)*	[203,204]
Daucus carota (Seeds)	-	-	-	*Gram-positive (0.32–0.64 µl/ml)* *Cryptococcus neoformans (0.16 µl/ml)* *Dermatophytes (0.32–0.64 µl/ml)*	[205]
Eucalyptus camaldulensi (Leaves)	-	-	-	*S. aureus (1500 ppm)* *coli (1500 ppm)* *Acinetobacter baumannii (1000 ppm)* *Proteus vulgaris (2500 ppm)*	[206]
Eucalyptus globulus (Leaves)	1650 mg/kg (mice)	1000 mg/kg: No significant changes were observed (mice - 28days)	-	*E. tarda (7,812 µg/ml)* *V. ichthyoenteri (125,000 µg/ml)* *V. harveyi (7,812 µg/ml)* *P. damselae (31,248 µg/ml)* *S. iniae (31,248 µg/ml)* *S. parauberis (15,624 µg/ml)* *L. garviae (31,248 µg/ml)*	[207,208]
Eugenia florida (Leaves)	-	-	-	*Candida albicans (500 µg/ml)* *Candida krusei (500 µg/ml)* *Candida glabrata (500 µg/ml)* *Candida parapsilosis (500 µg/ml)* *Staphylococcus aureus (500 µg/ml)* *Escherichia coli (1000 µg/ml)*	[209]
Eupatorium adenophorum (Aerial parts)	-	-	-	*Klebsiella pneumoniae (0.40 µl/ml)* *Staphylococcus aureus (0.05 µl/ml)* *Pseudomonas aeruginosa (0.10 µl/ml)* *Xanthomonas oryzae (0.10 µl/ml)* *Erwinia chrysanthemi (0.10 µl/ml)*	[83]
Ferula assa-foetida (Seeds)	-	-	-	*S. typhi (0.093 mg/ml)* *E. coli (0.111 mg/ml)* *S. aureus (0.032 mg/ml)* *B. subtilis (0.027 mg/ml)* *A. niger (0.036 mg/ml)* *C. albicans (0.028 mg/ml)*	[85]
Ferula macrecolea (Aerial parts)	1.79 ml/kg (mice)	0.1, 0.2, 0.4, 0.6 ml/kg: No significant change was observed (mice - 28days)	-	*C. albicans ATCC 5027 (1.6 µg/ml)* *C. albicans ATCC 76616 (3.3 µg/ml)*	[210,211]
Foeniculum vulgare (Seeds)	1.038 ml/kg (mice)	-	-	*E. coli (0.781 µl /ml)* *P. aeruginosa (25 µl /ml)* *A. flavus (0.125 µl /ml)* *A. niger (0.125 µl /ml)* *M. canis (<0.0625 µl /ml)* *S.aureus (0.781 µl /ml)*	[188,212]
Gnaphalium affine (Aerial parts)	-	-	-	*E. coli (1.56 µg/ml)* *S. aureus (0.39 µg/ml)* *B. subtilis (0.78 µg/ml)* *B. cereus (0.78 µg/ml)* *B. laubach (0.78 µg/ml)* *S. typhimurium (0.78 µg/ml)* *S. cerevisiae (0.20 µg/ml)* *A. niger (0.20 µg/ml)* *P. citrinum (0.20 µg/ml)* *R. oryzae (0.20 µg/ml)*	[213]

				A. flavus (0.20 µg/ml)	
Hedychium spicatum (Rhizomes)	-	-	-	*Staphylococcus aureus (15.6 µl/ml)* *Pasteurella multocida (31.3 µl/ml)* *Escherichia coli (15.6 µl/ml)* *Salmonella enterica (7.8 µl/ml)*	[214]
Heracleum sphondylium (Aerial parts)	-	-	-	*E. coli (>44.8 mg/ml)* *P. aeruginosa (22.4 mg/ml)* *S. enteritidis (>44.8 mg/ml)* *Bacillus cereus (1.39 mg/ml)* *L. monocytogenes (11.2 mg/ml)* *S. aureus (11.2 mg/ml)* *C. albicans (22.4 mg/ml)*	[91]
Hyptis suaveolens (Leaves)	-	-	-	*S.aureus (3.12 mg/ml)* *P.aeruginosa (12.5 mg/ml)*	[215]
Juniperus communis (Cones and leaves)	-	-	-	*Staphylococcus aureus (125 µl/ml)* *Streptococcus pyogenes (125 µl/ml)* *Streptococcus agalactiae, Haemophilus influnzae, Corynebacterium spp. Campylobacter jejuni (>500 µl/ml)*	[97,216]
Lavandula angustifolia (Flowers and leaves)	>2 g/kg (mice)	2000 mg/kg: No significant changes were observed (mice – 21days)	-	*Bacillus cereus (3 mg/ml)* *Enterococcus faecalis (2 mg/ml)* *Listeria monocytogenes (1 mg/ml)* *Staphylococcus aureus (2 mg/ml)* *Streptococcus pyogenes (1 mg/ml)* *Escherichia coli (1 mg/ml)* *Klebsiella pneumoniae (1.5 mg/ml)* *Proteus mirabilis (2 mg/ml)* *Pseudomonas aeruginosa (0.5 mg/ml)* *Salmonella enteritidis (1.5 mg/ml)* *Candida albicans (0.75 mg/ml)* *Cryptococcus neoformans (0.75 mg/ml)* *Microsporum canis (0.5 mg/ml)* *Microsporum gypseum (0.25 mg/ml)* *Trichophyton mentagrophytes (0.5 mg/ml)* *Trichophyton rubrum (0.5 mg/ml)* *Aspergillus fumigatus (1 mg/ml)* *Aspergillus niger (2 mg/ml)* *Fusarium oxysporum (1 mg/ml)* *Penicillium citrinum (1 mg/ml)*	[217,218]
Lippia gracilis (Leaves)	4000 mg/kg (mice)	-	-	*F. oxysporum (0.625 mg/ml)* *F. solani (0.625 mg/ml)* *C. gloeosporioides (0.31 mg/ml)* *C. lindemuthianum (0.31 mg/ml)*	[101,219]
Lippia origanoides (Leaves and stems)	3500 mg/kg (mice)	120 mg/kg: No detectable toxic effects a significant char in mean corpuscular volume (MCV) (rats - days)	-	*E. coli (5.263 mg/ml)* *S. aureus (1.316 mg/ml)* *P. aeruginosa (5.263 mg/ml)* *C. albicans (2.631 mg/ml)* *C. parapsilosis (2.631 mg/ml)*	[220] [102,221]
Litsea elliptica (Leaves)	3488.86 mg/kg (rats)	125, 250, 500 mg/kg: No significant change was observed (rats-28days)	-	-	[222]
Matricaria chamomilla (Leaves)	-	-	-	*B. cereus (4 µg/ml)* *E. faecalis (4 µg/ml)* *E. coli (4 µg/ml)* *L. innocua (2 µg/ml)*	[223]

				S. enterica (2 µg/ml) *S. dysenteria (1 µg/ml)* *S. aureus (2 µg/ml)* *S.camorum (2 µg/ml)* *P. mirabilis (4 µg/ml)*	
Melaleuca alternifolia maiden (Leaves)	1.9–2.6 ml/kg (rats)	-	-	*Bacillus subtilis (18.36 µg/ml)* *Enterococcus faecalis (18.45 µg/ml)* *Micrococcus luteus (18.68 µg/ml)* *Staphylococcus aureus (14.26 µg/ml)* *Pseudomonas aeruginosa (12.32 µg/ml)* *Yersinia enterocolitica (15.46 µg/ml)* *Salmonella enterica (16.36 µg/ml)* *Serratia marcescens (16.24 µg/ml)* *Pseudomonas fluorescens (28.5 µg/ml) 9* *Salmonella enterica (25.43 µg/ml)* *Candida albicans (26.76 µg/ml)* *Candida glabrata (29.85 µg/ml)* *Candida krusei (26.32 µg/ml)* *Candida tropicalis (27.46 µg/ml)*	[224,225]
Melaleuca leucadendron (Twigs and flowers)	-	-	-	*B. spizizenii (4 µg/ml)* *S. aureus (8 µg/ml)* *E. aerogenes (4 µg/ml)* *E. coli (4 µg/ml)* *K. pneumoniae (4 µg/ml)* *P. aeruginosa (8 µg/ml)* *S. enterica (8 µg/ml)*	[109]
Melissa officinalis (Leaves)	>2000 mg/kg (mice)	-	100,200mg/kg The kidney has modifications, decrease in glucose, increase in urea in high doses (mice-3month)	*S.aureus (3 µl/ml)* *B.subtilis (2 µl/ml)* *P.aeruginosa (2 µl/ml)* *E.coli (2 µl/ml)* *S.enterica (5 µl/ml)* *C.albicans (3 µl/ml)*	[110,226]
Mentha longifolia (Flowers, leaves, and stems)	470 mg/kg (rats)	-	-	*Salmonella typhimurium (1560 µg/ml)* *E. coli (780 µg/ml)* *Micrococcus luteus (190 µg/ml)* *S. aureus (780 µg/ml)*	[17,227]
Mentha mozaffarianii (Leaves and frits)	>2000 mg/kg (mice and rats)	100 mg/kg: Significant increases in blood glucose, cholesterol, ALT, AST, ALP, and TSH microscopic lesions in some organs were observed 200 mg/kg: Some of the animals died on the 5th day (rats - 28days)	-	*Bacillus subtilis (1.87 mg/ml)* *B. pumulis (1.87 mg/ml)* *Enterococcus faecalis (15 mg/ml)* *Staphylococcus aureus (7.5 mg/ml)* *Staphylococcus epidermidis (7.5 mg/ml)* *Escherichia coli (15 mg/ml)* *Candida albicans (10 mg/ml)*	[114,228]
Mentha piperita (Aerial parts)	1612.45 mg/kg (mice)	-	-	*S. aureus (1 µl/ml)* *S. epidermidis (1 µl/ml)* *S. saprophyticus (1 µl/ml)* *S. pneumoniae (1 µl/ml)* *E. coli (1 µl/ml)*	[229,230]

				E. aerugenes (0.25 µl/ml) *C. albicans (0.125 µl/ml)*	
Mentha pulegium (Aerial parts)	>5000 mg/kg (rats)	-	-	*Salmonella typhimurium (3.8 mg/ml)* *Escherichia coli (3.2 mg/ml)* *Listeria innocua (1.8 mg/ml)* *Listeria monocytogenes (2.6 mg/ml)* *Brochothrix thermosphacta (0.8 mg/ml)* *Pseudomonas putida (1.3 mg/ml)*	[117,231]
Monarda citriodora (Aerial parts)	-	-	-	*Enterococcus faecalis (0.25%v/v)* *Escherichia coli (0.06%v/v)* *Streptococcus pyogenes (0.06%v/v)* *Klebsiella penumoniae (0.06%v/v)* *Staphyloccocus aureus (0.125%v/v)* *Pseudomonas aeruginosa (0.25%v/v)* *Candida albicans (1 % v/v)* *Meyerozyma caribbica (0.125%v/v)* *Saccharomyces cerevisiae (0.125%v/v)*	[232]
Monodora myristica (Seeds)	316 mg/kg (mice)	-	-	*S. aureus (3.0 mg/ml)* *E. coli (3.5 mg/ml)* *K. pneumonia (2.5 mg/ml)* *S. typhi (3.0 mg/ml)*	[233,234]
Myrtus communis (Leaves)	1000 mg/kg (mice)	-	-	*Staphylococcus aureus (1.32 mg/ml)* *Acinetobacter baumannii (2.64 mg/ml)* *Staphylococcus epidermis (6.6 mg/ml)*	[235,236]
Nardostachys jatamansi (Roots)	>3160 mg/kg (mice)	-	-	*M.luteus (2000 µg/ml)* *E.coli (1500 µg/ml)* *S.aureus (3100 µg/ml)* *B.subtilis (1600 µg/ml)* *P.neumnae (2500 µg/ml)*	[122,237]
Nepeta faassenii (Flowers, leaves, and stems)	-	-	-	*Streptococcus mutans (5 mg/ml)* *Streptococcus pyogenes (5 mg/ml)* *Staphylococcus aureus (10 mg/ml)* *Enterococcus faecalis (10 mg/ml)* *Escherichia coli (10 mg/ml)* *Klebsiella pneumoniae (10 mg/ml)* *Salmonella enterica (10 mg/ml)* *Shigella flexneri (10 mg/ml)* *Pseudomonas aeruginosa (10 mg/ml)* *Candida albicans (5 mg/ml)* *Candida parapsilosis (5 mg/ml)*	[123]
Nepeta sintenisii (Aerial parts)	-	-	-	*Bacillus cereus (5.62 µg/ml)* *Bacillus subtilis (1.40 µg/ml)* *Listeria monocytogenes (5.62 µg/ml)* *Staphylococcus aureus (1.40 µg/ml)* *Staphylococcus epidermidis (11.25 µg/ml)* *Lactobacillus plantarum (1.40 µg/ml)* *Lactobacillus sakei (1.40 µg/ml)* *Micrococcus luteus (1.40 µg/ml)*	[124]

				Salmonella typhi (1.40 µg/ml) *Escherichia coli E. coli (22.50 µg/ml)* *Candida albicans (<0.35 µg/ml)*	
Ocimum basilicum (Aerial parts)	3.64 ml/kg (mice)	-	-	*S.aureus (18 µg/ml)* *B.cereus (18 µg/ml)* *E.coli (9 µg/ml)* *P.aeruginosa (9 µg/ml)*	[238,239]
Ocimum gratissimum (Leaves)	intra-peritoneal: 0.27 g/kg (mice) 0.43 g/kg (rats) oral: 1.41 g/kg (mice) 2.29 g/kg (rats)	80, 133, 213 mg/kg: Some significant changes in behaviour, enlargement in some organs, increase in weight, some changes in brain and liver (rats - 30days)	-	*Staphylococcus aureus (0.75 µg/ml)* *Shigella flexineri (3 µg/ml)* *Salmonella enteritidis (3 µg/ml)* *Escherichia coli (6 µg/ml)* *Klebsiella sp. (6 µg/ml)* *Proteus mirabilis (12 µg/ml)* *Pseudomonas aeruginosa (≥24 µg/ml)*	[240,241]
Origanum compactum (Aerial parts)	>5000 mg/kg (rats)	-	-	*P. aeruginosa (1% v/v)* *S. aureus (0.031% v/v)*	[17,242]
Origanum vulgare (Leaves)	-	-	50, 100, 200 mg/kg: Some significant changes (rats - 90days)	*E. coli (0.625 µl/ml)* *P. aeruginosa (1648 µg/ml)* *S. aureus (0.6 µL/mL or 575 µg/ml)* *Three Candida spp. (10–20 µl/ml)*	[17,243]
Rosa damascena (Flowers)	350 mg/kg (mice)	-	-	*S.aureus (500 µg/ml)* *S.epidermidis (500 µg/ml)* *B.subtilis (250 µg/ml)* *Sh.dysenteriae (250 µg/ml)* *P.aeruginosa (62.5 µg/ml)* *E.coli (125 µg/ml)* *C.albicans (500 µg/ml)*	[244,245]
Rosmarinus officinalis (Leaves)	>2000 mg/kg (mice)	1000-2000 mg/kg: Only changes in body weights no histopathologic changes (mice - 28days)	-	*C. albicans (10 µg/ml)* *Saccharomyces cerevisiae (5 µg/ml)* *B. subtilis (10 µg/ml)* *E. coli (0.1% v/v or 40 µg/ml)* *S. aureus (0.1% v/v or 20 µg/ml)*	[17,246]
Satureja hortensis (Aerial parts)	-	-	-	*K. pneumoniae (12.5 µl/ml)* *K. oxytoca (3.125 µl/ml)* *Acinetobacter spp. (0.78 µl/ml)* *S. aureus (3.125 µl/ml)* *E. coli (6.25 µl/ml)* *Staphylococcus spp. (6.25 µl/ml)* *P. mirabilis,S. pyogenes, Enterobacter spp. And Enterococcus spp. (12.5 µl/ml)* *P. aeruginosa (50 µl/ml)*	[247]
Satureja khuzestanica (Aerial parts)	1.79 ml/kg (mice)	0.2,0.4,0.6 ml/kg: No significant toxicity on the liver and kidney tissues as well as on the haematological parameters in the mice (mice - 28days)	-	*Escherichia coli (720 µg/ml)* *Klebsiella pneumoniae (540 µg/ml)* *Salmonella typhimurium (360 µg/ml)* *Pseudomonas aeroginaosa (1080 µg/ml)* *Listeria monocytogenes (270 µg/ml)* *Streptococcus pneumoniae (360 µg/ml)* *Staphylococcus aureus (360 µg/ml)* *Bacillus cereus (540 µg/ml)* *Bacillus subtilis (540 µg/ml)* *Candida albicans (180 µg/ml)* *Candida tropicalis (270 µg/ml)*	[138,248]

				Rhodotorula rubra (130 µg/ml) *Rhodotorula mucilaginosa (90 µg/ml)*	
Satureja montana (Aerial parts)	-	-	-	*C. albicans (5 µg/ml)* *S. cerevisiae (5 µg/ml)* *E. coli (0.05% v/v or 40 µg/ml)* *S. Typhimurium (0.05% v/v)* *S. aureus (0.013% v/v or 5 µg/ml)* *L. monocytogenes (0.05% v/v)*	[17]
Syzygium aromaticum (Flowers)	-	-	-	*C. jejuni (0.05% v/v)* *E. coli (0.04% v/v)* *L. monocytogenes (0.03% v/v)* *S. enteritidis (0.04% v/v)* *S. aureus (0.04% v/v)*	[17]
Tagetes elliptica (Leaves)	-	-	-	*S.aureus (5.29 µg/ml)* *E.coli (10.57 µg/ml)* *S.infantis (10.57 µg/ml)*	[249]
Tagetes erecta (Leaves and flowers)	-	-	-	*S.aureus (20.83 µg/ml)* *K.pneumonia (41.67 µg/ml)* *P.aeroginosa (93.33 µg/ml)* *X.oryzae (83.38 µg/ml)*	[144]
Tanacetum parthenium (Flowers and leaves)	2130 mg/kg (rats)	1000 mg/kg: No significant changes (rats-28days)	-	*Citrobacter amalonaficus (25 µl/ml)* *Proteus vulgaris (20 µl/ml)* *Serratia marcescens (25 µl/ml)* *Enterobacter aerogenes (38 µl/ml)* *Staphylococcus aureus (8 µl/ml)* *Staphylococcus subtilis (4 µl/ml)* *Bacillus megaterium (20 µl/ml)* *Bacillus cereus (16 µl/ml)*	[145,250]
Thymus schimperi (Flowers and leaves)	1284.2 mg/kg (rats)	65, 130,260 mg/kg: A significant decrement WBC counts and a significant increase of MCV in high dose (260 mg/kg) (rats - 28days)	-	*Tricophyton spp.* *Microsporum spp.* *(0.08 µl/ml to 0.31 µl/ml)*	[147,251]
Thymus vulgaris (Leaves)	2000 mg/kg (rats)	100,250 mg/kg: No significant changes 500 mg/kg: severe changes in the lung (rats - 28days)	-	*C. albicans (1 µg/ml)* *E. coli (0.05% v/v or 2 µg/ml)* *L. monocytogenes (0.02% v/v)* *S. aureus (0.02% v/v or 5 µg/ml)* *C. jejuni (0.04% v/v)* *B. subtilis (2 µg/ml)* *S. enteritidis (0.04% v/v)*	[17,252]
Trachyspermum ammi (Fruits)	2294 mg/kg (rats)	1000 mg/kg: No significant change (rats -23 and -45days)	-	*Bacillus cereus (2 µl/ml)* *Enterococcus faecalis (2 µl/ml)* *Staphylococcus aureus (0.5 µl/ml)* *Pseudomonas aeruginosa (4 µl/ml)* *Escherichia coli (0.5 µl/ml)* *Candida albicans (0.5 µl/ml)* *Aspergillus flavus (0.5 µl/ml)*	[253,254]
Vitex agnus (Leaves and friuts)	> 5000 mg/kg (mice)	1000, 2000, 3000,5000 mg/kg: No significant change (mice - 28days)	-	*B. subtilis (890 µg/ml)* *S. aureus (219 µg/ml)* *E. coli (219 µg/ml)* *S. typhimurium (44.5 µg/ml)* *B. subtilis (445-890 µg/ml)* *M. flavus (445 µg/ml)* *A. alternata (44.5-130 µg/ml)* *T. viride (219–267 µg/ml)*	[152,255]
Vitex negundo (Leaves)	>2000 mg/kg (rats)	-	250, 500, 1000 mg/kg: No significant change	*Staphylococcus aureus (>64 µg/ml)* *Escherichia coli (64 µg/ml)* *Pseudomonas aeruginosa (>64 µg/ml)*	[256,257]

			(rats-13weeks)	*Streptococcus faecalis (>64 µg/ml)* *Micrococcus catarrhalis (>64 µg/ml)* *Candida albicans (4 µg/ml)* *Cryptococcus neoformans (64 µg/ml)* *Candida parapsilosis (>64 µg/ml)* *Candida tropicalis (>64 µg/ml)* *Trichophyton rubrum (32 µg/ml)* *Fonsecaea compacta (>64 µg/ml)* *Microsporum gypseum (64 µg/ml)* *Aspergillus fumigatus (64 µg/ml)*	
Zingiber officinale (Rhizomes)	8660 mg/kg (mice)	-	-	*S. aureus (0.25 mg/ml)* *S. epidemidis (0.5 mg/ml)* *E. faecalis (1.0 mg/ml)*	[162,258]

*MIC: Minimum inhibitory concentrations ** Reference
Sub-acute: All data obtained from articles which toxicity researches performed in the range of 20 - 30 days
Chronic: All data obtained from articles which toxicity researches performed in approximately 90 days and more

3. DISCUSSION

Essential oils are natural gifts with various applications in different industries. They are widely used in the food industry due to their biological effects, such as antimicrobial, antioxidant, and anti-aflatoxin properties. The toxicity of essential oils should be thoroughly considered, particularly in relation to their application as food preservatives. The molecular interactions of essential oils with pathogens should be explored to understand the mechanism of action of volatile oils as antimicrobial agents.

3.1 Molecular interaction

Studies on the antimicrobial activity of essential oils indicate that these materials target oxidative pathways in bacteria because, after exposure to bacterial cells, they produce many more oxidative stress-sensitive proteins such as glycyl radical cofactor, catalase-peroxidase, DNA mismatch repair protein, clpB, btpG, and luxS. These changes indicate that oxidative stress in cells is increased, resulting in membrane lipid peroxidation, which leads to cell content leakage and, eventually, the cells' death. In addition, the increase in oxidative stress causes damage to proteins and genetic structures and removes the ability of bacteria to recover. [259] Essential oils have an anti-aflatoxigenic effect by affecting parts of the fungi gene and inhibiting or reducing the gene's transcription. [42,260]

Terpenes such as p-cymene have a hydrocarbon structure without an influential functional group, and when used alone, they have a negligible antimicrobial effect. p-Cymene is one of the most abundant compounds in essential oils. This compound attaches firmly to the membrane, making it uneven and causing a change in its enthalpy and melting temperature. By affecting the membrane potential, it changes the movement of flagellated cells because their movement depends on the membrane potential and protons of the cell.[8,17,25]

The aldehyde group of cinnamaldehyde can covalently bond with DNA proteins and disrupt their normal function, but it has three forms for its antimicrobial effect. At low doses, it interferes with the cell's cytokinesis and with less essential enzymes and disrupts its division. At sublethal doses, it affects ATPase enzymes; at high and lethal doses, it causes damage to the membrane. In fungi, it interferes with division by having a non-competitive inhibitory effect on the enzymes required to build the wall. [8,17,25]

Terpenoids, which have a structure similar to terpenes, have oxygenated and phenolic groups that are essential for their antimicrobial effects. Thymol is a monoterpenoid that interacts with the inner and outer membranes, changes the permeability, and causes ions and cell compounds to leak. Some changes in the membrane lipid profile occur at concentrations that are not immediately lethal to the cell, known as sublethal concentrations. By interacting with the outer membrane proteins, thymol changes its shape. Its effect on citrate metabolism and enzymes involved in ATP production reduces the cell's ability to recover. Interference with the outer membrane causes the release of lipopolysaccharides, which can also cause the growth of gram-negative bacteria. In yeast and fungi, thymol induces cell lysis in proliferating cells and causes Ca^{2+} bursts, similar to those during stress and nutrient starvation. Thymol in yeast causes a disturbance in the pH gradient, regardless of the glucose level and leakage of ions. [8,17,22,25]

3.2 Main compounds of essential oils

Since phytochemicals in essential oils play an important role in their biological effects, we tabulated their dominant ingredients. We extracted the dominant compounds from the plants with MIC values of µg/ml. These plants included *Bowsellia papyrifera, Bunium persicum, Cedrus deodara, Matricaria chamomilla, Melaleuca altemifolia, Melaleuca leucadendron, Nepeta sintenisii, Ocimum gratissimum, Satureja montana, Tagetes elliptica,* and *Thymus vulgaris*. The main phytochemicals in the mentioned plants were α-terpineol, β-terpineol, γ-terpineol, and terpene-4-ol.

Considering the data gathered in Table 2, the efficacy of terpineol cannot be denied. For instance, in two plants' essential oils, *Myrtus communis* and *Melaleuca leucadendron*, 1,8-cineole was predominant. Still, in *Melaleuca leucadendron*, the second substance was terpineol, and the MIC value of *Melaleuca leucadendron* was a thousand times less than that of *Myrtus communis*, which shows the efficacy of terpineol as an antimicrobial substance. Terpineol is a monoterpenoid, and as discussed in the mechanism of action, the alcohol group of its structure is key to its antimicrobial activity.[17]

Of these 11 plants, β-farnesene was present in two plants, which showed high antimicrobial activity in MIC tests. β-Farnesene belongs to a terpene family named sesquiterpenes, and as stated in the mechanism of action, terpenes show better activity against gram-positive bacteria than against gram-negative bacteria. β-farnesene showed great antimicrobial activity against both, but it had a higher inhibitory activity against gram-positive bacteria.

Satureja montana and *Thymus vulgaris* are two plants whose main compounds are thymol and carvacrol. Both are monoterpenoids with similar structures. They differed only in the location of the alcohol group. Similar to terpineol, the chemical group is key to its antimicrobial activity. There is a lack of studies on chemicals such as tagetenone, which comprises most essential oils with a high MIC value. Studying their structure and mechanism of action can improve our understanding of the potential antimicrobial activity of essential oils.

Of these 14 essential oils, terpineol and its isomers were present in seven. As discussed previously, terpineol shows promise as an antimicrobial agent. However, it was also present in half of the essential oils, which showed some toxicity in the animal tests. This highlights the need for more studies on its possible toxic effects and underscores its potential as a key area for future antimicrobial research.

Three of these essential oils contained p-cymene, all of which showed signs of toxicity. However, a recent study [261] found no adverse toxic effects of p-cymene. This underscores the need for further research on the potentially toxic effects of p-cymene, which could provide valuable insights into the safety of essential oils.

Six of these essential oils, either alone or together, contained thymol, carvacrol, menthone, and limonene, which have similar basic structures. This raises the possibility of toxicity, especially because some studies have shown that thymol causes cellular damage. [262]

Among the phytochemicals mentioned above, the toxicity of eugenol has been extensively studied, and studies have indicated the risk of using eugenol. Some health-threatening evidence has been observed in some cases, such as cytotoxicity and genotoxicity. [263]

3.3 Potential toxicity of essential oils

Based on the information presented in Table 3, the essential oils of eight plants, *Acorus calamus, Cedrus deodara, Chenopodium ambrosioides, Cuminum cyminum, Foeniculum vulgare, Mentha longifolia, Monodora myristic* and *Rosa damascena*, had an LD_{50} value of less than 1 g/kg, indicating their potency to be toxic. Those for whom sub-acute toxicity was performed showed the same toxic potency. Several essential oils showed concernable toxicity on subacute tests, which are *Ageratum conyzoides, Chenopodium ambrosioides, Citrus aurantifolia, Thymus vulgaris, Bunium persicum, Thymus schimperi,* and *Ocimum gratissimum*. However, despite the toxicity, only *Cedrus deodara, Thymus vulgaris, Bunium persicum,* and *Ocimum gratissimum* showed exceptional MIC values in the range of µg/ml, and the MIC values of others were in the range of mg/ml.

3.4 Biologically-active compounds of essential oils

Table 4 shows the dominant components of the essential oils, which could be responsible for their pharmacological activities and toxicity.

Table 4. Biologically active compounds of essential oils

Compound name	Type of the compound	Functional groups	Properties	Toxicity	References
Limonene	Monocyclic monoterpene	Ketone	Antibacterial, antifungal, antiviral, and antioxidant	LD_{50}: 5200 mg/kg (Rat) Carcinogenic properties in animals Safe in terms of mutagenicity	[264-267]
p-Cymene	Monocyclic monoterpene Alkyl isoprenoid aromatic	Aromatic	Antimicrobial, antitumor antioxidant, antidiabetic anti-aflatoxin, and anti-inflammatory	LD_{50}: 4750 mg/kg (Rat)	[261,268] [269,270]
γ-Terpinene	Aromatic monoterpene	-	Antimicrobial, antioxidant, and anti-inflammatory	LD_{50}: >2000 mg/kg (Rat)	[270-272]
Linalool	Alcoholic and aromatic monoterpene	Hydroxyl	Antimicrobial, antioxidant, anti-inflammatory, and antiparasitic feature against Plasmodium and Leishmania	LD_{50}: 2790 mg/kg (Rat) minimal irritation, and lack of mutagenicity	[270,273,274]
Thymol	Monoterpenoid phenol with an alcoholic structure	Aromatic and Hydroxyl	Antibacterial, antifungal, antioxidant, anti-carcinogenesis, anti-aflatoxigenic, and anti-inflammatory	LD_{50}: 980 mg/kg (Rat)	[270,275,276]
Caryophyllene	Bicyclic sesquiterpene	-	Antimicrobial, antioxidant, and anti-inflammatory	LD_{50}: >5000 mg/kg (Rat)	[277-279]
1,8-Cineole	Saturated monoterpene	Ether	Bactericidal, anti-bacterial, anti-inflammatory, anti-oxidative, and anti-cancer	LD_{50}: 2480 mg/kg (Rat)	[280-283]

3.5 Investigating plant families that are abundantly mentioned in Table 2

The plants listed in Tables 2 and 3 belong to different plant families. The Lamiaceae, Asteraceae, Apiaceae, Myrtaceae, and Rutaceae families are seen more frequently than other plant families. We examined these plant families in Table 5.

Table 5. Important plant families, their characteristics, properties, and toxicity

Plants family	Properties	Important plants of mentioned family	Useful characteristics	Toxicity	Reference
Lamiaceae	236 Genera 7,000 species	Basil, mint, sage, savory, oregano, thyme, and lavender	Anti-inflammatory, analgesic, anti-bacterial, antioxidant, antimicrobial, antimalarial, anticancer	Not show much toxicity	[284-286]
Asteraceae	1,500 Genera 20,000 species	Yarrow, chicory, sunflower, st. john's wort, and roman chamomile	Antioxidant, anti-inflammatory, antimicrobial, anti-mutagenic	Not show much toxicity	[287]
Apiaceae	400 Genera 3,700	Carrots, celery,	Anti-tumor,	Not show much	[288,289]

	species	parsley, anise, fennel, dill, cumin, black cumin, and chives	antimicrobial, anti-inflammatory, analgesic, antioxidant, antifungal	toxicity minor changes in chronic and sub-chronic toxicity	
Myrtaceae	150 Genera 5,800 species	Myrtle, eucalyptus, syzygium, eugenia, clove, feijoa, and rainforest cherry	Antioxidants, antiviral, antibacterial, antifungal, anti-inflammatory anticancer	Not show much toxicity more studies suggested	[290,291]
Rutaceae	150 Genera 900 species	Oranges, grapefruits, lemons, and limes	Antimicrobial, antioxidant, anti-inflammatory	Not show much toxicity	[292-294]

3.6. Comparing the toxicity of essential oils that have MIC in range µg/ml

According to the data in Table 3 and as mentioned before, some plants have perfect MICs, which means that plants with a lower concentration can prevent many microorganisms that are harmful to the body. Now, we will explore the toxicity of these plants to see whether or not it is cost-effective to use their essential oils. There is a lack of information on the toxicity of plants such as *Boswellia papyrifera, Daucus carota, Eupatorium adenophorum, Gnaphalium affine, Matricaria chamomilla, Melaleuca Leucadendron, Monarda citriodora, Nepeta sintenisii,* and *Syzygium aromaticum*. More studies should be conducted to identify the toxicity status of these plants. If deemed suitable after examining other aspects, the essential oils of these plants could prove to be valuable assets in the industry. *Bunium persicum, Carum carvi, Cedrus deodara, Cuminum cyminum, Cymbopogon winterianus, Ferula macrecolea, Foeniculum vulgare, Melissa officinalis, Ocimum gratissimum, Thymus schimperi, Thymus vulgaris,* and *Trachyspermum ammi* are among the plants whose MIC is in the order of mg/l. However, their toxicity is in the range of mg/l, which means there is a large gap between these two properties of the essential oils of these plants. These plants can be effectively used by considering all other aspects and characteristics.

Based on available data, *Mentha piperita*, a widely popular herb, exhibits a significant gap between its MIC and toxicity. This is a promising sign, suggesting that if no other issues or limitations are associated with this plant, it could be a safer and more practical option for industrial use, particularly in the food and pharmaceutical sectors. The names of some plants that can be seen in the tables are not given in this section; this does not mean that they do not have a suitable MIC or have shown high toxicity. It is worth mentioning that it is true that they have not demonstrated excellent MICs, similar to the mentioned plants, but they have shown good MICs in dealing with microbial agents. Changing the composition of these essential oils or other substances or adding another series of compositions can shift the level of toxicity and MIC in a way that favors the MIC.

3.7. Comparing the antimicrobial and antifungal potency of essential oils with antibiotics

A series of antibiotics are used for each microorganism, some of which are first-line drugs. Table 6 compares the MIC levels of common antibiotics for each microorganism with the MIC level of plant essential oils effective against the same microorganism.

Table 6. A comparison of the antimicrobial and antifungal potency of essential oils with antibiotics

Microorganism name	Effective antibiotics and antifungals	MIC*	Most effective essential oils	MIC*	R**
Aspergillus spp.	Caspofungin	0.008 - 0.061 µg/ml	*Cedrus deodara*	1 - 10 µg/ml	[295]
Bacillus cereus	Imipenem and Levofloxacin	≤ 5 µg/ml	*Matricaria chamomilla,*	5 µg/ml	[296]
			Nepeta sintenisii,	5 µg/ml	
	Other antibiotics	> 10 µg/ml	*Boswellia papyrifera,*	5 µg/ml	
			Cedrus deodara,	< 1 µg/ml	
			Bunium persicum	< 1 µg/ml	
Campylobacter jejuni	Erythromycin	2 µg/ml	*Thymus vulgaris*	2 µg/ml	[297]
	Other antibiotics	> 2 µg/ml			
Candida albicans	Micafungin	0.06 µg/ml	*Melaleuca altemifolia,*	25 - 30 µg/ml	[298]
	Other antifungals	0.06 - 16 µg/ml	*Nepeta sintenisii*	0.35 µg/ml	
Enterococcus faecalis	Teicoplanin and Amoxicillin/	≤0.25 µg/ml	*Boswellia papyrifera,*	2 µg/ml	[299]
			Matricaria chamomilla,	4 µg/ml	

	Clavulanate		*Melaleuca altemifolia*	18 µg/ml	
	Other antibiotics	0.25 - 8 µg/ml			
Escherichia coli	In sensitive strains:		*Boswellia papyrifera, Cedrus deodara, Matricaria chamomilla, Melaleuca leucadendron, Nepeta sintenisii, Satureja montana, Tagetes elliptica, Thymus vulgaris, Ocimum gratissimum*		[300]
	Norfloxacin and Ciprofloxacin	0.01 – 0.02 µg/ml			
	Other antibiotics	1 - 10 µg/ml		1.5 - 40 µg/ml and most of them	
	In resistant strains:			4 µg/ml	
	Ceftazidime	7.5 µg/ml			
	Other antibiotics	30 - 240 µg/ml			
Proteus mirabilis	Ciprofloxacin	2 µg/ml	*Boswellia papyrifera, Matricaria chamomilla, Ocimum gratissimum*	16 µg/ml	[301]
	Imipenem	4 µg/ml		4 µg/ml	
	Other antibiotics	2 - 256 µg/ml		12 µg/ml	
Rhizopus oryzae	Amphotericin B	3 µg/ml	*Cedrus deodara*	0.2 µg/ml	[295]
	Other antifungals	16 µg/ml			
Salmonella	Ciprofloxacin	0.125 - 4 µg/ml	*Nepeta sintenisii*	1.4 µg/ml	[302]
	Other antibiotics	≫ 4 µg/ml			
Staphylococcus aureus	Rifampicin and Gentamycin	0.25 µg/ml	*Boswellia papyrifera, Cedrus deodara, Matricaria chamomilla, Melaleuca altemifolia, Melaleuca leucadendron, Nepeta sintenisii, Satureja montana, Tagetes elliptica, Thymus vulgaris, Bunium persicum, Ocimum gratissimum*		[303]
	Quinupristin/ Dalfopristin	0.25 µg/ml			
	Other antibiotics	0.25 - 32 µg/ml		0.25 - 15 µg/ml	

*MIC written in the table depending on the type of microorganism varies between antibiotics and antifungal agents.
**References

3.8. The impact of processing and storage on the toxicity of essential oils

Chemical compounds are sensitive to different environmental factors owing to the formation of various materials with different functions and characteristics. These environmental factors include light, oxygen, temperature, humidity, and pH. Light provides the energy needed to excite electrons and causes changes in the molecular structure. However, temperature changes have significant effects on the structure and microbial activities. As a result of pH changes, some compounds change, and the foundations of the substances are changed, which cannot show its effect as before.[304]

During storage and processing, owing to the time-consuming nature of these operations, changes have occurred that facilitate the oxidation process, and the oxidation of the substance is equal to the loss of the property and proper performance of the substance in question and then by turning into radicals. Radicals can cause significant damage to cell structures and various problems, including cancer. For example, essential oils prepared for a long time, especially oxidized terpenoids, cause skin irritation, whereas non-oxidized terpenoid compounds have no or minimal skin irritation effects. The unsaturated parts can react with air and create a variety of harmful substances, including peroxyl radicals. These radicals can have various effects and induce a series of reactions. These radicals can also react with each other to form multiple compounds, such as alcohols, aldehydes, and others, which interact with the primary structure. However, some of these interactions remain unclear.[305] Therefore, it is vital to check the toxicity of essential oils in detail, and the changes that occur over time during the processing, storage, and distribution processes are especially worthy of attention.

3.9. Safety data requirement for essential oil as food preservatives

When considering the addition of substances to food, whether as preservatives or additives, it is imperative to conduct comprehensive studies to assess both short- and long-term toxicity in animals. This is crucial for mitigating potential unnecessary and adverse side effects. Preservatives are utilized to prolong the shelf life of foods and prevent spoilage; however, their properties can evolve over time and under varying conditions. Even after assessing their toxicity, further research is necessary to comprehensively understand their evolution and interactions with other substances, preservatives, and additives. This issue is multifaceted, particularly when considering food safety and public health.[305,306]

3.10. Regulatory frameworks for a safe and effective use of essential oils a critical appraisal

Regulations and guidelines play a crucial role in safeguarding the quality and safety of the ingredients used in food and health products. These measures are essential to ensure their appropriate use and to minimize unnecessary side effects, thereby protecting public health. At the international level, the World Health Organization (WHO) plays a key role in setting regulations and guidelines for assessing the quality and safety of materials used in food and health products. It provides comprehensive information about many online materials, which is updated monthly. In addition to the WHO, every country has organizations that monitor and evaluate the quality and safety of objects in the food industry. Even in some countries such as Canada and Japan, the use of essential oils is regulated, and to comply with these regulations, complete information about the source, potency, medicinal ingredients, non-medicinal ingredients, dosage, etc., needs to be presented to the related organization.

The JECFA (Joint FAO/WHO Expert Committee on Food Additives) committee, a joint initiative by the WHO and FAO, has been established to use EOs as preservatives. This committee evaluates the safety of food additives and publishes the findings. Organizations such as FAOLEX also provide information about the regulations and guidelines for foods and herbal ingredients.[307]

3.11. Risk assessment methods for evaluating the toxicity of essential oils

Risk assessment is vital for minimizing negative impacts and health risks associated with various factors. Different methods have been recommended to control and effectively achieve these risks. A common approach involves a four-step process.

3.11.1. Hazard identification:

This step involves evaluating a chemical's potential toxicity and examining documents detailing its effects to assess the health risk assessments of using essential oils in quantitative metrics. This method considers the chronic and sub-chronic risks of using certain chemicals combined in farm animals, which incorporates various toxicological information about the tested animals.[308]

3.11.2. Dose-response analysis:

This is a complex and intellectually stimulating step, as it aims to establish the relationship between a substance's dose and its potential effects. It involves extrapolating results from experimental animals to humans and accounting for individual differences, which can significantly influence the results.

3.11.3. Exposure quantification:

This step involves evaluating the chemical dosage to which different groups will be exposed based on their geographical locations, lifestyles, and other factors. It provides a range of values and identifies vulnerable groups.

3.11.4. Risk characterization:

The final step involves combining the results from the previous three steps to estimate risk. This risk varies among populations. However, it is important to note that risk assessment is often used to protect the group at greatest risk, emphasizing ethical considerations in the process.

It's essential to recognize that risk assessment is a dynamic field that demands continuous feedback and improvement. This ongoing process of feedback and adjustments is not only important but also a shared commitment to refine the process and achieve more accurate risk estimates, considering the various factors that can influence the results.[309] Several tests can be performed to evaluate the risk of using essential oils in different industries, such as other volatile materials. The skin irritation test stands out because of the nature of essential oils and the potential skin exposure to these materials. This test, which can be conducted using methods such as in vivo semi-occlusive single-patch testing and clinical tests in specific numbers and ranges of age, is of paramount importance.[310]Another test is the mucous membrane irritation test, which requires specific attention and comprehensive study because these materials can be exposed after oral usage. A modified HET-CAM assay can be performed at an irritation threshold concentration (ITC).[311]

Another test is the phototoxicity test. Because essential oils are volatile, the skin and eyes can be exposed to the material and become sensitive to light after some changes. Methods such as the 3T3 neutral red uptake phototoxicity test can be used to evaluate this risk. Many toxicology tests, such as acute and subacute toxicity tests, must be performed to assess the materials' severe side effects and prevent them from

occurring. These tests are mainly performed on animals such as rats in the laboratory in specific terms over a particular time range. [171]

Mutagenic tests are of massive importance because their effects occur over the long term, and the source of their impact cannot be diagnosed and related to these effects, which makes them a hidden and dangerous side effect. One of these test methods involves exposing a Drosophila larva to essential oil and evaluating the mutagenic effects in the larva.[312] In addition, many analytical methods are required to ensure the safety of these chemicals. Analysis of centrifuged blood serum of the animal test for Haematological and biochemical parameters, analysis of biochemical parameters such as specific amounts of metabolites and electrolyte proteins, and hematology, histology, and tissue embedding analysis are some of the safety assessment processes of using food additives such as essential oils.[180]

3.12. Limitations of the study and suggestions for future research

There is a significant lack of information on the toxicity of plant essential oils, which causes several limitations in the practical and industrial use of these materials. For the effective use of these materials as preservatives, it is crucial to understand the three types of toxicities that may manifest at different time intervals. Regarding the chemical compounds that were discussed and examined, depending on the geographical area, climatic conditions, and many other factors, the percentage of these compounds in essential oil varies. Of course, the main ingredients are, in most cases, the same as the declared compounds, but the percentage of the composition of the substances varies, which requires further investigation into the use of these plants. When used together or in combination with other preservatives, these essential oils present the potential for synergistic effects. Although promising, such effects also pose the risk of unpredictable outcomes. Therefore, further studies, especially in the field of toxicity, are necessary for a more effective and safe use of these essential oils. This call for more research should motivate us to investigate this important study area further.

4. CONCLUSION

Plants' essential oils are one of the most important natural substances with many uses in various industries, especially in the food industry as a preservative. These essential oils have different properties, such as antimicrobial, antioxidant, and anti-aflatoxin activities, which can prevent the growth and activity of many microorganisms inside food. In addition, the chemical structures inside these compounds cause biological effects in essential oils. MIC is one of the parameters that show the level of antimicrobial properties. By examining this factor, essential oils are potentially active compounds in dealing with pathogens, and in some cases, they even work better than antibiotics and antifungals. Despite all these cases, the toxicity of these essential oils remains a problem. In the case of essential oils of some plants, despite their unique and practical properties, due to oral toxicity occurring in small doses, their use in the food industry is limited. Owing to the different characteristics of essential oils, using these plant compounds in the food industry as preservatives should be increased. However, the toxicity of these compounds should also be considered, and further in-depth studies are required.

5. MATERIALS AND METHODS

5.1. Inclusion criteria from databases

In this systematic review, we concentrated on pertinent studies using specific MeSH keywords across databases, such as WOS, Scopus, PubMed, Embase, and Google Scholar. Keywords encompassed essential oil, food preservatives, antimicrobials, toxicity, and MIC. We carefully reviewed the retrieved articles to ensure they met the inclusion criteria. This screening process involved thoroughly examining the titles, abstracts, and keywords. Only articles that directly addressed the intersection of these keywords were included in the dataset. Irrelevant, duplicate, and unpublished references, as well as manuscripts without full text, were excluded.

5.2. Quality Assessment

To preserve the integrity of our research, we implemented stringent quality assessment criteria for the chosen articles. This process involved evaluating the peer-reviewed papers for their methodological robustness, relevance, and reliability.

5.3. Synthesis of Information

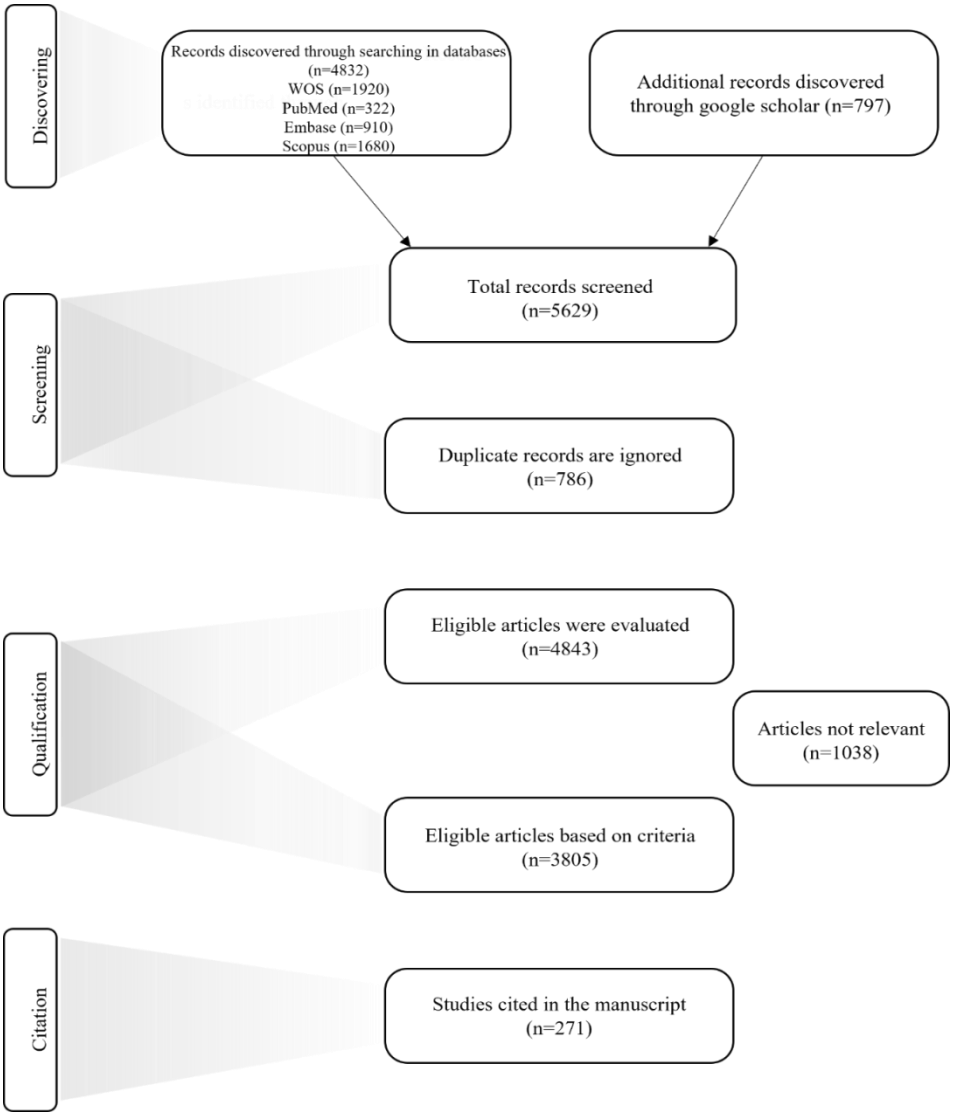

Figure 4. The flow chart of the search strategy

The consolidated data from 312 selected articles was the foundation for our research and analysis. This methodological strategy guaranteed a comprehensive review, enabling us to extract significant insights from the current literature and enhance our understanding of potential keyword interactions. Figure 4 illustrates the search strategy used by the authors.

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REFERENCES

[1] Rawat S. Food Spoilage: Microorganisms and their prevention. Asian J Plant Sci Res. 2015; 5(4): 47-56.
[2] Sahu M, Bala S. Food processing, food spoilage and their prevention: An overview. Int J Life-Sci Sci Res. 2017; 3(1): 753-759. https://doi.org/10.21276/ijlssr.2017.3.1.1

[3] Sherawat M, Rahi RK, Gupta V, Neelam D, Sain D. Prevention and control of food spoilage: an overview. Int J Pharm Biol Sci. 2021; 11(1): 124-130. https://doi.org/10.21276/ijpbs.2021.11.1.1
[4] Silva MM, Lidon F. Food preservatives–An overview on applications and side effects. Emirates J Food Agric. 2016: 366-373. https://doi.org/10.9755/ejfa.2016-04-351
[5] Anand S, Sati N. Artificial preservatives and their harmful effects: looking toward nature for safer alternatives. Int J Pharm Sci Res. 2013; 4(7): 2496-2501. https://doi.org/10.13040/IJPSR.0975-8232.4(7).24960-01
[6] Sharma S. Food preservatives and their harmful effects. Int J Sci Res Pub. 2015; 5(4): 1-2.
[7] Kumari PK, Akhila S, Rao YS, Devi BR. Alternative to artificial preservatives. Syst Rev Pharm. 2019; 10: 99-102. https://doi.org/10.5530/srp.2019.1.17
[8] Mihai AL, Popa ME. Essential oils utilization in food industry-a literature review. Sci Bull Ser F.2013; 17: 187-192.
[9] Salanță LC, Cropotova J. An update on effectiveness and practicability of plant essential oils in the food industry. Plants. 2022; 11(19): 2488. https://doi.org/10.3390/plants11192488
[10] Raut JS, Karuppayil SM. A status review on the medicinal properties of essential oils. Ind Crop Prod. 2014; 62: 250-264. https://doi.org/10.1016/j.indcrop.2014.05.055
[11] Wojtunik-Kulesza KA. Toxicity of selected monoterpenes and essential oils rich in these compounds. Molecules. 2022; 27(5): 1716. https://doi.org/10.3390/molecules27051716
[12] Loying R, Gogoi R, Sarma N, Borah A, Munda S, Pandey SK, Lal M. Chemical compositions, in-vitro antioxidant, anti-microbial, anti-inflammatory and cytotoxic activities of essential oil of *Acorus calamus* L. rhizome from North-East India. J Essent Oil Bear Plants. 2019; 22(5): 1299-1312. https://doi.org/10.1080/0972060X.2019.1696236
[13] Shukla R, Singh P, Prakash B, Dubey NK. Efficacy of A corus calamus L. essential oil as a safe plant-based antioxidant, A flatoxin B 1 suppressor and broad spectrum antimicrobial against food-infesting fungi. Int J Food Sci Technol. 2013; 48(1): 128-135. https://doi.org/10.1111/j.1365-2621.2012.03168.x
[14] Kouame BKFP, Toure D, Kablan L, Bedi G, Tea I, Robins R, Chalchat JC, Tonzibo F. Chemical constituents and antibacterial activity of essential oils from flowers and stems of A*geratum conyzoides* from Ivory Coast. Rec Nat Prod. 2018; 12(2):160-168. http://doi.org/10.25135/rnp.22.17.06.040
[15] Chahal R, Nanda A, Akkol EK, Sobarzo-Sánchez E, Arya A, Kaushik D, Dutt R, Bhardwaj R, Rahman MH, Mittal V. *Ageratum conyzoides* L. and its secondary metabolites in the management of different fungal pathogens. Molecules. 2021; 26(10): 2933. https://doi.org/10.3390/molecules26102933
[16] Satyal P, Craft JD, Dosoky NS, Setzer WN. The chemical compositions of the volatile oils of garlic (*Allium sativum*) and wild garlic (*Allium vineale)*. Foods. 2017; 6(8): 63. https://doi.org/10.3390/foods6080063
[17] Hyldgaard M, Mygind T, Meyer RL. Essential oils in food preservation: mode of action, synergies, and interactions with food matrix components. Front Microbiol. 2012; 3: 12. https://doi.org/10.3389/fmicb.2012.00012
[18] Zhou C, Li C, Siva S, Cui H, Lin L. Chemical composition, antibacterial activity and study of the interaction mechanisms of the main compounds present in the *Alpinia galanga* rhizomes essential oil. Ind Crop Prod. 2021; 165: 113441. https://doi.org/10.1016/j.indcrop.2021.113441
[19] Alves-Silva JM, Zuzarte M, Girão H, Salgueiro L. The role of essential oils and their main compounds in the management of cardiovascular disease risk factors. Molecules. 2021; 26(12): 3506. https://doi.org/10.3390/molecules26123506
[20] Kerdudo A, Ellong EN, Burger P, Gonnot V, Boyer L, Chandre F, Adenet S, Rochefort K, Michel T, Fernandez X. Chemical composition, antimicrobial and insecticidal activities of flowers essential oils of *Alpinia zerumbet* (Pers.) BL Burtt & RM Sm. from Martinique Island. Chem Biodivers. 2017; 14(4): e1600344. https://doi.org/10.1002/cbdv.201600344
[21] Be Tu PT, Tawata S. Anti-oxidant, anti-aging, and anti-melanogenic properties of the essential oils from two varieties of *Alpinia zerumbet.* Molecules. 2015; 20(9): 16723-16740. https://doi.org/10.3390/molecules200916723
[22] Chouhan S, Sharma K, Guleria S. Antimicrobial activity of some essential oils—present status and future perspectives. Medicines. 2017; 4(3): 58. https://doi.org/10.3390/medicines4030058
[23] Altameme HJ, Hameed IH, Hamza LF. *Anethum graveolens*: Physicochemical properties, medicinal uses, antimicrobial effects, antioxidant effect, anti-inflammatory and analgesic effects: A review. Int J Pharm Qual Assur. 2017; 8(3): 88-91. https://doi.org/10.25258/ijpqa.v8i03.9569
[24] Bailen M, Julio LF, Diaz CE, Sanz J, Martínez-Díaz RA, Cabrera R, Burillo J, Gonzalez-Coloma A. Chemical composition and biological effects of essential oils from *Artemisia absinthium* L. cultivated under different environmental conditions. Ind Crop Prod. 2013; 49: 102-107. https://doi.org/10.1016/j.indcrop.2013.04.055
[25] Pandey AK, Kumar P, Singh P, Tripathi NN, Bajpai VK. Essential oils: Sources of antimicrobials and food preservatives. Front Microbiol. 2017; 7: 2161. https://doi.org/10.3389/fmicb.2016.02161
[26] Al Jahid A, Essabaq S, Elamrani A, Blaghen M, Jamal Eddine J. Chemical composition, antimicrobial and antioxidant activities of the essential oil and the hydro-alcoholic extract of *Artemisia campestris* L. leaves from southeastern Morocco. J Biol Act Prod Nat. 2016; 6(5-6): 393-405. https://doi.org/10.1080/22311866.2016.1268068
[27] Houicher A, Hechachna H, Özogul F. In vitro determination of the antifungal activity of *Artemisia campestris* essential oil from Algeria. Int J Food Prop. 2016; 19(8): 1749-1756. https://doi.org/10.1080/10942912.2015.1107734
[28] Bertella A, Benlahcen K, Abouamama S, Pinto DC, Maamar K, Kihal M, Silva AM. Artemisia herba-alba Asso. essential oil antibacterial activity and acute toxicity. Ind Crop Prod. 2018; 116: 137-143. https://doi.org/10.1016/j.indcrop.2018.02.064

[29] DeCarlo A, Agieb S, Johnson S, Satyal P, Setzer WN. Inter-tree variation in the chemical composition of *Boswellia papyrifera* oleo-gum-resin. Nat Prod Commun. 2022; 17(7): 1934578X221117411. https://doi.org/10.1177/1934578X221117411

[30] Abdelsamad A, Ahmed K, Al-magboul A, Fadul E. Antimicrobial activity of essential oils and extracts of oleo-gum resins from *Boswellia papyrifera* (Tarak tarak) grown in some parts of the Sudan. Arab J Med Arom Plant. 2020; 6(1): 22-35. https://doi.org/10.48347/IMIST.PRSM/ajmap-v6i1.20370

[31] Shahsavari N, Barzegar M, Sahari MA, Naghdibadi H. Antioxidant activity and chemical characterization of essential oil of *Bunium persicum*. Plant Food Hum Nutr. 2008; 63: 183-188. https://doi.org/10.1007/s11130-008-0091-y

[32] Moghtader M, Mansori AI, Salari H, Farahmand A. Chemical composition and antimicrobial activity of the essential oil of *Bunium persicum* Boiss. seed. Iran J Med Arom Plant. 2009; 25(1): 20-28.

[33] Ak G, Zengin G, Ceylan R, Fawzi Mahomoodally M, Jugreet S, Mollica A, Stefanucci A. Chemical composition and biological activities of essential oils from *Calendula officinalis* L. flowers and leaves. Flavour Fragr J. 2021; 36(5): 554-563. https://doi.org/10.1002/ffj.3661

[34] Hajlaoui H, Arraouadi S, Noumi E, Aouadi K, Adnan M, Khan MA, Kadri A, Snoussi M. Antimicrobial, antioxidant, anti-acetylcholinesterase, antidiabetic, and pharmacokinetic properties of *Carum carvi* L. and *Coriandrum sativum* L. essential oils alone and in combination. Molecules. 2021; 26(12): 3625. https://doi.org/10.3390/molecules26123625

[35] Lasram S, Zemni H, Hamdi Z, Chenenaoui S, Houissa H, Tounsi MS, Ghorbel A. Antifungal and antiaflatoxinogenic activities of *Carum carvi* L., *Coriandrum sativum* L. seed essential oils and their major terpene component against *Aspergillus flavus*. Ind Crop Prod. 2019; 134: 11-18. https://doi.org/10.1016/j.indcrop.2019.03.037

[36] Zeng WC, Zhang Z, Gao H, Jia LR, He Q. Chemical composition, antioxidant, and antimicrobial activities of essential oil from pine needle (*Cedrus deodara*). J Food Sci. 2012; 77(7): C824-C829. https://doi.org/10.1111/j.1750-3841.2012.02767.x

[37] Degenhardt RT, Farias IV, Grassi LT, Franchi Jr GC, Nowill AE, Bittencourt CMdS, Wagner TM, Souza MMd, Cruz AB, Malheiros A. Characterization and evaluation of the cytotoxic potential of the essential oil of *Chenopodium ambrosioides*. Rev Brasil Farmacogn. 2016; 26: 56-61. https://doi.org/10.1016/j.bjp.2015.08.012

[38] Chekem MSG, Lunga PK, Tamokou JDD, Kuiate JR, Tane P, Vilarem G, Cerny M. Antifungal properties of *Chenopodium ambrosioides* essential oil against *Candida* species. Pharmaceuticals. 2010; 3(9): 2900-2909. https://doi.org/10.3390/ph3092900

[39] Poudel DK, Rokaya A, Ojha PK, Timsina S, Satyal R, Dosoky NS, Satyal P, Setzer WN. The chemical profiling of essential oils from different tissues of *Cinnamomum camphora* L. and their antimicrobial activities. Molecules. 2021; 26(17): 5132. https://doi.org/10.3390/molecules26175132

[40] Chang C-T, Chang W-L, Hsu J-C, Shih Y, Chou S-T. Chemical composition and tyrosinase inhibitory activity of *Cinnamomum cassia* essential oil. Bot Stud. 2013; 54(1): 1-7. https://doi.org/10.1186/1999-3110-54-10

[41] Kačániová M, Galovičová L, Valková V, Tvrdá E, Terentjeva M, Žiarovská J, Kunová S, Savitskaya T, Grinshpan D, Štefániková J. Antimicrobial and antioxidant activities of *Cinnamomum cassia* essential oil and its application in food preservation. Open Chem. 2021; 19(1): 214-227. https://doi.org/10.1515/chem-2021-0191

[42] Singh A, Deepika, Chaudhari AK, Das S, Prasad J, Dwivedy AK, Dubey NK. Efficacy of Cinnamomum cassia essential oil against food-borne molds and aflatoxin B1 contamination. Plant Biosyst. 2021; 155(4): 899-907. https://doi.org/10.1080/11263504.2020.1810804

[43] Lin L-Y, Chuang C-H, Chen H-C, Yang K-M. Lime (*Citrus aurantifolia* (Christm.) Swingle) essential oils: Volatile compounds, antioxidant capacity, and hypolipidemic effect. Foods. 2019; 8(9): 398. https://doi.org/10.3390/foods8090398

[44] Lemes RS, Alves CC, Estevam EB, Santiago MB, Martins CH, Santos TCD, Crotti AE, Miranda ML. Chemical composition and antibacterial activity of essential oils from *Citrus aurantifolia* leaves and fruit peel against oral pathogenic bacteria. An Acad Brasil Ciên. 2018; 90: 1285-1292. https://doi.org/10.1590/0001-3765201820170847

[45] Sarma R, Adhikari K, Mahanta S, Khanikor B. Insecticidal activities of *Citrus aurantifolia* essential oil against *Aedes aegypti* (Diptera: Culicidae). Toxicol Rep. 2019; 6: 1091-1096. https://doi.org/10.1016/j.toxrep.2019.10.009

[46] Ammar AH, Bouajila J, Lebrihi A, Mathieu F, Romdhane M, Zagrouba F. Chemical composition and in vitro antimicrobial and antioxidant activities of *Citrus aurantium* L. flowers essential oil (Neroli oil). Pakistan J Biol Sci. 2012; 15(21): 1034-1040. https://doi.org/10.3923/pjbs.2012.1034.104

[47] Bhandari DP, Poudel DK, Satyal P, Khadayat K, Dhami S, Aryal D, Chaudhary P, Ghimire A, Parajuli N. Volatile compounds and antioxidant and antimicrobial activities of selected citrus essential oils originated from Nepal. Molecules. 2021; 26(21): 6683. https://doi.org/10.3390/molecules26216683

[48] Van Hung P, Chi PTL, Phi NTL. Comparison of antifungal activities of Vietnamese citrus essential oils. Nat Prod Res. 2013; 27(4-5): 506-508. https://doi.org/10.1080/14786419.2012.706293

[49] Othman HIA, Alkatib HH, Zaid A, Sasidharan S, Rahiman SSF, Lee TP, Dimitrovski G, Althakafy JT, Wong YF. Phytochemical composition, antioxidant and antiproliferative activities of *Citrus hystrix*, *Citrus limon*, *Citrus pyriformis*, and *Citrus microcarpa* leaf essential oils against human cervical cancer cell line. Plants. 2022; 12(1): 134. https://doi.org/10.3390/plants12010134

[50] Sreepian A, Sreepian P, Chanthong C, Mingkhwancheep T, Prathit P. Antibacterial activity of essential oil extracted from *Citrus hystrix* (kaffir lime) peels: an in vitro study. Trop Biomed. 2019; 36(2): 531-541.
[51] Tao N, Jia L, Zhou H. Anti-fungal activity of *Citrus reticulata* Blanco essential oil against *Penicillium italicum* and *Penicillium digitatum*. Food Chem. 2014; 153: 265-271. https://doi.org/10.1016/j.foodchem.2013.12.070
[52] Velázquez-Nuñez MJ, Avila-Sosa R, Palou E, López-Malo A. Antifungal activity of orange (*Citrus sinensis* var. Valencia) peel essential oil applied by direct addition or vapor contact. Food Control. 2013; 31(1): 1-4. https://doi.org/10.1016/j.foodcont.2012.09.029
[53] Ben Miri Y, Arino A, Djenane D. Study of antifungal, anti-aflatoxigenic, antioxidant activity and phytotoxicity of Algerian *Citrus limon* var. Eureka and *Citrus sinensis* var. Valencia essential oils. J Essent Oil Bear Plant. 2018; 21(2): 345-361. https://doi.org/10.1080/0972060X.2018.1456363
[54] Guo S-S, Wang Y, Chen Z-Y, Zhang Z, Cao J-Q, Pang X, Geng Z-F, Du S-S. Essential oils from Clausena species in China: Santalene Sesquiterpenes resource and toxicity against *Liposcelis bostrychophila*. J Chem. 2018; 2018: 1-8. https://doi.org/10.1155/2018/7813675
[55] He X, Zhang L, Chen J, Sui J, Yi G, Wu J, Ma Y. Correlation between chemical composition and antifungal activity of *Clausena lansium* essential oil against *Candida* spp. Molecules. 2019; 24(7): 1394. https://doi.org/10.3390/molecules24071394
[56] Dosoky NS, Pokharel SK, Setzer WN. Leaf essential oil composition, antimicrobial; and cytotoxic activities of *Cleistocalyx operculatus* from Hetauda, Nepal. Am J Essent Oils Nat Prod. 2015; 2(5): 34-37.
[57] Minh TTL, Kieu LTB, Mai STT, Ngoc DLB, Thuy LTB, Quyen NT, Anh TT, Huy LV, Phong NV, Duyen CTM. Addition of *Mentha arvensis* in infusions of *Cleistocalyx operculatus* improves the hedonic score and retains the high antioxidant and anti lipid-peroxidation effects. Appl Sci. 2023; 13(5): 2873. https://doi.org/10.3390/app13052873
[58] Soares BV, Morais SM, dos Santos Fontenelle RO, Queiroz VA, Vila-Nova NS, Pereira CM, Brito ES, Neto MA, Brito EH, Cavalcante CS. Antifungal activity, toxicity and chemical composition of the essential oil of *Coriandrum sativum* L. fruits. Molecules. 2012; 17(7): 8439-8448. https://doi.org/10.3390/molecules17078439
[59] Neri T, Silva K, Maior L, Oliveira-Silva S, Azevedo P, Gomes D, Souza M, Pavão J, Costa J, Cunha A. Phytochemical characterization, antioxidant potential and antibacterial activity of the *Croton argyrophylloides* Muell. Arg.(Euphorbiaceae). Brazil J Biol. 2021; 83. https://doi.org/10.1590/1519-6984.236649
[60] Fontenelle R, Morais S, Brito E, Brilhante R, Cordeiro R, Nascimento N, Kerntopf M, Sidrim J, Rocha M. Antifungal activity of essential oils of *Croton* species from the Brazilian *Caatinga biome*. J Appl Microbiol. 2008; 104(5): 1383-1390. https://doi.org/10.1111/j.1365-2672.2007.03707.x
[61] Andrade TC, Lima SG, Freitas RM, Rocha MS, Islam T, Silva TG, Militao GC. Isolation, characterization and evaluation of antimicrobial and cytotoxic activity of estragole, obtained from the essential oil of *Croton zehntneri* (Euphorbiaceae). An Acad Brasil Ciên. 2015; 87: 173-182. https://doi.org/10.1590/0001-3765201520140111
[62] Kedia A, Prakash B, Mishra PK, Dubey N. Antifungal and antiaflatoxigenic properties of *Cuminum cyminum* (L.) seed essential oil and its efficacy as a preservative in stored commodities. Int J Food Microbiol. 2014; 168: 1-7. https://doi.org/10.1016/j.ijfoodmicro.2013.10.008
[63] Kumar A, Agarwal K, Singh M, Saxena A, Yadav P, Maurya AK, Yadav A, Tandon S, Chanda D, Bawankule DU. Essential oil from waste leaves of *Curcuma longa* L. alleviates skin inflammation. Inflammopharmacology. 2018; 26(5): 1245-1255. https://doi.org/10.1007/s10787-018-0447-3
[64] Dosoky NS, Setzer WN. Chemical composition and biological activities of essential oils of *Curcuma* species. Nutrients. 2018; 10(9): 1196. https://doi.org/10.3390/nu10091196
[65] Majewska E, Kozlowska M, Gruszczynska-Sekowska E, Kowalska D, Tarnowska K. Lemongrass (*Cymbopogon citratus*) essential oil: extraction, composition, bioactivity and uses for food preservation-a review. Pol J Food Nutr Sci. 2019; 69(4):327-341. http://dx.doi.org/10.31883/pjfns/113152
[66] Sawadogo I, Paré A, Kaboré D, Montet D, Durand N, Bouajila J, Zida EP, Sawadogo-Lingani H, Nikiéma PA, Nebié RHC. Antifungal and antiaflatoxinogenic effects of *Cymbopogon citratus, Cymbopogon nardus*, and *Cymbopogon schoenanthus* essential oils alone and in combination. J Fungi. 2022; 8(2): 117. https://doi.org/10.3390/jof8020117
[67] Alitonou GA, Avlessi F, Tchobo F, Noudogbessi J-P, Tonouhewa A, Yehouenou B, Menut C, Sohounhloue DK. Chemical composition and biological activities of essential oils from the leaves of *Cymbopogon giganteus* Chiov. and *Cymbopogon schoenanthus* (L.) Spreng (Poaceae) from Benin. Int J Biol Chem Sci. 2012; 6(4): 1819-1827. https://doi.org/10.4314/ijbcs.v6i4.37
[68] Ayenew KD, Sewale Y, Amare YE, Ayalew A. Acute and subacute toxicity study of essential oil of *Cymbopogon martini* in mice. J Toxicol. 2022;2022:1995578. https://doi.org/10.1155/2022/1995578
[69] Prasad CS, Shukla R, Kumar A, Dubey N. In vitro and in vivo antifungal activity of essential oils of *Cymbopogon martini* and *Chenopodium ambrosioides* and their synergism against dermatophytes. Mycoses. 2010; 53(2): 123-129. https://doi.org/10.1111/j.1439-0507.2008.01676.x
[70] Lawrence K, Lawrence R, Parihar D, Srivastava R, Charan A. Antioxidant activity of Palmarosa essential oil (*Cymbopogon martini*) grown in north Indian plains. Asian Pac J Trop Biomed. 2012; 2(2): S888-S891. https://doi.org/10.1016/S2221-1691(12)60330-X
[71] Gemeda N, Tadele A, Lemma H, Girma B, Addis G, Tesfaye B, Abebe A, Gemechu W, Yirsaw K, Teka F, Haile C, Amano A, Woldkidan S, Geleta B, Debella A. Development, characterization, and evaluation of novel broad-

spectrum antimicrobial topical formulations from *Cymbopogon martini* (Roxb.) W. Watson essential oil. Evid Based Complement Alternat Med. 2018;2018:9812093. https://doi.org/10.1155/2018/9812093

[72] Hellali N, Mahammed MH, Ramdane F, Talli A. Antimicrobial and antioxidant activities of *Cymbopogon schoenanthus* (L.) spreng. essential oil, growing in Illizi-Algeria. J Med Plant Res. 2016; 10(14): 188-194. https://doi.org/10.5897/JMPR2015.5985

[73] Shrestha D, Sharma P, Pandey A, Dhakal K, Baral RP, Adhikari A. Chemical characterization, antioxidant and antibacterial activity of essential oil of *Cymbopogon winterianus* jowitt (Citronella) from western Nepal. Curr Biotechnol. 2022; 11(1): 86-91. https://doi.org/10.2174/2211550111666220405133558

[74] Simic A, Rančic A, Sokovic MD, Ristic M, Grujic-Jovanovic S, Vukojevic J, Marin PD. Essential Oil Composition of *Cymbopogon winterianus*. and *Carum carvi*. and their antimicrobial activities. Pharm Biol. 2008; 46(6): 437-441. https://doi.org/10.1080/13880200802055917

[75] Ghannadi A, Rabbani M, Ghaemmaghami L, Malekian N. Phytochemical screening and essential oil analysis of one of the Persian sedges; *Cyperus rotundu*s L. Int J Pharm Sci Res. 2012; 3(2): 424.

[76] Ksouri A, Dob T, Belkebir A, Krimat S, Chelghoum C. Chemical composition and antioxidant activity of the essential oil and the methanol extract of Algerian wild carrot *Daucus carota* L. ssp. carota.(L.) Thell. J Mater Environ Sci. 2015; 6(3): 784-791.

[77] Rokbeni N, M'rabet Y, Dziri S, Chaabane H, Jemli M, Fernandez X, Boulila A. Variation of the chemical composition and antimicrobial activity of the essential oils of natural populations of Tunisian *Daucus carota* L.(Apiaceae). Chem Biodivers. 2013; 10(12): 2278-2290. https://doi.org/10.1002/cbdv.201300137

[78] Sabo VA, Knezevic P. Antimicrobial activity of *Eucalyptus camaldulensis* Dehn. plant extracts and essential oils: A review. Ind Crop Prod. 2019; 132: 413-429. https://doi.org/10.1016/j.indcrop.2019.02.051

[79] Gakuubi MM, Maina AW, Wagacha JM. Antifungal activity of essential oil of *Eucalyptus camaldulensis* Dehnh. against selected *Fusarium* spp. Int J Microbiol. 2017; 2017. https://doi.org/10.1155/2017/8761610

[80] Harkat-Madouri L, Asma B, Madani K, Said ZB-OS, Rigou P, Grenier D, Allalou H, Remini H, Adjaoud A, Boulekbache-Makhlouf L. Chemical composition, antibacterial and antioxidant activities of essential oil of *Eucalyptus globulus* from Algeria. Ind Crop Prod. 2015; 78: 148-153. https://doi.org/10.1016/j.indcrop.2015.10.015

[81] Ferreira OO, da Silva SHM, de Oliveira MS, Andrade EHdA. Chemical composition and antifungal activity of *Myrcia multiflora* and *Eugenia florida* essential oils. Molecules. 2021; 26(23): 7259. https://doi.org/10.3390/molecules26237259

[82] Ferreira OO, Franco CdJP, Varela ELP, Silva SG, Cascaes MM, Percário S, de Oliveira MS, Andrade EHdA. Chemical Composition and Antioxidant activity of essential oils from leaves of two specimens of *Eugenia florida* DC. Molecules. 2021; 26(19): 5848. https://doi.org/10.3390/molecules26195848

[83] Ahluwalia V, Sisodia R, Walia S, Sati OP, Kumar J, Kundu A. Chemical analysis of essential oils of *Eupatorium adenophorum* and their antimicrobial, antioxidant and phytotoxic properties. J Pest Sci. 2014; 87: 341-349. https://doi.org/10.1007/s10340-013-0542-6

[84] de França-Neto A, Cardoso-Teixeira AC, Medeiros TC, do Socorro Quinto-Farias M, de Souza Sampaio CM, Coelho-de-Souza AN, Lahlou S, Leal-Cardoso JH. Essential oil of *Croton argyrophylloides*: toxicological aspects and vasorelaxant activity in rats. Nat Prod Commun. 2012; 7(10): 1934578X1200701040. https://doi.org/10.1177/1934578X1200701040.

[85] Kavoosi G, Rowshan V. Chemical composition, antioxidant and antimicrobial activities of essential oil obtained from *Ferula assafoetida* oleo-gum-resin: effect of collection time. Food Chem. 2013; 138(4): 2180-2187. https://doi.org/10.1016/j.foodchem.2012.11.131

[86] Mahmoudvand H, Yadegari JG, Khalaf AK, Hashemi MJ, Dastyarhaghighi S, Salimikia I. Chemical composition, antileishmanial, and cytotoxic effects *Ferula macrecolea* essential oil against *Leishmania tropica*. Parasite Epidemiol Control. 2022; 19: e00270. https://doi.org/10.1016/j.parepi.2022.e00270

[87] Roby MHH, Sarhan MA, Selim KA-H, Khalel KI. Antioxidant and antimicrobial activities of essential oil and extracts of fennel (*Foeniculum vulgare* L.) and chamomile (*Matricaria chamomilla* L.). Ind Crop Prod. 2013; 44: 437-445. https://doi.org/10.1016/j.indcrop.2012.10.012

[88] Kumar A, Singh PP, Prakash B. Unravelling the antifungal and anti-aflatoxin B1 mechanism of chitosan nanocomposite incorporated with *Foeniculum vulgare* essential oil. Carbohydr Polym. 2020; 236: 116050. https://doi.org/10.1016/j.carbpol.2020.116050

[89] Zeng W-C, Zhang W-C, Zhang W-H, He Q, Shi B. The antioxidant activity and active component of *Gnaphalium affine* extract. Food Chem Toxicol. 2013; 58: 311-317. https://doi.org/10.1016/j.fct.2013.05.004

[90] Rawat A, Prakash O, Kumar R, Arya S, Srivastava R. *Hedychium spicatum* Sm.: Chemical composition with biological activities of methanolic and ethylacetate oleoresins from rhizomes. J Biol Act Prod Nat. 2021; 11(3): 269-288. https://doi.org/10.1080/22311866.2021.1923572

[91] Matejic JS, Dzamic AM, Mihajilov-Krstev T, Ristic MS, Randelovic VN, Krivošej ZĐ, Marin PD. Chemical composition, antioxidant and antimicrobial properties of essential oil and extracts from *Heracleum sphondylium* L. J Essent Oil Bear Plant. 2016; 19(4): 944-953. https://doi.org/10.1080/0972060X.2014.986538

[92] Noudogbessi J-P, Agbangnan P, Yehouenou B, Adjalian E, Nonviho G, Osseni MA, Wotto V, Figueredo G, Chalchat J-C, Sohounhloue D. Physico-chemical properties of *Hyptis suaveolens* essential oil. Int J Med Arom Plants. 2013; 3: 191-199.

[93] Xu D-H, Huang Y-S, Jiang D-Q, Yuan K. The essential oils chemical compositions and antimicrobial, antioxidant activities and toxicity of three Hyptis species. Pharm Biol. 2013; 51(9): 1125-1130. https://doi.org/10.3109/13880209.2013.781195

[94] Moreira ACP, Carmo ES, Wanderley PA, da Souza EL, da Oliveira Lima E. Inhibitory effect of the essential oil from *Hyptis suaveolens* (l.) Poit on the growth and aflatoxins synthesis of *Aspergillus flavus*. J Life Sci. 2013; 7(3): 276.

[95] Höferl M, Stoilova I, Schmidt E, Wanner J, Jirovetz L, Trifonova D, Krastev L, Krastanov A. Chemical composition and antioxidant properties of Juniper berry (*Juniperus communis* L.) essential oil. Action of the essential oil on the antioxidant protection of *Saccharomyces cerevisiae* model organism. Antioxidants. 2014; 3(1): 81-98.

[96] Cabral C, Francisco V, Cavaleiro C, Gonçalves M, Cruz M, Sales F, Batista M, Salgueiro L. Essential oil of *Juniperus communis* subsp. alpina (Suter) Čelak needles: Chemical composition, antifungal activity and cytotoxicity. Phytother Res. 2012; 26(9): 1352-1357. https://doi.org/10.1002/ptr.3730

[97] Sela F, Karapandzova M, Stefkov G, Cvetkovikj I, Trajkovska-Dokik E, Kaftandzieva A, Kulevanova S. Chemical composition and antimicrobial activity of leaves essential oil of *Juniperus communis* (Cupressaceae) grown in Republic of Macedonia. Maced Pharm Bull. 2013; 59(1-2): 23-32.

[98] Mekonnen A, Tesfaye S, Christos SG, Dires K, Zenebe T, Zegeye N, Shiferaw Y, Lulekal E. Evaluation of skin irritation and acute and subacute oral toxicity of *Lavandula angustifolia* essential oils in rabbit and mice. J Toxicol. 2019; 2019: 5979546. https://doi.org/10.1155/2019/5979546

[99] de Rapper S, Kamatou G, Viljoen A, van Vuuren S. The In Vitro Antimicrobial Activity of *Lavandula angustifolia* Essential Oil in Combination with Other Aroma-Therapeutic Oils. Evid-Based Complement Altern Med. 2013; 2013: 852049. https://doi.org/10.1155/2013/852049

[100] Franco CdS, Ribeiro AF, Carvalho NC, Monteiro OS, da Silva JKR, Andrade EHA, Maia JGS. Composition and antioxidant and antifungal activities of the essential oil from *Lippia gracilis* Schauer. Afr J Biotechnol. 2014; 13(30). https://doi.org/10.5897/AJB2012.2941

[101] Oliveira T, Silva-Filho C, Malveira E, Aguiar T, Santos H, Albuquerque C, Morais M, Teixeira E, Vasconcelos M. Antifungal and antibiofilm activities of the essential oil of leaves from *Lippia gracilis* Schauer against phytopathogenic fungi. J Appl Microbiol. 2021; 130(4): 1117-1129. https://doi.org/10.1111/jam.14857

[102] Andrade VA, Almeida AC, Souza DS, Colen KG, Macêdo AA, Martins ER, Fonseca FS, Santos RL. Antimicrobial activity and acute and chronic toxicity of the essential oil of *Lippia origanoides*. Pesquisa Vet Brasil. 2014; 34: 1153-1161. https://doi.org/10.1590/S0100-736X2014001200002

[103] Stashenko E, Ruiz C, Muñoz A, Castañeda M, Martínez J. Composition and antioxidant activity of essential oils of *Lippia origanoides* HBK grown in Colombia. Nat Prod Commun. 2008; 3(4): 1934578X0800300417. https://doi.org/10.1177/1934578X0800300417

[104] Wong M-H, Lim L-F, bin Ahmad F, bin Assim Z. Antioxidant and antimicrobial properties of *Litsea elliptica* Blume and *Litsea resinosa* Blume (Lauraceae). Asian Pac J Trop Biomed. 2014; 4(5): 386-392. https://doi.org/10.12980/APJTB.4.2014C1129

[105] Pillai M, Hj Yakop F, Metussin N, Hamid M, Yasin H, Majid H, Young D. Phytochemical characterization of essential oils from shoots, mature leaves and branchlets of *Litsea elliptica* (Lauraceae) collected in Brunei Darussalam. Scientia Bruneiana. 2019; 17. https://doi.org/10.46537/scibru.v17i2.77

[106] Stanojevic LP, Marjanovic-Balaban ZR, Kalaba VD, Stanojevic JS, Cvetkovic DJ. Chemical composition, antioxidant and antimicrobial activity of chamomile flowers essential oil (*Matricaria chamomilla* L.). J Essent Oil Bear Plant. 2016; 19(8): 2017-2028. https://doi.org/10.1080/0972060X.2016.1224689

[107] Wińska K, Mączka W, Łyczko J, Grabarczyk M, Czubaszek A, Szumny A. Essential oils as antimicrobial agents-myth or real alternative? Molecules. 2019; 24(11): 2130. https://doi.org/10.3390/molecules24112130

[108] Nikolić MM, Jovanović KK, Marković TL, Marković DL, Gligorijević NN, Radulović SS, Kostić M, Glamočlija JM, Soković MD. Antimicrobial synergism and cytotoxic properties of *Citrus limon* L., *Piper nigrum* L. and *Melaleuca alternifolia* (Maiden and Betche) Cheel essential oils. J Pharm Pharmacol. 2017; 69(11): 1606-1614. https://doi.org/10.1111/jphp.12792

[109] Siddique S, Parveen Z, Mazhar S. Chemical composition, antibacterial and antioxidant activities of essential oils from leaves of three *Melaleuca* species of Pakistani flora. Arab J Chem. 2020; 13(1): 67-74. https://doi.org/10.1016/j.arabjc.2017.01.018

[110] Abdellatif F, Boudjella H, Zitouni A, Hassani A. Chemical composition and antimicrobial activity of the essential oil from leaves of Algerian *Melissa officinalis* L. EXCLI J. 2014; 13: 772. https://doi.org/10.1080/0972060x.2008.10643602

[111] Skotti E, Sotiropoulou NS, Lappa I, Kaiafa M, Tsitsigiannis D, Tarantilis P. Screening of lemon balm extracts for anti-aflatoxigenic, antioxidant and other biological activities. Preprints (www.preprints.org); 2019. https://doi.org/10.20944/preprints201907.0005.v1

[112] Bai X, Aimila A, Aidarhan N, Duan X, Maiwulanjiang M. Chemical constituents and biological activities of essential oil from *Mentha longifolia*: Effects of different extraction methods. Int J Food Prop. 2020; 23(1): 1951-1960. https://doi.org/10.1080/10942912.2020.1833035

[113] Dehghanpour-Farashah S, Taheri P. Antifungal and antiaflatoxigenic effects of *Mentha longifolia* essential oil against *Aspergillus flavus*. Int J New Technol Res. 2016; 2(9): 263437.

[114] Arman M, Yousefzadi M, Khademi SZ. Antimicrobial activity and composition of the essential oil from *Mentha mozaffarianii*. J Essent Oil Bear Plant. 2011; 14(1): 131-135. https://doi.org/10.1080/0972060X.2011.10643912
[115] Moghaddam M, Pourbaige M, Tabar HK, Farhadi N, Hosseini SMA. Composition and antifungal activity of peppermint (*Mentha piperita*) essential oil from Iran. J Essent Oil Bear Plant. 2013; 16(4): 506-512. https://doi.org/10.1080/0972060X.2013.813265
[116] Abd El-Hack ME, Kamal M, Altaie HA, Youssef IM, Algarni EH, Almohmadi NH, Abukhalil MH, Khafaga AF, Alqhtani AH, Swelum AA. Peppermint essential oil and its nano-emulsion: Potential against aflatoxigenic fungus Aspergillus flavus in food and feed. Toxicon. 2023; 234: 107309. https://doi.org/10.1016/j.toxicon.2023.107309
[117] Teixeira B, Marques A, Ramos C, Batista I, Serrano C, Matos O, Neng NR, Nogueira JM, Saraiva JA, Nunes ML. European pennyroyal (*Mentha pulegium*) from Portugal: Chemical composition of essential oil and antioxidant and antimicrobial properties of extracts and essential oil. Industrial Crops and Products. 2012; 36(1): 81-87.
[118] Wani AR, Yadav K. Chemical Characterization, antimicrobial, antiproliferative and antioxidant activities of the essential oil of *Monarda citriodora* growing in Kashmir. Int J Pharm Investig. 2021; 11(2): 170-175. https://doi.org/10.5530/ijpi.2021.2.31
[119] Deepika, Singh A, Chaudhari AK, Das S, Dubey NK. Nanoencapsulated *Monarda citriodora* Cerv. ex Lag. essential oil as potential antifungal and antiaflatoxigenic agent against deterioration of stored functional foods. J Food Sci Technol. 2020; 57: 2863-2876. https://doi.org/10.1007/s13197-020-04318-4
[120] Okechukwu QN, Ugwuona FU, Ofoedu CE, Juchniewicz S, Okpala COR. Chemical composition, antibacterial efficacy, and antioxidant capacity of essential oil and oleoresin from *Monodora myristica* and *Tetrapleura tetraptera* in Southeast Nigeria. Sci Rep. 2022; 12(1): 19861. https://doi.org/10.1038/s41598-022-23161-5
[121] Aleksic V, Knezevic P. Antimicrobial and antioxidative activity of extracts and essential oils of *Myrtus communis* L. Microbiol Res. 2014; 169(4): 240-254. https://doi.org/10.1016/j.micres.2013.10.003
[122] Majeed A, Guleria S, Sharma N, Salaria KH, Aiman F, Singh B, Gupta VK. Antioxidant capacity and combinatorial antimicrobial effects of *Nardostachys jatamansi* essential oil with conventional antibiotics against some drug resistant bacteria. Curr Res Biotechnol. 2023; 5: 100118. https://doi.org/10.1016/j.crbiot.2022.100118
[123] Jianu C, Moleriu R, Stoin D, Cocan I, Bujancă G, Pop G, Lukinich-Gruia AT, Muntean D, Rusu L-C, Horhat DI. Antioxidant and antibacterial activity of *Nepeta faassenii* bergmans ex stearn essential oil. Appl Sci. 2021; 11(1): 442. https://doi.org/10.3390/app11010442
[124] Shakeri A, Khakdan F, Soheili V, Sahebkar A, Shaddel R, Asili J. Volatile composition, antimicrobial, cytotoxic and antioxidant evaluation of the essential oil from *Nepeta sintenisii* Bornm. Ind Crop Prod. 2016; 84: 224-229. https://doi.org/10.1016/j.indcrop.2015.12.030
[125] Alimi D, Hajri A, Jallouli S, Sebai H. Acaricidal and anthelmintic efficacy of *Ocimum basilicum* essential oil and its major constituents estragole and linalool, with insights on acetylcholinesterase inhibition. Vet Parasitol. 2022; 309: 109743. https://doi.org/10.1016/j.vetpar.2022.109743
[126] Beatovic D, Krstic-Milosevic D, Trifunovic S, Siljegovic J, Glamoclija J, Ristic M, Jelacic S. Chemical composition, antioxidant and antimicrobial activities of the essential oils of twelve *Ocimum basilicum* L. cultivars grown in Serbia. Rec Nat Prod. 2015; 9(1): 62-75.
[127] Mohr F, Lermen C, Gazim Z, Gonçalves J, Alberton O. Antifungal activity, yield, and composition of *Ocimum gratissimum* essential oil. Genet Mol Res. 2017; 16(1): 1-10. http://dx.doi.org/10.4238/gmr16019542
[128] Matasyoh LG, Matasyoh JC, Wachira FN, Kinyua MG, Muigai AWT, Mukiama TK. Chemical composition and antimicrobial activity of the essential oil of *Ocimum gratissimum* L. growing in Eastern Kenya. Afr J Biotechnol. 2007; 6(6).
[129] Gutiérrez-Grijalva EP, Picos-Salas MA, Leyva-López N, Criollo-Mendoza MS, Vazquez-Olivo G, Heredia JB. Flavonoids and phenolic acids from oregano: Occurrence, biological activity and health benefits. Plants. 2017; 7(1): 2. https://doi.org/10.3390/plants7010002
[130] Rodriguez-Garcia I, Silva-Espinoza B, Ortega-Ramirez L, Leyva J, Siddiqui M, Cruz-Valenzuela M, Gonzalez-Aguilar G, Ayala-Zavala J. Oregano essential oil as an antimicrobial and antioxidant additive in food products. Crit Rev Food Sci Nutr. 2016; 56(10): 1717-1727. https://doi.org/10.1080/10408398.2013.800832
[131] Gómez JV, Tarazona A, Mateo-Castro R, Gimeno-Adelantado JV, Jiménez M, Mateo EM. Selected plant essential oils and their main active components, a promising approach to inhibit aflatoxigenic fungi and aflatoxin production in food. Food Addit Contam Part A. 2018; 35(8): 1581-1595. https://doi.org/10.1080/19440049.2017.1419287
[132] Shohayeb M, Abdel-Hameed E-SS, Bazaid SA, Maghrabi I. Antibacterial and antifungal activity of *Rosa damascena* Mill. essential oil, different extracts of rose petals. Glob J Pharmacol. 2014; 8(1): 1-7. https://doi.org/10.5829/idosi.gjp.2014.8.1.81275
[133] Stojiljkovic J, Trajchev M, Nakov D, Petrovska M. Antibacterial activities of rosemary essential oils and their components against pathogenic bacteria. Adv Cytol Pathol. 2018;3(4):93–96. https://doi.org/10.15406/acp.2018.03.00060
[134] da Silva Bomfim N, Kohiyama CY, Nakasugi LP, Nerilo SB, Mossini SAG, Romoli JCZ, Graton Mikcha JM, Abreu Filho BAd, Machinski Jr M. Antifungal and antiaflatoxigenic activity of rosemary essential oil (*Rosmarinus officinalis* L.) against *Aspergillus flavus*. Food Addit Contam Part A. 2020; 37(1): 153-161. https://doi.org/10.1080/19440049.2019.1678771

[135] Seyedtaghiya MH, Fasaei BN, Peighambari SM. Antimicrobial and antibiofilm effects of *Satureja hortensis* essential oil against *Escherichia coli* and *Salmonella* isolated from poultry. Iran J Microbiol. 2021; 13(1): 74. https://doi.org/10.18502/ijm.v13i1.5495

[136] Valizadeh S, Fakheri T, Mahmoudi R, Katiraee F, Gajarbeygi P. Evaluation of antioxidant, antibacterial, and antifungal properties of *Satureja hortensis* essential oil. Biotech Health Sci. 2014; 1(3): e24733. https://doi.org/10.17795/bhs-24733.

[137] Yazdanpanah Goharrizi L, Tasharofi S. Inhibiting Aspergillus flavus growth and aflatoxin decrement in aquatic feed with *Satureja hortensis* essential oil. Res J Vet Pract. 2017; 4(4): 71-75. http://dx.doi.org/10.14737/journal.rjvp/2016/4.4.71.75

[138] Fallahi S, Beyranvand M, Mahmoudvand H, Nayebzadeh H, Kheirandish F, Jahanbakhsh S. Chemical composition, acute and sub-acute toxicity of *Satureja khuzestanica* essential oil in mice. Marmara Pharm J. 2017; 21(3): 515-521. https://doi.org/10.12991/marupj.318614

[139] Mahboubi M, Kazempour N. Antioxidant and antimicrobial activity of *Satureja khuzistanica* Jamzad essential oil, ethanol and aqueous extracts. Biharean Biologist. 2017: 12 (1): 37-39.

[140] Mihajilov-Krstev T, Radnović D, Kitić D, Jovanović V, Mitić V, Stojanović-Radić Z, Zlatković B. Chemical composition, antimicrobial, antioxidative and anticholinesterase activity of *Satureja montana* L. ssp montana essential oil. Open Life Sci. 2014; 9(7): 668-677. https://doi.org/10.2478/s11535-014-0298-x

[141] Radünz M, da Trindade MLM, Camargo TM, Radünz AL, Borges CD, Gandra EA, Helbig E. Antimicrobial and antioxidant activity of unencapsulated and encapsulated clove (*Syzygium aromaticum* L.) essential oil. Food Chem. 2019; 276: 180-186. https://doi.org/10.1016/j.foodchem.2018.09.173

[142] Cerrón-Mercado F, Perez-Alvarez JA, Nolazco-Cama D, Salva-Ruíz B, Tellez-Monzon L, Fernández-López J, Viuda-Martos M. Chemical composition, antioxidant and antibacterial activities of essential oil obtained from Chincho (*Tagetes elliptica* Sm) leaves grown in the Peruvian Andes. Foods. 2023; 12(4): 894. https://doi.org/10.3390/foods12040894

[143] Armas K, Rojas J, Rojas L, Morales A. Comparative study of the chemical composition of essential oils of five *Tagetes* species collected in Venezuela. Nat Prod Commun. 2012; 7(9): 1934578X1200700932. https://doi.org/10.1177/1934578X1200700932

[144] Tripathi B, Bhatia R, Walia S, Kumar B. Chemical composition and evaluation of *Tagetes erecta* (var. Pusa narangi genda) essential oil for its antioxidant and antimicrobial activity. Biopest Int. 2012; 8(2): 138-146.

[145] Lechkova B, Karcheva-Bahchevanska D, Ivanov K, Todorova V, Benbassat N, Penkova N, Atanassova P, Peychev L, Hrischev P, Peychev Z. A Study of the chemical composition, acute and subacute toxicity of Bulgarian *Tanacetum parthenium* essential oil. Molecules. 2023; 28(13): 4906. https://doi.org/10.3390/molecules28134906

[146] Damtie D, Braunberger C, Conrad J, Mekonnen Y, Beifuss U. Composition and hepatoprotective activity of essential oils from Ethiopian thyme species (*Thymus serrulatus* and *Thymus schimperi*). J Essent Oil Res. 2019; 31(2): 120-128. https://doi.org/10.1080/10412905.2018.1512907

[147] Nasir M, Tafess K, Abate D. Antimicrobial potential of the Ethiopian *Thymus schimperi* essential oil in comparison with others against certain fungal and bacterial species. BMC Complement Altern Med. 2015; 15: 1-5. https://doi.org/10.1186/s12906-015-0784-3

[148] Kowalczyk A, Przychodna M, Sopata S, Bodalska A, Fecka I. Thymol and thyme essential oil—new insights into selected therapeutic applications. Molecules. 2020; 25(18): 4125. https://doi.org/10.3390/molecules25184125

[149] Borugă O, Jianu C, Mişcă C, Goleț I, Gruia A, Horhat F. *Thymus vulgaris* essential oil: chemical composition and antimicrobial activity. J Med Life. 2014; 7(Spec Iss 3): 56.

[150] Tian F, Lee SY, Chun HS. Comparison of the antifungal and antiaflatoxigenic potential of liquid and vapor phase of *Thymus vulgaris* essential oil against *Aspergillus flavus*. J Food Protect. 2019; 82(12): 2044-2048. https://doi.org/10.4315/0362-028X.JFP-19-016

[151] Vitali LA, Beghelli D, Nya PCB, Bistoni O, Cappellacci L, Damiano S, Lupidi G, Maggi F, Orsomando G, Papa F. Diverse biological effects of the essential oil from Iranian *Trachyspermum ammi*. Arab J Chem. 2016; 9(6): 775-786. https://doi.org/10.1016/j.arabjc.2015.06.002

[152] Khalilzadeh E, Saiah GV, Hasannejad H, Ghaderi A, Ghaderi S, Hamidian G, Mahmoudi R, Eshgi D, Zangisheh M. Antinociceptive effects, acute toxicity and chemical composition of *Vitex agnus-castus* essential oil. Avicenna J Phytomed. 2015; 5(3): 218.

[153] Sarikurkcu C, Arisoy K, Tepe B, Cakir A, Abali G, Mete E. Studies on the antioxidant activity of essential oil and different solvent extracts of *Vitex agnus castus* L. fruits from Turkey. Food Chem Toxicol. 2009; 47(10): 2479-2483. https://doi.org/10.1016/j.fct.2009.07.005

[154] Balasubramani S, Rajendhiran T, Moola AK, Diana RKB. Development of nanoemulsion from *Vitex negundo* L. essential oil and their efficacy of antioxidant, antimicrobial and larvicidal activities (*Aedes aegypti* L.). Environ Sci Pollut Res. 2017; 24: 15125-15133. https://doi.org/10.1007/s11356-017-9118-y

[155] De Lima DAN, Pelegrini BB, Uechi FAA, Varago RC, Pimenta BB, de Souza Kaneshima AM, Kaneshima EN, da Costa Souza P, Pedroso RB, Silveira TGV. Evaluation of Antineoplasic Activity of *Zingiber officinale* Essential Oil in the Colorectal Region of Wistar Rats. Asian Pac J Cancer Prevent. 2020; 21(7): 2141. https://doi.org/10.31557/APJCP.2020.21.7.2141

[156] Bellik Y. Total antioxidant activity and antimicrobial potency of the essential oil and oleoresin of *Zingiber officinale* Roscoe. Asian Pac J Trop Dis. 2014; 4(1): 40-44. https://doi.org/10.1016/S2222-1808(14)60311-X
[157] Nerilo SB, Rocha GHO, Tomoike C, Mossini SA, Grespan R, Mikcha JM, Machinski Jr M. Antifungal properties and inhibitory effects upon aflatoxin production by Zingiber officinale essential oil in A*spergillus flavus*. Int J Food Sci Technol. 2016; 51(2): 286-292. https://doi.org/10.1111/ijfs.12950
[158] Rani AS, Satyakala M, Devi VS, Murty US. Evaluation of antibacterial activity from rhizome extract of *Acorus calamus* Linn. J Sci Ind Res.2003; 62(6).
[159] Aryal S, Poudel A, Kafle K, Aryal LN. Insecticidal toxicity of essential oil of Nepalese *Acorus calamus* (Acorales: Acoraceae) against *Sitophilus zeamais* (Coleoptera: Curculionidae). Heliyon. 2023; 9(11): e22130. https://doi.org/10.1016/j.heliyon.2023.e22130
[160] Adnyana IK, Anggadiredja K, Sukmawan YP. Essential oil of *Ageratum conyzoides* (L.) L.: Acute and subchronic toxicity studies. J Pharm Pharmacogn Res. 2023; 11(4): 625-634. https://doi.org/10.56499/jppres23.1590_11.4.625
[161] Lin Y-E, Lin M-H, Yeh T-Y, Lai Y-S, Lu K-H, Huang H-S, Peng F-C, Liu S-H, Sheen L-Y. Genotoxicity and 28-day repeated dose oral toxicity study of garlic essential oil in mice. J Tradit Complement Med. 2022; 12(6): 536-544. https://doi.org/10.1016/j.jtcme.2022.05.001
[162] Ihekwereme PC, Asomugha RN, Mbagwu SI, Oraekei DI, Ajaghaku DL. Phytochemicals, acute toxicities and actual median lethal doses (actual LD50) of *Zingiber officinal*e and *Allium sativum* given singly and in combination via mice models. GSC Biol Pharm Sci. 2023; 25(1): 008-018. https://doi.org/10.30574/gscbps.2023.25.1.0396
[163] Thuy Quynh VT, Duszkiewicz–Reinhard W. Antimicrobial activity of essential oils from fresh and dried A*lpinia galanga* rhizomes. J Essent Oil Bear Plants. 2004; 7(2): 165-170. https://doi.org/10.1080/0972-060X.2004.10643385
[164] Lahlou S, Galindo CAB, Leal-Cardoso JH, Fonteles MC, Duarte GP. Cardiovascular effects of the essential oil of *Alpinia zerumbet* leaves and its main constituent, terpinen-4-ol, in rats: role of the autonomic nervous system. Planta Med. 2002; 68(12): 1097-1102. https://doi.org/10.1055/s-2002-36336
[165] Derakhshan S, Navidinia M, Ahmadi A. Antibacterial activity of Dill (Anethum graveolens) essential oil and antibiofilm activity of Cumin (*Cuminum cyminum*) alcoholic extract. Infect Epidemiol Microbiol. 2017; 3(4): 122-126. https://doi.org/10.18869/modares.iem.3.4.122
[166] Vieira TM, Dias HJ, Medeiros TC, Grundmann CO, Groppo M, Heleno VC, Martins CH, Cunha WR, Crotti AE, Silva EO. Chemical composition and antimicrobial activity of the essential oil of *Artemisia absinthium* Asteraceae leaves. J Essent Oil Bear Plant. 2017; 20(1): 123-131. https://doi.org/10.1080/0972060X.2016.1257370
[167] Mihajilov-Krstev T, Jovanović B, Jović J, Ilić B, Miladinović D, Matejić J, Rajković J, Đorđević L, Cvetković V, Zlatković B. Antimicrobial, antioxidative, and insect repellent effects of *Artemisia absinthium* essential oil. Planta Med. 2014; 80(18): 1698-1705. https://doi.org/10.1055/s-0034-1383182
[168] Mammeri B, Bahri F, Kouidri M, Boudani B, Arioui F. Evaluation of chemical composition, anti-inflammatory, antibacterial activity and synergistic effect between antibiotics and the essential oil of *Artemisia campestris* L. J Appl Biol Sci. 2022; 16(2): 230-247. https://doi.org/10.5281/zenodo.6590285
[169] Auti ST, Kulkarni YA. Acute and 28-day repeated dose oral toxicity study of caraway oil in rats. Drug Metabol Pers Ther. 2019; 34(3): 20190011. https://doi.org/10.1515/dmpt-2019-0011
[170] Abdoul-latif FM, Obame L-C, Bassolé IH, Dicko MH. Antimicrobial activities of essential oil and methanol extract of *Boswellia sacra* Flueck. and *Boswellia papyrifera* (Del.) Hochst from Djibouti. Int J Manag Modern Sci Technol. 2012; 1: 1-10.
[171] Tabarraei H, Hassan J, Parvizi MR, Golshahi H. Evaluation of the acute and sub-acute toxicity of the black caraway seed essential oil in Wistar rats. Toxicol Rep. 2019; 6: 869-874. https://doi.org/10.1016/j.toxrep.2019.08.010
[172] Behravan J, Ramezani M, Hassanzadeh M, Eskandari M, Kasaian J, Sabeti Z. Composition, antimycotic and antibacterial activity of *Ziziphora clinopodioides* Lam. essential oil from Iran. J Essent Oil Bear Plant. 2007; 10(4): 339-345. https://doi.org/10.1080/0972060X.2007.10643565
[173] Mishra AK, Mishra A, Chattopadhyay P. Screening of acute and sub-chronic dermal toxicity of *Calendula officinalis* L essential oil. Regul Toxicol Pharmacol. 2018; 98: 184-189. https://doi.org/10.1016/j.yrtph.2018.07.027
[174] Simic A, Rančic A, Sokovic M, Ristic M, Grujic-Jovanovic S, Vukojevic J, Marin PD. Essential oil composition of *Cymbopogon winterianus* and *Carum carvi* and their antimicrobial activities. Pharm Biol. 2008; 46(6): 437-441.
[175] Showraki A, Emamghoreishi M, Oftadegan S. Anticonvulsant effect of the aqueous extract and essential oil of *Carum carvi* L. seeds in a pentylenetetrazol model of seizure in mice. Iran J Med Sci. 2016; 41(3): 200.
[176] Chaudhary AK, Ahmad S, Mazumder A. *Cedrus deodara* (Roxb.) Loud.: A review on its ethnobotany, phytochemical and pharmacological profile. Pharmacogn J. 2011; 3(23): 12-17. https://doi.org/10.5530/pj.2011.23.2
[177] Li J, Yang X, Yu J, Li Z, Deng Q, Cao Y, Chen X, Zhang H, Wang Y. Chemical composition of the volatile oil of *Chenopodium ambrosioides* L. from Mianyang in Sichuan Province of China and its sub-chronic toxicity in mice. Trop J Pharm Res. 2020; 19(9): 1985-1991. https://doi.org/10.4314/tjpr.v19i9.26
[178] Fidalgo LM. Essential oil from *Chenopodium ambrosioides* as a promising antileishmanial agent. Nat Prod Commun. 2007; 2(12): 1934578X0700201214. https://doi.org/10.1177/1934578X0700201214

[179] Xiao S, Yu H, Xie Y, Guo Y, Fan J, Yao W. Evaluation of the analgesic potential and safety of *Cinnamomum camphora* chvar. Borneol essential oil. Bioeng. 2021; 12(2): 9860-9871. https://doi.org/10.1080/21655979.2021.1996149
[180] Adokoh CK, Asante D-B, Acheampong DO, Kotsuchibashi Y, Armah FA, Sirikyi IH, Kimura K, Gmakame E, Abdul-Rauf S. Chemical profile and in vivo toxicity evaluation of unripe *Citrus aurantifolia* essential oil. Toxicol Rep. 2019; 6: 692-702. https://doi.org/10.1016/j.toxrep.2019.06.020
[181] Ouedrhiri W, Bouhdid S, Balouiri M, Lalami AEO, Moja S, Chahdi FO, Greche H. Chemical composition of *Citrus aurantium* L. leaves and zest essential oils, their antioxidant, antibacterial single and combined effects. J Chem Pharm Res. 2015; 7(1): 78-84.
[182] Bengag A, Allem R, Meziane M. Acute oral, intravenous and peritoneal toxicity evaluation of the peel Citrus species. South Asian J Exp Biol. 2020; 10(6). https://doi.org/10.38150/sajeb.10(6).p395-403
[183] Tao N-G, Liu Y-J. Chemical composition and antimicrobial activity of the essential oil from the peel of shatian pummelo (*Citrus grandis* Osbeck). Int J Food Prop. 2012; 15(3): 709-716. https://doi.org/10.1080/10942912.2010.500067
[184] Wongsariya K, Phanthong P, Bunyapraphatsara N, Srisukh V, Chomnawang MT. Synergistic interaction and mode of action of *Citrus hystrix* essential oil against bacteria causing periodontal diseases. Pharm Biol. 2014; 52(3): 273-280. https://doi.org/10.3109/13880209.2013.833948
[185] Tao Ng, Liu Yj, Zhang Ml. Chemical composition and antimicrobial activities of essential oil from the peel of bingtang sweet orange (*Citrus sinensis* Osbeck). Int J Food Sci Technol. 2009; 44(7): 1281-1285. https://doi.org/10.1111/j.1365-2621.2009.01947.x
[186] Guo Y-N, Tang L-P. The effect and mechanism of volatile oil emulsion from leaves of *Clausena lansium* (Lour.) Skeels on *Staphylococcus aureus* in vitro. Front Microbiol. 2024; 15: 1376819. https://doi.org/10.3389/fmicb.2024.1376819
[187] Dosoky NS, Pokharel SK, Setzer WN. Leaf essential oil composition, antimicrobial and cytotoxic activities of *Cleistocalyx operculatus* from Hetauda, Nepal. Am J Essent Oils Nat Prod. 2015; 2(5): 34-37.
[188] Özbek H, Öztürk M, Öztürk A, Ceylan E, Yener Z. Determination of lethal doses of volatile and fixed oils of several plants. East J Med. 2004; 9(1): 4-6.
[189] de Lima GPG, de Souza TM, de Paula Freire G, Farias DF, Cunha AP, Ricardo NMPS, de Morais SM, Carvalho AFU. Further insecticidal activities of essential oils from *Lippia sidoides* and *Croton* species against *Aedes aegypti* L. Parasitol Res. 2013; 112: 1953-1958. https://doi.org/10.1007/s00436-013-3351-1
[190] Alves JAB, da Silva Nunes M, Fakhouri R, Martins-Filho PRS, de Oliveira Ribeiro MdC, de Vasconcellos AC, Santos PO, Marchioro M, de Cassia Trindade R, Frazão GGS. Inhibition of drug-sensitive and drug-resistant *Mycobacterium tuberculosis* strains by essential oil from *Croton argyrophylloides* Mull. Arg. Int Archiv Med. 2016; 9. https://doi.org/10.3823/2047
[191] de França-Neto A, Cardoso-Teixeira AC, Medeiros TC, do Socorro Quinto-Farias M, de Souza Sampaio CM, Coelho-de-Souza AN, Lahlou S, Leal-Cardoso JH. Essential oil of *Croton argyrophylloides*: Toxicological aspects and vasorelaxant activity in rats. Nat Prod Commun. 2012; 7(10): 1934578X1200701040. https://doi.org/10.1177/1934578X1200701040
[192] Coelho-de-Souza AN, Rocha MVA, Oliveira KA, Vasconcelos YA, Santos EC, Silva-Alves KS, Diniz LRL, Ferreira-da-Silva FW, Oliveira AC, Ponte EL. Volatile oil of *Croton zehntneri* per oral sub-acute treatment offers small toxicity: perspective of therapeutic use. Rev Brasil Farmacogn. 2019; 29: 228-233. https://doi.org/10.1016/j.bjp.2018.11.005
[193] Oliveira A, Leal-Cardoso J, Santos C, Morais S, Coelho-de-Souza A. Antinociceptive effects of the essential oil of *Croton zehntneri* in mice. Brazil J Med Biol Res. 2001; 34: 1471-1474. https://doi.org/10.1590/S0100-879X2001001100016
[194] Taghizadeh M, Ostad SN, Asemi Z, Mahboubi M, Hejazi S, Sharafati-Chaleshtori R, Rashidi A, Akbari H, Sharifi N. Sub-chronic oral toxicity of *Cuminum cyminum* L.'s essential oil in female Wistar rats. Reg Toxicol Pharmacol. 2017; 88: 138-143. https://doi.org/10.1016/j.yrtph.2017.06.007
[195] Liju VB, Jeena K, Kuttan R. Acute and subchronic toxicity as well as mutagenic evaluation of essential oil from turmeric (*Curcuma longa* L). Food Chem Toxicol. 2013; 53: 52-61. https://doi.org/10.1016/j.fct.2012.11.027
[196] Apisariyakul A, Vanittanakom N, Buddhasukh D. Antifungal activity of turmeric oil extracted from *Curcuma longa* (Zingiberaceae). J Ethnopharmacol. 1995; 49(3): 163-169. https://doi.org/10.1016/0378-8741(95)01320-2
[197] Lulekal E, Tesfaye S, Gebrechristos S, Dires K, Zenebe T, Zegeye N, Feleke G, Kassahun A, Shiferaw Y, Mekonnen A. Phytochemical analysis and evaluation of skin irritation, acute and sub-acute toxicity of *Cymbopogon citratus* essential oil in mice and rabbits. Toxicol Rep. 2019; 6: 1289-1294. https://doi.org/10.1016/j.toxrep.2019.11.002
[198] Toukourou H, Uwambayinema F, Yakoub Y, Mertens B, Laleye A, Lison D, Quetin-Leclercq J, Gbaguidi F. In vitro and in vivo toxicity studies on *Cymbopogon giganteus* Chiov. leaves essential oil from Benin. J Toxicol. 2020;2020:8261058. https://doi.org/10.1155/2020/8261058
[199] Bassolé I, Lamien-Meda A, Bayala B, Obame L, Ilboudo A, Franz C, Novak J, Nebié R, Dicko M. Chemical composition and antimicrobial activity of *Cymbopogon citratus* and *Cymbopogon giganteus* essential oils alone and in combination. Phytomedicine. 2011; 18(12): 1070-1074. https://doi.org/10.1016/j.phymed.2011.05.009

[200] Verma RS, Padalia RC, Goswami P, Verma SK, Chauhan A, Singh VR, Darokar MP. Chemical composition and antibacterial activity of p-menthane chemotype of *Cymbopogon martini* (Roxb.) W. Watson (Poaceae) from India. J Essent Oil Res. 2018; 30(3): 182-188. https://doi.org/10.1080/10412905.2018.1429327
[201] Fathifar E, Rastegar T, Asgarpanah J. Histopathological and biochemical toxicity of *Cymbopogon schoenanthus* essential oil in female mice. Res J Pharmacogn. 2021; 8(1): 53-62. https://doi.org/10.22127/rjp.2020.120330
[202] Upatoom P, Visetson S. Mechanisms of essential oils from citronella (*Cymbopogon winterianus* Jowitt) against Siamensis subterranean termite workers (*Coptotermes gestroi* Wasmann) and mice (*Mus musculus* L.). Thai Agric Res J. 2017; 35(3): 270-287.
[203] Hu Q-P, Cao X-M, Hao D-L, Zhang L-L. Chemical composition, antioxidant, DNA damage protective, cytotoxic and antibacterial activities of *Cyperus rotundus* rhizomes essential oil against foodborne pathogens. Sci Rep. 2017; 7(1): 1-9. https://doi.org/10.1038/srep45231
[204] Al-Snafi AE. A review on *Cyperus rotundus* A potential medicinal plant. IOSR J Pharm. 2016; 6(7): 32-48.
[205] Alves-Silva JM, Zuzarte M, Gonçalves MJ, Cavaleiro C, Cruz MT, Cardoso SM, Salgueiro L. New claims for wild carrot (*Daucus carota* subsp. carota) essential oil. Evid-Based Complement Altern Med. 2016;2016:9045196. https://doi.org/10.1155/2016/9045196
[206] Asiaei EO, Moghimipour E, Fakoor MH. Evaluation of antimicrobial activity of *Eucalyptus camaldulensis* essential oil against the growth of drug-resistant bacteria. Jundishapur J Nat Pharm Prod. 2018; 13(4). https://doi.org/10.5812/jjnpp.65050.
[207] Mengiste B, Zenebe T, Dires K, Lulekal E, Mekonnen A, Zegeye N, Shiferaw Y. Safety evaluation of *Eucalyptus globulus* essential oils through acute and sub-acute toxicity and skin irritation in mice and rats. Curr Chem Biol. 2020; 14(3): 187-195. https://doi.org/10.2174/2212796814999200818095036
[208] Park J-W, Wendt M, Heo G-J. Antimicrobial activity of essential oil of *Eucalyptus globulus* against fish pathogenic bacteria. Lab Anim Res. 2016; 32: 87-90. https://doi.org/10.5625/lar.2016.32.2.87
[209] Bastos RG, Rosa CP, Oliver JC, Silva NC, Dias AL, Da Rocha CQ, Vilegas W, Da Silva GA, Da Silva MA. Chemical characterization and antimicrobial activity of hydroethanolic crude extract of *Eugenia florida* DC (Myrtaceae) leaves. Int J Pharm Pharm Sci. 2016; 8: 110-115.
[210] Mirzania F, Salimikia I, Ghasemian Yadegari J, Nazarzadeh A, Najmaddini H. Investigating the effect of acute and subacute toxicity of *Ferula macrecolea* (Boiss.) Boiss essential oil in BALB/c Mice. J Med Plant By-Prod. 2024. https://doi.org/10.22034/jmpb.2024.363350.1598
[211] Sadeghi N, Sadeghi H, Mohan DN, Sepahvand A, Alizadeh A, Garavand S. Chemical composition, anti-fungal and cytotoxic effects of *Ferula macrecolea* essential oil against *Candida albicans* resistant and sensitive strains. J Herbmed Pharmacol. 2023; 12(2): 228-232. https://doi.org/10.34172/jhp.2023.24
[212] AbduRahim SA, Elamin BEK, Bashir AAA, Almagboul AZ. In vitro test of antimicrobial activity of *Foeniculum vulgare* Mill.(Fennel) essential oil. J Multidisc Eng Sci Stud. 2017; 3(4): 1609-1614.
[213] Zeng W-C, Zhu R-X, Jia L-R, Gao H, Zheng Y, Sun Q. Chemical composition, antimicrobial and antioxidant activities of essential oil from *Gnaphlium affine*. Food Chem Toxicol. 2011; 49(6): 1322-1328. https://doi.org/10.1016/j.fct.2011.03.014
[214] Joshi S, Chanotiya CS, Agarwal G, Prakash O, Pant AK, Mathela CS. Terpenoid compositions, and antioxidant and antimicrobial properties of the rhizome essential oils of different *Hedychium* species. Chem Biodivers. 2008; 5(2): 299-309. https://doi.org/10.1002/cbdv.200890027
[215] Goly KRC, Soro Y, Dadie A, Kassi ABB, Djé M. Antibacterial activity of essential oils and extracts from the leaves of *Hyptis suaveolens* and *Lippia multiflora* on multi-resistant bacteria. Rasayan J Chem. 2015; 8(4): 396-403.
[216] Glišić S, Milojević S, Dimitrijević S, Orlović A, Skala D. Antimicrobial activity of the essential oil and different fractions of *Juniperus communis* L. and a comparison with some commercial antibiotics. J Serb Chem Soc. 2007; 72(4): 311-320. https://doi.org/10.2298/JSC0704311G
[217] Blažeković B, Yang W, Wang Y, Li C, Kindl M, Pepeljnjak S, Vladimir-Knežević S. Chemical composition, antimicrobial and antioxidant activities of essential oils of *Lavandula intermedia* 'Budrovka'and *L. angustifolia* cultivated in Croatia. Ind Crops Prod. 2018; 123: 173-182. https://doi.org/10.1016/j.indcrop.2018.06.041
[218] Mekonnen A, Tesfaye S, Christos SG, Dires K, Zenebe T, Zegeye N, Shiferaw Y, Lulekal E. Evaluation of skin irritation and acute and subacute oral toxicity of *Lavandula angustifolia* essential oils in rabbit and mice. J Toxicol. 2019; 2019(1): 5979546. https://doi.org/10.1155/2019/5979546
[219] Guilhon CC, Raymundo LJ, Alviano DS, Blank AF, Arrigoni-Blank MF, Matheus ME, Cavalcanti SC, Alviano CS, Fernandes PD. Characterisation of the anti-inflammatory and antinociceptive activities and the mechanism of the action of *Lippia gracilis* essential oil. J Ethnopharmacol. 2011; 135(2): 406-413. https://doi.org/10.1016/j.jep.2011.03.032
[220] Hernandes C, Pina E, Taleb-Contini S, Bertoni B, Cestari I, Espanha L, Varanda E, Camilo K, Martinez E, França S. *Lippia origanoides* essential oil: An efficient and safe alternative to preserve food, cosmetic and pharmaceutical products. J Appl Microbiol. 2017; 122(4): 900-910. https://doi.org/10.1111/jam.13398
[221] Pinto Cda P, Rodrigues VD, Pinto Fda P, Pinto Rda P, Uetanabaro AP, Pinheiro CS, Gadea SF, Silva TR, Lucchese AM. Antimicrobial activity of lippia species from the brazilian semiarid region traditionally used as antiseptic and anti-infective agents. Evid Based Complement Alternat Med. 2013;2013:614501. https://doi.org/10.1155/2013/614501

[222] Budin SB, Siti Nor Ain SM, Omar B, Taib IS, Hidayatulfathi O. Acute and subacute oral toxicity of *Litsea elliptica* Blume essential oil in rats. J Zhejiang Univ Sci B. 2012; 13(10): 783-790. https://doi.org/10.1631/jzus.B1100021
[223] Abdoul-Latif FM, Mohamed N, Edou P, Ali AA, Djama SO, Obame L-C, Bassolé IH, Dicko MH. Antimicrobial and antioxidant activities of essential oil and methanol extract of *Matricaria chamomilla* L. from Djibouti. J Med Plant Res. 2011; 5(9): 1512-1517.
[224] Borotová P, Galovičová L, Vukovic NL, Vukic M, Tvrdá E, Kačániová M. Chemical and biological characterization of *Melaleuca alternifolia* essential oil. Plants. 2022; 11(4): 558. https://doi.org/10.3390/plants11040558
[225] Hammer KA, Carson CF, Riley TV, Nielsen JB. A review of the toxicity of *Melaleuca alternifolia* (tea tree) oil. Food Chem Toxicol. 2006; 44(5): 616-625. https://doi.org/10.1016/j.fct.2005.09.001
[226] Jalilzadeh-Amin G, Maham M. Antidiarrheal activity and acute oral toxicity of *Mentha longifolia* L. essential oil. Avicenna J Phytomed. 2015; 5(2): 128-137.
[227] Daneshbakhsh D, Asgarpanah J, Najafizadeh P, Rastegar T, Mousavi Z. Safety assessment of *Mentha mozaffarianii* essential oil: acute and repeated toxicity studies. Iran J Med Sci. 2018; 43(5): 479.
[228] Mahboubi M, Kazempour N. Chemical composition and antimicrobial activity of peppermint (*Mentha piperita* L.) essential oil. Songklanakarin J Sci Technol. 2014; 36(1): 83-87.
[229] Debbab A, Mosaddak B, Aly A, Hakiki A, Mosaddak M. Chemical characterization and toxicological evaluation of the essential oil of *Mentha piperita* L. growing in Morocco. Sci Stud Resour. 2007; 8(3): 281-288.
[230] Teixeira B, Marques A, Ramos C, Batista I, Serrano C, Matos O, Neng NR, Nogueira JM, Saraiva JA, Nunes ML. European pennyroyal (*Mentha pulegium*) from Portugal: Chemical composition of essential oil and antioxidant and antimicrobial properties of extracts and essential oil. Ind Crops Prod. 2012; 36(1): 81-87. https://doi.org/10.1016/j.indcrop.2011.08.011
[231] Ez-Zriouli R, El Yacoubi H, Imtara H, El-Hessni A, Mesfioui A, Tarayrah M, Mothana RA, Noman OM, Mouhsine F, Rochdi A. Chemical composition and antimicrobial activity of essential oils from *Mentha pulegium* and *Rosmarinus officinalis* against multidrug-resistant microbes and their acute toxicity study. Open Chem. 2022; 20(1): 694-702. https://doi.org/10.1515/chem-2022-0185
[232] Di Vito M, Bellardi MG, Mondello F, Modesto M, Michelozzi M, Bugli F, Sanguinetti M, Sclocchi MC, Sebastiani ML, Biffi S. *Monarda citriodora* hydrolate vs essential oil comparison in several anti-microbial applications. Ind Crop Prod. 2019; 128: 206-212. https://doi.org/10.1016/j.indcrop.2018.11.007
[233] Enabulele SA, Oboh FO, Uwadiae EO. Antimicrobial, nutritional and phytochemical properties of M*onodora myristica* seeds. IOSR J Pharm Biol Sci. 2014; 9(4): 01-06.
[234] Miediegha O, Owaba A, Okori-West L. Acute toxicity studies, physicochemical and GC/MS analyses of *Monodora myristica* (Gaertn.) Dunal oil. Niger J Pharm Res. 2022; 18(2): 91-99. https://doi.org/10.4314/njpr.v18i2.1
[235] El Hartiti H, El Mostaphi A, Barrahi M, Ben Ali A, Chahboun N, Amiyare R, Zarrouk A, Bourkhiss B, Ouhssine M. Chemical composition and antibacterial activity of the essential oil of *Myrtus communis* leaves. Karbala Int J Modern Sci. 2020; 6(3): 3. https://doi.org/10.33640/2405-609X.1546
[236] Touaibia M. Composition and anti-inflammatory effect of the common myrtle (*Myrtus communis* L.) essential oil growing wild in Algeria. Phytothérapie. 2017: 1-6. https://doi.org/10.1007/s10298-017-1100-9
[237] Disket J, Mann S, Gupta RK. A review on spikenard (*Nardostachys jatamansi* DC.)-an 'endangered'essential herb of India. Int J Pharm Chem. 2012; 2(3): 52-60.
[238] Moghaddam AMD, Shayegh J, Mikaili P, Sharaf JD. Antimicrobial activity of essential oil extract of *Ocimum basilicum* L. leaves on a variety of pathogenic bacteria. J Med Plants Res. 2011; 5(15): 3453-3456.
[239] Ismail M. Central properties and chemical composition of *Ocimum basilicum*. essential oil. Pharm Biol. 2006; 44(8): 619-626. https://doi.org/10.1080/13880200600897544
[240] Orafidiya L, Agbani E, Iwalewa E, Adelusola K, Oyedapo O. Studies on the acute and sub-chronic toxicity of the essential oil of *Ocimum gratissimum* L. leaf. Phytomedicine. 2004; 11(1): 71-76. https://doi.org/10.1078/0944-7113-00317
[241] Nakamura CV, Ueda-Nakamura T, Bando E, Melo AFN, Cortez DAG, Dias Filho BP. Antibacterial activity of *Ocimum gratissimum* L. essential oil. Memórias do Instituto Oswaldo Cruz. 1999; 94: 675-678. https://doi.org/10.1590/S0074-02761999000500022
[242] Houda E, Abdelhalim M, Aboubaker E, Younes EYE, Atmane R. Assessment of bioactive compounds, antibacterial potential and acute toxicity of a volatile *Origanum compactum* extract, an endemic plant of northern Morocco. Arab J Med Arom Plant. 2021; 7(3): 422-437. https://doi.org/10.48347/IMIST.PRSM/ajmap-v7i3.26574
[243] Llana-Ruiz-Cabello M, Maisanaba S, Puerto M, Pichardo S, Jos A, Moyano R, Cameán AM. A subchronic 90-day oral toxicity study of *Origanum vulgare* essential oil in rats. Food Chem Toxicol. 2017; 101: 36-47. https://doi.org/10.1016/j.fct.2017.01.001
[244] Ghavam M, Afzali A, Manconi M, Bacchetta G, Manca ML. Variability in chemical composition and antimicrobial activity of essential oil of *Rosa damascena* Herrm. from mountainous regions of Iran. Chem Biol Technol Agric. 2021; 8: 1-16. https://doi.org/10.1186/s40538-021-00219-6
[245] Mulkijanyan K, Gogitidze N, Sulakvelidze M, Mushkiashvili N, Novikova Z, Mskhiladze L. Pharmacological assessment of the aqueous extract of rose oil waste from *Rosa damascena* Herrm cultivated in Georgia. World J Biol Pharm Health Sci. 2021; 7(1): 001-008. https://doi.org/10.30574/wjbphs.2021.7.1.0069

[246] Mengiste B, Dires K, Lulekal E, Arayaselassie M, Zenebe T, Feleke G, Makonnen E, Mekonnen A. Acute skin irritation, acute and sub-acute oral toxicity studies of *Rosmarinus officinalis* essential oils in mice and rabbit. Afr J Pharm Pharmacol. 2018; 12(26): 389-396. https://doi.org/10.5897/AJPP2018.4957

[247] Mihajilov-Krstev T, Radnović D, Kitić D, Zlatković B, Ristić M, Branković S. Chemical composition and antimicrobial activity of *Satureja hortensis* L. essential oil. Open Life Sci. 2009; 4(3): 411-416. https://doi.org/10.2478/s11535-009-0027-z

[248] Siavash Saei-Dehkordi S, Fallah AA, Heidari-Nasirabadi M, Moradi M. Chemical composition, antioxidative capacity and interactive antimicrobial potency of *Satureja khuzestanica* Jamzad essential oil and antimicrobial agents against selected food-related microorganisms. Int J Food Sci Technol. 2012; 47(8): 1579-1585. https://doi.org/10.1111/j.1365-2621.2012.03006.x

[249] Cerrón-Mercado F, Salva-Ruíz BK, Nolazco-Cama D, Espinoza-Silva C, Fernández-López J, Pérez-Alvarez JA, Viuda-Martos M. Development of Chincho (*Tagetes elliptica* Sm.) essential oil organogel nanoparticles through ionic gelation and process optimization with Box–Behnken Design. Gels. 2022; 8(12): 815. https://doi.org/10.3390/gels8120815

[250] Mohsenzadeh F, Chehregani A, Amiri H. Chemical composition, antibacterial activity and cytotoxicity of essential oils of *Tanacetum parthenium* in different developmental stages. Pharm Biol. 2011; 49(9): 920-926. https://doi.org/10.3109/13880209.2011.556650

[251] Adane F, Asres K, Ergete W, Woldekidan S, Abebe A, Lengiso B, Seyoum G. Composition of the essential oil *Thymus schimperi* and evaluation of its acute and subacute toxicity in wistar albino rats: in silico toxicity studies. Evid-Based Complement Altern Med. 2021;2021:5521302. https://doi.org/10.1155/2021/5521302

[252] Rojas-Armas J, Arroyo-Acevedo J, Ortiz-Sánchez M, Palomino-Pacheco M, Castro-Luna A, Ramos-Cevallos N, Justil-Guerrero H, Hilario-Vargas J, Herrera-Calderón O. Acute and repeated 28-day oral dose toxicity studies of *Thymus vulgaris* L. essential oil in rats. Toxicol Res. 2019; 35: 225-232. https://doi.org/10.5487/TR.2019.35.3.225

[253] Vazirian M, Hekmati D, Ostad S, Manayi A. Toxicity evaluation of essential oil of *Trachyspermum ammi* in acute and sub-chronic toxicity experiments. J Med Plants. 2019; 18(69): 70-77.

[254] Moein MR, Zomorodian K, Pakshir K, Yavari F, Motamedi M, Zarshenas MM. Trachyspermum ammi (L.) sprague: chemical composition of essential oil and antimicrobial activities of respective fractions. J Evid Based Complementary Altern Med. 2015;20(1):50-56. https://doi.org/10.1177/2156587214553302

[255] Stojković D, Soković M, Glamočlija J, Džamić A, Ćirić A, Ristić M, Grubišić D. Chemical composition and antimicrobial activity of *Vitex agnus-castus* L. fruits and leaves essential oils. Food Chem. 2011; 128(4): 1017-1022. https://doi.org/10.1016/j.foodchem.2011.04.007

[256] Chattopadhyay P, Banerjee S, Pathak MP, Agnihotri A, Karmakar S, Goyary D, Dhiman S, Veer V. Acute and subchronic dermal toxicity of *Vitex negundo* essential oil. Cutan Ocul Toxicol. 2014; 33(1): 16-21. https://doi.org/10.3109/15569527.2013.791829.

[257] Ai H-W, Kang Y-X, Cao Y, Zheng C-J. Antifungal properties and chemical analysis of essential oil from *Vitex negundo* seeds. J Pharm Res I. 2014; 4(5): 541-548. https://doi.org/10.9734/BJPR/2014/7079.

[258] López EIC, Balcázar MFH, Mendoza JMR, Ortiz ADR, Melo MTO, Parrales RS, Delgado TH. Antimicrobial activity of essential oil of *Zingiber officinale* Roscoe (Zingiberaceae). Am J Plant Sci. 2017; 8(7): 1511-1524. https://doi.org/10.4236/ajps.2017.87104

[259] Yang S-K, Tan N-P, Chong C-W, Abushelaibi A, Lim S-H-E, Lai K-S. The missing piece: Recent approaches investigating the antimicrobial mode of action of essential oils. Evol Bioinform. 2021; 17: 1176934320938391. https://doi.org/10.1177/1176934320938391

[260] Oliveira RC, Carvajal-Moreno M, Mercado-Ruaro P, Rojo-Callejas F, Correa B. Essential oils trigger an antifungal and anti-aflatoxigenic effect on *Aspergillus flavus* via the induction of apoptosis-like cell death and gene regulation. Food Control. 2020; 110: 107038. https://doi.org/10.1016/j.foodcont.2019.107038

[261] Kuwagata M, Doi Y, Saito H, Tsurumoto M, Igarashi T, Nishimura T, Taquahashi Y, Hirabayashi Y, Kitajima S. A 90-day repeated oral dose toxicity study of p-cymene in rats. Fundam Toxicol Sci. 2024; 11(4): 169-181. https://doi.org/10.2131/fts.11.169

[262] Salehi B, Mishra AP, Shukla I, Sharifi-Rad M, Contreras MdM, Segura-Carretero A, Fathi H, Nasrabadi NN, Kobarfard F, Sharifi-Rad J. Thymol, thyme, and other plant sources: Health and potential uses. Phytotherapy Res. 2018; 32(9): 1688-1706. https://doi.org/10.1002/ptr.6109

[263] Nejad SM, Özgüneş H, Başaran N. Pharmacological and toxicological properties of eugenol. Turk J Pharm Sci. 2017; 14(2): 201. https://doi.org/10.4274/tjps.62207

[264] Sun J. D-Limonene: safety and clinical applications. Altern Med Rev. 2007;12(3):259-264.

[265] Gupta A, Jeyakumar E, Lawrence R. Journey of limonene as an antimicrobial agent. J Pure Appl Microbiol. 2021; 15(3). https://doi.org/10.22207/JPAM.15.3.01

[266] Shah BB, Mehta AA. In vitro evaluation of antioxidant activity of D-Limonene. Asian J Pharm Pharmacol. 2018; 4(6): 883-887. https://doi.org/10.31024/ajpp.2018.4.6.25

[267] Fisher, Scientific. Safety Data Sheet for (-)-Limonene 92%. https://www.fishersci.com/store/msds?partNumber=AC203731000&productDescription=%28-%29-LIMONENE+92%25+100ML&vendorId=VN00032119&countryCode=US&language=en (accessed 2024).

[268] Balahbib A, El Omari N, Hachlafi NE, Lakhdar F, El Menyiy N, Salhi N, Mrabti HN, Bakrim S, Zengin G, Bouyahya A. Health beneficial and pharmacological properties of p-cymene. Food Chem Toxicol. 2021; 153: 112259. https://doi.org/10.1016/j.fct.2021.112259

[269] Tian F, Woo SY, Lee SY, Chun HS. p-Cymene and its derivatives exhibit antiaflatoxigenic activities against Aspergillus flavus through multiple modes of action. Appl Biol Chem. 2018; 61: 489-497. https://doi.org/10.1007/s13765-018-0382-4

[270] Carl Roth Gmb, H. Co K. G. Safety Data Sheet for Chemical Compound. https://www.carlroth.com/medias/SDB-3465-AU-EN.pdf?context=bWFzdGVyfHNlY3VyaXR5RGF0YXNoZWV0c3wyNzMxNTN8YXBwbGljYXRpb24vcGRmfGgxYS9oNmQvOTE0NDM5MjIyMDcwMi9TREJfMzQ2NV9BVV9FTi5wZGZ8YmMzYTE1NDAxMmQ5OTMyOGM1MGZlMWE2NTQ5NDE0ZDU1Mjg4Yjg1MTY0Y2VhYjUyY2JmMTc2ZTFmOTIwZTEzNg (accessed 2024).

[271] Sato K, Krist S, Buchbauer G. Antimicrobial effect of vapours of geraniol,(R)-(–)-linalool, terpineol, γ-terpinene and 1, 8-cineole on airborne microbes using an airwasher. Flavour Fragr J. 2007; 22(5): 435-437. https://doi.org/10.1002/ffj.1818

[272] Mollica F, Gelabert I, Amorati R. Synergic antioxidant effects of the essential oil component γ-terpinene on high-temperature oil oxidation. ACS Food Sci Technol. 2022; 2(1): 180-186. https://doi.org/10.1021/acsfoodscitech.1c00399

[273] An Q, Ren J-N, Li X, Fan G, Qu S-S, Song Y, Li Y, Pan S-Y. Recent updates on bioactive properties of linalool. Food Funct. 2021; 12(21): 10370-10389. https://doi.org/10.1039/D1FO02120F

[274] Kamatou GP, Viljoen AM. Linalool–A review of a biologically active compound of commercial importance. Nat Prod Commun. 2008; 3(7): 1934578X0800300727. https://doi.org/10.1177/1934578X0800300727

[275] Nakasugi LP, Silva Bomfim N, Romoli JCZ, Botião Nerilo S, Veronezi Silva M, Rocha Oliveira GH, Machinski Jr M. Antifungal and antiaflatoxigenic activities of thymol and carvacrol against *Aspergillus flavus*. Saúde e Pesquisa. 2021; 14(1). https://doi.org/10.17765/2176-9206.2021v14n1.e7727

[276] Escobar A, Perez M, Romanelli G, Blustein G. Thymol bioactivity: A review focusing on practical applications. Arab J Chem. 2020; 13(12): 9243-9269. https://doi.org/10.1016/j.arabjc.2020.11.009

[277] Dahham SS, Tabana YM, Iqbal MA, Ahamed MB, Ezzat MO, Majid AS, Majid AM. The anticancer, antioxidant and antimicrobial properties of the sesquiterpene β-caryophyllene from the essential oil of *Aquilaria crassna*. Molecules. 2015; 20(7): 11808-11829. https://doi.org/10.3390/molecules200711808

[278] Francomano F, Caruso A, Barbarossa A, Fazio A, La Torre C, Ceramella J, Mallamaci R, Saturnino C, Iacopetta D, Sinicropi MS. β-Caryophyllene: a sesquiterpene with countless biological properties. Appl Sci. 2019; 9(24): 5420. https://doi.org/10.3390/app9245420

[279] Carl Roth Gmb, H. Co K. G. Safety Data Sheet for Caryophyllene. https://www.carlroth.com/medias/SDB-7232-GB-EN.pdf?context=bWFzdGVyfHNlY3VyaXR5RGF0YXNoZWV0c3wyNDQ0NDR8YXBwbGljYXRpb24vcGRmfGFHTTJMMmd6Wmk4NU1UUTJPVEExTURBeU1ERTBMMU5FUWw4M01qTXlYMGRDWDBWT0xuQmtaZ3w3ZWI0YTAxMWYwNzhmZDAzZjg1ZDg2OGQ4YzJlNDJlNzRhYzY4ZTYyYmIxYWZiNTczMTZhY2VjYmJkYWNlN2U5 (accessed 2024).

[280] Cai Z-M, Peng J-Q, Chen Y, Tao L, Zhang Y-Y, Fu L-Y, Long Q-D, Shen X-C. 1, 8-Cineole: A review of source, biological activities, and application. J Asian Nat Prod Res. 2021; 23(10): 938-954. https://doi.org/10.1080/10286020.2020.1839432

[281] Xu J, Hu Z-Q, Wang C, Yin Z-Q, Wei Q, Zhou L-J, Li L, Du Y-H, Jia R-Y, Li M. Acute and subacute toxicity study of 1, 8-cineole in mice. Int J Clin Exp Pathol. 2014; 7(4): 1495.

[282] Kim H-M, Kwon H, Kim K, Lee S-E. Antifungal and Antiaflatoxigenic Activities of 1, 8-Cineole and t-Cinnamaldehyde on *Aspergillus flavus*. Appl Sci. 2018; 8(9): 1655. https://doi.org/10.3390/app8091655

[283] Carl Roth Gmb, H. Safety Data Sheet for Eucalyptol. https://www.carlroth.com/medias/SDB-7244-IE-EN.pdf?context=bWFzdGVyfHNlY3VyaXR5RGF0YXNoZWV0c3wyNzUzMDB8YXBwbGljYXRpb24vcGRmfGg4NS9oNDMvOTE0NjkwNTEzMzA4Ni9TREJfNzI0NF9JRV9FTi5wZGZ8MWMxYTQwZTdhNWM4ZDI1ZjA3NzMzOWVhMjAyNGY2MWIzYWJjNTIxY2I2OTQ1M2Y5ODIyOGU0MzdkNmM3NWQ4NA (accessed 2023).

[284] Xu Z, Chang L, Xu Z, Chang L. Lamiaceae. Identification and Control of Common Weeds: Volume 3. 2017: 181-265. https://doi.org/10.1007/978-981-10-5403-7_8

[285] Uritu CM, Mihai CT, Stanciu G-D, Dodi G, Alexa-Stratulat T, Luca A, Leon-Constantin M-M, Stefanescu R, Bild V, Melnic S. Medicinal plants of the family Lamiaceae in pain therapy: A review. Pain Res Manag 2018; 2018(1): 7801543. https://doi.org/10.1155/2018/7801543

[286] Tan PV, Mezui C, Enow-Orock G, Njikam N, Dimo T, Bitolog P. Teratogenic effects, acute and sub chronic toxicity of the leaf aqueous extract of *Ocimum suave* Wild (Lamiaceae) in rats. J Ethnopharmacol. 2008; 115(2): 232-237. https://doi.org/10.1016/j.jep.2007.09.022

[287] Rolnik A, Olas B. The plants of the Asteraceae family as agents in the protection of human health. Int J Mol Sci. 2021; 22(6): 3009. https://doi.org/10.3390/ijms22063009

[288] Amiri MS, Joharchi MR. Ethnobotanical knowledge of Apiaceae family in Iran: A review. Avicenna J Phytomed. 2016; 6(6): 621.

[289] Sayed-Ahmad B, Talou T, Saad Z, Hijazi A, Merah O. The Apiaceae: Ethnomedicinal family as source for industrial uses. Ind Crops Prod. 2017; 109: 661-671. https://doi.org/10.1016/j.indcrop.2017.09.027
[290] de Paulo Farias D, Neri-Numa IA, de Araujo FF, Pastore GM. A critical review of some fruit trees from the Myrtaceae family as promising sources for food applications with functional claims. Food Chem. 2020; 306: 125630. https://doi.org/10.1016/j.foodchem.2019.125630
[291] Faleiro JH, Gonçalves RC, dos Santos MNG, da Silva DP, Naves PLF, Malafaia G. The chemical featuring, toxicity, and antimicrobial activity of *Psidium cattleianum* (Myrtaceae) leaves. New J Sci. 2016; 2016(1): 7538613. https://doi.org/10.1155/2016/7538613
[292] Khalil AA, Khan M, Rauf A, Naz S, Al-Awthan YS, Bahattab O. The Family Rutaceae: An Overview of Its Traditional Uses. In: Phytochemical and Pharmacological Investigation of the Family Rutaceae. 2024: 15-31.
[293] Liaqat I, Riaz N, Saleem Q-u-A, Tahir HM, Arshad M, Arshad N. Toxicological evaluation of essential oils from some plants of Rutaceae family. Evid-Base Complement Altern Med. 2018; 2018(1): 4394687. https://doi.org/10.1155/2018/4394687
[294] Khalil AA, Khan AA, Khan MA, Naz S. Antioxidant Properties of the Family Rutaceae. In: Phytochemical and Pharmacological Investigation of the Family Rutaceae. Apple Academic Press, 2024.
[295] Kachuei R, Khodavaisy S, Rezaie S, Sharifynia S. In vitro antifungal susceptibility of clinical species belonging to *Aspergillus genus* and *Rhizopus oryzae*. J Mycol Méd. 2016; 26(1): 17-21. https://doi.org/10.1016/j.mycmed.2015.12.002
[296] Ikeda M, Yagihara Y, Tatsuno K, Okazaki M, Okugawa S, Moriya K. Clinical characteristics and antimicrobial susceptibility of *Bacillus cereus* blood stream infections. Ann Clin Microbiol Antimicrob. 2015; 14: 1-7. https://doi.org/10.1186/s12941-015-0104-2
[297] Senok A, Yousif A, Mazi W, Sharaf E, Bindayna K, Elnima E-A, Botta G. Pattern of antibiotic susceptibility in *Campylobacter jejuni* isolates of human and poultry origin. Japan J Infect Dis. 2007; 60(1): 1-4. https://doi.org/10.7883/yoken.JJID.2007.1
[298] Lyon GM, Karatela S, Sunay S, Adiri Y. Antifungal susceptibility testing of *Candida* isolates from the C*andida* surveillance study. J Clin Microbiol. 2010; 48(4): 1270-1275. https://doi.org/10.1128/jcm.02363-09
[299] Rams TE, Feik D, Mortensen JE, Degener JE, van Winkelhoff AJ. Antibiotic susceptibility of periodontal *Enterococcus faecalis*. J Periodontol. 2013; 84(7): 1026-1033. https://doi.org/10.1902/jop.2012.120050
[300] Kumar Y, Sood S, Sharma A, Mani KR. Antibiogram and characterization of resistance markers among *Escherichia coli* Isolates from urinary tract infections. J Infect Develop Countr. 2013; 7(07): 513-519. https://doi.org/10.3855/jidc.2706
[301] Khayyat AN, Abbas HA, Mohamed MF, Asfour HZ, Khayat MT, Ibrahim TS, Youns M, Khafagy E-S, Abu Lila AS, Safo MK. Not only antimicrobial: metronidazole mitigates the virulence of *Proteus mirabilis* isolated from macerated diabetic foot ulcer. Appl Sci. 2021; 11(15): 6847. https://doi.org/10.3390/app11156847
[302] Nagshetty K, Channappa ST, Gaddad SM. Antimicrobial susceptibility of *Salmonella typhi* in India. J Infect Develop Countr. 2010; 4(02): 070-073. https://doi.org/10.3855/jidc.109
[303] Falcone M, Russo A, Pacini G, Merli M, Venditti M. Spontaneous bacterial peritonitis due to methicillin-resistant *Staphylococcus aureus* in a patient with cirrhosis: the potential role for daptomycin and review of the literature. Infect Dis Repo. 2015; 7(3). https://doi.org/10.4081/idr.2015.6127
[304] Dima C, Dima S. Essential oils in foods: extraction, stabilization, and toxicity. Curr Opin Food Sci. 2015; 5: 29-35. https://doi.org/10.1016/j.cofs.2015.07.003
[305] Turek C, Stintzing FC. Stability of essential oils: a review. In: Comprehensive reviews in food science and food safety. 2013; 12(1): 40-53. https://doi.org/10.1111/1541-4337.12006
[306] Parke D, Lewis D. Safety aspects of food preservatives. Food Addit Contam. 1992; 9(5): 561-577. https://doi.org/10.1080/02652039209374110
[307] Naja F, Hamadeh R, Alameddine M. Regulatory frameworks for a safe and effective use of essential oils: a critical appraisal. Adv Biomed Health Sci. 2022; 1(1): 7-12. https://doi.org/10.4103/abhs.abhs_8_21
[308] Authority EFS, Dorne JLC, Manini P, Hogstrand C. Animal Health Risk assessment of multiple chemicals in essential oils for farm animals. 2020. https://doi.org/10.2903/sp.efsa.2020.EN-1760
[309] Tisserand R, Young R. Essential oil safety: a guide for health care professionals. Elsevier Health Sciences, 2013.
[310] Rahmi D, Yunilawati R, Jati BN, Setiawati I, Riyanto A, Batubara I, Astuti RI. Antiaging and skin irritation potential of four main Indonesian essential oils. Cosmetics. 2021; 8(4): 94. https://doi.org/10.3390/cosmetics8040094
[311] Reichling J, Suschke U, Schneele J, Geiss HK. Antibacterial activity and irritation potential of selected essential oil components–structure-activity relationship. Nat Prod Commun. 2006; 1(11): 1934578X0600101116. https://doi.org/10.1177/1934578X0600101116
[312] Mezzoug N, Idaomar M, Baudoux D, Debauche P, Liemans V, Zhiri A. Genotoxicity of some essential oils frequently used in aromatherapy. Adv Biosci Biotechnol. 2016; 7(2): 63-73. http://dx.doi.org/10.4236/abb.2016.72008