

Planta Medica

The Clinical Translation of α -humulene – A Scoping Review

Nishaanth Dalavaye, Martha Nicholas, Manaswini Pillai, Simon Erridge, Mikel H Sodergen.

Affiliations below.

DOI: 10.1055/a-2307-8183

Please cite this article as: Dalavaye N, Nicholas M, Pillai M et al. The Clinical Translation of α -humulene – A Scoping Review. *Planta Medica* 2024. doi: 10.1055/a-2307-8183

Conflict of Interest: SE is the Head of Research at Curaleaf Clinic. MHS is the Chief Medical Officer at Curaleaf International.

Abstract:

α -humulene, a sesquiterpene found in essential oils of various plant species, has garnered interest due to its potential therapeutic applications. This scoping review aims to consolidate α -humulene's evidence base, informing clinical translation and guiding future research directions. A scoping review was conducted of EMBASE, MEDLINE and PubMed databases up to 14th July 2023. All studies describing original research on α -humulene extraction, pre-clinical and clinical research were included for review. Three-hundred and forty articles were analyzed. α -humulene yields ranged from negligible to 60.90% across plant species. In vitro experiments demonstrated cytotoxicity against adenocarcinomas (such as colorectal, pulmonary, breast, prostatic, lung, and ovarian), with varying responses in other cell models. Mechanistic insights revealed its involvement in mitochondrial dysfunction, diminished intracellular glutathione levels, and the induction of oxidative stress. In rodent studies, oral administration of α -humulene at 50 mg/kg reduced inflammation markers in paw edema and ovalbumin-induced airway inflammation. Intraperitoneal administration of α -humulene (50-200 mg/kg) exhibited cannabimimetic properties through cannabinoid 1 and adenosine A2a receptors. α -humulene also exhibited a multitude of properties with potential scope for therapeutic utilization. However, there is a paucity of studies which have successfully translated this research into clinical populations with the associated disease. Potential barriers to clinical translation were identified, including yield variability, limited isolation studies, and challenges associated with terpene bioavailability. Consequently, rigorous pharmacokinetic studies and further mechanistic investigations are warranted to effectively uncover the potential of α -humulene.

Corresponding Author:

Nishaanth Dalavaye, Imperial College London Faculty of Medicine, South Kensington Campus, SW7 2AZ London, United Kingdom of Great Britain and Northern Ireland, nish.dalavaye21@imperial.ac.uk

Contributors' Statement: Data collection: N. Dalavaye, M. Nicholas, M. Pillai; Design of the study: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge, M.H.Sodergren; Statistical analysis: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge; analysis and interpretation of the data: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge, M.H.Sodergren; drafting the manuscript: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge; critical revision of the manuscript: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge, M.H.Sodergren

Affiliations:

Nishaanth Dalavaye, Imperial College London Faculty of Medicine, London, United Kingdom of Great Britain and Northern Ireland
Martha Nicholas, Imperial College London Faculty of Medicine, London, United Kingdom of Great Britain and Northern Ireland
Manaswini Pillai, Imperial College London Faculty of Medicine, London, United Kingdom of Great Britain and Northern Ireland
[...]
Mikel H Sodergen, Curaleaf International, London, United Kingdom of Great Britain and Northern Ireland

The Clinical Translation of α -humulene – A Scoping Review

Nishaanth Dalavaye¹, Martha Nicholas¹, Manaswini Pillai¹, Simon Erridge^{1,2},

Mikael H. Sodergren^{1,3}

1. Medical Cannabis Research Group, Department of Surgery and Cancer, Imperial College London, UK

2. Curaleaf Clinic, London, UK

3. Curaleaf International, London, UK

* Nishaanth Dalavaye, Martha Nicholas and Manaswini Pillai are to be considered as joint first authors

Correspondence to:

Mr Mikael H Sodergren FRCS PhD

Division of Surgery, Department of Surgery & Cancer, Imperial College London, Academic Surgical Unit, 10th Floor QEOM, St Mary's Hospital, South Wharf Road, London, W2 1NY.

Email: m.sodergren@imperial.ac.uk

Fax: +44 [0] 203 312 6309

Phone: +44 [0] 203 312 6666

Abstract

α -humulene, a sesquiterpene found in essential oils of various plant species, has garnered interest due to its potential therapeutic applications. This scoping review aims to consolidate α -humulene's evidence base, informing clinical translation and guiding future research directions. A scoping review was conducted of EMBASE, MEDLINE and PubMed databases up to 14th July 2023. All studies describing original research on α -humulene extraction, pre-clinical and clinical research were included for review. Three-hundred and forty articles were analyzed. α -humulene yields ranged from negligible to 60.90% across plant species. *In vitro* experiments demonstrated cytotoxicity against adenocarcinomas (such as colorectal, pulmonary, breast, prostatic, lung, and ovarian), with varying responses in other cell models. Mechanistic insights revealed its involvement in mitochondrial dysfunction, diminished intracellular glutathione levels, and the induction of oxidative stress. In rodent studies, oral administration of α -humulene at 50 mg/kg reduced inflammation markers in paw edema and ovalbumin-induced airway inflammation. Intraperitoneal administration of α -humulene (50-200 mg/kg) exhibited cannabimimetic properties through cannabinoid 1 and adenosine A2a receptors. α -humulene also exhibited a multitude of properties with potential scope for therapeutic utilization. However, there is a paucity of studies which have successfully translated this research into clinical populations with the associated disease. Potential barriers to clinical translation were identified, including yield variability, limited isolation studies, and challenges associated with terpene bioavailability. Consequently, rigorous pharmacokinetic studies and further mechanistic investigations are warranted to effectively uncover the potential of α -humulene.

Keywords: Terpenes; Anti-bacterial Agents; α -humulene; *Humulus lupulus*; *Cannabis Indica*; *Cannabis Sativa*; Cannabaceae

Introduction

Terpenoids are a vast and diverse group encompassing several classes of secondary metabolites from plants, each being investigated for biomedical properties [1]. Notably, they have been described as having anti-inflammatory, analgesic, antimicrobial, antioxidant, and estrogenic properties [2,3]. Sesquiterpenes are a class of terpene, to which α -humulene (also known as α -caryophyllene) and its isomer β -caryophyllene belong. These sesquiterpenes share a three-isoprene unit structure, formed from the precursor farnesyl diphosphate, leading to the formation of cyclic or multi-ring compounds that contribute to their distinctive aroma [1].

α -humulene and β -caryophyllene, though structurally similar, are differentiated by the opening structure present in α -humulene [4]. Historically, α -humulene was first identified as a major component in the essential oils of *Humulus lupulus* L., Cannabaceae, the common hop plant, from which it derived its name. Its structural elucidation was achieved through nuclear magnetic resonance spectroscopy. Furthermore, α -humulene has not only been sourced from *Humulus lupulus* but also from *Cannabis Indica* L., Cannabaceae, signifying its prevalence in botanical species for which there are already well-established agricultural processes [5]. The isolation and extraction of α -humulene from its botanical sources have been refined over time. Modern techniques, such as steam distillation, are employed to capture the volatile essential oils containing this sesquiterpene. Its abundance in various botanical sources makes it a subject of interest for both traditional and modern medicinal applications.

There is continual demand to identify novel compounds which possess anticancer, anti-inflammatory, and antimicrobial properties, in light of a persisting cancer burden, rising incidence of inflammatory conditions, and emergence of antimicrobial resistance [6–8]. Despite promising preclinical evidence supporting the multimodal therapeutic potential of α -

humulene, there are several barriers to its clinical translation. Whilst certain plant species are known to be rich sources of α -humulene, plant yields are often reported as being low and so far researchers have not reached a consensus on a named plant species which consistently yields high concentrations of α -humulene. At present, biosynthesis pathways are therefore being explored as an avenue to create synthetic α -humulene to overcome inherent challenges with the manufacturing of compounds which are reliant upon favorable agricultural conditions [9]. In addition, much of the research conducted to date has utilized a combination of organic compounds contained within the plant essential oil, rather than assessing the properties of α -humulene in isolation, resulting in a paucity of evidence summarising α -humulene's individual properties. It is therefore important to evaluate studies which report specifically the properties of α -humulene and identify species with acceptable yields in order to advance this scientific field.

A systematic review by Leite et al. [10] summarised the preclinical properties of sesquiterpene compounds, including α -humulene and β -caryophyllene. Whilst preclinical evidence has been promising regarding the properties of α -humulene, there has been minimal progress into clinical translation of this research. Hence, this review aimed to provide a synthesised evidence base for the prioritization of future research, including optimisation of agriculture and manufacturing, alongside identification of the most promising biomedical applications.

Results

Search results

The database and manual bibliography search initially returned 544 studies (Fig. 1). Four hundred and twelve full-text articles were assessed for eligibility, with 340 articles included for qualitative synthesis. Three hundred and seven (n = 307) studies included reported the extraction yields of α -humulene (Supplementary Material A). Thirty-two studies (n = 32) [11–42] were included for evaluation of the pre-clinical properties of α -humulene. These included investigations conducted *in vitro* [11–30], *in vivo* [31–36], and combined *in vitro* and *in vivo* experiments [37–42]. Notably, no studies were found to assess the clinical properties of α -humulene.

Yield of α -humulene from extraction

Yields of α -humulene were reported from 462 different plant and animal species (Supplementary Material B). Reported yields varied from nil to 60.90%. Table 1 highlights the five species that exhibited the highest reported yields among the included studies. The most common method of α -humulene extraction was hydrodistillation in a Clevenger-Type apparatus. Concurrently, isolation was most frequently relied on gas chromatography mass spectrometry (GC-MS). Among the species analyzed, *Lantana camara* L., Verbenaceae; *Origanum majorana* L., Lamiaceae; *Cordia verbenacea* DC., Boraginaceae; *Cannabis sativa*; and *Daucus carota* L., Apiaceae were prominent contributors, with the greatest number of studies reporting α -humulene extraction data.

Specific properties of α -humulene

Antiproliferative properties

Thirteen studies evaluated the effects of α -humulene in cancer models (Table 2) [11–20,31,37,38]. Across these studies, α -humulene consistently demonstrated cytotoxic activity against tumor cells, with one exception by Loizzo et al (2008) [20] involving human amelanotic melanoma (C32) and renal cell adenocarcinoma (ACHN) at a concentration of 9.3×10^{-7} - 1.2×10^{-4} . α -humulene, sourced from *Myrica rubra* Siebold & Zucc., Myricaceae, has demonstrated substantial anti-proliferative effects on colorectal cancer cell lines *in vitro*, marked by mitochondrial membrane potential disruption and enhanced efficacy when combined with conventional anticancer drugs [11]. In hepatocellular carcinoma (HCC), α -humulene from *Eupatorium odoratum* L., Asteraceae exhibited selective inhibition of HCC cell proliferation primarily *in vitro*, associated with the suppression of protein kinase B signaling [37]. Notably, α -humulene demonstrated dose-dependent inhibition of ovarian and lymphoblast cancer cell proliferation *in vitro* and synergistic effects with doxorubicin [12]. Its preferential cytotoxicity towards tumor cells, sparing non-tumor cells, indicates potential selectivity for actively dividing cancer cells. This anti-proliferative activity has also been related to apoptosis induction and modulation of reactive oxygen species (ROS) production [37]. In an *in vivo* study on clove terpenes, α -humulene induced significant glutathione S-transferase activity in mouse liver and small intestine tissues, suggesting a role in detoxification processes [31]. Fukuoka et al. (2004) [21] showed α -humulene's antiproliferative properties in rat arterial smooth muscle cells, utilizing a cell assay that induced proliferation with heat shock protein. The study reported an IC₅₀ value of 0.122 μ M, showcasing dose-dependent effects and superior potency compared to its analogue Zerumbone. Inhibitory effects were demonstrated even at a concentration of 4.89×10^{-6} mol/L.

Anti-inflammatory properties

Exploration into the *in-vivo* anti-inflammatory properties of α -humulene, isolated from *Cordia verbenacea* has yielded significant insights as well. Passos et al. (2007) [39] showed its potent anti-inflammatory attributes of α -humulene by demonstrating its ability to significantly inhibit carrageenan-induced paw oedema in murine models and a notable reduction in tumor necrosis factor (TNF)- α levels in response to carrageenan.. Fernandes et al. (2007) [32] conducted a similar evaluation using through oral administration of α -humulene against several experimental murine and rat models. Notably, administration of α -humulene at 50 mg/kg demonstrated a dose-dependent reduction in paw edema, indicating its efficacy in mitigating the acute phase of inflammation. Additionally, it exhibited a sustained anti-inflammatory effect by inhibiting the late phase of carrageenan-induced edema. Mechanistically, α -humulene interfered with multiple pathways involved in inflammation, including the inhibition of bradykinin, platelet-activating factor, and histamine-induced edema. Basting et al. (2019) [33] also observed a reduction in carrageenan-induced paw edema. Despite not significantly affecting neutrophil migration, α -humulene suppressed the release of TNF- α and interleukin (IL)-1 β and inhibited prostaglandin E2 production.. Similar findings were observed by Medeiros et al. (2007) [34] in lipopolysaccharide-induced rat paw edema. Key observations included a reduction in pro-inflammatory cytokines, inhibition of kinin B1 receptor upregulation, and suppressing neutrophil recruitment by targeting nuclear factor-kappa B (NF- κ B) activation. Notably, α -humulene's efficacy surpassed that of trans-caryophyllene.

In a murine model of airway allergic inflammation, female BALB/c mice challenged with ovalbumin experienced a significant reduction in eosinophil recruitment to bronchoalveolar lavage fluid and lung tissue when administered α -humulene preventively or therapeutically [35]. α -humulene exhibited modulation of critical asthma-related mediators, including IL-5,

C-C motif chemokine11, and leukotriene B4, along with the inhibition of P-selectin expression, a crucial factor in eosinophil migration. Additionally, α -humulene showed inhibitory effects on NF- κ B and activator protein-1. Histological analysis indicated a decrease in mucus hypersecretion, suggesting a potential role in balancing T-helper cell responses.

Contrary to the widely positive findings reported regarding the anti-inflammatory activity of α -humulene, Viveiro et al. (2022) [22] investigated pterygium fibroblasts through *in vitro* exposure experiments. Third-passage pterygium fibroblasts were subjected to α -humulene concentrations (0.25, 2.5, and 25 μ mol/L), and the subsequent cell viability assay revealed no significant cytotoxicity and minimal variation in inflammatory markers. This highlights the importance of considering cell-type-specific responses and experimental conditions in evaluating potential therapeutic benefits.

Antimicrobial properties

Early exploration into the *in vitro* antimicrobial potential of α -humulene was done by Pichette et al. (2006) [23] who observed antibacterial activity against *Staphylococcus aureus* at a mean inhibitory concentration (MIC) of 1.3×10^{-5} mol/L. Subsequent investigations by Azizan et al. (2017) [24] expanded on this by demonstrating dose-dependent bacteriostatic and bactericidal effects of α -humulene. Employing the broth microdilution method and α -humulene sourced from *Orthosiphon stamineus* and *Ficus deltoidei*, the study showed moderate to strong inhibition across a range of bacteria. Notably, oral Gram-negative species (*Porphyromonas gingivalis*, *Fusobacterium nucleatum*, *Aggregatibacter Actinomycetemcomitans*) exhibited greater susceptibility compared to Gram-positive bacteria (*Enterococcus faecalis*, *Streptococcus mutans*, *Streptococcus mitis*, *Streptococcus salivarius*).

Mechanistically, electron microscopy revealed morphological alterations, indicating α -humulene interfered with membrane structure or cell wall of oral bacteria. This effect was ascribed to the substantial electronegativity resulting from the carbon double bond configurations in its molecular structure.

Jang et al. (2020) [25] evaluated the *in vitro* antibacterial and antibiofilm effects of α -humulene extracted from *Bacteroides fragilis*. The study determined the MIC for cell growth and biofilm formation to be 9.8×10^{-6} mol/L. Through qRT-PCR analysis, concentration-dependent reductions in the expression of *bmeB1* and *bmeB3* genes were observed in various *Bacteroides fragilis* strains. This indicated increased antibiofilm action given these genes are implicated in the development of the biofilm matrix and antibiotic resistance. Notably, there was a marked reduction in cellular metabolic activity at concentrations of 3.9×10^{-5} - 7.8×10^{-5} mol/L. Moreover, confocal laser scanning microscopy revealed that α -humulene not only diminished cell density and thickness but also effectively reduced protein, carbohydrate, and nucleic acid levels. Rossato et al. (2022) [26] evaluated α -humulene's antibacterial potential against *Staphylococcus aureus* and *Enterococcus faecalis* using experimental light-cured periodontal dressing formulations and the modified direct contact model. Formulations with 10% and 20% α -humulene reduced bacterial growth after 1 and 24 hours of incubation compared to the control group, indicating sustained antibacterial activity.

Xing et al. (2018) [40] focused on evaluating the antifungal properties of humulene. Findings revealed a dose-dependent impediment of *Peronophythora litchii* growth, with scanning and transmission electron microscopy uncovering discernible morphological and ultrastructural changes. *In vivo* evaluations on litchi foliage and fruits demonstrated a notable reduction in

disease severity. α -humulene exhibited weak inhibitory effects against *Peronophythora litchi* at high concentrations (8.7×10^{-4} - 4.4×10^{-3} mol/L) [40].

Antiallergic properties

The antiallergic potential of α -humulene was demonstrated by Tanaka et al. (1996) [36], in the context of treatment for atopic conditions. Using a sensitised murine model of passive cutaneous anaphylaxis, α -humulene administration prior to antigen challenge demonstrated dose-dependent inhibition of allergic reactions at 20, 40 and 80 mg/kg, with approximately four times the potency of the reference drug tranilast. However, the observed effects were less potent than the antiallergy effects triggered by β -caryophyllene. The study suggested the bicyclic ring structure inherent in β -caryophyllene may have contributed to the enhanced antiallergy activity of the compound. Additionally, Fernandes et al. (2007) [32] demonstrated α -humulene reduced paw oedema in sensitized mice challenged with ovalbumin, suggesting its anti-inflammatory properties in alleviating allergic responses.

Antiparasitic properties

De Oliveria et al. (2017) [27] evaluated the antischistosomal effects of α -humulene against *Schistosoma mansoni* following *in vitro* exposure. At concentrations of 1 mol/L, α -humulene exhibited notable efficacy, causing mortality rates of 60% for female worms and 80% for male worms after a 72-hour incubation period. The sesquiterpene also induced a substantial reduction in motor activity and oviposition across all concentrations, highlighting its potential as a promising antiparasitic agent. Additionally, there were significant inhibitory effects of α -humulene on the excretory system of male *Schistosoma mansoni* adult worms. However, this inhibitory activity was not observed in female worms. The mechanism underlying this was attributed to the inhibition of the expression of P-glycoprotein, a product of the multidrug

resistance 2 gene, within the excretory system of male *Schistosoma mansoni* worms. The study further employed Hoechst probe and scanning electron microscopy to assess the impact of α -humulene on the membrane integrity of *Schistosoma mansoni*. This highlighted the substantial damage caused to the tegument by α -humulene exposure.

Gastroprotective properties

Lemos et al. (2015) [41] investigated the potential gastroprotective effects of α -humulene through their study involving murine gastric ulcer models. The researchers administered an oral dose of 30mg/kg of isolated α -humulene, equivalent to omeprazole dosing. This dose led to a substantial reduction of 76.20% in gastric lesions induced by 0.2 ml of an ethanol/hydrogen chloride solution (60%/0.3 M). This investigation revealed two significant mechanisms contributing to the gastroprotective effects: a reduction in gastric acid secretion and an increase in mucus production.

Larvicidal properties

The larvicidal potential of α -humulene was examined by Govindarajan et al (2016) [28] in an *in vivo* study encompassing three vector species: *Anopheles subpictus* Grassi (Culicidae); *Aedes albopictus* Skuse (Culicidae); and *Culex tritaeniorhynchus* Giles (Culicidae). The researchers determined the lethal concentration 50 (LC50) values as 3.0×10^{-5} , 3.4×10^{-5} and 3.6×10^{-5} mol/L for the respective species. The impact on non-target species was notably less, with a significantly lower LC50 of 5.0×10^{-3} mol/L observed in *Gambusia affinis* fish. Furthermore, there were no adverse effects on fish survival or swimming activity following the administration of α -humulene concentrations approaching the calculated larvae LC90.

Hung et al. (2021) [29] also evaluated the larvicidal effects of α -humulene from the essential oil of *Lantana camara*. It showed promising larvicidal activities against important mosquito vectors, with 48-hour LC50 values of 1.9×10^{-4} mol/L for *Anopheles aegypti* L. (Culicidae); 1.9×10^{-4} mol/L for *Aedes albopictus*; and 4.3×10^{-4} mol/L for *Culex quinquefasciatus* Say (Culicidae). Additionally, α -humulene exhibited notable mosquito larvicidal effects with an inhibitory concentration (IC50) value of 7.9×10^{-4} against electric eel acetylcholinesterase. Furthermore, in-silico studies have demonstrated α -humulene exhibits significant binding energy in docking studies targeting sterol carrier protein-2, indicating its potential as an effective antilarvicidal agent [30].

Molluscicidal properties

In the context of molluscs acting as intermediate hosts for several helminths, α -humulene's potential molluscicidal properties have been subjected to scrutiny [29]. Notably, its LC50 values at 24 hours have been reported as 9.3×10^{-5} mol/L, 9.3×10^{-5} mol/L, and 9.1×10^{-5} mol/L for *Pomacea canaliculate* (Lam.), Ampullariidae; *Gyraulus convexiusculus* (Hutton), Planorbidae; and *Tarebia granifera* (Lam.), Thiaridae, respectively.

Cannabimimetic properties

The cannabimimetic properties of α -humulene were demonstrated by LaVigne et al. (2021) [42] through *in vivo* and *in vitro* experiments. Using various behavioral assays in mice, α -humulene manifested notable antinociceptive effects. The study identified specific receptor targets influenced by α -humulene, revealing interactions with cannabinoid type 1 (CB1) and types 2 (CB2) receptors, as well as adenosine receptor A2a, through *in vitro* experiments. Furthermore, *in vivo* experiments demonstrated a synergistic interaction between α -humulene and the synthetic cannabinoid agonist WIN55,212-2, leading to enhanced antinociceptive

effects. There were selective effects of α -humulene on various behaviors associated with the tetrad, emphasising its complex interplay with multiple receptor systems. Notably, the *in vitro* studies showed the CB1-dependent nature of α -humulene activation, requiring relatively high concentrations for receptor activation, a phenomenon reversible by the CB1 antagonist rimonabant.

Discussion

The scoping review undertaken in this study unveils the landscape of α -humulene's pharmacological potential, revealing a diverse spectrum of documented properties across various studies. These encompass anti-inflammatory, antimicrobial, antiproliferative, antiallergic, gastroprotective, and even cannabimimetic effects. α -humulene interacts with diverse biological pathways, suggesting its potential for addressing various health conditions.

The review further emphasises the pivotal role played by specific species that yield substantial amounts of α -humulene, carrying profound implications for pharmaceutical applications. Noteworthy among these is *Aframomum melegueta*, a West African spice renowned for its historical medicinal uses and significant α -humulene content, rendering it an enticing candidate for therapeutic extraction [43]. Likewise, several *Leptospermum* species, known for their potent antimicrobial properties, exhibit notable levels of α -humulene [44]. Additionally, *Humulus lupulus*, commonly known as hops, has a high α -humulene content. Given its well-documented applications and extensively studied properties, hops offer a versatile avenue for the development of α -humulene-based therapeutics [45]. Another plant of significance is *Cannabis sativa*, in which α -humulene is already utilized in full-spectrum

cannabis-based medicinal products. The cannabimimetic effects of α -humulene may give rise to potential additive or synergistic effects when administered alongside cannabinoids and other active pharmaceutical ingredients, broadly referred to as ‘the entourage effect’ [46]. Collectively, these species enrich the available sources of α -humulene, highlighting its prevalence across a diverse range of botanicals. These species hold promise as potential sources for pharmaceutical extraction due to their abundant α -humulene content. By harnessing extracts derived from these species, either in combination with other compounds or as standalone treatments, further exploration of potential solutions for various health conditions becomes viable.

The translation of promising preclinical findings to clinical practice encounters barriers. Variability in α -humulene yield across different botanical sources poses logistical challenges for large-scale extraction [47]. The limited exploration of isolated α -humulene outside of whole essential oils highlights the importance of comprehensive investigations into isolated properties [48]. Addressing this inconsistency requires the identification of further plant species with high α -humulene yields or increased investigation of biosynthesis pathways for synthetic production.

The potential of α -humulene as an anticancer agent is particularly promising. Studies have established wide-ranging effects on various cancer cell lines, revealing nuanced interactions with distinct tumor types. This is coherent with preclinical studies on other terpenes, which similarly find anticancer potential [49]. The mechanism of action of α -humulene appears multifactorial, including increasing the production of reactive oxidative species and induction of apoptosis [16,37]. Moreover, α -humulene was associated with glutathione depletion, which makes cancer cells more sensitive to stress caused by reactive oxidative species [16]. α -humulene was associated with an increase in GST activity, which is also seen with other

terpenes [50]. This feature, however, is typically associated with improved cancer cell survival and resistance to certain chemotherapeutics, due to the associated efflux of anticancer agents from the cell [51]. Putra et al investigated α -humulene's interaction with the overexpressed HER-2 protein using docking methods and shed light on its potential as an anti-breast cancer agent. The in silico molecular docking simulations reveal a binding energy of -7.50 kcal/mol, affirming its efficacy against breast cancer [52]. As such its effects within human studies are eagerly awaited, especially as preclinical studies showing that α -humulene may have synergistic effects with doxorubicin and other chemotherapeutics [13]. This is particularly important as present studies indicate that α -humulene would not be a suitable chemotherapeutic agent in isolation and would otherwise be best used alongside traditional chemotherapeutics [53]. Its lower toxicity profile also supports this as a potential future use, provided efficacy can be determined [54]. Further mechanistic studies, including investigations into synergistic interactions with established chemotherapeutics, are ultimately necessary to fully leverage α -humulene's potential in cancer biology [55].

Beyond its cancer-related properties, α -humulene is as a compelling anti-inflammatory agent. Its modulation of the NF- κ B pathway and subsequent suppression of key inflammatory mediators demonstrates its potential in various inflammatory conditions [56]. Insights gained from murine models of asthma highlight its immunomodulatory potential, positioning α -humulene as a contender for treating inflammatory and atopic conditions [35]. Additionally, its analgesic potential and observed gastroprotective effects hold significance [57]. In contrast to traditional non-steroidal anti-inflammatory drugs, notorious for causing peptic ulcer disease and adverse renal effects, α -humulene offers a potentially safer alternative for managing inflammation-associated conditions [58].

The pharmacodynamic profile of α -humulene indicates its capability of addressing various aspects of health and disease. Its interactions with different molecular pathways suggest complex biochemical dialogues within cells and tissues. This complexity is particularly relevant for multifactorial conditions like cancer and chronic inflammatory diseases, where several dysregulated pathways contribute to aetiology and pathogenesis [59,60]. By targeting these pathways, α -humulene introduces a novel therapeutic approach distinct from the traditional "one-target-one-drug" paradigm [61,62].

The antimicrobial properties of α -humulene enrich its pharmacological profile, spanning antibacterial, antiparasitic, and antifungal effects. Its efficacy in restraining biofilm formation and curtailing gene expression associated with biofilm matrix development and antibiotic resistance is particularly relevant given the growing appreciation for the role of biofilm in antibiotic resistance [63,64]. This enhances the potential to address antibiotic-resistant infections, a pressing global health concern [65].

The paucity of clinical studies involving α -humulene necessitates thorough evaluation in the clinical setting to validate its efficacy, safety, and optimal dosage regimens in human subjects before widespread use [66]. In addition, it is crucial to emphasise the necessity of pharmacokinetic studies, particularly for terpenes like α -humulene. Due to their lipophilic nature, terpenes often exhibit poor water solubility and are susceptible to rapid metabolism and elimination, leading to low oral bioavailability [2,67]. Therefore, rigorous pharmacokinetic studies in animals and humans are essential to optimise dosing strategies to understand α -humulene's therapeutic potential [68]. Strategies to enhance α -humulene's bioavailability, such as formulations that improve solubility and stability, could significantly enhance its clinical utility [69]. There is one pilot study currently underway seeking to

explore the effects of α -humulene on stress when combined with forest bathing, for which the results will be eagerly awaited [70].

Acknowledging the limitations of this scoping review is vital. The heterogeneity of study methodologies, including variations in cell lines, experimental conditions, and assessment methods, poses a challenge in directly comparing the results. This heterogeneity limits the ability to perform quantitative meta-analyses and emphasises the need for cautious interpretation. Variations in study design, quality, sample size, and reporting practices could impact the overall strength of evidence. The limited number of *in vivo* studies and the absence of clinical trials restrict the ability to directly extrapolate findings to human populations directly to provide clinical validation [71]. Preclinical studies often involve isolated cells or animal models which may not fully replicate human physiological responses [72]. Furthermore, it's important to acknowledge the limitations associated with the compilation of α -humulene yield data from various locations, with a focus solely on the highest reported yields. This approach might not account for potential variations in cultivation practices, environmental factors, and genetic influences that can significantly affect yield outcomes. Relying solely on the highest reported yields could lead to an incomplete understanding of the compound's availability and potentially skew the representation of humulene yields. Moreover, studies often failed to specify whether the α -humulene yield was from the whole plant, flower, or another plant component. This lack of clarity restricts the interpretation, as there can be substantial variation in terpene content across various flower structures [73].

Overall, this systematic review provides valuable insights into α -humulene's potential therapeutic properties. However, addressing limitations through standardised methodologies,

clinical trials, and consistent reporting practices is crucial for an accurate understanding of its multifaceted effects and clinical applications. The future of α -humulene's clinical translation hinges on collaborative efforts, pharmacokinetic evaluations, rigorous clinical trials, innovative formulation strategies, and partnerships across disciplines. Through these efforts, α -humulene's clinical translation can be accelerated in light of its many promising therapeutic properties.

Materials and Methods

A scoping review, utilizing methods outlined by Arksey & O'Malley and Levac et al. [74,75], was conducted of the current literature on α -humulene.

Research question

This scoping review focused on identifying and clarifying key research aspects and characteristics of available literature with regards to α -humulene. Given its potential therapeutic effects in the clinical setting, this review evaluated the evidence base for α -humulene in terms of its extraction and properties that may be translated for medicinal purposes. This review also aimed to identify any specific gaps in the evidence base that may inform the work of future researchers in this area of sesquiterpene research.

Data sources and search strategy

A broad search was conducted of MEDLINE, PubMed, and EMBASE databases in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [76]. A search was conducted from 1946 to July 14, 2023, utilizing the search terms 'humulene,' 'alpha-humulene,' and 'alpha-caryophyllene' with the Boolean operator 'OR' (Table S1, S1a-c). The literature search was conducted by three independent

researchers. For discrepancies identified, a senior author was planned to review these if necessary. Additional relevant articles were included through manual search of bibliographies of included studies. Articles were screened in relation to the topic area and included if deemed to meet the inclusion criteria. The precise search strategies performed can be found in Supplementary Material C.

Study selection criteria

Inclusion criteria consisted of original articles related to α -humulene including extraction, pre-clinical and clinical research. Studies were excluded if they did not constitute original primary research or the outcomes of α -humulene were not reported in isolation to other essential oils extracted from plant species.

Data extraction and presentation

Data extraction was performed independently by three authors. If outcomes were not reported within the published article, but described within the methodology, corresponding authors were contacted for additional information. Concentrations are presented as percentage yield or micromolar concentrations (μM) with the standard deviation (S.D.), standard error (S.E.) or range if reported.

Supporting information

Supplementary material A: References for studies of extraction yields for different species

Supplementary material B: Reported yields of α -humulene

Supplementary material C: Search strategy

Contributors Statement

Data collection: N. Dalavaye, M. Nicholas, M. Pillai; Design of the study: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge, M.H.Sodergren; Statistical analysis: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge; analysis and interpretation of the data: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge, M.H.Sodergren; drafting the manuscript: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge; critical revision of the manuscript: N. Dalavaye, M. Nicholas, M. Pillai, S. Erridge, M.H.Sodergren

Conflicts of interest

SE is the Head of Research at Curaleaf Clinic. MHS is the Chief Medical Officer at Curaleaf International.

References

1. Degenhardt J, Köllner TG, Gershenzon J. Monoterpene and sesquiterpene synthases and the origin of terpene skeletal diversity in plants. *Phytochemistry*. 2009;70(15–16):1621–37.
2. Masyita A, Mustika Sari R, Dwi Astuti A, Yasir B, Rahma Rumata N, Emran TB, Nainu F, Simal-Gandara J. Terpenes and terpenoids as main bioactive compounds of essential oils, their roles in human health and potential application as natural food preservatives. *Food Chemistry: X*. 2022;13:100217–100217.
3. Yang W, Chen X, Li Y, Guo S, Wang Z, Yu X. Advances in Pharmacological Activities of Terpenoids. *Natural Product Communications*. 2020 Mar 1;15(3):1934578X20903555.
4. *Comprehensive Natural Products II: Chemistry and Biology, Volumes 1–10*. Journal of the American Chemical Society. 2010;132(28):9929–9929.
5. Simonsen JL, Todd AR. 32. *Cannabis indica*. Part X. The essential oil from Egyptian hashish. *Journal of the Chemical Society (Resumed)*. 1942;188–188.
6. Ugai T, Sasamoto N, Lee HY, Ando M, Song M, Tamimi RM, Kawachi I, Campbell PT, Giovannucci EL, Weiderpass E, Rebbeck TR, Ogino S. Is early-onset cancer an emerging global epidemic? Current evidence and future implications. *Nature Reviews Clinical Oncology*. 2022;19(10):656–73.
7. Furman D, Campisi J, Verdin E, Carrera-Bastos P, Targ S, Franceschi C, Ferrucci L, Gilroy DW, Fasano A, Miller GW, Miller AH, Mantovani A, Weyand CM, Barzilai N, Goronzy JJ, Rando TA, Effros RB, Lucia A, Kleinstreuer N, Slavich GM. Chronic

inflammation in the etiology of disease across the life span. *Nature Medicine*. 2019;25(12):1822–32.

8. Andersson DI, Balaban NQ, Baquero F, Courvalin P, Glaser P, Gophna U, Kishony R, Molin S, Tønjum T. Antibiotic resistance: turning evolutionary principles into clinical reality. *FEMS Microbiology Reviews*. 2020;44(2):171–88.
9. Harada H, Yu F, Okamoto S, Kuzuyama T, Utsumi R, Misawa N. Efficient synthesis of functional isoprenoids from acetoacetate through metabolic pathway-engineered *Escherichia coli*. *Applied Microbiology & Biotechnology*. 2009;81(5):915–25.
10. Leite GM, Barbosa MO, Lopes MJP, Delmondes GA, Bezerra DS, Araújo IM, Carvalho de Alencar CD, Coutinho HDM, Peixoto LR, Barbosa-Filho JM, Felipe CFB, Barbosa R, Alencar de Menezes IR, Kerntof MR. Pharmacological and toxicological activities of α -humulene and its isomers: A systematic review. *Trends in Food Science & Technology*. 2021;115:255–74.
11. Ambrož M, Šmatová M, Šadibolová M, Pospíšilová E, Hadravská P, Kašparová M, Hanušová Skarková V, Králová V, Skálová L. Sesquiterpenes α -humulene and β -caryophyllene oxide enhance the efficacy of 5-fluorouracil and oxaliplatin in colon cancer cells. *Acta Pharmaceutica*. 2019;69(1):121–8.
12. Ambrož M, Matoušková P, Skarka A, Zajdlová M, Žáková K, Skálová L. The Effects of Selected Sesquiterpenes from *Myrica rubra* Essential Oil on the Efficacy of Doxorubicin in Sensitive and Resistant Cancer Cell Lines. *Molecules*. 2017;22(6):1021–1021.
13. Ambrož M, Boušová I, Skarka A, Hanušová V, Králová V, Matoušková P, Szotáková B, Skálová L. The Influence of Sesquiterpenes from *Myrica rubra* on the Antiproliferative and Pro-Oxidative Effects of Doxorubicin and Its Accumulation in Cancer Cells. *Molecules*. 2015;20(8):15343–58.
14. Su YC, Hsu KP, Wang EIC, Ho CL. Composition, in vitro Cytotoxic, and Antimicrobial Activities of the Flower Essential Oil of *Diospyros discolor* from Taiwan. *Natural Product Communications*. 2015;10(7):1934578X1501000-1934578X1501000.
15. Hadri A, Gómez del Río MA, Sanz J, González Coloma A, Idaomar M, Ribas Ozonas B, Benedí González J, Sánchez Reus MI. Cytotoxic activity of α -humulene and β -caryophyllene from *Salvia officinalis* in animal and human tumor cells. *Anales de la Real Academia Nacional de Farmacia*. 2010;76:343–56.
16. Legault J, Dahl W, Debiton E, Pichette A, Madelmont JC. Antitumor activity of balsam fir oil: Production of reactive oxygen species induced by α -humulene as possible mechanism of action. *Planta medica*. 2003;69:402–7.
17. Legault J, Pichette A. Potentiating effect of β -caryophyllene on anticancer activity of α -humulene, isocaryophyllene and paclitaxel. *Journal of Pharmacy and Pharmacology*. 2010;59(12):1643–7.
18. Cole RA, Bansal A, Moriarity DM, Haber WA, Setzer WN. Chemical composition and cytotoxic activity of the leaf essential oil of *Eugenia zuchowskiae* from Monteverde, Costa Rica. *Journal of Natural Medicines*. 2007;61(4):414–7.

19. Silva SL da, Chaar J da S, Figueiredo P de MS, Yano T. Cytotoxic evaluation of essential oil from *Casearia sylvestris* Sw on human cancer cells and erythrocytes. *Acta Amazonica*. 2008;38(1):107–12.
20. Loizzo MR, Tundis R, Saab AM, Statti GA, Menichini F. Antiproliferative effects of essential oils and their major constituents in human renal adenocarcinoma and amelanotic melanoma cells. *Cell proliferation*. 2008;41(6):1002–12.
21. Fukuoka K, Sawabe A, Sugimoto T, Koga M, Okuda H, Kitayama T, Shirai M, Komai K, Komemushi S, Matsuda K. Inhibitory actions of several natural products on proliferation of rat vascular smooth muscle cells induced by Hsp60 from *Chlamydia pneumoniae* J138. *J Agric Food Chem*. 2004 Oct 6;52(20):6326-9.
22. Viveiros MMH, Silva MG, da Costa JGM, de Oliveira AG, Rubio C, Padovani CR, Rainho CA, Schellini SA. Anti-inflammatory effects of α -humulene and β -caryophyllene on pterygium fibroblasts. *Int J Ophthalmol*. 2022 Dec 18;15(12):1903–7.
23. Pichette A, Larouche PL, Lebrun M, Legault J. Composition and antibacterial activity of *Abies balsamea* essential oil. *Phytotherapy Research*. 2006;20(5):371–3.
24. Azizan N, Mohd Said S, Zainal Abidin Z, Jantan I. Composition and Antibacterial Activity of the Essential Oils of *Orthosiphon stamineus* Benth and *Ficus deltoidea* Jack against Pathogenic Oral Bacteria. *Molecules*. 2017;22(12):2135–2135.
25. Jang HI, Rhee KJ, Eom YB. Antibacterial and antibiofilm effects of alpha-humulene against *Bacteroides fragilis*. *Canadian journal of microbiology*. 2020;66(6):389–99.
26. Rossato TC de A, Alves T, Cuevas-Suárez CE, Rosa WL de O da, Silva AF da, Piva E, ZANCHI CH, Lund RG. Effect of alpha-humulene incorporation on the properties of experimental light-cured periodontal dressings. *Brazilian Oral Research*. 2022;36.
27. de Oliveira RN, Dos Santos KR, Mendes TMF, Garcia VL, Santos Oliveira AS, de Lourdes Sierpe Jeraldo V, Allegretti SM. Sesquiterpenes evaluation on *Schistosoma mansoni*: Survival, excretory system and membrane integrity. *Biomedicine & Pharmacotherapy*. 2017;90:813–20.
28. Govindarajan M, Benelli G. α -Humulene and β -elemene from *Syzygium zeylanicum* (Myrtaceae) essential oil: highly effective and eco-friendly larvicides against *Anopheles subpictus*, *Aedes albopictus*, and *Culex tritaeniorhynchus* (Diptera: Culicidae). *Parasitol Res*. 2016 Jul;115(7):2771–8.
29. Nguyen Huy Hung, Do Ngoc Dai, Prabodh Satyal, Le Thi Huong, Bui Thi Chinh, Dinh Quang Hung, Thieu Anh Tai, William N. Setzer. *Lantana camara* Essential Oils from Vietnam: Chemical Composition, Molluscicidal, and Mosquito Larvicidal Activity. *Chemistry & Biodiversity*. 2021;18(5).
30. Andrade-Ochoa S, Correa-Basurto J, Rodríguez-Valdez LM, Sánchez-Torres LE, Noguera-Torres B, Nevárez-Moorillón GV. In vitro and in silico studies of terpenes, terpenoids and related compounds with larvicidal and pupaecidal activity against *Culex quinquefasciatus* Say (Diptera: Culicidae). *Chemistry Central Journal*. 2018 May 10;12(1):53.

31. Zheng GQ, Kenney PM, Lam LKT. Sesquiterpenes from Clove (*Eugenia caryophyllata*) as Potential Anticarcinogenic Agents. *Journal of Natural Products*. 1992;55(7):999–1003.
32. Fernandes ES, Passos GF, Medeiros R, da Cunha FM, Ferreira J, Campos MM, Pianowski LF, Calixto JB. Anti-inflammatory effects of compounds alpha-humulene and (-)-trans-caryophyllene isolated from the essential oil of *Cordia verbenacea*. *Eur J Pharmacol*. 2007;569(3):228–36.
33. Basting RT, Spindola HM, Sousa IMO, Queiroz NCA, Trigo JR, de Carvalho JE, Foglio MA. *Pterodon pubescens* and *Cordia verbenacea* association promotes a synergistic response in antinociceptive model and improves the anti-inflammatory results in animal models. *Biomed Pharmacother*. 2019;112:108693.
34. Medeiros R, Passos GF, Vitor CE, Koepp J, Mazzuco TL, Pianowski LF, Campos MM, Calixto JB. Effect of two active compounds obtained from the essential oil of *Cordia verbenacea* on the acute inflammatory responses elicited by LPS in the rat paw. *Br J Pharmacol*. 2007;151(5):618–27.
35. Rogerio AP, Andrade EL, Leite DFP, Figueiredo CP, Calixto JB. Preventive and therapeutic anti-inflammatory properties of the sesquiterpene α -humulene in experimental airways allergic inflammation. *British Journal of Pharmacology*. 2009;158(4):1074–87.
36. Tanaka S, Akimoto M, Tambe Y, Tabata M, Ikeshiro Y. Volatile Antiallergic Principles from a Traditional Herbal Prescription of Kampo Medicine. *Phytotherapy Research*. 1996;10(3):238–41.
37. Chen H, Yuan J, Hao J, Wen Y, Lv Y, Chen L, Yang X. α -Humulene inhibits hepatocellular carcinoma cell proliferation and induces apoptosis through the inhibition of Akt signaling. *Food and Chemical Toxicology*. 2019;134:110830–110830.
38. Costa EV, Menezes LRA, Rocha SLA, Baliza IRS, Dias RB, Rocha CAG, Soares MBP, Bezerra DP. Antitumor Properties of the Leaf Essential Oil of *Zornia brasiliensis*. *Planta Medica*. 2015;81(07):563–7.
39. Passos GF, Fernandes ES, da Cunha FM, Ferreira J, Pianowski LF, Campos MM, Calixto JB. Anti-inflammatory and anti-allergic properties of the essential oil and active compounds from *Cordia verbenacea*. *Journal of Ethnopharmacology*. 2007;110(2):323–33.
40. Xing M, Zheng L, Deng Y, Xu D, Xi P, Li M, Kong G, Jiang Z. Antifungal Activity of Natural Volatile Organic Compounds against Litchi Downy Blight Pathogen *Peronophythora litchii*. *Molecules*. 2018;23(2):358–358.
41. Lemos M, Santin JR, Mizuno CS, Boeing T, De Sousa JPB, Nanayakkara D, Kenupp Bastos J, Faloni de Andrade S. *Copaifera langsdorffii*: Evaluation of potential gastroprotective of extract and isolated compounds obtained from leaves. *Rev Bras Farmacogn*. 2015;25(3):238–45.

42. LaVigne JE, Hecksel R, Keresztes A, Streicher JM. Cannabis sativa terpenes are cannabimimetic and selectively enhance cannabinoid activity. *Scientific Reports*. 2021;11(1):8232–8232.
43. Ilic N, Schmidt BM, Poulev A, Raskin I. Toxicological evaluation of Grains of Paradise (*Aframomum melegueta*) [Roscoe] K. Schum. *Journal of Ethnopharmacology*. 2010;127(2):352–6.
44. Caputo L, Smeriglio A, Trombetta D, Cornara L, Trevena G, Valussi M, Fratianni F, De Feo V, Nazzaro F. Chemical Composition and Biological Activities of the Essential Oils of *Leptospermum petersonii* and *Eucalyptus gunnii*. *Frontiers in Microbiology*. 2020;11.
45. Astray G, Gullón P, Gullón B, Munekata PES, Lorenzo JM. *Humulus lupulus* L. as a Natural Source of Functional Biomolecules. *Applied Sciences*. 2020;10(15):5074–5074.
46. Russo EB. Taming THC: potential cannabis synergy and phytocannabinoid-terpenoid entourage effects. *British Journal of Pharmacology*. 2011 Aug;163(7):1344–64.
47. Sharmeen J, Mahomoodally F, Zengin G, Maggi F. Essential Oils as Natural Sources of Fragrance Compounds for Cosmetics and Cosmeceuticals. *Molecules*. 2021;26(3):666–666.
48. Guzmán E, Lucia A. Essential Oils and Their Individual Components in Cosmetic Products. *Cosmetics*. 2021;8(4):114–114.
49. Tomko AM, Whynot EG, Ellis LD, Dupré DJ. Anti-Cancer Potential of Cannabinoids, Terpenes, and Flavonoids Present in Cannabis. *Cancers*. 2020 Jul;12(7):1985–1985.
50. Elegbede JA, Maltzman TH, Elson CE, Gould MN. Effects of anticarcinogenic monoterpenes on phase II hepatic metabolizing enzymes. *Carcinogenesis*. 1993;14(6):1221–3.
51. Singh RR, Reindl KM. Glutathione S-Transferases in Cancer. *Antioxidants*. 2021 Apr;10(5):701–701.
52. Putra IMH, Pratama IPAAC, Putra KDA, Pradnyaswari GAD, Laksmani NPL. The potency of alpha-humulene as HER-2 inhibitor by molecular docking. *Pharmacy Reports*. 2022 Jan 12;2(1):19–19.
53. Zhu S, Zhang T, Zheng L, Liu H, Song W, Liu D, Li Z, Pan CX. Combination strategies to maximize the benefits of cancer immunotherapy. *J Hematol Oncol*. 2021;14(1):156.
54. Blowman K, Magalhães M, Lemos MFL, Cabral C, Pires IM. Anticancer Properties of Essential Oils and Other Natural Products. *Evidence-Based Complementary and Alternative Medicine*. 2018;2018:1–12.
55. Boshuizen J, Peeper DS. Rational Cancer Treatment Combinations: An Urgent Clinical Need. *Molecular Cell*. 2020;78(6):1002–18.
56. Yu H, Lin L, Zhang Z, Zhang H, Hu H. Targeting NF-κB pathway for the therapy of diseases: mechanism and clinical study. *Signal Transduction and Targeted Therapy*. 2020;5(1):209–209.

57. Liktor-Busa E, Keresztes A, LaVigne J, Streicher JM, Largent-Milnes TM. Analgesic Potential of Terpenes Derived from Cannabis sativa. *Pharmacological Reviews*. 2021;73(4):1269–97.
58. Tai FWD, McAlindon ME. Non-steroidal anti-inflammatory drugs and the gastrointestinal tract. *Clinical Medicine*. 2021;21(2):131–4.
59. Wu S, Zhu W, Thompson P, Hannun YA. Evaluating intrinsic and non-intrinsic cancer risk factors. *Nature Communications*. 2018;9(1):3490–3490.
60. Zhao H, Wu L, Yan G, Chen Y, Zhou M, Wu Y, Li Y. Inflammation and tumor progression: signaling pathways and targeted intervention. *Signal Transduction and Targeted Therapy*. 2021;6(1):263–263.
61. Hashem S, Ali TA, Akhtar S, Nisar S, Sageena G, Ali S, Al-Mannai S, Therachiyil L, Mir R, Elfaki I, Mir MM, Jamal F, Masoodi T, Uddin S, Singh M, Haris M, Macha M, Bhat AA. Targeting cancer signaling pathways by natural products: Exploring promising anti-cancer agents. *Biomedicine & Pharmacotherapy*. 2022;150:113054–113054.
62. Stine ZE, Schug ZT, Salvino JM, Dang CV. Targeting cancer metabolism in the era of precision oncology. *Nature Reviews Drug Discovery*. 2022;21(2):141–62.
63. Sharma D, Misba L, Khan AU. Antibiotics versus biofilm: an emerging battleground in microbial communities. *Antimicrobial Resistance & Infection Control*. 2019;8(1):76–76.
64. Bowler P, Murphy C, Wolcott R. Biofilm exacerbates antibiotic resistance: Is this a current oversight in antimicrobial stewardship? *Antimicrobial Resistance & Infection Control*. 2020;9(1):162–162.
65. Antimicrobial Resistance Collaborators. Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*. 2022;399(10325):629–55.
66. Subbiah V. The next generation of evidence-based medicine. *Nature Medicine*. 2023;29(1):49–58.
67. Prasanthi D, Lakshmi PK. Terpenes: Effect of lipophilicity in enhancing transdermal delivery of alfuzosin hydrochloride. *Journal of Advanced Pharmaceutical Technology & Research*. 2012;3(4):216–216.
68. Palmer ME, Andrews LJ, Abbey TC, Dahlquist AE, Wenzler E. The importance of pharmacokinetics and pharmacodynamics in antimicrobial drug development and their influence on the success of agents developed to combat resistant gram negative pathogens: A review. *Frontiers in Pharmacology*. 2022;13.
69. Palrasu M, Wright L, Patel M, Leech L, Branch S, Harrelson S, Khan S. Perspectives on Challenges in Cannabis Drug Delivery Systems: Where Are We? *Medical Cannabis and Cannabinoids*. 2022 Jul;5(1):102–19.

70. University of Washington. Do Terpenes Play a Role in the Stress-reducing Effects of a Forest Bathing Intervention? ClinicalTrials.gov Identifier: NCT05316597. 2022 Nov 1. Available from: <https://clinicaltrials.gov/ct2/show/NCT05316597>.
71. Sun D, Gao W, Hu H, Zhou S. Why 90% of clinical drug development fails and how to improve it? *Acta Pharmaceutica Sinica B*. 2022;12(7):3049–62.
72. Seyhan AA. Lost in translation: the valley of death across preclinical and clinical divide – identification of problems and overcoming obstacles. *Translational Medicine Communications*. 2019;4(1):18–18.
73. Keefover-Ring K. The chemical biogeography of a widespread aromatic plant species shows both spatial and temporal variation. *Ecology and Evolution*. 2022;12(9).
74. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology*. 2005;8(1):19–32.
75. Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implementation Science*. 2010;5(1):69–69.
76. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;n71–n71.
77. Ajaiyeoba EO, Ekundayo O. Essential oil constituents of *Aframomum melegueta* (Roscoe) K. Schum. seeds (alligator pepper) from Nigeria. *Flavour and Fragrance Journal*. 1999;14(2):109–11.
78. Brophy JJ, Goldsack RJ, Bean AR, Forster PI, Lepsch BJ. Leaf essential oils of the genus *Leptospermum* (Myrtaceae) in eastern Australia. Part 6. *Leptospermum polygalifolium* and allies. *Flavour and Fragrance Journal*. 2000;15(4):271–7.
79. Duarte PF, do Nascimento LH, Fischer B, Lohmann AM, Bandiera VJ, Fernandes IA, Dal Magro J, Valduga E, Cansian RL, Paroul N, Junges A. Effect of Extraction Time on the Yield, Chemical Composition, and Antibacterial Activity of Hop Essential Oil Against Lactic Acid Bacteria (*Lactobacillus brevis* and *Lactobacillus casei*) Beer Spoilage. *Current Microbiology*. 2023;80(7):237–237.
80. Sakurai K, Tomiyama K, Yaguchi Y, Asakawa Y. The characteristic smell emitted from two scale insects, *Ceroplastes japonicus* and *Ceroplastes rubens*. *Bioscience, Biotechnology, and Biochemistry*. 2020 Aug 2;84(8):1541–5.
81. Govindarajan M, Rajeswary M, Arivoli S, Tennyson S, Benelli G. Larvicidal and repellent potential of *Zingiber nimmonii* (J. Graham) Dalzell (*Zingiberaceae*) essential oil: an eco-friendly tool against malaria, dengue, and lymphatic filariasis mosquito vectors? *Parasitol Res*. 2016 May;115(5):1807–16.

Legends for Figures

Fig.1 PRISMA flow chart showing the process of inclusion and exclusion of patients for analysis in this scoping review.

Table 1: Summarising the species with the top five highest reported yields of α -humulene

Species	Chemovar	Extraction	Isolation	Yield	Reference
<i>Aframomum melegueta</i> [alligator pepper]	Nigeria	Hydrodistillation for 3h	Fractionation	60.90%	Ajaiyeoba E et al 1999 [77]
<i>Leptospermum sp.</i> [Mt Maroon A.R. Bean 6665]	Australia	Hydrodistillation with incubation	GC-MS	44.00-51.00%	Brophy J et al 2000 [78]
<i>Humulus lupulus.</i> [Chinook variety]	Brazil	Hydrodistillation using a Clevenger- type apparatus	GC-MS	31.50 - 34.62%	Duarte et al 2023 [79]
<i>Camponotus japonicus</i> [insect]	Japan	Macerated in 10mL of pentane	GC-MS	35.80%	Sakurai K et al 2020 [80]
<i>Zingiber nimmonii</i>	India	Hydrodistillation	GC-MS	19.60%	Govindarajan et al

		using a Clevenger-type apparatus for 8h			2016 [81]
--	--	---	--	--	-----------

GC-MS – gas chromatography – mass spectrometry

Table 2: Summary of studies investigating the anticancer properties of isolated α -humulene

Model	Concentration/ Dose	Results	Reference
<i>In vitro</i> colorectal adenocarcinoma epithelial cells [CaCo-2 and SW-620]	5×10^{-5} , 1×10^{-4} and 1.5×10^{-4} M	α -humulene exhibited antiproliferative activity in combination with oxaliplatin and 5-fluorouracil at 100 and 150 $\mu\text{mol/L}$ due to decreased mitochondrial membrane potential.	Ambroz et al 2019 [11]
<i>In vitro</i> hepatocellular carcinoma cells [huh7, SMMC-7721, HepG2 and Hep3B] and <i>in vivo</i> HepG2-bearing nude mice	<i>In vitro</i> : 6.1×10^{-6} – 2.4×10^{-4} M <i>In vivo</i> : 10 and 20 mg/kg	<i>In vitro</i> , α -humulene inhibited proliferation of all hepatocellular carcinoma cell lines at 15 $\mu\text{mol/L}$, inducing cytotoxicity via intrinsic apoptotic pathways. Similar findings were reported <i>in vivo</i> at 10 mg/kg.	Chen et al 2019 [37]
<i>In vitro</i> ovarian cancer cells [A2780 and SKOV3 and lymphoblasts CCRF/CEM and CEM/ADR]	20, 40, 100 and 200 μM	α -humulene showed antiproliferative activity against certain ovarian cancer cell lines [A2780 at 40 μM , SKOV3 at 200 μM] and lymphoblast cell lines [CCRF/CEM at 200 μM , no effect on CEM/ADR at 200 μM].	Ambroz et al 2017 [12]
<i>In vitro</i> colon adenocarcinoma	$0 - 2.4 \times 10^{-4}$ M	α -humulene demonstrated antiproliferative	Ambroz et al

Model	Concentration/ Dose	Results	Reference
[CaCo-2] and non-cancer cells [rat hepatocytes]		activity against cancer cells at 4.9×10^{-5} mol/L, with an IC50 of 24.4 ± 2.4 . Additionally, α -humulene potentiated doxorubicin's anticancer properties in cancer cells, while showing no effect on non-cancer cell viability	2015 [13]
<i>In vitro</i> mice melanoma, human hepatocellular carcinoma, chronic human myelocytic leukaemia and human promyelocytic leukaemia	9.3×10^{-7} - 1.2×10^{-4} M	No significant anticancer activity of α -humulene was identified for any concentration tested.	Costa et al 2015 [38]
<i>In vitro</i> : colon human cancer [HT-29], human hepatocellular carcinoma [J5] and human pulmonary adenocarcinoma [A549]	$0 - 9.8 \times 10^{-4}$ M	α -humulene exhibited significant cytotoxicity against all cell lines, with IC50 values of 5.2×10^{-5} , 1.8×10^{-4} and 1.3×10^{-4} mol/L for HT-29, J5 and A549 respectively.	Su et al 2015 [14]
<i>In vitro</i> : human colorectal adenocarcinoma [HCT-116], human breast cancer [MCF-7] and murine macrophages [RAW264.7]	7.6×10^{-6} - 4.9×10^{-4} M	α -humulene demonstrated cytotoxic potential by inhibiting cancer cell growth, with IC50 values of 3.1×10^{-4} , 4.2×10^{-4} and 1.9×10^{-4} mol/L for HCT-116 MCF-7 and RAW264.7 cell lines respectively.	Hadri et al 2010 [15]
Murine small bowel mucosa and liver	9.8×10^{-5} M	α -humulene showed potential inhibitory action against carcinogenesis by increasing Glutathione S-transferase [GST] activity. The enzyme activity increased by 99% in the liver and 152% in the small bowel.	Zheng et al 1992 [31]
Cell lines of human breast adenocarcinoma [MCF-7], prostatic adenocarcinoma [PC-3], lung carcinoma [A-549],	2.4×10^{-4} and 9.8×10^{-4} M	α -humulene caused dose-dependent glutathione depletion of 38% and 71% at 50 and 200 μ M respectively, along with increased production of reactive oxygen	Legault et al 2003 [16]

Model	Concentration/ Dose	Results	Reference
colon adenocarcinoma and fibroblasts [DLD-1 e L-929]		species by 163% and 278% after 1 and 4 hours. Normal human fibroblasts showed lower cytotoxic effects.	
Cell lines of human breast adenocarcinoma [MCF-7], colon adenocarcinoma [DLD-1: ATCC # CCL-221], murine fibroblasts [L-929 ATCC # CCL-1]	$7.8 \times 10^{-5} - 3.1 \times 10^{-4}$ M	α -humulene showed cytotoxicity at 1.6×10^{-4} and 3.1×10^{-4} mol/L. Cell growth inhibition by α -humulene was significantly increased from $50 \pm 6\%$ alone to $75 \pm 6\%$ by co-administration of non-cytotoxic levels [$10 \mu\text{g/mL}$] of caryophyllene, potentially due to altered membrane permeability.	Legault et al 2010 [17]
Cell lines of human breast adenocarcinoma [MCF-7 and MDA-MB-468], human malignant melanoma: [UACC-257]	Concentration not reported	α -humulene from <i>Eugenia zuchowskiae</i> inhibited all cell lines, with similar cytotoxicity against MCF-7 line as doxorubicin [LC50 of 1.1×10^{-4} and 1.4×10^{-4} mol/L respectively].	Cole et al 2007 [18]
Cell lines of human cervical carcinoma [HeLa], human colon adenocarcinoma [HT-29], monkey kidney [Vero]	$9.8 \times 10^{-7} - 9.8 \times 10^{-4}$ M	α -humulene demonstrated cytotoxicity against all cell lines. Tumor cell lines were more sensitive to cytotoxic activity than non-tumor Vero cells and murine macrophages.	Silva et al 2008 [19]
Cell lines of human amelanotic melanoma [C32], renal cell adenocarcinoma [ACHN]	up to 4.9×10^{-4} M	α -humulene did not demonstrate cytotoxicity with $\text{IC}_{50} > 4.9 \times 10^{-4}$ mol/L against both C32 and ACHN lines. However, β -caryophyllene showed cytotoxic activity against both.	Loizzo et al 2008 [20]

IC50 - half maximal inhibitory concentration; LC50 - half maximal lethal concentration

Additional file 1
Search strategies and results

Table S1: Summary of Databases Searched

Table	Vendor/ Interface	Database	Date searched	Database update	Searcher(s)
1a	Ovid	MEDLINE	14/07/2023	1946 to July 13 2023	N. Dalavaye; M. Nicholas; M. Pillai
1b	National Library of Medicine	PubMed	14/07/2023	13/07/2023	N. Dalavaye; M. Nicholas; M. Pillai
1c	Ovid	EMBASE	14/07/2023	1947 to July 13 2023	N. Dalavaye; M. Nicholas; M. Pillai

Table S1a: Ovid MEDLINE search strategy

Provider/Interface Ovid
Database MEDLINE
Date searched 14/07/2023
Database update 1946 to July 13 2023
Search developer(s) S. Erridge
Limit to English No
Date Range 1946-2023

1	Humulene.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kf, fx, dq, nm, ox, px, rx, an, ui, sy]
2	Alpha-Humulene.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kf, fx, dq, nm, ox, px, rx, an, ui, sy]
3	Alpha-Caryophyllene.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kf, fx, dq, nm, ox, px, rx, an, ui, sy]
4	1 or 2 or 3

S1b: PubMed search strategy

Provider/Interface National Library of Medicine
Database PubMed
Date searched 14/07/2023
Database update 13/07/2023
Search developer(s) S. Erridge
Limit to English No
Date Range -13/07/2023

1	Humulene
2	Alpha-Humulene
3	Alpha-Caryophyllene
4	1 OR 2 OR 3

S1c: Ovid EMBASE search strategy

Provider/Interface Ovid
Database EMBASE
Date searched 14/07/2023
Database update 1947 to July 13 2023
Search developer(s) S. Erridge
Limit to English No
Date Range 1947-2023

1	Humulene.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kf, fx, dq, nm, ox, px, rx, an, ui, sy]
2	Alpha-Humulene.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kf, fx, dq, nm, ox, px, rx, an, ui, sy]
3	Alpha-Caryophyllene.mp. [mp=ti, ab, hw, tn, ot, dm, mf, dv, kf, fx, dq, nm, ox, px, rx, an, ui, sy]
4	1 or 2 or 3

Supplementary Material A

Included studies reporting extraction yields of α -humulene

1. Abreu IN, Reis MG, Marsaioli AJ, Mazzafera P. Essential oil composition of *Hypericum brasiliense* Choisy. *Flavour and Fragrance Journal*. 2004;19(1):80–2.
2. Adamenko K, Kawa-Rygielska J. Effect of Hop Varieties and Forms in the Hopping Process on Non-Alcoholic Beer Quality. *Molecules*. 2022 Nov 16;27(22):7910.
3. Agnani H, Menut C, Bessiere JM. Aromatic plants of tropical central Africa. Part XLIX+: Chemical composition of essential oils of the leaf and rhizome of *Aframomum giganteum* K. Schum from Gabon. *Flavour and Fragrance Journal*. 2004;19(3):205–9.
4. bin Ahmad F, bin Jantan I. The essential oils of *Boesenbergia stenophylla* R. M. Sm. as natural sources of methyl (E)-cinnamate. *Flavour and Fragrance Journal*. 2003;18(6):485–6.
5. Ahmad FB, Jantan IB. The essential oils of *Boesenbergia stenophylla* R. M. Sm. as natural sources of methyl (E)-cinnamate. *Flavour Fragr J*. 2003 Nov;18(6):485–6.
6. Ahmad N, Alam MK, Shehbaz A, Khan A, Mannan A, Hakim SR, et al. Antimicrobial activity of clove oil and its potential in the treatment of vaginal candidiasis. *Journal of drug targeting*. 2005;13(10):555–61.
7. Ahuja A, Bakshi SK, Sharma SK, Thappa RK, Agarwal SG, Kichlu SK, et al. Production of volatile terpenes by proliferating shoots and micropropagated plants of *santolina chamaecyparissus* L. (cotton lavender). *Flavour and Fragrance Journal*. 2005;20(4):403–6.
8. Ajaiyeoba EO, Ekundayo O. Essential oil constituents of *Aframomum melegueta* (Roscoe) K. Schum. seeds (alligator pepper) from Nigeria. *Flavour and Fragrance Journal*. 1999;14(2):109–11.
9. Ak G, Zengin G, Ceylan R, Fawzi Mahomoodally M, Jugreet S, Mollica A, et al. Chemical composition and biological activities of essential oils from *Calendula officinalis* L. flowers and leaves. *Flavour and Fragrance Journal*. 2021;36(5):554–63.
10. Alwakil NH, Mohamad Annuar MS, Jalil M. Synergistic Effects of Plant Growth Regulators and Elicitors on α -Humulene and Zerumbone Production in *Zingiber zerumbet* Smith Adventitious Root Cultures. *Molecules*. 2022 Jul 25;27(15):4744.
11. Andrade MS, Sampaio TS, Nogueira PCL, Ribeiro AS, Bittrich V, Amaral M. do CE. Volatile compounds of the leaves, flowers and fruits of *Kielmeyera rugosa* Choisy (Clusiaceae). *Flavour and Fragrance Journal*. 2007;22(1):49–52.
12. Andrianoelisoa HS, Menut C, de Chatelperron PC, Saracco J, Ramanoelina P, Danthu P. Intraspecific chemical variability and highlighting and chemotypes of leaf essential oils from *Ravensara aromatica* Sonnerat, a tree endemic to Madagascar. *Flavour and Fragrance Journal*. 2006;21(5):833–8.

13. Apel MA, Sobral M, Menut C, Bassiere JM, Zuanazzi JA, Schapoval EES, et al. Volatile constituents of four *Hexachlamys* species growing in South Brazil. *Flavour and Fragrance Journal*. 2005;20(2):176–9.
14. Apel MA, Sobral M, Zuanazzi JA, Henriques AT. Essential oil composition of four *Plinia* species (Myrtaceae). *Flavour and Fragrance Journal*. 2006;21(3):565–7.
15. Apel MA, Sobral M, Zuanazzi JAS, Henriques AT. Essential oil composition of *Calycorectes australis* and *Calycorectes psidiiflorus* (Myrtaceae). *Flavour and Fragrance Journal*. 2006;21(4):656–8.
16. Ardekani NT, Khorram M, Zomorodian K, Yazdanpanah S, Veisi H. Evaluation of electrospun poly (vinyl alcohol)-based nanofiber mats incorporated with *Zataria multiflora* essential oil as potential wound dressing. *International journal of biological macromolecules*. 2019;125:743–50.
17. Jang HI, Rhee KJ, Eom YB. Antibacterial and antibiofilm effects of α -humulene against *Bacteroides fragilis*. *Can J Microbiol*. 2020 Jun;66(6):389–99.
18. Asadollahi Baboli M, Aghakhani A. Rapid analysis of *Origanum majorana* L. fragrance using a nanofiber sheet, gas chromatography with mass spectrometry, and chemometrics. *Journal of Separation Science*. 2014;37(8):990–6.
19. Avelar-Freitas BA, Almeida VG, Santos MG, Santos JAT, Barroso PR, Graef CFF, et al. Essential oil from *Ageratum fastigiatum* reduces expression of the pro-inflammatory cytokine tumor necrosis factor- α in peripheral blood leukocytes subjected to in vitro stimulation with phorbol myristate acetate. *Revista Brasileira de Farmacognosia*. 2015 Mar;25(2):129–33.
20. Awad NE, Kassem HA, Hamed MA, ElFeky AM, ElNaggar MAA. Hepatoprotective evaluation and isolation of the major secondary metabolites from the ethyl acetate extract of liquid culture filtrate of *Chaetomium globosum*. *Biomedicine and Pharmacotherapy*. 2018;97:174–80.
21. Ayoub N, AlAzizi M, Konig W, Kubeczka KH. Essential oils and a novel polyacetylene from *Eryngium yuccifolium* Michaux. (Apiaceae). *Flavour and Fragrance Journal*. 2006;21(6):864–8.
22. Ayuob NN, El Wahab MGA, Ali SS, AbdelTawab HS. *Ocimum basilicum* improve chronic stress-induced neurodegenerative changes in mice hippocampus. *Metabolic brain disease*. 2018;33(3):795–804.
23. Babu GDK, Shanmugam V, Ravindranath SD, Joshi VP. Comparison of chemical composition and antifungal activity of *Curcuma longa* L. leaf oils produced by different water distillation techniques. *Flavour and Fragrance Journal*. 2007;22(3):191–6.
24. Legault J, Dahl W, Debiton E, Pichette A, Madelmont JC. Antitumor activity of balsam fir oil: Production of reactive oxygen species induced by α -humulene as possible mechanism of action. *Planta medica*. 2003;69:402–7.

25. Bader A, Caponi C, Cioni PL, Flamini G, Morelli I. Acorenone in the essential oil of flowering aerial parts of *Seseli tortuosum* L. *Flavour and Fragrance Journal*. 2003;18(1):57–8.
26. Bakr RO, El Bishbishy MH. Profile of bioactive compounds of *Capparis spinosa* var. *Aegyptiaca* growing in Egypt. *Revista Brasileira de Farmacognosia*. 2016;26(4):514–20.
27. Bakro F, Jedryczka M, Wielgusz K, Sgorbini B, Inchingolo R, Cardenia V. Simultaneous determination of terpenes and cannabidiol in hemp (*Cannabis sativa* L.) by fast gas chromatography with flame ionization detection. *Journal of Separation Science*. 2020;43(14):2817–26.
28. Balusamy SR, Perumalsamy H, Huq MA, Balasubramanian B. Anti-proliferative activity of *Origanum vulgare* inhibited lipogenesis and induced mitochondrial mediated apoptosis in human stomach cancer cell lines. *Biomedicine and Pharmacotherapy*. 2018;108:1835–44.
29. Baranauskienė R, Venskutonis PR, Demyttenaere JCR. Sensory and instrumental evaluation of sweet marjoram (*Origanum majorana* L.) aroma. *Flavour and Fragrance Journal*. 2005;20(5):492–500.
30. Baser KHC, Tabanca N, Ozek T, Demirci B, Duran A, Duman H. Composition of the essential oil of *Chaerophyllum aksekiense* A. Duran et Duman, a recently described endemic from Turkey. *Flavour and Fragrance Journal*. 2000;15(1):43–4.
31. Baser KHC, Ozek G, Ozek T, Duran A. Composition of the essential oil of *Centaurea huber-morathii* Wagenitz isolated from seeds by microdistillation. *Flavour and Fragrance Journal*. 2006;21(3):568–70.
32. Baser KHC, Ozek G, Ozek T, Duran A, Duman H. Composition of the essential oils of *Rhabdosciadium oligocarpum* (Post ex Boiss.) Hedge et Lamond and *Rhabdosciadium microcalycinum* Hand.-Mazz. *Flavour and Fragrance Journal*. 2006;21(4):650–5.
33. Basting RT, Spindola HM, Sousa IM de O, Queiroz N de CA, Trigo JR, de Carvalho JE, et al. *Pterodon pubescens* and *Cordia verbenacea* association promotes a synergistic response in antinociceptive model and improves the anti-inflammatory results in animal models. *Biomedicine & Pharmacotherapy*. 2019;112:108693–108693.
34. Belhadj S, Hentati O, Hammami M, Ben Hadj A, Boudawara T, Dammak M, et al. Metabolic impairments and tissue disorders in alloxan-induced diabetic rats are alleviated by *Salvia officinalis* L. essential oil. *Biomedicine and Pharmacotherapy*. 2018;108:985–95.
35. Ben Farhat M, Jordan MJ, Chaouech-Hamada R, Landoulsi A, Sotomayor JA. Variations in essential oil, phenolic compounds, and antioxidant activity of tunisian cultivated *Salvia officinalis* L. *Journal of Agricultural & Food Chemistry*. 2009;57(21):10349–56.

36. Bicchi C, Rubiolo P, Saranz Camargo EE, Vilegas W, de Souza Gracioso J, Monteiro Souza Brito AR. Components of *Turnera diffusa* Willd. var. *afrodisiaca* (Ward) Urb. essential oil. *Flavour and Fragrance Journal*. 2003;18(1):59–61.
37. Biondi DM, Sari M, Ghani ZA, Ruberto G. Essential oil of Algerian *Saccocalyx satureioides* Coss. et Durieu. *Flavour and Fragrance Journal*. 2006;21(3):546–8.
38. Blanc MC, Muselli A, Bradesi P, Casanova J. Chemical composition and variability of the essential oil of *Inula graveolens* from Corsica. *Flavour and Fragrance Journal*. 2004;19(4):314–314.
39. Blazquez MA, Perez I, Boira H. Essential oil analysis of *Teucrium libanitis* and *T. turredanum* by GC and GC-MS. *Flavour and Fragrance Journal*. 2003;18(6):497–501.
40. Block S, Flamini G, Brkic D, Morelli I, QuetinLeclercq J. Analysis of the essential oil from leaves of *Croton zambesicus* Muell. Arg. growing in Benin. *Flavour and Fragrance Journal*. 2006;21(2):222–4.
41. Borges R, Rojas LB, Cegarra JA, Usubillaga A. Study of the essential oils from the leaves and flowers of *Lepechinia conferta* (Benth) Epl. *Flavour and Fragrance Journal*. 2006;21(1):155–7.
42. Boszormenyi A, Hethelyi E, Farkas A, Horvath G, Papp N, Lemberkovics E, et al. Chemical and genetic relationships among sage (*Salvia officinalis* L.) cultivars and Judean sage (*Salvia judaica* Boiss.). *Journal of Agricultural & Food Chemistry*. 2009;57(11):4663–7.
43. Boti JB, Bighelli A, Cavaleiro C, Salgueiro L, Casanova J. Chemical variability of *Juniperus oxycedrus* ssp. *oxycedrus* berry and leaf oils from Corsica, analysed by combination of GC, GC-MS and ¹³C-NMR. *Flavour and Fragrance Journal*. 2006;21(2):268–73.
44. Boti JB, Koukoua G, N'Guessan TY, Casanova J. Chemical variability of *Conyza sumatrensis* and *microglossa pyrifolia* from cote d'Ivoire. *Flavour and Fragrance Journal*. 2007;22(1):27–31.
45. Boti JB, Yao PA, Koukoua G, N'Guessan TY, Casanova J. Components and chemical variability of *Isolona campanulata* Engler & Diels leaf oil. *Flavour and Fragrance Journal*. 2006;21(1):166–70.
46. Bouaziz M, Yangui T, Sayadi S, Dhouib A. Disinfectant properties of essential oils from *Salvia officinalis* L. cultivated in Tunisia. *Food and Chemical Toxicology*. 2009;47(11):2755–60.
47. Bougatsos C, Meyer JJM, Magiatis P, Vagias C, Chinou IB. Composition and antimicrobial activity of the essential oils of *Helichrysum kraussii* Sch. Bip. and *H. rugulosum* Less. from South Africa. *Flavour and Fragrance Journal*. 2003;18(1):48–51.
48. Boukhari F, TigrineKordjani N, Youcef Meklati B. Phytochemical investigation by microwave-assisted extraction of essential oil of the leaves of walnut cultivated in Algeria. *Helvetica chimica acta*. 2013;96(6):1168–75.

49. Boutekedjiret C, Bentahar F, Belabbes R, Bessiere JM. Extraction of rosemary essential oil by steam distillation and hydrodistillation. *Flavour and Fragrance Journal*. 2003;18(6):481–4.
50. Brito MT, Ferreira RC, Beltrao DM, Moura APG, Xavier AL, Pita JCLR, et al. Antitumor activity and toxicity of volatile oil from the leaves of *Annona leptopetala*. *Revista Brasileira de Farmacognosia*. 2018;28(5):602–9.
51. Brophy JJ, Goldsack RJ, Bean AR, Forster PI, Lepsch BJ. Leaf essential oils of the genus *Leptospermum* (Myrtaceae) in eastern Australia. Part 6. *Leptospermum polygalifolium* and allies. *Flavour and Fragrance Journal*. 2000;15(4):271–7.
52. Brophy JJ, Goldsack RJ, Punruckvong A, Bean AR, Forster PI, Lepschi BJ, et al. Leaf essential oils of the genus *Leptospermum* (Myrtaceae) in eastern Australia. Part 7. *Leptospermum petersonii*, *L. liversidgei* and allies. *Flavour and Fragrance Journal*. 2000;15(5):342–51.
53. Brophy JJ, Goldsack RJ, Forster PI, Bean AR, Clarkson JR, Lepschi BJ. Leaf essential oils of the genus *Leptospermum* (Myrtaceae) in Eastern Australia. Part 1. *Leptospermum brachyandrum* and *Leptospermum pallidum* groups. *Flavour and Fragrance Journal*. 1998;13(1):19–25.
54. Caneschi CA, Martins FJ, Larrude DG, Romani EC, Brandao MAF, Raposo NRB. In vitro antifungal activity of *baccharis trimera* less (DC) essential oil against dermatophytes. *Tropical Journal of Pharmaceutical Research*. 2015;14(11):2083–9.
55. Carrer RP, Vanderlinde R, Dutra S, Marcon A, Echeverrigaray S. Essential oil variation among Brazilian accessions of *Salvia guaranitica* L. *Flavour and Fragrance Journal*. 2007;22(5):430–4.
56. Carvalho HO, Santos IVFD, Rocha CFD, Barros ASA, Faria e Souza BS, Ferreira IM, et al. Effect of the treatment of *Copaifera duckei* oleoresin (copaiba) in streptozotocin-induced diabetic rats. *Revista Brasileira de Farmacognosia*. 2018;28(6):724–31.
57. Cavalleri R, Becker JS, Pavan AM, Bianchetti P, Goettert MI, Ethur EM, et al. Essential oils rich in monoterpenes are unsuitable as additives to boar semen extender. *Andrologia*. 2018;50(8):no pagination-no pagination.
58. Cavalli JF, Tomi F, Bernardini AF, Casanova J. Chemical variability of the essential oil of *Helichrysum faradifani* Sc. Ell. from Madagascar. *Flavour and Fragrance Journal*. 2006;21(1):111–4.
59. Cavalli JF, Tomi F, Bernardini AF, Casanova J. Composition and chemical variability of the bark oil of *Cedrelopsis grevei* H. Baillon from Madagascar. *Flavour and Fragrance Journal*. 2003;18(6):532–8.
60. Cecchini C, Coman MM, Cresci A, Tirillini B, Cristalli G, Papa F, et al. Essential oil from fruits and roots of *Ferulago campestris* (Besser) Grecescu (Apiaceae): Composition and antioxidant and anti-*Candida* activity. *Flavour and Fragrance Journal*. 2010;25(6):493–502.

61. Çelik G, Kılıç G, Kanbolat Ş, Özlem Şener S, Karaköse M, Yaylı N, et al. Biological activity, and volatile and phenolic compounds from five Lamiaceae species. *Flavour and Fragrance Journal*. 2021;36(2):223–32.
62. Chagonda LS, Chalchat JC. The essential oil of wild and cultivated *Hoslundia opposita* Vahl. from Zimbabwe. *Flavour and Fragrance Journal*. 2005;20(2):193–5.
63. Andrade-Ochoa S, Correa-Basurto J, Rodríguez-Valdez LM, Sánchez-Torres LE, Noguera-Torres B, Nevárez-Moorillón GV. In vitro and in silico studies of terpenes, terpenoids and related compounds with larvicidal and pupaecidal activity against *Culex quinquefasciatus* Say (Diptera: Culicidae). *Chemistry Central Journal*. 2018 May 10;12(1):53.
64. Chagonda LS, Chalchat JC. The essential oil of the fruit of *Garcinia huillensis* Welw. ex. Oliv. from Zimbabwe. *Flavour and Fragrance Journal*. 2005;20(3):313–5.
65. Chaves AR, Silva SM, Queiroz RHC, Lanças FM, Queiroz MEC. Stir bar sorptive extraction and liquid chromatography with UV detection for determination of antidepressants in plasma samples. *Journal of Chromatography B*. 2007 May;850(1–2):295–302.
66. Checucci A, Maida I, Bacci G, Ninno C, Bilia AR, Biffi S, et al. Is the plant-associated microbiota of *Thymus* spp. adapted to plant essential oil?. *Research in microbiology*. 2017;168(3):276–82.
67. Chen C, Chen H, Ni M, Yu F. Methyl jasmonate application and flowering stage affect scent emission of *Styrax japonicus*. *Flavour and Fragrance Journal*. 2021;36(4):497–504.
68. Chen X, Jin X, Li Y, Chen G, Chen K, Kan J. Preparation and characterization of molecularly-imprinted polymers for extraction of sanshool acid amide compounds followed by their separation from pepper oil resin derived from Chinese prickly ash (*Zanthoxylum bungeanum*). *Journal of Separation Science*. 2018;41(2):590–601.
69. Chen XB, Chen R, Luo ZR. Chemical composition and insecticidal properties of essential oil from aerial parts of *Mosla soochowensis* against two grain storage insects. *Tropical Journal of Pharmaceutical Research*. 2017;16(4):905–10.
70. Cheriti A, Saad A, Belboukhari N, Ghezali S. The essential oil composition of *Bubonium graveolens* (Forssk.) Maire from the Algerian Sahara. *Flavour and Fragrance Journal*. 2007;22(4):286–8.
71. Cho IH, Lee HJ, Kim YS. Differences in the volatile compositions of ginseng species (*Panax* sp.). *Journal of Agricultural & Food Chemistry*. 2012;60(31):7616–22.
72. Chu SS, Liu QZ, Du SS, Liu ZL. Chemical composition and insecticidal activity of the essential oil of the aerial parts of *Ostericum grosseserratum* (maxim) Kitag (Umbelliferae). *Tropical Journal of Pharmaceutical Research*. 2013;12(1):99–103.
73. Conti B, Benelli G, Flamini G, Cioni PL, Profeti R, Ceccarini L, et al. Larvicidal and repellent activity of *Hyptis suaveolens* (Lamiaceae) essential oil against the mosquito

Aedes albopictus Skuse (Diptera: Culicidae). Parasitology research. 2012;110(5):2013–21.

74. Conti B, Flamini G, Cioni PL, Ceccarini L, Macchia M, Benelli G. Mosquitocidal essential oils: Are they safe against non-target aquatic organisms?. Parasitology research. 2014;113(1):251–9.
75. Couladis M, Tzakou O, Stojanovic D, MimicaDukic N, Jancic R. The essential oil composition of *Salvia argentea* L. Flavour and Fragrance Journal. 2001;16(3):227–9.
76. Couladis M, Tzakou O, MimicaDuki N, Jani R, Stojanovi D. Essential oil of *Salvia officinalis* L. from Serbia and Montenegro. Flavour and Fragrance Journal. 2002;17(2):119–26.
77. Cruz EMDO, CostaJunior LM, Pinto JAO, Santos DDA, Araujo SAD, ArrigoniBlank MDF, et al. Acaricidal activity of *Lippia gracilis* essential oil and its major constituents on the tick *Rhipicephalus (Boophilus) microplus*. Veterinary parasitology. 2013;195(1–2):198–202.
78. Cui B, Zheng T, Deng P, Zhang S, Zhao Z. Chemotaxonomic Variation in Volatile Component Contents in Ancient *Platycladus orientalis* Leaves with Different Tree Ages in Huangdi Mausoleum. Molecules. 2023 Feb 22;28(5):2043.
79. Cunha GH, Fechine FV, Frota Bezerra FA, Moraes MO, Silveira ER, Canuto KM, et al. Comparative study of the antihypertensive effects of hexane, chloroform and methanol fractions of essential oil of *Alpinia zerumbet* in rats Wistar. Revista Brasileira de Plantas Mediciniais. 2016;18(1):113–24.
80. D’Auria FD, Tecca M, Strippoli V, Salvatore G, Battinelli L, Mazzanti G. Antifungal activity of *Lavandula angustifolia* essential oil against *Candida albicans* yeast and mycelial form. Medical Mycology. 2005;43(5):391–6.
81. Da Costa JS, Andrade WMS, De Figueiredo RO, Santos PVL, Freitas JJDS, Setzer WN, et al. Chemical Composition and Variability of the Volatile Components of *Myrciaria* Species Growing in the Amazon Region. Molecules. 2022 Mar 30;27(7):2234.
82. da Silva JD, Luz AIR, da Silva MHL, Andrade EHA, Zoghbi MGB, Maia JGS. Essential oils of the leaves and stems of four *Psidium* spp. Flavour and Fragrance Journal. 2003;18(3):240–3.
83. da Silva MHL, Andrade EHA, Maia JGS. The essential oil of *Pectis elongata* Kunth occurring in North Brazil. Flavour and Fragrance Journal. 2005;20(5):462–4.
84. Da Silva MHL, Andrade EHA, Zoghbi MDGB, Luz AIR, Da Silva JD, Maia JGS. The essential oils of *Lantana camara* L. occurring in North Brazil. Flavour and Fragrance Journal. 1999;14(4):208–10.
85. Dabiri M, Sefidkon F. Chemical composition of *Nepeta crassifolia* Boiss. & Buhse oil from Iran. Flavour and Fragrance Journal. 2003;18(3):225–7.

86. Dabiri M, Sefidkon F. Analysis of the essential oil from aerial parts of *Perovskia atriplicifolia* Benth. at different stages of plant growth. *Flavour and Fragrance Journal*. 2001;16(6):435–8.
87. Das M, Ram G, Singh A, Mallavarapu GR, Ramesh S, Ram M, et al. Volatile constituents of different plant parts of *Chamomilla recutita* L. Rausch grown in the Indo-Gangetic plains. *Flavour Fragr J*. 2002 Jan;17(1):9–12.
88. Dawra M, El Rayess Y, El Beyrouthy M, Nehme N, El Hage R, Taillandier P, et al. Biological activities and chemical characterization of the Lebanese endemic plant *Origanum ehrenbergii* Boiss. *Flavour and Fragrance Journal*. 2021;36(3):339–51.
89. de Albuquerque RL, V SMG de, Machado MIL, A MFJ de, de Moraes SM, Neto JS. Chemical composition and antioxidant activity of *Plectranthus grandis* and *P. ornatus* essential oils from north-eastern Brazil. *Flavour and Fragrance Journal*. 2007;22(1):24–6.
90. De Feo V, Soria EU, Soria RU, Senatore F. Chemical composition of essential oils of *Senecio nutans* Sch.-Bip. (Asteraceae). *Flavour and Fragrance Journal*. 2003;18(3):234–6.
91. De K. Martin MAC, Joseph H, Bercion S, Menut C. Chemical composition of essential oils from aerial parts of *Aframomum exscapum* (Sims) Hepper collected in Guadeloupe, French West Indies. *Flavour Fragr J*. 2006 Nov;21(6):902–5.
92. de Vasconcelos Silva MG, de Abreu Matos FJ, Lacerda Machado MI, Aragao Craveiro A. Essential oils of *Ocimum basilicum* L., *O. basilicum* var. *minimum* L. and *O. basilicum* var. *purpurascens* Benth. grown in north-eastern Brazil. *Flavour and Fragrance Journal*. 2003;18(1):13–4.
93. Del C. Coronel A, Cerda-García-Rojas CM, Joseph-Nathan P, Catalán CAN. Chemical composition, seasonal variation and a new sesquiterpene alcohol from the essential oil of *Lippia integrifolia*. *Flavour Fragr J*. 2006 Sep;21(5):839–47.
94. Demirci B, Demirci F, Baser KHC. Headspace-SPME and hydrodistillation of two fragrant *Artemisia* sp. *Flavour and Fragrance Journal*. 2005;20(4):395–8.
95. Demirci B, Tsikolia M, Bernier UR, Agramonte NM, Alqasoumi SI, AlYahya MA, et al. Phoenix dactylifera L. spathe essential oil: Chemical composition and repellent activity against the yellow fever mosquito. *Acta Tropica*. 2013;128(3):557–60.
96. Demirpolat A, Akman F, Kazachenko AS. An Experimental and Theoretical Study on Essential Oil of *Aethionema sancakense*: Characterization, Molecular Properties and RDG Analysis. *Molecules*. 2022 Sep 19;27(18):6129.
97. Deterre S, Rega B, Delarue J, Decloux M, Lebrun M, Giampaoli P. Identification of key aroma compounds from bitter orange (*Citrus aurantium* L.) products: Essential oil and macerate-distillate extract. *Flavour and Fragrance Journal*. 2012;27(1):77–88.
98. Djarri L, Medjroubi K, Akkal S, Elomri A, Verite P. Composition of the essential oil of aerial parts of an endemic species of the Apiaceae of Algeria, *Daucus reboudii* Coss. *Flavour and Fragrance Journal*. 2006;21(4):647–9.

99. Duarte PF, do Nascimento LH, Fischer B, Lohmann AM, Bandiera VJ, Fernandes IA, et al. Effect of Extraction Time on the Yield, Chemical Composition, and Antibacterial Activity of Hop Essential Oil Against Lactic Acid Bacteria (*Lactobacillus brevis* and *Lactobacillus casei*) Beer Spoilage. *Current Microbiology*. 2023;80(7):237–237.
100. Dudai N, Lewinsohn E, Larkov O, Katzir I, Ravid U, Chaimovitch D, et al. Dynamics of yield components and essential oil production in a commercial hybrid sage (*Salvia officinalis* x *Salvia fruticosa* cv. Newe Ya'ar no. 4). *Journal of Agricultural & Food Chemistry*. 1999;47(10):4341–5.
101. Duschatzky CB, Almeida NV, Possetto M, Michis F, Scappini E, de Lampasona MP, et al. Essential oil composition of *heterothalamus alienus* (Spreng.) Kuntze (Romerillo) from Argentina. Effect of harvesting period on the essential oil composition. *Flavour and Fragrance Journal*. 2007;22(1):39–41.
102. Dutta S, Mehrotra RC, Paul S, Tiwari RP, Bhattacharya S, Srivastava G, et al. Remarkable preservation of terpenoids and record of volatile signalling in plant-animal interactions from Miocene amber. *Scientific Reports*. 2017;7(1):10940–10940.
103. Dwivedi S, Khan M, Srivastava SK, Syamasunnder KV, Srivastava A. Essential oil composition of different accessions of *Mentha x piperita* L. grown on the northern plains of India. *Flavour and Fragrance Journal*. 2004;19(5):437–40.
104. Elmann A, Mordechay S, Rindner M, Larkov O, Elkabetz M, Ravid U. Protective Effects of the Essential Oil of *Salvia fruticosa* and Its Constituents on Astrocytic Susceptibility to Hydrogen Peroxide-Induced Cell Death. *J Agric Food Chem*. 2009 Aug 12;57(15):6636–41.
105. Erdem B, Bagci E, Dogan G, Aktoklu E, Dayangac A. Chemical composition and antimicrobial activities of essential oil and ethanol extract of *Cyperus fuscus* L burs from Turkey. *Trop J Pharm Res*. 2018 Oct 5;17(8):1637.
106. Evergetis E, Michaelakis A, Papachristos DP, Badieritakis E, Kapsaski-Kanelli VN, Haroutounian SA. Seasonal variation and bioactivity of the essential oils of two *Juniperus* species against *Aedes (Stegomyia) albopictus* (Skuse, 1894). *Parasitol Res*. 2016 Jun;115(6):2175–83.
107. Fanciullino AL, Tomi F, Luro F, Desjobert JM, Casanova J. Chemical variability of peel and leaf oils of mandarins. *Flavour Fragr J*. 2006 Mar;21(2):359–67.
108. Farah A, Afifi A, Fechtal M, Chhen A, Satrani B, Talbi M, et al. Fractional distillation effect on the chemical composition of Moroccan myrtle (*Myrtus communis* L.) essential oils. *Flavour Fragr J*. 2006 Mar;21(2):351–4.
109. Feijó EVRDS, De Oliveira RA, Costa LCDB. Light affects *Varronia curassavica* essential oil yield by increasing trichomes frequency. *Revista Brasileira de Farmacognosia*. 2014 Sep;24(5):516–23.
110. Feizbakhsh A, Pazoki H, Mohammadrezaei V, Ebrahimzadeh M. Effect of Phytohormones on the Composition of *Sambucus ebulus* Leaf Essential Oil. *Trop J Pharm Res*. 2014 May 28;13(4):573.

111. Fekam Boyom F, Keumedjio F, Jazet Dongmo PM, Ngadjui BT, Amvam Zollo PH, Menut C, et al. Essential oils from *Croton zambesicus* Muell. Arg. growing in Cameroon. *Flavour Fragr J.* 2002 May;17(3):215–7.
112. Ferhat MA, Meklati BY, Chemat F. Comparison of different isolation methods of essential oil from Citrus fruits: cold pressing, hydrodistillation and microwave 'dry' distillation. *Flavour Fragr J.* 2007 Nov;22(6):494–504.
113. Fernandes MG, Gomes RA, Brito-Filho SG, Silva-Filho RN, Agra MF, Falcão-Silva VS, et al. Characterization and anti-staphylococcal activity of the essential oil from *Turnera subulata* Sm. *Rev bras plantas med.* 2014 Sep;16(3):534–8.
114. Fernandez X, Lizzani-Cuvelier L, Loiseau AM, Perichet C, Delbecque C, Arnaudo JF. Chemical composition of the essential oils from Turkish and Honduras *Styrax*. *Flavour Fragr J.* 2005 Jan;20(1):70–3.
115. Fernandez X, Pintaric C, Lizzani-Cuvelier L, Loiseau AM, Morello A, Pellerin P. Chemical composition of absolute and supercritical carbon dioxide extract of *Aframomum melegueta*. *Flavour Fragr J.* 2006 Jan;21(1):162–5.
116. Fernández-Ocaña AM, Gómez-Rodríguez MV, Velasco-Negueruela A, Camacho-Simarro AM, Fernández-López C, Altarejos J. In Vivo Antifungal Activity of the Essential Oil of *Bupleurum gibraltarium* against *Plasmopara halstedii* in Sunflower. *J Agric Food Chem.* 2004 Oct 1;52(21):6414–7.
117. Ferreira MJP, Costantin MB, Sartorelli P, Rodrigues GV, Limberger R, Henriques AT, et al. Computer-aided method for identification of components in essential oils by 13 C NMR spectroscopy. *Analytica Chimica Acta.* 2001 Nov;447(1–2):125–34.
118. Ferreira RO, Junior ARDC, Da Silva TMG, Castro RN, Da Silva TMS, De Carvalho MG. Distribution of metabolites in galled and non-galled leaves of *Clusia lanceolata* and its antioxidant activity. *Revista Brasileira de Farmacognosia.* 2014 Nov;24(6):617–25.
119. Fischer U, Lopez R, Pöll E, Vetter S, Novak J, Franz CM. Two chemotypes within *Lippia alba* populations in Guatemala. *Flavour Fragr J.* 2004 Jul;19(4):333–5.
120. Flamini G, Cioni PL, Morelli I. Essential oils of *Galeopsis pubescens* and *G. tetrahit* from Tuscany (Italy). *Flavour Fragr J.* 2004 Jul;19(4):327–9.
121. Fojtová J, Lojková L, Kubáň V. GC/MS of terpenes in walnut-tree leaves after accelerated solvent extraction. *J Sep Sci.* 2008 Jan;31(1):162–8.
122. Fokialakis N, Melliou E, Magiatis P, Harvala C, Mitaku S. Composition of the steam volatiles of six *Euphorbia* spp. from Greece. *Flavour Fragr J.* 2003 Jan;18(1):39–42.
123. Formisano C, Senatore F, Bruno M, Bellone G. Chemical composition and antimicrobial activity of the essential oil of *Phlomis ferruginea* Ten. (Lamiaceae) growing wild in Southern Italy. *Flavour Fragr J.* 2006 Sep;21(5):848–51.
124. Fournier G, Hadjiakhoondi A, Lebœuf M, Cavé A, Charles B. Essential Oils of Annonaceae. Part VII. Essential Oils of *Monanthes dielma* (Sprague) Verdcourt and *Unonopsis guatterioidea* R. E. Fries. *Flavour Fragr J.* 1997 Mar;12(2):95–8.

125. Gabriele B, Fazio A, Dugo P, Costa R, Mondello L. Essential oil composition of *Citrus medica* L. Cv. Diamante (Diamante citron) determined after using different extraction methods. *J Sep Sci*. 2009 Jan;32(1):99–108.
126. Gagliano Candela R, Ilardi V, Badalamenti N, Bruno M, Rosselli S, Maggi F. Essential oil compositions of *Teucrium fruticans*, *T. scordium* subsp. *scordioides* and *T. siculum* growing in Sicily and Malta. *Natural Product Research*. 2021 Oct 18;35(20):3460–9.
127. Garneau FX, Collin G, Gagnon H, Jean FI, Strobl H, Pichette A. The essential oil composition of devil's club, *Oplopanax horridus* J. E. Smith Miq. *Flavour Fragr J*. 2006 Sep;21(5):792–4.
128. Giovannoni S, Lancioni C, Vaccarini C, Sedan D, Andrinolo D, Castells C. Determination of variability of terpenes and terpenoids in *Cannabis sativa* by gas chromatography-flame ionization detection and gas chromatography-mass spectrometry. *Journal of Chromatography A*. 2023 Jan;1687:463669.
129. Gohari AR, Hadjiakhoondi A, Sadat-Ebrahimi E, Saeidnia S, Shafiee A. Composition of the volatile oils of *Satureja spicigera* C. Koch Boiss. and *S. macrantha* C. A. Mey from Iran. *Flavour Fragr J*. 2006 Mar;21(2):348–50.
130. Gomes MVDS, Da Silva JD, Ribeiro AF, Cabral LM, De Sousa VP. Development and validation of a quantification method for α -humulene and trans-caryophyllene in *Cordia verbenacea* by high performance liquid chromatography. *Revista Brasileira de Farmacognosia*. 2019 Mar;29(2):182–90.
131. Gonçalves J, Figueira J, Rodrigues F, Câmara JS. Headspace solid-phase microextraction combined with mass spectrometry as a powerful analytical tool for profiling the terpenoid metabolomic pattern of hop-essential oil derived from Saaz variety: Other Techniques. *J Sep Science*. 2012 Sep;35(17):2282–96.
132. Gonçalves RDA, Pinheiro AB, Oliveira MAD, Nascimento RTD, Rosalem PF, Garcia VL, et al. Anatomical characters and chemical profile of leaves of three species in Lauraceae family. *Revista Brasileira de Farmacognosia*. 2018 Jan;28(1):1–8.
133. González S, Guerra PE, Bottaro H, Molares S, Demo MS, Oliva MM, et al. Aromatic plants from Patagonia. Part I. Antimicrobial activity and chemical composition of *Schinus polygamus* (Cav.) Cabrera essential oil. *Flavour Fragr J*. 2004 Jan;19(1):36–9.
134. Gooré SG, Ouattara ZA, Yapi AT, Békro YA, Bighelli A, Paoli M, et al. Chemical composition of the leaf oil of *Artabotrys jollyanus* from Côte d'Ivoire. *Revista Brasileira de Farmacognosia*. 2017 Jul;27(4):414–8.
135. Govindarajan M, Rajeswary M, Arivoli S, Tennyson S, Benelli G. Larvicidal and repellent potential of *Zingiber nimmonii* (J. Graham) Dalzell (Zingiberaceae) essential oil: an eco-friendly tool against malaria, dengue, and lymphatic filariasis mosquito vectors? *Parasitol Res*. 2016 May;115(5):1807–16.
136. Govindarajan M, Rajeswary M, Hoti SL, Bhattacharyya A, Benelli G. Eugenol, α -pinene and β -caryophyllene from *Plectranthus barbatus* essential oil as eco-friendly larvicides against malaria, dengue and Japanese encephalitis mosquito vectors. *Parasitol Res*. 2016 Feb;115(2):807–15.

137. Havlik J, Kokoska L, Vasickova S, Valterova I. Chemical composition of essential oil from the seeds of *Nigella arvensis* L. and assessment of its antimicrobial activity. *Flavour Fragr J.* 2006 Jul;21(4):713–7.
138. Hoi TM, Satyal P, Huong LT, Hau DV, Binh TD, Duyen DTH, et al. Essential Oils from Vietnamese Asteraceae for Environmentally Friendly Control of *Aedes* Mosquitoes. *Molecules.* 2022 Nov 17;27(22):7961.
139. Houël E, Rodrigues AMS, Jahn-Oyac A, Bessière JM, Eparvier V, Deharo E, et al. *In vitro* antidermatophytic activity of *Otacanthus azureus* (Linden) Ronse essential oil alone and in combination with azoles. *J Appl Microbiol.* 2014 Feb;116(2):288–94.
140. Hymete A, Rohloff J, Iversen TH. Essential oil from seeds and husks of *Aframomum corrorima* from Ethiopia. *Flavour Fragr J.* 2006 Jul;21(4):642–4.
141. Jamoussi B, Romdhane M, Abderraba A, Hassine BB, Gadri AE. Effect of harvest time on the yield and composition of Tunisian myrtle oils. *Flavour Fragr J.* 2005 May;20(3):274–7.
142. Jantan I, Ahmad AS, Bakar SAA, Ahmad AR, Trockenbrodt M, Chak CV. Constituents of the essential oil of *Baekkea frutescens* L. from Malaysia. *Flavour Fragr J.* 1998 Jul;13(4):245–7.
143. Jantan IB, Ayop N, Mohd Ali NA, Ahmad AS, Yalvema MF, Muhammad K, et al. The essential oils of *Cinnamomum rhyncophyllum* Miq. as natural sources of benzyl benzoate, safrole and methyl(E)-cinnamate. *Flavour Fragr J.* 2004 May;19(3):260–2.
144. Jassbi AR, Ahmad VU, Tareen RB. Constituents of the essential oil of *Perovskia atriplicifolia* Benth. *Flavour Fragr J.* 1999 Jan;14(1):38–40.
145. Javidnia K, Miri R, Jafari A, Rezai H. Analysis of the volatile constituents of *Nepeta macrosiphon* Boiss. grown in Iran. *Flavour Fragr J.* 2004 Mar;19(2):156–8.
146. Jesus AS, Blank AF, Alves MF, Arrigoni-Blank MF, Lima RN, Alves PB. Influence of storage time and temperature on the chemical composition of the essential oil of *Hyptis pectinata* L. Poit. *Rev bras plantas med.* 2016;18(1 suppl 1):336–40.
147. Jiang C, Sun Y, Zhu X, Gao Y, Wang L, Wang J, et al. Solvent-free microwave extraction coupled with headspace single-drop microextraction of essential oils from flower of *Eugenia caryophyllata* Thunb. *J Sep Science.* 2010 Sep;33(17–18):2784–90.
148. Jiang J. Volatile composition of the laksa plant (*Polygonum hydropiper* L.), a potential source of green note aroma compounds. *Flavour Fragr J.* 2005 Sep;20(5):455–9.
149. Jinhua S, Yufei Z, Zhiyong Z, Xiaoming C, Fulin H. Chemical components of volatile oil from *Cinnamomum jensenianum* Hand Mazz leaf in Yongzhou, and its antibacterial and antioxidant properties. *Trop J Pharm Res.* 2018 Oct 3;17(9):1839.
150. Jirovetz L, Buchbauer G, Stoilova I, Stoyanova A, Krastanov A, Schmidt E. Chemical Composition and Antioxidant Properties of Clove Leaf Essential Oil. *J Agric Food Chem.* 2006 Aug 1;54(17):6303–7.

151. Jovanovic T, Kitic D, Palic R, Stojanovic G, Ristic M. Chemical composition and antimicrobial activity of the essential oil of *Acinos arvensis* (Lam.) Dandy from Serbia. *Flavour Fragr J.* 2005 May;20(3):288–90.
152. Juliani HR, Zygadlo JA, Scrivanti R, De La Sota E, Simon JE. The essential oil of *Anemia tomentosa* (Savigny) Sw. var. *anthriscifolia* (Schrad.) Mickel. *Flavour Fragr J.* 2004 Nov;19(6):541–3.
153. Kambiré DA, Boti JB, Ouattara ZA, Yapi TA, Bighelli A, Tomi F, et al. Leaf essential oil from Ivorian *Isolona dewevrei* (Annonaceae): Chemical composition and structure elucidation of four new natural sesquiterpenes. *Flavour Fragr J.* 2021 Jan;36(1):22–33.
154. Kapoor R, Ali M, Mir SR, Rafiullah MRM. Essential oil constituents of aerial parts of *Artemisia scoparia* Waldst. & Kit. *Flavour Fragr J.* 2004 Mar;19(2):109–11.
155. Kasali AA, Ekundayo O, Winterhalter P, Koenig WA, Eshilokun AO. Chemical constituents of the essential oil of *Lippia adoensis* Hochst. ex Walp. *Flavour Fragr J.* 2004 May;19(3):210–2.
156. Keskin Ş. Orange peel volatile oil: A green solvent for propolis extraction, enhanced α -amylase inhibition activity. *Flavour Fragr J.* 2020 Jul;35(4):411–6.
157. Khan M, Srivastava SK, Jain N, Syamasundar KV, Yadav AK. Chemical composition of fruit and stem essential oils of *Lantana camara* from northern India. *Flavour Fragr J.* 2003 Sep;18(5):376–9.
158. Kim MR, Kim CW. Human blood plasma preparation for two-dimensional gel electrophoresis. *Journal of Chromatography B.* 2007 Apr;849(1–2):203–10.
159. Kim TH, Thuy NT, Shin JH, Baek HH, Lee HJ. Aroma-Active Compounds of Miniature Beefsteakplant (*Mosla dianthera* Maxim.). *J Agric Food Chem.* 2000 Jul 1;48(7):2877–81.
160. Kimbaris AC, Koliopoulos G, Michaelakis A, Konstantopoulou MA. Bioactivity of *Dianthus caryophyllus*, *Lepidium sativum*, *Pimpinella anisum*, and *Illicium verum* essential oils and their major components against the West Nile vector *Culex pipiens*. *Parasitol Res.* 2012 Dec;111(6):2403–10.
161. Kishimoto T, Wanikawa A, Kagami N, Kawatsura K. Analysis of Hop-Derived Terpenoids in Beer and Evaluation of Their Behavior Using the Stir Bar–Sorptive Extraction Method with GC-MS. *J Agric Food Chem.* 2005 Jun 1;53(12):4701–7.
162. Kitic D, Palic R, Ristic M, Sojanovic G, Jovanovic T. The volatile constituents of *Calamintha sylvatica* Bromf. subsp. *sylvatica*. *Flavour Fragr J.* 2001 Jul;16(4):257–8.
163. Kjeldsen F, Christensen LP, Edelenbos M. Quantitative Analysis of Aroma Compounds in Carrot (*Daucus carota* L.) Cultivars by Capillary Gas Chromatography Using Large-Volume Injection Technique. *J Agric Food Chem.* 2001 Sep 1;49(9):4342–8.
164. Kjeldsen F, Christensen LP, Edelenbos M. Changes in Volatile Compounds of Carrots (*Daucus carota* L.) During Refrigerated and Frozen Storage. *J Agric Food Chem.* 2003 Aug 1;51(18):5400–7.

165. Koundal R, Kumar D, Walia M, Kumar A, Thakur S, Chand G, et al. Chemical and *in vitro* cytotoxicity evaluation of essential oil from *Eucalyptus citriodora* fruits growing in the Northwestern Himalaya, India: Chemical and *in vitro* cytotoxicity of the essential oil of *E. citriodora*. *Flavour Fragr J*. 2016 Mar;31(2):158–62.
166. Kowalski R, Wolski T. The chemical composition of essential oils of *Silphium perfoliatum* L. *Flavour Fragr J*. 2005 May;20(3):306–10.
167. Krishnamoorthy S, Chandrasekaran M, Raj GA, Jayaraman M, Venkatesalu V. Identification of chemical constituents and larvicidal activity of essential oil from *Murraya exotica* L. (Rutaceae) against *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus* (Diptera: Culicidae). *Parasitol Res*. 2015 May;114(5):1839–45.
168. Kukić J, Petrović S, Pavlović M, Couladis M, Tzakou O, Niketić M. Composition of essential oil of *Stachys alpina* L. ssp. *dinarica* Murb. *Flavour Fragr J*. 2006 May;21(3):539–42.
169. Kundakovic T, Fokialakis N, Kovacevic N, Chinou I. Essential oil composition of *Achillea lingulata* and *A. umbellata*. *Flavour Fragr J*. 2007 May;22(3):184–7.
170. Lago JHG, deÁvila P, De Aquino EM, Moreno PRH, Ohara MT, Limberger RP, et al. Volatile oils from leaves and stem barks of *Cedrelafissilis* (Meliaceae): chemical composition and antibacterial activities. *Flavour Fragr J*. 2004 Sep;19(5):448–51.
171. Langsdorf A, Drommershausen AL, Volkmar M, Ulber R, Holtmann D. Fermentative α -Humulene Production from Homogenized Grass Clippings as a Growth Medium. *Molecules*. 2022 Dec 8;27(24):8684.
172. Le NT, Donadu MG, Ho DV, Doan TQ, Le AT, Raal A, et al. Biological activities of essential oil extracted from leaves of *Atalantia sessiflora* Guillaumin in Vietnam. *J Infect Dev Ctries*. 2020 Sep 30;14(09):1054–64.
173. Le TX, Ho ASH, Mah SH, Wong TW, Ong HC, Loh PHM, et al. Determination of borneol and other chemical compounds of essential oil of *Dryobalanops aromatica* exudate from Malaysia. *Trop J Pharm Res*. 2016 Jul 12;15(6):1293.
174. Le TX, Ho ASH, Mah SH, Wong TW, Ong HC, Loh PHM, et al. Determination of borneol and other chemical compounds of essential oil of *Dryobalanops aromatica* exudate from Malaysia. *Trop J Pharm Res*. 2016 Jul 12;15(6):1293.
175. Lemos M, Santin JR, Mizuno CS, Boeing T, De Sousa JPB, Nanayakkara D, et al. *Copaifera langsdorffii*: evaluation of potential gastroprotective of extract and isolated compounds obtained from leaves. *Revista Brasileira de Farmacognosia*. 2015 May;25(3):238–45.
176. Letchamo W, Ward W, Heard B, Heard D. Essential Oil of *Valeriana officinalis* L. Cultivars and Their Antimicrobial Activity As Influenced by Harvesting Time under Commercial Organic Cultivation. *J Agric Food Chem*. 2004 Jun 1;52(12):3915–9.
177. Lima MAS, Barros MCP, Pinheiro SM, Do Nascimento RF, De Abreu Matos FJ, Silveira ER. Volatile compositions of two Asteraceae from the north-east of

Brazil: *Ageratum conyzoides* and *Acritopappus confertus* (Eupatorieae). *Flavour Fragr J.* 2005 Nov;20(6):559–61.

178. Lis A, Boczek E, Góra J. Chemical composition of the essential oils from fruits, leaves and flowers of the Amur cork tree (*Phellodendron amurense* Rupr.): ESSENTIAL OILS OF *PHELLODENDRON AMURENSE*. *Flavour Fragr J.* 2004 Nov;19(6):549–53.
179. Liu J, Nan P, Tsering Q, Tsering T, Bai Z, Wang L, et al. Volatile constituents of the leaves and flowers of *Salvia przewalskii* Maxim. from Tibet. *Flavour Fragr J.* 2006 May;21(3):435–8.
180. Liu XC, Liu QY, Zhou L, Liu QR, Liu ZL. Chemical Composition of *Zanthoxylum avicennae* Essential Oil and its Larvicidal Activity on *Aedes albopictus* Skuse. *Trop J Pharm Res.* 2016 Jun 23;13(3):399.
181. Lo Presti M, Ragusa S, Trozzi A, Dugo P, Visinoni F, Fazio A, et al. A comparison between different techniques for the isolation of rosemary essential oil. *J Sep Science.* 2005 Feb;28(3):273–80.
182. Lockwood GB, Asghari G, Hakimi B. Production of essential oil constituents by cultured cells of *Carum copticum* L. *Flavour Fragr J.* 2002 Nov;17(6):456–8.
183. López MA, Stashenko EE, Fuentes JL. Chemical composition and antigenotoxic properties of *Lippia alba* essential oils. *Genet Mol Biol.* 2011 Jul 29;34(3):479–88.
184. Lorenzo D, Loayza I, Dellacassa E. Composition of the essential oils from leaves of two *Hedyosmum* spp. from Bolivia. *Flavour Fragr J.* 2003 Jan;18(1):32–5.
185. Lorenzo D, Loayza I, Dellacassa E. Composition and chiral characterization of the essential oil of *Buddleja tucumanensis* from Bolivia. *Flavour Fragr J.* 2006 Jan;21(1):95–8.
186. Lorenzo D, Paz D, Davies P, Villamil J, Vila R, Cañigueral S, et al. Characterization and enantiomeric distribution of some terpenes in the essential oil of a Uruguayan biotype of *Salvia sclarea* L. *Flavour Fragr J.* 2004 Jul;19(4):303–7.
187. Machado JC, Lehnhardt F, Martins ZE, Kollmannsberger H, Gastl M, Becker T, et al. Prediction of Fruity-Citrus Intensity of Beers Dry Hopped with Mandarinina Bavaria Based on the Content of Selected Volatile Compounds. *J Agric Food Chem.* 2020 Feb 19;68(7):2155–63.
188. Machado M, Dinis AM, Salgueiro L, Cavaleiro C, Custódio JBA, Sousa MDC. Anti-Giardia activity of phenolic-rich essential oils: effects of *Thymbra capitata*, *Origanum virens*, *Thymus zygis* subsp. *sylvestris*, and *Lippia graveolens* on trophozoites growth, viability, adherence, and ultrastructure. *Parasitol Res.* 2010 Apr;106(5):1205–15.
189. Magalhães LG, De Souza JM, Wakabayashi KAL, Da S. Laurentiz R, Vinhólis AHC, Rezende KCS, et al. In vitro efficacy of the essential oil of *Piper cubeba* L. (Piperaceae) against *Schistosoma mansoni*. *Parasitol Res.* 2012 May;110(5):1747–54.

190. Maggi F, Tirillini B, Papa F, Sagratini G, Vittori S, Cresci A, et al. Chemical composition and antimicrobial activity of the essential oil of *Ferulago campestris* (Besser) Grecescu growing in central Italy. *Flavour Fragr J.* 2009 Nov;24(6):309–15.
191. Maia JGS, Andrade EHA, Carreira LMM, Oliveira J, Araújo JS. Essential oils of the Amazon *Guatteria* and *Guatteriopsis* species. *Flavour Fragr J.* 2005 Sep;20(5):478–80.
192. Maia JGS, Da Silva MHL, Andrade EHA, Rosa NA. Essential oil composition of *Scleria hirtella* Swartz (Cyperaceae). *Flavour Fragr J.* 2005 Sep;20(5):472–3.
193. Maietti S, Rossi D, Guerrini A, Useli C, Romagnoli C, Poli F, et al. A multivariate analysis approach to the study of chemical and functional properties of chemo-diverse plant derivatives: lavender essential oils: Chemodiversity and multivariate analysis: the lavender case. *Flavour Fragr J.* 2013 May;28(3):144–54.
194. Malenčić Dj, Couladis M, Mimica-Dukić N, Popović M, Boža P. Essential oils of three *Salvia* species from the Pannonian part of Serbia. *Flavour Fragr J.* 2004 May;19(3):225–8.
195. Marongiu B, Porcedda APS, Casu R, Pierucci P. Chemical composition of the oil and supercritical CO₂ extract of *Schinus molle* L. *Flavour Fragr J.* 2004 Nov;19(6):554–8.
196. Marongiu B, Porcedda S, Piras A, Sanna G, Murreddu M, Loddo R. Extraction of *Juniperus communis* L. ssp. *nana* Willd. essential oil by supercritical carbon dioxide. *Flavour Fragr J.* 2006 Jan;21(1):148–54.
197. Marques FG, De Oliveira Neto JR, Da Cunha LC, De Paula JR, Bara MTF. Identification of terpenes and phytosterols in *Dipteryx alata* (baru) oil seeds obtained through pressing. *Revista Brasileira de Farmacognosia.* 2015 Sep;25(5):522–5.
198. Masola B, Oguntibeju OO, Oyenihni AB. *Centella asiatica* ameliorates diabetes-induced stress in rat tissues via influences on antioxidants and inflammatory cytokines. *Biomedicine & Pharmacotherapy.* 2018 May;101:447–57.
199. Masoudi S, Esmaili A, Ali Khalilzadeh M, Rustaiyan A, Moazami N, Akhgar MR, et al. Volatile constituents of *Dorema aucheri* Boiss., *Seseli libanotis* (L.) W. D. Koch var. *armeniacum* Bordz. and *Conium maculatum* L. three Umbelliferae herbs growing wild in Iran. *Flavour Fragr J.* 2006 Sep;21(5):801–4.
200. Meccia G, Rosquete C, Rojas LB, Feliciano AS. New labdane derivative from the essential oil of *Acalypha plicata* Müll. Arg. *Flavour Fragr J.* 2006 May;21(3):559–61.
201. Meekijjaroenroj A, Bessièrè JM, Anstett MC. Chemistry of floral scents in four *Licuala* species (Arecaceae). *Flavour Fragr J.* 2007 Jul;22(4):300–10.
202. Mendes GD, Hamamoto D, Ilha J, Pereira ADS, De Nucci G. Anastrozole quantification in human plasma by high-performance liquid chromatography coupled to photospray tandem mass spectrometry applied to pharmacokinetic studies. *Journal of Chromatography B.* 2007 May;850(1–2):553–9.

203. Merle H, Verdeguer M, Blázquez MA, Boira H. Chemical composition of the essential oils from *Eriocephalus africanus* L. var. *africanus* populations growing in Spain. *Flavour Fragr J.* 2007 Nov;22(6):461–4.
204. Mevy JP, Bessiere JM, Rabier J, Dherbomez M, Ruzzier M, Millogo J, et al. Composition and antimicrobial activities of the essential oil of *Triumfetta rhomboidea* Jacq. *Flavour Fragr J.* 2006 Jan;21(1):80–3.
205. Mezzoug N, Elhadri A, Dallouh A, Amkiss S, Skali NS, Abrini J, et al. Investigation of the mutagenic and antimutagenic effects of *Origanum compactum* essential oil and some of its constituents. *Mutation Research/Genetic Toxicology and Environmental Mutagenesis.* 2007 May;629(2):100–10.
206. Michielin EMZ, Salvador AA, Riehl CAS, Smânia A, Smânia EFA, Ferreira SRS. Chemical composition and antibacterial activity of *Cordia verbenacea* extracts obtained by different methods. *Bioresource Technology.* 2009 Dec;100(24):6615–23.
207. Mir SR, Ali M, Kapoor R. Chemical composition of essential oil of *Cinnamomum tamala* Nees et Eberm. leaves. *Flavour Fragr J.* 2004 Mar;19(2):112–4.
208. Mirjalili MH, Salehi P, Badi HN, Sonboli A. Volatile constituents of the flowerheads of three Echinacea species cultivated in Iran. *Flavour Fragr J.* 2006 Mar;21(2):355–8.
209. Mirza M, Ahmadi L, Tayebi M. Volatile constituents of *Hymenocrater incanus* Bunge, an Iranian endemic species. *Flavour Fragr J.* 2001 Jul;16(4):239–40.
210. Mirza M, Nik ZB. Volatile constituents of *Phlomis olivieri* Benth. from Iran. *Flavour Fragr J.* 2003 Mar;18(2):131–2.
211. Miyazawa M, Yamafuji C, Kurose K, Ishikawa Y. Volatile components of the rhizomes of *Cirsium japonicum* DC. *Flavour Fragr J.* 2003 Jan;18(1):15–7.
212. Moemenbellah-Fard MD, Abdollahi A, Ghanbariasad A, Osanloo M. Antibacterial and leishmanicidal activities of *Syzygium aromaticum* essential oil versus its major ingredient, eugenol. *Flavour Fragr J.* 2020 Sep;35(5):534–40.
213. Mohammadi Pour P, Bidad S, Bahrami G, Hosseinzadeh L, Mojarrab M, Farzaei MH. Evaluation of the Cytotoxicity of Aqueous Extract and Oleo-Essential Oil of *Dorema ammoniacum* Plant Oleo-Gum Resin in Some Human Cancer Cell Lines. Amantini C, editor. *Analytical Cellular Pathology.* 2022 Aug 9;2022:1–9.
214. Mondêgo-Oliveira R, De Sá Sousa JC, Moragas-Tellis CJ, De Souza PVR, Dos Santos Chagas MDS, Behrens MD, et al. *Vernonia brasiliensis* (L.) Druce induces ultrastructural changes and apoptosis-like death of *Leishmania infantum* promastigotes. *Biomedicine & Pharmacotherapy.* 2021 Jan;133:111025.
215. Mukherjee M, Blair RH, Wang ZQ. Machine-learning guided elucidation of contribution of individual steps in the mevalonate pathway and construction of a yeast platform strain for terpenoid production. *Metabolic Engineering.* 2022 Nov;74:139–49.

216. Musenga A, Ferranti A, Saracino MA, Fanali S, Raggi MA. Simultaneous determination of aromatic and terpenic constituents of cloves by means of HPLC with diode array detection. *J Sep Sci*. 2006 Jun;29(9):1251–8.
217. Musenga A, Mandrioli R, Ferranti A, D’Orazio G, Fanali S, Raggi MA. Analysis of aromatic and terpenic constituents of pepper extracts by capillary electrochromatography. *J Sep Sci*. 2007 Mar;30(4):612–9.
218. Najjar B, Pistelli L, Mancini S, Fratini F. Chemical composition and in vitro antibacterial activity of essential oils from different species of *Juniperus* (section *Juniperus*). *Flavour Fragr J*. 2020 Nov;35(6):623–38.
219. Ng F, Basri N, Wu W, Thong A, Thong G, Chew W, et al. Characterization of volatile compounds in Ylang-Ylang essential oils from Comoros and Madagascar by gas chromatography and principal component analysis. *Flavour Fragr J*. 2021 Jan;36(1):159–66.
220. Ngassapa OD, Runyoro DKB, Vagionas K, Graikou K, Chinou IB. Chemical Composition and Antimicrobial Activity of *Geniosporum rotundifolium* Briq and *Haumaniastrum villosum* (Bene) AJ Paton (Lamiaceae) Essential Oils from Tanzania. *Trop J Pharm Res*. 2016 May 11;15(1):107.
221. Niu JF, Wang GC, Lin X zhi, Zhou BC. Large-scale recovery of C-phycocyanin from *Spirulina platensis* using expanded bed adsorption chromatography. *Journal of Chromatography B*. 2007 May;850(1–2):267–76.
222. Norouzi-Arasi H, Yavari I, Chalabian F, Kiarostami V, Ghaffarzadeh F, Nasirian A. Chemical constituents and antimicrobial activities of the essential oil of *Acroptilon repens* (L.) DC. *Flavour Fragr J*. 2006 Mar;21(2):247–9.
223. Novak J, Langbehn J, Pank F, Franz CM. Essential oil compounds in a historical sample of marjoram (*Origanum majorana* L., Lamiaceae). *Flavour Fragr J*. 2002 May;17(3):175–80.
224. Novak J, Zitterl-Eglseer K, Deans SG, Franz CM. Essential oils of different cultivars of *Cannabis sativa* L. and their antimicrobial activity. *Flavour Fragr J*. 2001 Jul;16(4):259–62.
225. Ogunwande IA, Olawore NO, Kasali AA, König WA. Chemical composition of the leaf volatile oils of *Callitris intratropica* R. T. Baker & H. G. Smith from Nigeria: LEAF VOLATILE OIL OF *CALLITRIS INTRATROPICA*. *Flavour Fragr J*. 2003 Sep;18(5):387–9.
226. Olawore NO, Ogunwande IA, Ekundayo O, Adeleke KA. Chemical composition of the leaf and fruit essential oils of *Murraya paniculata* (L.) Jack. (Syn. *Murraya exotica* Linn.). *Flavour Fragr J*. 2005 Jan;20(1):54–6.
227. Oliveira GL, Moreira DDL, Mendes ADR, Guimarães EF, Figueiredo LS, Kaplan MAC, et al. Growth study and essential oil analysis of *Piper aduncum* from two sites of Cerrado biome of Minas Gerais State, Brazil. *Revista Brasileira de Farmacognosia*. 2013 Sep;23(5):743–53.

228. Ottavioli J, Bighelli A, Casanova J. Diterpene-rich needle oil of *Pinus pinaster* Ait. from Corsica. *Flavour Fragr J.* 2008 Mar;23(2):121–5.
229. Ouamba JM, Ouabonzi A, Ekouya A, Bessière JM, Menut C, Abena AA, et al. Volatile constituents of the essential oil leaf of *Lantana salvifolia* Jacq. (Verbenaceae). *Flavour Fragr J.* 2006 Jan;21(1):158–61.
230. Oyedeji OA, Ekundayo O, König WA. Volatile leaf oil constituents of *Lantana camara* L from Nigeria: VOLATILE LEAF OIL OF *LANTANA CAMARA*. *Flavour Fragr J.* 2003 Sep;18(5):384–6.
231. Palmeira SF, Moura FDS, Alves VDL, Oliveira FMD, Bento ES, Conserva LM, et al. Neutral components from hexane extracts of *Croton sellowii*. *Flavour Fragr J.* 2004 Jan;19(1):69–71.
232. Paolini J, Muselli A, Bernardini AF, Bighelli A, Casanova J, Costa J. Thymol derivatives from essential oil of *Doronicum corsicum* L. *Flavour Fragr J.* 2007 Nov;22(6):479–87.
233. Parrot S, Lambás-Señas L, Sentenac S, Denoroy L, Renaud B. Highly sensitive assay for the measurement of serotonin in microdialysates using capillary high-performance liquid chromatography with electrochemical detection. *Journal of Chromatography B.* 2007 May;850(1–2):303–9.
234. Pavlović M, Tzakou O, Petrakis PV, Couladis M. The essential oil of *Hypericum perforatum* L., *Hypericum tetrapterum* Fries and *Hypericum olympicum* L. growing in Greece. *Flavour Fragr J.* 2006 Jan;21(1):84–7.
235. Pavlović M, Kovačević N, Tzakou O, Couladis M. Essential oil composition of *Anthemis triumfetti* (L.) DC. *Flavour Fragr J.* 2006 Mar;21(2):297–9.
236. Péres VF, Moura DJ, Sperotto ARM, Damasceno FC, Caramão EB, Zini CA, et al. Chemical composition and cytotoxic, mutagenic and genotoxic activities of the essential oil from *Piper gaudichaudianum* Kunth leaves. *Food and Chemical Toxicology.* 2009 Sep;47(9):2389–95.
237. Petrakis PV, Tsitsimpikou C, Tzakou O, Couladis M, Vagias C, Roussis V. Needle volatiles from five *Pinus* species growing in Greece. *Flavour Fragr J.* 2001 Jul;16(4):249–52.
238. Pitarokili D, Couladis M, Petsikos-Panayotarou N, Tzakou O. Composition and Antifungal Activity on Soil-Borne Pathogens of the Essential Oil of *Salvia sclarea* from Greece. *J Agric Food Chem.* 2002 Nov 1;50(23):6688–91.
239. Podduturi R, Petersen MA, Mahmud S, Rahman MdM, Jørgensen NOG. Potential Contribution of Fish Feed and Phytoplankton to the Content of Volatile Terpenes in Cultured *Pangasius* (*Pangasianodon hypophthalmus*) and *Tilapia* (*Oreochromis niloticus*). *J Agric Food Chem.* 2017 May 10;65(18):3730–6.
240. Pourmortazavi SM, Sefidkon F, Hosseini SG. Supercritical Carbon Dioxide Extraction of Essential Oils from *Perovskia atriplicifolia* Benth. *J Agric Food Chem.* 2003 Aug 1;51(18):5414–9.

241. Pripdeevech P, Chukeatirote E. Chemical compositions, antifungal and antioxidant activities of essential oil and various extracts of *Melodorum fruticosum* L. flowers. *Food and Chemical Toxicology*. 2010 Oct;48(10):2754–8.
242. Qnais E, Bseiso Y, Wedyan M, Al-Omari M, Alkhateeb H. Chemical composition and antinociceptive effects of essential oil from aerial parts of *Gundelia tournefortii* L Asteraceae (Compositae) in rats. *Trop J Pharm Res*. 2016 Nov 15;15(10):2183.
243. Quijano CE, Salamanca G, Pino JA. Aroma volatile constituents of Colombian varieties of mango (*Mangifera indica* L.). *Flavour Fragr J*. 2007 Sep;22(5):401–6.
244. Rajeswara Rao BR, Sastry KP, Saleem SM, Prakasa Rao EVS, Syamasundar KV, Ramesh S. Volatile flower oils of three genotypes of rose-scented geranium (*Pelargonium* sp.). *Flavour Fragr J*. 2000 Mar;15(2):105–7.
245. Rana VS, Juyal JP, Blazquez MA, Bodakhe SH. Essential oil composition of *Artemisia parviflora* aerial parts. *Flavour Fragr J*. 2003 Jul;18(4):342–4.
246. Ravi Kiran S, Sita Devi P. Evaluation of mosquitocidal activity of essential oil and sesquiterpenes from leaves of *Chloroxylon swietenia* DC. *Parasitol Res*. 2007 Jul;101(2):413–8.
247. Rezende WP, Borges LL, Alves NM, Ferri PH, Paula JR. Chemical variability in the essential oils from leaves of *Syzygium jambos*. *Revista Brasileira de Farmacognosia*. 2013 May;23(3):433–40.
248. Rodrigues FSLM, Antunes LCS, Figueiredo AC, Costa MM, Pereira JDS, Colaço RDR, et al. Composition of the leaf, flower and fruit volatile oils of *Pittosporum tobira* (Thunb.) W. T. Aiton grown in three locations in Portugal. *Flavour Fragr J*. 2007 Jul;22(4):311–6.
249. Rout PK, Rao YR, Sree A, Naik SN. Composition of essential oil, concrete, absolute, wax and headspace volatiles of *Murraria paniculata* (Linn.) Jack flowers. *Flavour Fragr J*. 2007 Sep;22(5):352–7.
250. Sá SD, Fiuza TS, Borges LL, Ferreira HD, Tresvenzol LMF, Ferri PH, et al. Chemical composition and seasonal variability of the essential oils of leaves and morphological analysis of *Hyptis carpinifolia*. *Revista Brasileira de Farmacognosia*. 2016 Nov;26(6):688–93.
251. Saei-Dehkordi SS, Tajik H, Moradi M, Khalighi-Sigaroodi F. Chemical composition of essential oils in *Zataria multiflora* Boiss. from different parts of Iran and their radical scavenging and antimicrobial activity. *Food and Chemical Toxicology*. 2010 Jun;48(6):1562–7.
252. Sajjadi SE, Ghassemi N. Volatile constituents of *Nepeta glomerulosa* Boiss. subsp. *carmanica*. *Flavour Fragr J*. 1999 Sep;14(5):265–7.
253. Sajjadi SE, Mehregan I, Khatamsaz M, Asgari Gh. Chemical composition of the essential oil of *Perovskia abrotanoides* Karel. growing wild in Iran. *Flavour Fragr J*. 2005 Jul;20(4):445–6.

254. Sakurai K, Tomiyama K, Yaguchi Y, Asakawa Y. The characteristic smell emitted from two scale insects, *Ceroplastes japonicus* and *Ceroplastes rubens*. *Bioscience, Biotechnology, and Biochemistry*. 2020 Aug 2;84(8):1541–5.
255. Santos AP, Lopes MC, Limberger RP, Apel MA, Henriques AT, Moreno PRH. Analysis of the volatile oil from *Pilocarpus pennatifolius* Lemmaire(Rutaceae) leaves by GC–MS. *Flavour Fragr J*. 2004 Jul;19(4):325–6.
256. Santos DL, Ferreira HD, Borges LL, Paula JR, Tresvenzol LMF, Santos PA, et al. Chemical composition of essential oils of leaves, flowers and fruits of *Hortia oreadica*. *Revista Brasileira de Farmacognosia*. 2016 Jan;26(1):23–8.
257. Santos-Gomes PC, Fernandes-Ferreira M. Organ- and Season-Dependent Variation in the Essential Oil Composition of *Salvia officinalis* L. Cultivated at Two Different Sites. *J Agric Food Chem*. 2001 Jun 1;49(6):2908–16.
258. Santos-Gomes PC, Fernandes-Ferreira M. Essential Oils Produced by in Vitro Shoots of Sage (*Salvia officinalis* L.). *J Agric Food Chem*. 2003 Apr 1;51(8):2260–6.
259. Sari M, Biondi DM, Kaâbeche M, Mandalari G, D'Arrigo M, Bisignano G, et al. Chemical composition, antimicrobial and antioxidant activities of the essential oil of several populations of Algerian *Origanum glandulosum* Desf. *Flavour Fragr J*. 2006 Nov;21(6):890–8.
260. Sarkhail P, Amin G, Sha?ee A. Composition of the essential oil of *Phlomis persica* Boiss and *Phlomis chorassanica* Bunge from Iran. *Flavour Fragr J*. 2004 Nov;19(6):538–40.
261. Saroglou V, Arfan M, Shabir A, Hadjipavlou-Litina D, Skaltsa H. Composition and antioxidant activity of the essential oil of *Teucrium royleanum* Wall. ex Benth growing in Pakistan. *Flavour Fragr J*. 2007 Mar;22(2):154–7.
262. Satou T, Kasuya H, Takahashi M, Murakami S, Hayashi S, Sadamoto K, et al. Relationship between duration of exposure and anxiolytic-like effects of essential oil from *Alpinia zerumbet*: Effects of essential oil from *Alpinia zerumbet*. *Flavour Fragr J*. 2011 May;26(3):180–5.
263. Sefidkon F. Essential oil of *Lantana camara* L. occurring in Iran. *Flavour Fragr J*. 2002 Jan;17(1):78–80.
264. Sefidkon F, Khajavi MS. Chemical composition of the essential oils of two *Salvia* species from Iran: *Salvia verticillata* L. and *Salvia santolinifolia* Boiss. *Flavour Fragr J*. 1999 Mar;14(2):77–8.
265. Senatore F, Landolfi S, Celik S, Bruno M. Volatile components of *Centaurea calcitrapa* L. and *Centaurea sphaerocephala* L. ssp. *sphaerocephala*, two Asteraceae growing wild in Sicily. *Flavour Fragr J*. 2006 Mar;21(2):282–5.
266. Senthilkumar A, Venkatesalu V. Chemical composition and larvicidal activity of the essential oil of *Plectranthus amboinicus* (Lour.) Spreng against *Anopheles stephensi*: a malarial vector mosquito. *Parasitol Res*. 2010 Oct;107(5):1275–8.

267. Shafi PM, Jose B, Radhamani KT, Clery RA. Influence of pH on essential oil composition of *Zanthoxylum rhetsa* seeds obtained by steam distillation. *Flavour Fragr J*. 2006 Mar;21(2):317–8.
268. Sharma A, Rajendran S, Srivastava A, Sharma S, Kundu B. Antifungal activities of selected essential oils against *Fusarium oxysporum* f. sp. *lycopersici* 1322, with emphasis on *Syzygium aromaticum* essential oil. *Journal of Bioscience and Bioengineering*. 2017 Mar;123(3):308–13.
269. Sharmeen Jugreet B, Kouadio Ibrahime S, Zengin G, Abdallah HH, Fawzi Mahomoodally M. GC/MS Profiling, *In Vitro* and *In Silico* Pharmacological Screening and Principal Component Analysis of Essential Oils from Three Exotic and Two Endemic Plants from Mauritius. *Chem Biodiversity* [Internet]. 2021 Mar [cited 2023 Aug 16];18(3). Available from: <https://onlinelibrary.wiley.com/doi/10.1002/cbdv.202000921>
270. Shimizu Y, Imayoshi Y, Kato M, Maeda K, Iwabuchi H, Shimomura K. Volatiles from leaves of field-grown plants and shoot cultures of *Gynura bicolor* DC. *Flavour Fragr J*. 2009 Sep;24(5):251–8.
271. Shimizu Y, Imayoshi Y, Kato M, Maeda K, Iwabuchi H, Shimomura K. New eudesmane-type sesquiterpenoids and other volatile constituents from the roots of *Gynura bicolor* DC. *Flavour Fragr J*. 2011 Jan;26(1):55–64.
272. Silva GNS, Spader TB, Alves SH, Mallmann CA, Heinzmann BM. Composition and evaluation of the antimicrobial activity of the essential oil of *Senecio selloi* Spreng DC. *Rev bras plantas med*. 2013;15(4):503–7.
273. Silva Lima A, Milhomem MN, Santos Monteiro O, Arruda ACP, De Castro JAM, Fernandes YML, et al. Seasonal analysis and acaricidal activity of the thymol-type essential oil of *Ocimum gratissimum* and its major constituents against *Rhipicephalus microplus* (Acari: Ixodidae). *Parasitol Res*. 2018 Jan;117(1):59–65.
274. Sinan KI, Etienne OK, Stefanucci A, Mollica A, Mahomoodally MF, Jugreet S, et al. Chemodiversity and biological activity of essential oils from three species from the *Euphorbia* genus. *Flavour Fragr J*. 2021 Jan;36(1):148–58.
275. Singh AK, Raina VK, Naqvi AA, Patra NK, Kumar B, Ram P, et al. Essential oil composition and chemoarrays of menthol mint (*Mentha arvensis* L. f. *piperascens* Malinvaud ex. Holmes) cultivars. *Flavour Fragr J*. 2005 May;20(3):302–5.
276. Skalicka-Woźniak K, Walasek M, Ludwiczuk A, Głowniak K. Isolation of terpenoids from *Pimpinella anisum* essential oil by high-performance counter-current chromatography: Liquid Chromatography. *J Sep Science*. 2013 Aug;36(16):2611–4.
277. Sonboli A, Azizian D, Yousefzadi M, Kanani MR, Mehrabian AR. Volatile constituents and antimicrobial activity of the essential oil of *Tetrataenium lasiopetalum* (Apiaceae) from Iran. *Flavour Fragr J*. 2007 Mar;22(2):119–22.
278. Sperotto ARM, Moura DJ, Péres VF, Damasceno FC, Caramão EB, Henriques JAP, et al. Cytotoxic mechanism of *Piper gaudichaudianum* Kunth essential oil and its major compound nerolidol. *Food and Chemical Toxicology*. 2013 Jul;57:57–68.

279. Srivastava AK, Srivastava SK, Syamsundar KV. Volatile composition of *Curcuma angustifolia* Roxb. rhizome from central and southern India. *Flavour Fragr J.* 2006 May;21(3):423–6.
280. Stevanovic T, Garneau FX, Jean FI, Gagnon H, Vilotic D, Petrovic S, et al. The essential oil composition of *Pinus mugo* Turra from Serbia. *Flavour Fragr J.* 2005 Jan;20(1):96–7.
281. Su YC, Ho CL, Wang EIC. Analysis of leaf essential oils from the indigenous conifers of Taiwan. *Flavour Fragr J.* 2006 May;21(3):447–52.
282. Sulborska-Różycka A, Weryszko-Chmielewska E, Polak B, Stefańczyk B, Matysik-Woźniak A, Rejda R. Secretory Products in Petals of *Centaurea cyanus* L. Flowers: A Histochemistry, Ultrastructure, and Phytochemical Study of Volatile Compounds. *Molecules.* 2022 Feb 17;27(4):1371.
283. Šulniūtė V, Baranauskienė R, Ragažinskienė O, Venskutonis PR. Comparison of composition of volatile compounds in ten *Salvia* species isolated by different methods. *Flavour Fragr J.* 2017 Jul;32(4):254–64.
284. Sun D, Petracek PD. Grapefruit Gland Oil Composition Is Affected by Wax Application, Storage Temperature, and Storage Time. *J Agric Food Chem.* 1999 May 1;47(5):2067–9.
285. Sundufu AJ, Shoushan H. Chemical composition of the essential oils of *Lantana camara* L. occurring in south China. *Flavour Fragr J.* 2004 May;19(3):229–32.
286. Sutour S, Bradesi P, De Rocca-Serra D, Casanova J, Tomi F. Chemical composition and antibacterial activity of the essential oil from *Mentha suaveolens* ssp. *insularis* (Req.) Greuter. *Flavour Fragr J.* 2008 Mar;23(2):107–14.
287. Szafranek B, Chrapkowska K, Pawińska M, Szafranek J. Analysis of Leaf Surface Sesquiterpenes in Potato Varieties. *J Agric Food Chem.* 2005 Apr 1;53(8):2817–22.
288. Tabanca N, Demirci B, Baser KHC, Mincsovcics E, Khan SI, Jacob MR, et al. Characterization of volatile constituents of *Scaligeria tripartita* and studies on the antifungal activity against phytopathogenic fungi. *Journal of Chromatography B.* 2007 May;850(1–2):221–9.
289. Tavares Trindade FT, Stabeli RG, Pereira AA, Facundo VA, Almeida E Silva AD. *Copaifera multijuga* ethanolic extracts, oilresin, and its derivatives display larvicidal activity against *Anopheles darlingi* and *Aedes aegypti* (Diptera: Culicidae). *Revista Brasileira de Farmacognosia.* 2013 May;23(3):464–70.
290. Tirillini B, Pellegrino R, Bini LM. Essential oil composition of *Stachys sylvatica* L. from Italy. *Flavour Fragr J.* 2004 Jul;19(4):330–2.
291. Tonzibo ZF, Coffy AA, Chalachat JC, N'guessan YT. Chemical composition of essential oils of *Hoslundia opposita* Vahl. from Ivory Coast. *Flavour Fragr J.* 2006 Sep;21(5):789–91.

292. Tosun A, Kürkçüoğlu M, Dogan E, Duman H, Başer KHC. Essential oil composition of *Seseli petraeum* M. Bieb. and *Seseli andronakii* Woron. growing in Turkey. *Flavour Fragr J.* 2006 Mar;21(2):257–9.
293. Trilles BL, Bombarda I, Bouraïma-Madjebi S, Raharivelomanana P, Bianchini JP, Gaydou EM. Occurrence of various chemotypes in niaouli [*Melaleuca quinquenervia* (Cav.) S. T. Blake] essential oil from New Caledonia. *Flavour Fragr J.* 2006 Jul;21(4):677–82.
294. Tzakou O, Couladis M, Slavkovska V, Mimica-Dukic N, Jancic R. The essential oil composition of *Salvia brachyodon* Vandas. *Flavour Fragr J.* 2003 Jan;18(1):2–4.
295. Uçar G, Balaban M, Usta M. Volatile needle and wood extracts of oriental spruce *Picea orientalis* (L.) Link: VOLATILE OILS OF *PICEA ORIENTALIS*. *Flavour Fragr J.* 2003 Sep;18(5):368–75.
296. Vallejo MCG, Moujir L, Burillo J, Guerra LL, González M, Peñate RD, et al. Chemical composition and biological activities of the essential oils of *Salvia canariensis*. *Flavour Fragr J.* 2006 Jan;21(1):72–6.
297. Van Opstaele F, Praet T, Aerts G, De Cooman L. Characterization of Novel Single-Variety Oxygenated Sesquiterpenoid Hop Oil Fractions via Headspace Solid-Phase Microextraction and Gas Chromatography–Mass Spectrometry/Olfactometry. *J Agric Food Chem.* 2013 Nov 6;61(44):10555–64.
298. Vasiljević B, Knežević-Vukčević J, Mitić-Ćulafić D, Orčić D, Francišković M, Srdic-Rajic T, et al. Chemical characterization, antioxidant, genotoxic and in vitro cytotoxic activity assessment of *Juniperus communis* var. *saxatilis*. *Food and Chemical Toxicology.* 2018 Feb;112:118–25.
299. Vieira RF, Simon JE. Chemical characterization of basil (*Ocimum* spp.) based on volatile oils. *Flavour Fragr J.* 2006 Mar;21(2):214–21.
300. Vila R, Mundina M, Tomi F, Cicció JF, Gupta MP, Iglesias J, et al. Constituents of the essential oils from *Piper friedrichsthali* C.DC. and *P. pseudolindenii* C.DC. from Central America: ESSENTIAL OILS FROM *PIPER* SPP. *Flavour Fragr J.* 2003 May;18(3):198–201.
301. Vila R, Tomi F, Mundina M, Santana AI, Solís PN, López Arce JB, et al. Unusual composition of the essential oils from the leaves of *Piper aduncum*: UNUSUAL COMPOSITION OF ESSENTIAL OILS. *Flavour Fragr J.* 2005 Jan;20(1):67–9.
302. Vourlioti-Arapi F, Michaelakis A, Evergetis E, Koliopoulos G, Haroutounian SA. Essential oils of indigenous in Greece six *Juniperus* taxa: Chemical composition and larvicidal activity against the West Nile virus vector *Culex pipiens*. *Parasitol Res.* 2012 May;110(5):1829–39.
303. Vunda SLL, Sauter IP, Cibulski SP, Roehe PM, Bordignon SAL, Rott MB, et al. Chemical composition and amoebicidal activity of *Croton pallidulus*, *Croton ericoides*, and *Croton isabelli* (Euphorbiaceae) essential oils. *Parasitol Res.* 2012 Sep;111(3):961–6.

304. Wong KC, Lim TB, Ali DMH. Essential oil of *Homalomena sagittifolia* Jungh. *Flavour Fragr J.* 2006 Sep;21(5):786–8.
305. Wong KC, Sivasothy Y, Boey PL. Essential oil of *Elettariopsis elan* C.K. Lim. *Flavour Fragr J.* 2006 May;21(3):562–4.
306. Xiao Z, Chen J, Niu Y, Chen F. Characterization of the key odorants of fennel essential oils of different regions using GC–MS and GC–O combined with partial least squares regression. *Journal of Chromatography B.* 2017 Sep;1063:226–34.
307. Xie F, Rizvi SAH, Zeng X. Fumigant toxicity and biochemical properties of ($\alpha + \beta$) thujone and 1, 8-cineole derived from *Seriphidium brevifolium* volatile oil against the red imported fire ant *Solenopsis invicta* (Hymenoptera: Formicidae). *Revista Brasileira de Farmacognosia.* 2019 Nov;29(6):720–7.
308. Xing X, Ma JH, Fu Y, Zhao H, Ye XX, Han Z, et al. Essential oil extracted from *erythrina corallodendron* L. leaves inhibits the proliferation, migration, and invasion of breast cancer cells. *Medicine.* 2019 Sep;98(36):e17009.
309. Xu T, Gherib M, Bekhechi C, Atik-Bekkara F, Casabianca H, Tomi F, et al. Thymyl esters derivatives and a new natural product modhephanone from *Pulicaria mauritanica* Coss. (Asteraceae) root oil: Thymyl esters and modhephanone from *Pulicaria mauritanica* root oil. *Flavour Fragr J.* 2015 Jan;30(1):83–90.
310. Yahyaa M, Tholl D, Cormier G, Jensen R, Simon PW, Ibdah M. Identification and Characterization of Terpene Synthases Potentially Involved in the Formation of Volatile Terpenes in Carrot (*Daucus carota* L.) Roots. *J Agric Food Chem.* 2015 May 20;63(19):4870–8.
311. Yang YC, Lee SH, Lee WJ, Choi DH, Ahn YJ. Ovicidal and Adulticidal Effects of *Eugenia caryophyllata* Bud and Leaf Oil Compounds on *Pediculus capitis*. *J Agric Food Chem.* 2003 Aug 1;51(17):4884–8.
312. Yapi TA, Boti JB, Ahibo AC, Bighelli A, Casanova J, Tomi F. Combined analysis of *Xylopiya rubescens* Oliv. leaf oil using gas chromatography with flame ionization detection, gas chromatography with mass spectrometry and ^{13}C nuclear magnetic resonance: structure elucidation of new compounds: Structure elucidation of new compounds from *Xylopiya rubescens* oil. *Flavour Fragr J.* 2013 Nov;28(6):373–9.
313. Yüce E, Paksoy MY, Bagci E. Essential Oil Composition of Two *Grammosciadium* DC Species, *G. platycarpum* (Boiss et Hausskn) Schischk and *G. macrodon* Boiss (Apiaceae), from Turkey. *Trop J Pharm Res.* 2016 Mar 4;15(2):411.
314. Zaouali Y, Bouzaine T, Boussaid M. Essential oils composition in two *Rosmarinus officinalis* L. varieties and incidence for antimicrobial and antioxidant activities. *Food and Chemical Toxicology.* 2010 Nov;48(11):3144–52.
315. Zeng WC, Zhu RX, Jia LR, Gao H, Zheng Y, Sun Q. Chemical composition, antimicrobial and antioxidant activities of essential oil from *Gnaphlium affine*. *Food and Chemical Toxicology.* 2011 Jun;49(6):1322–8.

316. Zheljaskov VD, Cantrell CL, Tekwani B, Khan SI. Content, Composition, and Bioactivity of the Essential Oils of Three Basil Genotypes as a Function of Harvesting. *J Agric Food Chem*. 2008 Jan 1;56(2):380–5.
317. Zheljaskov VD, Maggi F. Valorization of CBD-hemp through distillation to provide essential oil and improved cannabinoids profile. *Sci Rep*. 2021 Oct 6;11(1):19890.
318. Zheljaskov VD, Noller JS, Maggi F, Dale R. Terpenes and Cannabinoids Yields and Profile from Direct-Seeded and Transplanted CBD- *Cannabis sativa*. *J Agric Food Chem*. 2022 Aug 31;70(34):10417–28.
319. Zini CA, Zanin KD, Christensen E, Caramão EB, Pawliszyn J. Solid-Phase Microextraction of Volatile Compounds from the Chopped Leaves of Three Species of *Eucalyptus*. *J Agric Food Chem*. 2003 Apr 1;51(9):2679–86.
320. Schmidt JM, Noletto JA, Vogler B, Setzer WN. Abaco Bush Medicine: Chemical Composition of the Essential Oils of Four Aromatic Medicinal Plants from Abaco Island, Bahamas. *Journal of Herbs, Spices & Medicinal Plants*. 2007;12(3):43–65.

Supplementary Table 2: Overview of extraction of α -humulene by included studies

Organism	Chemovar	Extraction	Isolation	Yield	Reference
<i>Acalypha plicata</i> Müll-Arg.	Venezuela	Hydrodistillation in a Clevenger-type apparatus for 5 h	GC-MS	1.20%	10.1002/ffj.1679
<i>Achillea lingulata</i>	Serbia	Hydrodistillation in a Clevenger-type apparatus for 2.5 h	GC-MS	0.48%	10.1002/ffj.1778
<i>Achillea Umbellata</i>	Greece	Hydrodistillation in a Clevenger-type apparatus for 2.5 h	GC-MS	0.04%	10.1002/ffj.1778
<i>Acinos arvensis</i> (Lam.) Dandy	Serbia	Hydrodistillation for 2.5 h using a Clevenger-type apparatus	GC-MS	0.70%	10.1002/ffj.1409
<i>Acritopappus confertus</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus modified by Gottlieb for 3 hours	GC-MS	1.30%	10.1002/ffj.1483
<i>Acroptilon repens</i> (L.) DC. (Russian knapweed)	Iran	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.00%	10.1002/ffj.1568
<i>Aethionema sancakense</i>	Turkey	Hydrodistillation using a Clevenger-type apparatus	GC-MS	19.8%	10.3390/molecules27186129
<i>Aframomum corrorima</i>	Ethiopia	Steam distillation	GC-MS	0.1% (Seeds) 1.1% (Husks)	10.1002/ffj.1634
<i>Aframomum exscapum</i> (Sims) hepper	Guadelope	Hydrodistillation using a Clevenger-type apparatus for 10 h	GC-MS	0.1% (Fruit pulp), 0.4% (Stems), nil (Leaves), nil (Seeds)	10.1002/ffj.1741
<i>Aframomum giganteum</i>	Gabon	Hydrodistillation	GC-MS	0.2% (Leaves) 0.6% (Rhizomes)	10.1002/ffj.1403
<i>Aframomum melegueta</i>	France	Commercial (hexane:ethyl acetate extract), supercritical fluid extraction product (Carbon dioxide extract)	GC-MS	10.5% [Commercial], 7.2% [supercritical fluid extraction product]	10.1002/ffj.1554
<i>Aframomum melegueta</i> (Roscoe) K. Schum. (alligator pepper)	Nigeria	Hydrodistillation for 3h	Fractionation	60.90%	10.1002/%28SICI%291099-1026%28199903/04%2914:2%3C109::AID-FFJ775%3E3.0.CO;2-M
<i>Ageratum fastigiatum</i>	Brazil	Hydrodistillation according to Method I of the Brazilian Pharmacopeia, 5th Edition (2010) for 4 h	GC-MS	3.52%	10.1016/j.bjpp.2015.03.002
<i>Alpinia zerumbet</i>	Japan	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.0 g/L (leaves)	10.1002/ffj.2047
	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.29%	10.1590/1983-084X/15_054

<i>Anemia tomentosavar.anthriscifolia</i>	Argentina	Hydrodistillation in a Clevenger-type apparatus	GC-MS	0.20%	10.1002/ffj.1341 Juliani
<i>Annona leptopetala</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	1.32%	10.1016/j.bjp.2018.06.009
<i>Anthemis triumfetti</i> (Asteraceae)	NR	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.60%	10.1002/ffj.1592
<i>Artabotrys jollyanus</i>	Cote d'Ivoire	Hydrodistillation in a Clevenger type apparatus	GC-MS	3.00%	10.1016/j.bjp.2017.04.001 Goore
<i>Artemisia scoparia</i> Waldst. & Kit	India	Hydrodistillation according to the method recommended by the British Pharmacopoeia, 1988.	GC-MS	0.30%	10.1002/ffj.1278
<i>Artemisia scoparia</i> Waldst. et Kit	Turkey	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	0.70%	10.1002/ffj.1426
<i>Artemisia spicigera</i> C. Koch	Turkey	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	nil	10.1002/ffj.1426
<i>Atlantia Sessiflorawere</i>	Vietnam	Hydrodistillation using a Clevenger apparatus for 3.5 hours	GC-MS	8.02+0.05%	10.3855/JIDC.12469
<i>Baccharis trimera</i> Less	Brazil	Commercial	GC-FID	3.10%	10.4314/tjpr.v14i11.19
<i>Baeckea frutescens</i>	Vietnam	Hydrodistillation using a Clevenger-type apparatus	GC-MS	5.80%	10.1016/j.jchromb.2006.11.042
<i>Baeckea frutescens</i> L	Malaysia	Hydrodistillation for 8 hours. Separated and dried over anhydrous magnesium sulphate	GC-MS	10.6% (Coastal sample)	10.1002/%28SICI%291099-1026%281998070%2913:4%3C245::AID-FFJ736%3E3.0.CO;2-J
<i>Blumea lacera</i>	Vietnam	Hydrodistillation using a Clevenger-type apparatus	GC-MS	3.7% (Flower), 3.5% (Leaf), 1.5% (Stem)	10.3390/molecules27227961
<i>Blumea sinuata</i>	Vietnam	Hydrodistillation using a Clevenger-type apparatus	GC-MS	4.3%	10.3390/molecules27227961
<i>Boesenbergia stenophylla</i> R. M. Sm	Malaysia	Hydrodistillation using a Clevenger-type apparatus for 8 h	GC-MS	5.3% (Leaf), 2.8% (Rhizome)	10.1002/ffj.1227
<i>Bubonium graveolens</i>	Algeria	Hydrodistillation using a Clevenger-type apparatus for 6 h	GC-MS	2.1% (Leaves), 1.9% (Flower)	10.1002/ffj.1794
<i>Buddleja tucumanensis</i>	Bolivia	Hydrodistillation with a Clevenger-type apparatus	GC-MS	1.10%	10.1002/ffj.1526 Lorenzo
<i>Bupleurum gibraltarium</i>	Spain	Hydrodistillation using a Clevenger-type apparatus for 8 h	GC-MS	0.40%	10.1021/jf040219n
<i>C. japonicus</i> (an insect, collected from the twigs of <i>Podocarpus nagi</i>)	Japan	Macerated in 10ml of pentane	GC-MS	35.80%	https://dx.doi.org/10.1080/09168451.2020.1763156
<i>C. obtusa</i> var. <i>formosana</i>	Taiwan	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	0.30%	10.1002/ffj.1685

<i>Calamintha sylvatica</i> Bromf. Subs. <i>Sylvatica</i>	Serbia	Hydrodistillation for 3 h using a Clevenger-type apparatus	GC-MS	0.2% (Pre-blossom) 0.6% (Full blossom) 0.8% (Post-blossom)	10.1002/ffj.995
<i>Calendula officinalis</i> L.	Bosnia	Hydrodistillation	GC-MS, GC-FID	1.9% (Leaves) 1.3% (Flowers)	10.1002/ffj.3661
<i>Callicarpa americana</i>	Mississippi	Hydrodistillation using a Clevenger-type apparatus	GC-MS	10.00%	10.1016/ j.jchromb.2006.11.045
<i>Callitris intratropica</i>	Nigeria	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.40%	10.1002/ffj.1214
<i>Calocedrus formosana</i>	Taiwan	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	0.40%	10.1002/ffj.1685
<i>Calycorectes australis</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	1%	10.1002/ffj.1640
<i>Calycorectes psidiiflorus</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	1%	10.1002/ffj.1640
<i>Cannabis Sativa</i> L	Argentina (Cepas Argentinas Terapéuticas)	Headspace extraction with NaCl at 90oC.	GC-FID	0.0059-0.0071 mg/g	https://doi.org/10.1016/j.chroma.2022.463669
	France	Commercial	GC-MS	8.71%	10.1002/ffj.993
	Poland (Henola variety; fiber type)	Ethanol extract filtered through a Millipore filter	GC-FID	0.206-0.534 mg/g (fast GC-FID); 0.138-0.531 mg/g (conventional GC-FID)	10.1002/jssc.201900822
	United states (Culver cultivar)	Steam distillation	GC-MS	7.365% (30 mins distillation of dioecious, densely seeded system); 7.336% (240 mins of distillation of dioecious, densely seeded system); 2.59% (30 mins distillation of open, all-female, clonal transplant system); 4.23% (240 mins of distillation of open, all-female, clonal transplant system)	https://doi.org/10.1021/acs.jafc.1c06912?urlappend=%3Fref%3DPDF&jav=VoR&rel=cite-as
	United states	Non-stop steam distillation	GC-MS	9.1% (chopped autoflower type hemp t&H)	https://dx.doi.org/10.1038/s41598-021-99335-4
<i>Capparis spinosa</i> var. <i>aegyptia</i> (Lam.) Boiss	Egypt	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	4.24%	10.1016/ j.bjp.2016.04.001
<i>Carum copticum</i>	Iran	Extracted with equal volumes redistilled dichloromethane	GC-MS	2.01%	10.1002/ffj.1129 Lockwood
<i>Cedrela fissilis</i>	Brazil	Hydrodistillation in a Clevenger-type apparatus for 4 h	GC-MS	4.9% (Leaf) 1.2% (Stem bark)	10.1002/ffj.1347

<i>Cedrelopsis grevei</i> H. Baillon	Madagascar	Commercial	GC-MS	0.8-5.4%	10.1002/ffj.1263
<i>Centaurea calcitrapa</i> L. (C.c.)	Italy	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.40%	10.1002/ffj.1585
	Poland	Solid phase microextraction	GC-MS	9.77%	10.3390/molecules27041371
<i>Centaurea huber-morathii</i> Wagenitz	Turkey	Plant material was placed in a Eppendorf Microdistiller sample vial together with water. n-Hexane (0.3 ml) was added to the collecting vial to trap volatile compounds.	GC-MS	0.30%	10.1002/ffj.1620
<i>Centaurea sphaerocephala</i> L. ssp. <i>sphaerocephala</i> (C.s.)	Italy	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.70%	10.1002/ffj.1585
<i>Centella asiatica</i> (L.) Urban (Family: Apiaceae)	South Africa	Leaf powder soaked in 1 L of methanol with continuous stirring for 72 h	GC-MS	1.25%	10.1016/j.biopha.2018.02.115
<i>Ceroplastes rubens</i> (an insect, collected from the twigs of <i>Podocarpus nagi</i>)	Japan	Macerated into 10ml of pentane	GC-MS	3.90%	https://dx.doi.org/10.1080/09168451.2020.1763156
<i>Chaerophyllum aksekiense</i>	Turkey	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	5.50%	10.1002/(SICI)1099-1026(200001/02)15:1<43::AID-FFJ864>3.0.CO;2-%23
<i>Chaetomium globosum</i>	N/A	Dried ethyl acetate extract of the liquid culture filtrate	GC-MS	1.60%	10.1016/j.biopha.2017.10.120
<i>Chamaecyparis formosensis</i>	Taiwan	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	2%	10.1002/ffj.1685
<i>Chamomilla recutita</i> L. Rausch	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS	NR	10.1002/ffj.1035
<i>Chloroxylon swietenia</i> DC.	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.46% (leaves)	10.1007/s00436-007-0485-z
<i>Cinnamomum camphora</i>	Mauritius	NR	GC-MS	1.00%	10.1002/cbdv.202000921
<i>Cinnamomum jensenianum</i>	China	Plant material soaked in distilled water, extracted with volatile oil extractor	GC-MS	0.26%	10.4314/tjpr.v17i9.23
<i>Cinnamomum rhyncophyllum</i> Miq.	Malaysia	Hydrodistillation using a Clevenger-type apparatus for 8 h	GC-MS	1.1% (Leaf), 0.1% (Bark), nil (Wood)	10.1002/ffj.1301
<i>Cinnamomum tamala</i> Nees et Eberm.	India	Hydrodistillation method recommended by the British Pharmacopoeia,	GC-MS	0.20%	10.1002/ffj.1236
<i>Cirsium japonicum</i> DC	Japan	Hydrodistillation in a Likens – Nickerson-type apparatus	GC-MS	0.60% (Rhizomes)	10.1002/ffj.1135
Citrus	France	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.1-0.2%	10.1002/ffj.1658
<i>Citrus aurantium</i> L.	West Indies	Raspings fresh bitter orange peels + cold pressing	GC-MS, GC-FID	0.01%	10.1002/ffj.2087
<i>Citrus limon</i> (L.)	Algeria	Hydrodistillation using a Clevenger-type apparatus for 3	GC-FID	0.04%	10.1002/ffj.1829

Citrus medical. Cv. Diamante	Italy	h Syringe aspiration	GC-MS, GC-FID	0.06% (Peel) 0.04% (Rind)	10.1002/ jssc.200800404
Clinopodium nepeta L	Turkey	Homogenised plant item was extracted with 250 ml extraction solvent (methanol) for 24 hours	GC-MS	0.10%	10.1002/ffj.3636
Clusia lanceolata	Brazil	Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS	8.42% (galled leaves), 8.941% (non-galled leaves)	10.1016/ j.bjp.2014.11.005
Conium maculatum L.	Iran	Hydrodistillation using a Clevenger-type apparatus for 3 h.	GC-MS	1.40%	10.1002/ffj.1722
Conyza sumatrensis	Côte d'Ivoire	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	1-1.4% (leaves), 1.9-2.4% (flower), 0.2% (roots)	10.1002/ffj.1743
Copaifera duckei oleoresin	Brazil	Commercial	GC-MS, GC-FID	2%	10.1016/ j.bjp.2018.09.004
Copaifera langsdorffii Desf., Fabaceae,	Brazil	Macerated for 72 h with 70% aqueous ethanol. Filtered and concentrated under reduced pressure	GC-MS	Major component	10.1016/ j.bjp.2015.05.005
Copaifera multijuga	Brazil	Distilled 4 h in distillation column and a serpentine condenser	GC-MS	10.20%	https://dx.doi.org/10.1590/S0102-695X2013005000038
Cordia verbenacea	Turkey	Steam distillation for 1.5 to 2 h	GC-MS, GC-FID	1.23%	10.1016/ j.biopha.2019.108693
	Brazil	NR	HPLC	2.90%	10.1016/ j.bjp.2019.01.009
	Brazil	Supercritical fluid extraction; Soxhlet extraction for 6h	GC-MS	2.10% (SFE) 1.10% (Soxhlet)	10.1016/ j.biortech.2009.07.061
Croton ericoides	Rio, Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.10%	10.1007/s00436-012-2918-6
Croton isabelli	Rio, Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.30%	10.1007/s00436-012-2918-6
Croton pallidulus	Rio, Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.20%	10.1007/s00436-012-2918-6
Croton sellowii Baill (shrub)	NR	Maceration with acetone. Solvent removed under vacuum	GC-MS, GC-FID	0.8% (leaves)	10.1002/ffj.1298
Croton zambesicus	Benin	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS, GC-FID	1.60%	10.1002/ffj.1558
	Cameroon	Hydrodistillation using a Clevenger-type apparatus for 12 h	GC-MS	2.2% (Leaves), 2% (Rootbark), 2.3% (Stembark)	10.1002/ffj.1081
Cunninghamia lanceolata var. konishii	Taiwan	Hydrodistillation using a Clevenger-	GC-MS, GC-FID	0.50%	10.1002/ffj.1685

Cupressus sempervirens ssp. Pyramidalis L.	NR	type apparatus Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.4% (Leaves) Trace (Cones)	10.1111/j.1365-2184.2008.00561.x
Cupriavidus necator	Germany	20% n-dodecane	GC-MS	2-10mg/L	https://doi.org/10.3390%2Fmolecules27248684
Curcuma angustifolia	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.30%	10.1002/ffj.1680
Curcuma longa L	India	Hydrodistillation using a Clevenger-type apparatus for 4.5 h	GC-MS	0.1 - 0.3%	10.1002/ffj.1780
Cyperus fuscus L	Turkey	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	0.60%	10.4314/tjpr.v17i8.24
Daucus carota L	Israel	Solid-phase microextraction device extraction	GC-MS	124.47 ng/g	https://dx.doi.org/10.1021/acs.jafc.5b00546
	Denmark	Dynamic headspace sampling with nitrogen	GC-MS	Cultivars (Brasilia -1200 , Duke -740 , Fancy- 1610, and Cortez - 2540) ng/50g	10.1021/jf010213n
	Denmark	Dynamic headspace sampling	GC-MS	294ng/g (Refrigerated (1 °C)) 64ng/g (Frozen (-24°C))	10.1021/jf030212q
Daucus reboudii Coss.	Algeria	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	0.10%	10.1002/ffj.1636
Dianthus caryophyllus	Greece	Steam distillation for 4 h in a modified Clevenger distillation apparatus	GC-MS	1.90%	10.1007/s00436-012-3097-1
Dipteryx alata Vogel, Fabaceae	Brazil	Manual hydraulic pressing and mechanical continuous pressing	GC-MS	0.08% (Hydraulic pressing) Nil (Continuous screw pressing)	10.1016/j.bjp.2015.07.019
Dorema ammoniacum	NR	Steam-distillation method via Clevenger apparatus	GC-MS	4.25%	https://doi.org/10.1155%2F2022%2F9725244
Dorema aucheri Boiss., Seseli	Iran	Hydrodistillation using a Clevenger-type apparatus for 3 h.	GC-MS	0.20%	10.1002/ffj.1722
Doronicum corsicum	France	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.40%	10.1002/ffj.1824
Dryobalanops aromatica	Malaysia	Fractional distillation in the presence of double distilled water for 2 h.	GC-MS	16.31%	10.4314/tjpr.v15i6.23
Echinacea Angustifolia	Iran	Hydrodistillation for 3 h, using a Clevenger-type apparatus.	GC-MS	2.80%	10.1002/ffj.1657
Echinacea Pallida	Iran	Hydrodistillation for 3 h, using a Clevenger-type apparatus.	GC-MS	1.50%	10.1002/ffj.1657

<i>Echinacea Purpurea</i>	Iran	Hydrodistillation for 3 h, using a Clevenger-type apparatus.	GC-MS	1.50%	10.1002/ffj.1657
<i>Elettariopsis elan</i> C.K. Lim	Malaysia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.1% (leaves), 0.2% (rhizomes), 0.2% roots	10.1002/ffj.1654
<i>Emilia sonchifolia</i>	Vietnam	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.8%	10.3390/ molecules27227961
<i>Eriocephalus africanus</i> L.var. <i>Africanus</i>	Spain	Hydrodistillation for 3 h in a Clevenger-type apparatus	GC-MS	0.09±0.09% (Burjassot) 0.03±0.04% (Sagunto) 0.03±0.02% (Valencia)	10.1002/ffj.1821
<i>Eryngium yuccifolium</i> Michaux	Germany	Hydrodistillation using n-pentane as a solvent for 6 h	GC-MS	0.60%	10.1002/ffj.1631
<i>Erythrina corallodendron</i> L.	China	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.57%	10.1097/ MD.0000000000017009
<i>Eucalyptus</i> (E.) <i>dunnii</i>	Brazil	Headspace solid-phase microextraction	CG- ion-trap MS	NR (predicted 1-10%)	10.1021/jf026047g
<i>Eucalyptus Citriodora</i>	Brazil	Headspace solid-phase microextraction	CG- ion-trap MS	nil	10.1021/jf026047g
	India	Hydrodistillation for 3 h using a Clevenger-type apparatus	GC-MS	0.6g/100g	10.1002/ffj.3296
<i>Eucalyptus saligna</i>	Brazil	Headspace solid-phase microextraction	CG- ion-trap MS	nil	10.1021/jf026047g
<i>Eugenia caryophyllata</i>	South Korea	NR	GC-MS, GC-FID	0.8% (bud oil) 3.4% (leaf oil)	10.1021/jf034225f
	China	Solvent free microwave extraction and hydrodistillation	GC-MS	3.09% (Hydrodistillation) 5.06% (Solvent free microwave extraction)	10.1002/ jssc.201000148
<i>Eugenia caryophyllus</i>	Germany	NR	GC-MS	2.10%	10.1021/jf060608c
<i>Euphorbia convolvuloides</i>	Ivory coast	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	1.7% (aerial plant parts)	https://dx.doi.org/10.1002/ffj.3624
<i>Euphorbia acanthothamnos</i>	Greece	Dichloromethane extract	GC-MS	nil	10.1002/ffj.1148
<i>Euphorbia apios</i>	Greece	Dichloromethane extract	GC-MS	0.60%	10.1002/ffj.1148
<i>Euphorbia characias</i>	Greece	Dichloromethane extract	GC-MS	nil	10.1002/ffj.1148
<i>Euphorbia dendroides</i>	Greece	Dichloromethane extract	GC-MS	1.10%	10.1002/ffj.1148
<i>Euphorbia helioscopia</i>	Greece	Dichloromethane extract	GC-MS	0.40%	10.1002/ffj.1148
<i>Euphorbia heterophylla</i>	Ivory coast	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	1.5% (aerial plant parts)	https://dx.doi.org/10.1002/ffj.3624
<i>Euphorbia hirta</i>	Ivory coast	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	1.4% (aerial plant parts)	https://dx.doi.org/10.1002/ffj.3624

<i>Euphorbia rigida</i>	Greece	Dichloromethane extract	GC-MS	0.70%	10.1002/ffj.1148
<i>Ferulago campestris</i> (Apiaceae)	Italy	Hydrodistillation in a Clevenger-type apparatus for 4 h	GC-MS GC-FID	1.6 ±0.14% (Flowers) 5.1 ±0.52% (Leaves)	10.1002/ffj.1941
<i>Ferulago campestris</i> (Besser) Grecescu	Italy	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS, GC-FID	0.6-0.7%	10.1002/ffj.2010
<i>Foeniculum vulgare</i> Mill (Fennel)	China	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.07%	https://dx.doi.org/10.1016/j.jchromb.2017.07.053
<i>Galeopsis pubescens</i>	Italy	Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS, GC-FID	0.80%	10.1002/ffj.1307
<i>Galeopsis tetrahit</i>	Italy	Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS, GC-FID	0.30%	10.1002/ffj.1307
<i>Garcinia atroviridis</i> Griff. Ex T. Anders (Clusiaceae)	Malaysia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	10.70%	10.1016/j.jchromb.2006.11.043
<i>Garcinia huillensis</i> Welw. ex. Oliv.	Zimbabwe	Hydrodistillation using a Clevenger-type apparatus for 1.5 h	GC-MS	10.1-23%	10.1002/ffj.1420
<i>Geniosporum rotundifolium</i> Briq	Tanzania	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.53%	10.4314/tjpr.v15i1.15
<i>Gnaphlium affine</i>	China	Hydrodistillation using a Clevenger-type apparatus	GC-MS	3.22%	https://dx.doi.org/10.1016/j.fct.2011.03.014
<i>Grammosciadium macrodon</i> Boiss	Turkey	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1%	10.4314/tjpr.v15i2.26
<i>Grammosciadium platycarpum</i>	Turkey	Hydrodistillation using a Clevenger-type apparatus	GC-MS	Nil	10.4314/tjpr.v15i2.26
<i>Guatteria juruensis</i>	Brazil	Hydrodistillation for 4 h, using a Clevenger-type apparatus	GC-MS	Nil	10.1002/ffj.1500
<i>Guatteria Microcalyx</i> ,	Brazil	Hydrodistillation for 4 h, using a Clevenger-type apparatus	GC-MS	0.10%	10.1002/ffj.1500
<i>Guatteria Poeppigiana</i>	Brazil	Hydrodistillation for 4 h, using a Clevenger-type apparatus	GC-MS	Trace	10.1002/ffj.1500
<i>Gundelia. tournefortii</i> (EOGT)	Zarka, Jordan	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	2.10%	10.4314/tjpr.v15i10.17
<i>Gynura bicolor</i> DC (Asteraceae - plants and shoots)	Japan	solvent-assisted flavour evaporation (SAFE) of solvent extracts	GC-MS	9.6% (plants), 11.6% (regenerates), 5.6% (cultured shoots)	10.1002/ffj.1938
<i>Gynura bicolor</i> DC (Asteraceae)- roots	Japan	Roots immersed in freshly distilled diethyl ether	GC-MS	8.1% (Field grown roots), 12.3% (cultured)	10.1002/ffj.2016
<i>Haumaniastrum villosum</i> (Bene) AJ Paton (Lamiaceae)	Tanzania	Hydrodistillation using a Clevenger-type apparatus	GC-MS	5.63%	10.4314/tjpr.v15i1.15
<i>Hedyosmum angustifolium</i>	Bolivia	A Clevenger-type glass hydrodistillation apparatus	GC-MS	0.20%	10.1002/ffj.1146
<i>Helichrysum faradifani</i> Sc. Ell.	Madagascar	Commercial	GC-MS	1.40%	10.1002/ffj.1531
<i>Helichrysum kraussii</i> Sch. Bip	South Africa	Steam distillation	GC-MS	9.80%	10.1002/ffj.1152

		using a Clevenger-type apparatus for 3 h			
<i>Helichrysum rugulosum</i> Less	South Africa	Steam distillation using a Clevenger-type apparatus for 3 h	GC-MS	Nil	10.1002/ffj.1152
<i>Heterothalamus alienus</i> (Spreng.) Kuntze	Argentina	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	1.6-2.1%	10.1002/ffj.1747
<i>Hexachlamys edulis</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	8.00%	10.1002/ffj.1385
<i>Hexachlamys hamiltonii</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	2.50%	10.1002/ffj.1385
<i>Hexachlamys humilis</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	2.70%	10.1002/ffj.1385
<i>Hexachlamys itatiaiensis</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	5.80%	10.1002/ffj.1385
<i>Homalomena sagittifolia</i> Jungh.	Malaysia	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	3.9% (leaves), 0.2% (rhizomes)	10.1002/ffj.1714
<i>Hortia oreadica</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.59%	10.1016/j.bjp.2015.08.008
<i>Hoslundia opposita</i> Vahl	Zimbabwe	Hydrodistillation using a Clevenger-type apparatus for 1.5 - 2 h	GC-MS	0.2-7.6%	10.1002/ffj.1402
	Ivory coast	Hydrodistillation using a Clevenger-type apparatus	GC-MS	5.70%	10.1002/ffj.1715
<i>Humulus lupulus</i> L.	Brazil (Chinook variety)	Hydrodistillation using a Clevenger-type apparatus	GC-MS	31.50% (90 mins distillation); 32.63% (180 mins distillation); 34.62% (300 mins distillation)	https://doi.org/10.1007/s00284-023-03359-0
	Germany	Supercritical fluid carbon dioxide extraction	GC-MS	6.72%	10.1021/jf402496t
	Japan	Stir bar-sorptive extraction (SBSE) method	GC-MS	0.73%	10.1021/jf050072f
	Poland (Marynka and Magnum varieties)	Headspace extraction at 40oC for 20 mins	GC-MS	0.0032-0.0169mg/L	https://doi.org/10.3390%2Fmolecules27227910
	Portugal	Headspace solid-phase microextraction	GC-MS	16.6 ± 0.8%	10.1002/jssc.201200244
<i>Hymenocrater incanus</i> Bunge	Iran	Hydrodistillation using a Clevenger-type apparatus for 3.5 h,	GC-MS	0.60%	10.1002/ffj.983
<i>Hypericum brasiliense</i>	Brazil	Hydrodistillation for 3 h	GC-MS	12.74%	10.1002/ffj.1319
<i>Hypericum olympicum</i> L	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	1.50%	10.1002/ffj.1521
<i>Hypericum perforatum</i> L.	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	Trace	10.1002/ffj.1521
<i>Hypericum tetrapterum</i> Fries	Greece	Hydrodistillation using a Clevenger-	GC-MS, GC-FID	Trace	10.1002/ffj.1521

<i>Hyptis carpinifolia</i> .	Brazil	type apparatus Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS	0.2-0.9%	10.1016/j.bjp.2016.05.011
<i>Hyptis pectinata</i>	Brazil	Hydrodistillation for 140 mins in Clevenger style apparatus	GC-MS	Room temperature storage 2.79% to 2.21% at 1 year. Freezer 2.79% to 2.43% at 1 year.	10.1590/1983-084X/15_177
<i>Hyptis suaveolens</i> (Lamiaceae)	Italy	Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS	0.90%	10.1007/s00436-011-2730-8
<i>Illicium verum</i>	Greece	Steam distillation for 4 h in a modified Clevenger distillation apparatus	GC-MS	Nil	10.1007/s00436-012-3097-1
<i>Inula graveolens</i>	France	Commercial	GC-MS	0.20%	10.1002/ffj.1304
<i>Isolona campanulata</i> Engler & Diels	Côte-d'Ivoire	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS, GC-FID	10.40%	10.1002/ffj.1555
<i>Isolona dewevrei</i>	Cote d'Ivoire	Hydrodistillation for 3h clevenger type apparatus	GC-MS	1.20%	https://dx.doi.org/10.1002/ffj.3612 Kambire
<i>J. drupacea</i> Labill.	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.80%	10.1007/s00436-011-2706-8
<i>J. foetidissima</i> Willd.	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	Nil	10.1007/s00436-011-2706-8
<i>J. oxycedrus</i> L. ssp. <i>macrocarpa</i>	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	Nil	10.1007/s00436-011-2706-8
<i>J. oxycedrus</i> L. ssp. <i>oxycedrus</i>	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.44%	10.1007/s00436-011-2706-8
<i>J. phoenicea</i> L	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.01%	10.1007/s00436-011-2706-8
<i>Juglans regia</i> L	Czech Republic	Solvent extraction with a shaker	GC-MS	≈ 9%	10.1002/jssc.200700371
	Algeria	Microwave-assisted hydrodistillation for 1 h, Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS, GC-FID	15.64% (Microwave-assisted hydrodistillation for 1 h), 8.08% (Hydrodistillation using a Clevenger-type apparatus for 3 h)	10.1002/hlca.201200359
<i>Juniperus communis</i>	Croatia and Bosnia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.40% (Fruit)	https://dx.doi.org/10.1002/ffj.3602
<i>Juniperus communis</i> var. <i>saxatilis</i>	Belgrade	Hydrodistillation using a Clevenger-type apparatus	GC-MS	3.08%	10.1016/j.fct.2017.12.044

<i>Juniperus communis</i> l. Ssp. Nana	Italy	Supercritical CO ₂ extractions and hydrodistillation: performed in a circulatory Clevenger-type apparatus for 5 h	GC-MS	Leaves: 0.8-2.7%; Berries: 1.5-2.0%; Wood: 2.8-4.9%	10.1002/ffj.1549
<i>Juniperus deltoides</i>	Croatia and Bosnia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.90% (Leaf)	https://dx.doi.org/10.1002/ffj.3602
<i>Juniperus drupacea</i>	Greece	Steam distillation using a Clevenger apparatus for 3 h	GC-MS	0.99%	10.1007/s00436-016-4959-8
<i>Juniperus macrocarpa</i>	Croatia and Bosnia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.30% (Leaf)	https://dx.doi.org/10.1002/ffj.3602
<i>Juniperus oxycedrus</i> ,	Croatia and Bosnia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.3% (Leaf)	https://dx.doi.org/10.1002/ffj.3602
<i>Juniperus oxycedrus</i> ssp. <i>oxycedrus</i>	France	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	0.8-1.2% (Berry oil), 0.2% (Leaf oil)	10.1002/ffj.1579
<i>Juniperus phoenicea</i>	Greece	Steam distillation using a Clevenger apparatus for 3 h	GC-MS	1.15%	10.1007/s00436-016-4959-9
<i>Juniperus- J. communis</i> L. ssp. <i>hemisphaerica</i>	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.44%	10.1007/s00436-011-2706-8
<i>Kielmeyera rugosa</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	3 - 5%	10.1002/ffj.1751
<i>Lantana camara</i> L.	Congo	Hydrodistillation using a Clevenger-type apparatus	GC-MS	10.6% (leaves)	10.1002/ffj.1553
	Nigeria	Hydrodistillation using a Clevenger-type apparatus	GC-MS	19.5% (leaves)	10.1002/ffj.1206
	India	Hydrodistillation in a conventional Clevenger-type apparatus for 4 h.	GC-MS	2.4% (Fruit); 0.7% (stem); 2.7% (leaves); 2.7% (flowers)	10.1002/ffj.1197
	Iran	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	6-10.8%	10.1002/ffj.1048
	NR	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	5.2% (Pink flowers) 2.6% (yellow flowers)	10.1002/ffj.1239
	Brazil	Hydrodistillation using n-pentane and a Chrompak distillation apparatus	GC-MS	1.2-10.7% (leaves and thin branches), 9.5% (flowers)	10.1002/(SICI)1099-1026(199907/08)14:4<208::AID-FFJ811>3.0.CO;2-F
	South China	Hydrodistillation using a Clevenger-type apparatus	GC-MS	9.31%	10.1002/ffj.1292
	Vietnam	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.3-6.9%	https://doi.org/10.1002/cbdv.202100145
<i>Lantana salvifolia</i> Jacq. (Verbenaceae)	Congo	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.5% (leaves)	10.1002/ffj.1553
<i>Lavandula angustifolia</i>	Italy	Commercial	GC-MS, GC-FID	0.41%	10.1080/1369378040004810

Lavandula angustifolia x hybrida cultivars	Italy	Hydrodistillation with a Clevenger apparatus for 2h	GC-MS	0.06% (L. Angustifolia) Hybrida cultivars: 0.25% (Ordinario) Nil (Alardii) 0.11% (Abrialis) 0.13% (R.C) 0.07% (Super Z)	10.1002/ffj.3145
Lepechinia conferta	Venezuela	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.70%	10.1002/ffj.1550
Lepidium sativum	Greece	Steam distillation for 4 h in a modified Clevenger distillation apparatus	GC-MS	Nil	10.1007/s00436-012-3097-1
Leptospermum amboinense	Australia	Hydrodistillation with cohobation	GC-MS	0.4 - 0.9%	10.1002/1099-1026(200009/10)15:5<342::AID-FFJ924>3.0.CO;2-V
Leptospermum brachyandrum (F. Muell.) Druce	Australia	Steam distillation with cohobation	GC-MS	9-18%	10.1002/(SICI)1099-1026(199801/02)13:1<19::AID-FFJ679>3.0.CO;2-9
Leptospermum emarginatum	Australia	Hydrodistillation with cohobation	GC-MS	0.10%	10.1002/1099-1026(200009/10)15:5<342::AID-FFJ924>3.0.CO;2-V
Leptospermum grandiflorum	Australia	Hydrodistillation with cohobation	GC-MS	0.6 - 0.8%	10.1002/1099-1026(200009/10)15:5<342::AID-FFJ924>3.0.CO;2-V
Leptospermum liversidgei	Australia	Hydrodistillation with cohobation	GC-MS	0.40%	10.1002/1099-1026(200009/10)15:5<342::AID-FFJ924>3.0.CO;2-V
Leptospermum luehmannii F. M. Bailey	Australia	Steam distillation with cohobation	GC-MS	3-5%	10.1002/(SICI)1099-1026(199801/02)13:1<19::AID-FFJ679>3.0.CO;2-9
Leptospermum madidum A. R. Bean subsp. madidum	Australia	Steam distillation with cohobation	GC-MS	4-11%	10.1002/(SICI)1099-1026(199801/02)13:1<19::AID-FFJ679>3.0.CO;2-9
Leptospermum madidum ssp. sativum	Australia	Hydrodistillation with incubation	GC-MS	2.30%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
Leptospermum morrisonii	Australia	Hydrodistillation with incubation	GC-MS	0.60%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
Leptospermum oreophilum	Australia	Hydrodistillation with incubation	GC-MS	1 - 2%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
Leptospermum pallidum A. R. Bean	Australia	Steam distillation with cohobation	GC-MS	0.30%	10.1002/(SICI)1099-1026(199801/02)13:1<19::AID-FFJ679>3.0.CO;2-9
Leptospermum petersonii	Australia	Hydrodistillation with cohobation	GC-MS	0.40%	10.1002/1099-1026(200009/10)15:5<342::AID-FFJ924>3.0.CO;2-V
Leptospermum polygalifolium ssp. 'wallum'	Australia	Hydrodistillation with incubation	GC-MS	7-11%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
Leptospermum polygalifolium ssp. howese	Australia	Hydrodistillation with incubation	GC-MS	0.20%	10.1002/1099-1026(200007/08)15:4<

					271::AID- FFJ910>3.0.CO;2-E
<i>Leptospermum polygalifolium</i> ssp. <i>montanum</i>	Australia	Hydrodistillation with incubation	GC-MS	1.00%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
<i>Leptospermum polygalifolium</i> ssp. <i>polygalifolium</i>	Australia	Hydrodistillation with incubation	GC-MS	0.10%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
<i>Leptospermum polygalifolium</i> ssp. <i>Transmontanum</i>	Australia	Hydrodistillation with incubation	GC-MS	1.20%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
<i>Leptospermum polygalifolium</i> ssp. <i>tropicum</i>	Australia	Hydrodistillation with incubation	GC-MS	nil	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
<i>Leptospermum polygalifolium</i> ssp. <i>cismontanum</i>	Australia	Hydrodistillation with incubation	GC-MS	0.8-9%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
<i>Leptospermum purpurascens</i> Joy Thomps	Australia	Steam distillation with cohobation	GC-MS	0.30%	10.1002/(SICI)1099-1026(199801/02)13:1<19::AID-FFJ679>3.0.CO;2-9
<i>Leptospermum rotundifolium</i>	Australia	Hydrodistillation with cohobation	GC-MS	0.20%	10.1002/1099-1026(200009/10)15:5<342::AID-FFJ924>3.0.CO;2-V
<i>Leptospermum</i> sp. (Mt Maroon A.R. Bean 6665)	Australia	Hydrodistillation with incubation	GC-MS	44-51%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
<i>Leptospermum speciosum</i> Schauer	Australia	Steam distillation with cohobation	GC-MS	0.10%	10.1002/(SICI)1099-1026(199801/02)13:1<19::AID-FFJ679>3.0.CO;2-9
<i>Leptospermum variabile</i>	Australia	Hydrodistillation with incubation	GC-MS	11-22%	10.1002/1099-1026(200007/08)15:4<271::AID-FFJ910>3.0.CO;2-E
<i>Leptospermum whitei</i> Cheel	Australia	Steam distillation with cohobation	GC-MS	0.50%	10.1002/(SICI)1099-1026(199801/02)13:1<19::AID-FFJ679>3.0.CO;2-9
<i>Leptospermum wooroonooran</i>	Australia	Hydrodistillation with cohobation	GC-MS	11 - 20%	10.1002/1099-1026(200009/10)15:5<342::AID-FFJ924>3.0.CO;2-V
<i>Libanotis</i> W. D. Koch var. <i>Armeniacum</i> Bordz.	Iran	Hydrodistillation using a Clevenger-type apparatus for 3 h.	GC-MS	Nil	10.1002/ffj.1722
<i>Licuala Grandis</i>	Thailand	Dynamic headspace extraction	GC-MS	1.60%	10.1002/ffj.1797
<i>Licuala lauterbachii</i>	Thailand	Dynamic headspace extraction	GC-MS	Nil	10.1002/ffj.1797
<i>Licuala Mattanensis</i> ,	Thailand	Dynamic headspace extraction	GC-MS	0.10%	10.1002/ffj.1797
<i>Licuala spinosa</i>	Thailand	Dynamic headspace extraction	GC-MS	Nil	10.1002/ffj.1797
<i>Lippia adoensis</i>	Nigeria	Hydrodistillation for 4 h	GC-MS	0.60%	10.1002/ffj.1234
<i>Lippia alba</i>	Guatemala	Hydrodistillation using a Clevenger-type apparatus for 1.5 h	GC-MS	1.10%	10.1002/ffj.1309

<i>Lippia alba</i> (Mill.) N.E. Brown (Verbenaceae)	Colombia	Microwave-assisted hydrodistillation method	Chromatog GC-MS	Nil	10.1590/S1415-47572011005000030
<i>Lippia gracilis</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 140 mins	GC-MS	0.47% (LGRA-106), 1% (LGRA-108), 0.38% (LGRA-109), 0.49% (LGRA-201)	10.1016/j.vetpar.2012.12.046
<i>Lippia Graveolens</i>	NR	Water distillation in a Clevenger-type apparatus	GC-MS	1.60%	10.1007/s00436-010-1800-7
<i>Lippia integrifolia</i>	Argentina	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	1.3-4.5%	10.1002/ffj.1736
<i>Lippia javanica</i> (Burm. f.)	Tanzania	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.40%	https://dx.doi.org/10.1002/ffj.3625
<i>Liquidambar orientalis</i> Mill.	Turkey	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	0%	10.1002/ffj.1370
<i>Liquidambar Styraciflua</i> ,	Honduras	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	1.10%	10.1002/ffj.1370
<i>Mandarina Bavaria hops</i>	Germany	Headspace-solidphase microextraction	GC-MS	25 ± 9%	10.1021/acs.jafc.9b06139 Machado
<i>Mangifera indica</i> (mango fruit)	Colombia	Simultaneous Distillation-extraction	GC-MS	0.90%	10.1002/ffj.1812
<i>Pinus pinaster</i> Ait	France	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.20%	10.1002/ffj.1865
Marsh white grapefruit	Florida	Fruit extract dissolved in 0.1 ml of methylene chloride.	Capillary gas chromatography	0.03%	10.1021/jf981064k
<i>Melaleuca alternifolia</i>	Italy	Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS	Nil	10.1007/s00436-013-3651-5
<i>Melaleuca quinquenervia</i> (Cav.) S. T. Blake	New Caledonia	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	0.21%	10.1002/ffj.1649
<i>Melodorum fruticosum</i> flowers	Thailand	modified Likens–Nickerson apparatus	GC-MS	0.18%	10.1016/j.fct.2010.07.002
<i>Mentha avensis</i> (corn mint)	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	<0.05%	10.1002/ffj.1417
<i>Mentha suaveolens</i> ssp. <i>insularis</i>	France	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.10%	10.1002/ffj.1863
<i>Mentha x piperita</i> L.	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS	Nil	10.1002/ffj.1333
<i>Meum athamanticum</i> (L.) Jacq.,	Germany	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.10%	10.1016/j.jchromb.2006.11.046
<i>Microglossa pyrifolia</i>	Côte d'Ivoire	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	27.1–36.4% (leaves), 1.4% (buds)	10.1002/ffj.1743
Miocene amber	India	Dichloromethane: methanol by ultrasonication for 20 mins	GC-MS	NR	10.1038/s41598-017-09385-w

<i>Monanthes diclina</i> (Sprague)	Congo (Zaire)	Steam distilled 3h	Filtered over anhydrous sodium sulphate	0.2% (Root) 6.9% (Fruit)	10.1002/%28SICI%291099-1026%28199703%2912:2%3C95::AID-FFJ611%3E3.0.CO;2-Z
<i>Mosla dianthera</i> Maxim	Vietnam	Steam distillation for 1h with distilled water	GC-MS	5.09%	https://pubmed.ncbi.nlm.nih.gov/10898640/Kim
<i>Mosla soochowensis</i>	China	Steam distillation	GC-MS	4.04%	10.4314/tjpr.v16i4.23
<i>Murraya exotica</i>	India	Hydro-distillation using the Clevenger X77 type of apparatus for 4 h	GC-MS	0.03%	https://dx.doi.org/10.1007/s00436-015-4370-x
<i>Murraya paniculata</i> (L.) Jack	Nigeria	Hydrodistillation using a Clevenger-type apparatus	GC-MS	5.10%	10.1002/ffj.1365
	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.80%	10.1002/ffj.1804
<i>Myrciaria tenella</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.3-5.3%	10.3390/molecules27072234
<i>Myriactis nepalensis</i> Less.	China	Hydrodistillation using a Clevenger-type apparatus for 3.5 h	GC-MS	3.2%	10.3390/molecules27144631
<i>Myrrhinium atropurpureum</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	1.42%	10.1111/and.13074
<i>Myrtus communis</i>	Tunisia	Steam distillation	GC-MS	0.25% (Flowering stage)	10.1002/ffj.1453
	Morocco	Continuous distillation	GC-MS	0.30%	10.1002/ffj.1651
<i>Nectandra Barbellata</i>	Brazil	Hydrodistillation in a Clevenger apparatus for 3h	Thin layer chromatography then GCMS	3.79%	10.1016/j.bjp.2017.11.008
<i>Nepeta crassifolia</i> Boiss	Iran	Hydrodistillation using a Clevenger-type apparatus for 6 h	GC-MS	nil	10.1002/ffj.1199
<i>Nepeta glomerulosa</i> Boiss. subsp. <i>carmanica</i>	Iran	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	3.20%	10.1002/(SICI)1099-1026(199909/10)14:5<265::AID-FFJ822>3.0.CO;2-A
<i>Nepeta italica</i> L	Turkey	Homogenized plant item was extracted with 250 ml extraction solvent (methanol) for 24 hours.	GC-MS	nil	10.1002/ffj.3636
<i>Nepeta macrosiphon</i> Boiss.	Iran	Steam-distilled for 5 h using a Clevenger-type apparatus .	GC-MS	0.60%	10.1002/ffj.1287
<i>Nigella arvensis</i> L	Czech Republic	Hydrodistillation in a Clevenger-type apparatus for 3 h	GC-MS	trace	10.1002/ffj.1713
<i>Ocimum basilicum</i>	Saudi	Hydrodistillation	GC-MS	0.93%	10.1007/s11011-017-

	Arabia	using a Clevenger-type apparatus for 4 h			0173-3
	West Lafayette, USA	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	11.50%	10.1002/ffj.1513
	Brazil	Steam distillation for 1 h	GC-MS	Nil	10.1002/ffj.1134
<i>Ocimum basilicum</i> L. (sweet basil)	Germany; Mesten	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.52% German 0.67% Mesten	https://doi.org/10.1021/jf0725629
<i>Ocimum basilicum</i> . var. <i>minimum</i>	Brazil	Steam distillation for 1 h	GC-MS	nil	10.1002/ffj.1134
<i>Ocimum basilicum</i> . var. <i>purpurascens</i> Benth	Brazil	Steam distillation for 1 h	GC-MS	1.60%	10.1002/ffj.1134
<i>Ocimum gratissimum</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.20%	10.1007/s00436-017-5662-0
<i>Ocimum sanctum</i>	Mississippi	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.99%	https://doi.org/10.1021/jf0725629
<i>Ocotea elegans</i>	Brazil	Hydrodistillation in a Clevenger apparatus for 3h	Thin layer chromatography then GCMS	Nil	10.1016/j.bjp.2017.11.008
<i>Ocotea Indecora</i>	Brazil	Hydrodistillation in a Clevenger apparatus for 3h	Thin layer chromatography then GCMS	Nil	10.1016/j.bjp.2017.11.008
<i>Oplopanax horridus</i>	Canada	Steam distillation	GC-MS	0.2% (Stem) 0.1% (Root)	10.1002/ffj.1716
<i>Origanum compactum</i>	Morocco	Hydrodistillation	GC-MS	0.22%	10.1016/j.mrgentox.2007.01.011
<i>Origanum ehrenbergii</i> Boiss	Lebanon	Cyclohexane, dichloromethane, ethyl acetate and methanol extracts	GC-MS	"low presence" (Cyclohexane extract), "low presence" (Dichloromethane extract), nil (Ethyl acetate extract), nil (Methanol extract)	10.1002/ffj.3646
<i>Origanum glandulosum</i> Desf	Algeria	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.30%	10.1002/ffj.1738
<i>Origanum majorana</i>	Iran	Leaves were placed in a sealed glass vial for 30 min at room temperature with a nanofiber sheet above it to collect volatiles. The nanofiber sheet was folded and inserted inside a 5 ml glass vial for solvent desorption using 2 ml of hexane for 10 min and the organic extract was concentrated by a gentle flow of nitrogen up to 0.5 ml.	GC-MS	0.17%	10.1002/jssc.201301355
	Lithuania	Hydrodistillation using a Clevenger-	GC-MS	0.2% (Hydrodistillation)	10.1002/ffj.1478

		type apparatus, Simultaneous distillation–solvent extraction		using a Clevenger-type apparatus) , 0.1% (Simultaneous distillation–solvent extraction)	
	Germany	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.20%	10.1002/ffj.1077
Origanum Virens		Water distillation in a Clevenger-type apparatus	GC-MS	0.10%	10.1007/s00436-010-1800-7
Origanum vulgare	USA	Commercial	GC-MS, GC-FID	0.51%	10.1016/j.biopha.2018.10.028
Ostericum grosseserratum	China	Hydrodistillation using a Clevenger-type apparatus for 6 h	GC-MS	0.70%	10.4314/tjpr.v12i1.16
Otacanthus azureus	French Guyana	Hydrodistillation	GC-MS	10.56%	10.1111/jam.12377
Panax ginseng	Korea	Dichloromethane extract	GC-MS	5.5 - 6.4%	10.1021/jf301835v
Panax notoginseng	Korea	Dichloromethane extract	GC-MS	3.70%	10.1021/jf301835v
Panax quinquefolius	Korea	Dichloromethane extract	GC-MS	nil	10.1021/jf301835v
Pangasius (Pangasianodon hypophthalmus)	Bangladesh	dynamic headspace sampling method (terpenes in the flesh)	GC-MS	8.3 ng/g	10.1021/acs.jafc.7b00497
Parthenium hysterophorus	Vietnam	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.5%	10.3390/molecules27227961
Pectis elongata Kunth	Brazil	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	0.10%	10.1002/ffj.1546
Pelargonium Geraniaceae	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.50%	10.1002/%28SICI%291099-1026%28200003/04%2915:2%3C105::AID-FFJ875%3E3.0.CO;2-G
Perovskia abrotanoides Karel.	Iran	Hydrodistillation using a Clevenger-type apparatus	GC-MS	6.40%	10.1002/ffj.1508
Perovskia atriplicifolia Benth	Iran	Hydrodistillation using a Clevenger-type apparatus	GC-MS	8.0% (arial plant parts)	10.1021/jf0341619
	Iran	Steam distillation	GC-MS	6.39% (flower), 9.36% (leaf), 9.55% (stem)	10.1002/ffj.988
Perovskia atriplicifolia Benth	Pakistan	Hydro-distillation in a Clevenger-type apparatus for 5 h.	GC-MS	5.70%	10.1002/%28SICI%291099-1026%28199901/02%2914:1%3C38::AID-FFJ778%3E3.0.CO;2-8
Petroselinum crispum	Mauritius	NR	GC-MS	nil	10.1002/cbdv.202000921

<i>Phellodendron amurense</i> Rupr.	Poland	Hydrodistillation	GC-MS	0.60% (Unripe fruit) 0.40% (Ripe fruit) 0.40% (Air-dried ripe fruit) 0.40% (Leaves) 0.30% (Flowers)	10.1002/ffj.1349 Lis
<i>Phlomis chorassanica</i> Bunge. (Lamiaceae)	Iran	Hydrodistillation using a Clevenger-type apparatus	GC-MS	3.3% (aerial plant parts)	10.1002/ffj.1338
<i>Phlomis cretica</i>	Greece	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	2.20%	10.1002/ffj.1717
<i>Phlomis ferruginea</i> Ten.	Italy	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	4.10%	10.1002/ffj.1740
<i>Phlomis olivieri</i> Benth	Iran	Steam distillation	GC-MS	2.70%	10.1002/ffj.1156
<i>Phlomis persica</i> Boiss	Iran	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.4% (aerial plant parts)	10.1002/ffj.1338
<i>Phoenix dactylifera</i> L.	Saudi Arabia	Hydrodistillation using a Clevenger-type apparatus for 4-5 h	GC-MS, GC-FID	0.40%	10.1016/j.actatropica.2013.08.003
<i>Pilocarpus pennatifolius</i> Lemmaire (Rutaceae)	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.1% (leaves)	10.1002/ffj.1306
<i>Pimpinella anisum</i>	Greece	Steam distillation for 4 h in a modified Clevenger distillation apparatus	GC-MS	Nil	10.1007/s00436-012-3097-1 KIMBARIS
	Poland	Hydrodistillation using a Clevenger-type apparatus	GC-MS, counter-current chromatography	0.19%	10.1002/jssc.201300407
<i>Pinus attenuata</i> Lemmon	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	3.50%	10.1002/ffj.990
<i>Pinus heldreichii</i> Christ	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.00%	10.1002/ffj.990
<i>Pinus mugo</i> Turra	Serbia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.40%	10.1002/ffj.1390
<i>Pinus peuce</i> Griseb	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.90%	10.1002/ffj.990
<i>Pinus pinaster</i> Ait.	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	14.80%	10.1002/ffj.990
	France	Hydrodistillation using a Clevenger-type apparatus	GC-MS	2.20%	10.1002/ffj.1865
<i>Pinus radiata</i> D. Don	Greece	Hydrodistillation using a Clevenger-type apparatus	GC-MS	Trace <0.05%	10.1002/ffj.990
<i>Piper aduncum</i>	Panama, Bolivia	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	1.9% (Panama), no trace (Bolivia)	10.1002/ffj.1369
	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	4.1% (leaves)	https://dx.doi.org/10.1590/S0102-695X2013000500005
<i>Piper cernuum</i>		Computer aided detection (SISTEMAT system)	¹³ C NMR spectroscopy	1.74%	10.1016/S0003-2670(01)01204-1

<i>Piper cubeba</i>	India	NR	GC-MS	0.19%	10.1007/s00436-011-2695-7
<i>Piper fridrichsthali</i>	Panama, Costa Rica	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	0.3% (Costa Rica), 1.4% (Panama)	10.1002/ffj.1181
<i>Piper gaudichaudianum</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	16.50%	https://dx.doi.org/10.1016/j.fct.2009.06.035
	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	16.50%	10.1016/j.fct.2013.03.013
<i>Piper nigrum</i>		Extraction with methanol and extraction with water reflux distillation	Capillary electrochromatography	0.70%	10.1002/jssc.200600456
<i>Piper pseudoliindenii</i>	Costa Rica	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	7.00%	10.1002/ffj.1181
<i>Piper regnellii</i>		Computer aided detection (SISTEMAT system)	¹³ C NMR spectroscopy	0.40%	10.1016/S0003-2670(01)01204-1
<i>Pittosporum senecia</i> subsp. <i>senecia</i>	Mauritius	NR	GC-MS	0.30%	10.1002/cbdv.202000921
<i>Pittosporum tobira</i>	Lisbon, Portugal	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.3% (leaves), 1.0% (fruit, capsules), 0.2% (flower)	10.1002/ffj.1798
<i>Platycladus orientalis</i> L.		Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.40%	10.1111/j.1365-2184.2008.00561.x
	China	Soaked in sodium chloride solution and distilled by electric heating	Headspace solid-phase microextraction combined with GC-MS	7.34–14.41%	https://doi.org/10.3390/molecules28052043
<i>Plectranthus amboinicus</i> (Lour.) Spreng	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS	9.67%	https://dx.doi.org/10.1007/s00436-010-1996-6
<i>Plectranthus barbatus</i>	India	Hydro-distillation of in a Clevenger apparatus for 8 h	GC-MS	1.62%	10.1007/s00436-015-4809-0
<i>Plectranthus grandis</i>	Brazil	Steam distillation using a Clevenger apparatus for 2 h	GC-MS	2.5 – 3.8%	10.1002/ffj.1730
<i>Plectranthus ornatus</i>	Brazil	Steam distillation using a Clevenger apparatus for 2 h	GC-MS	2.9 – 3.3%	10.1002/ffj.1730
<i>Plinia Cauliflora</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	nil	10.1002/ffj.1638
<i>Plinia cordifolia</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	1.80%	10.1002/ffj.1638
<i>Plinia Edulis</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	2.60%	10.1002/ffj.1638
<i>Plinia Trunciflora</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 5 h	GC-MS, GC-FID	0.90%	10.1002/ffj.1638
<i>Polygonum hydropiper</i> L.	Singapore	Dynamic headspace	GC-MS	1.3% (Dynamic)	10.1002/ffj.1363

		sampling, simultaneous distillation and extraction and liquid-liquid extraction with dichloromethane (D		headspace sampling) 0.9% (Liquid extraction)	
<i>Prangos asperula</i> Boiss.		Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.30%	10.1111/j.1365-2184.2008.00561.x
<i>Psidium acutangulum</i> ,	Brazil	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	4.90%	10.1002/ffj.1219
<i>Psidium guajava</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	1.10%	10.1002/ffj.1219
<i>Psidium guineense</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	nil	10.1002/ffj.1219
<i>Psidium striatum</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	2.80%	10.1002/ffj.1219
<i>Pterodon pubescens</i>	Turkey	Stainless steel tank with mechanical stirring using dichloromethane as liquid extractor	GC-MS, GC-FID	0.64%	10.1016/j.biopha.2019.108693
<i>Pulicaria mauritanica</i> Coss. (Asteraceae)	Algeria	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID, C-NMR	GC-MS trace <0.05% C-NMR 0.4%	https://doi.org/10.1002/ffj.3223
<i>Ravensara aromatica</i> Sonnerat	Madagascar	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	0 - 0.1%	10.1002/ffj.1735
<i>Rhabdosciadium microcalycinum</i> Hand.-Mazz	Turkey	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	0.20%	10.1002/ffj.1639
<i>Rhabdosciadium oligocarpum</i> (Post ex Boiss.) Hedge et Lamond	Turkey	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	0.20%	10.1002/ffj.1639
<i>Rosmarinus officinalis</i> var. <i>troglodytorum</i>	Tunisia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.38%	10.1016/j.fct.2010.08.010
<i>Rosmarinus officinalis</i> var. <i>typicus</i>	Tunisia	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.78%	
<i>Rosmarinus officinalis</i>	Algeria	Steam Distillation	GC-MS	0.4% (Steam Distillation), Nil (Hydrodistillation using a Clevenger-type apparatus)	10.1002/ffj.1226
	Messina, Sicily	MAHD- milestone dry dist microwave reactor.	GC-MS, GC-FID	0.78%	10.1002/jssc.200400037
<i>Saccharomyces cerevisiae</i> (with engineered mevalonate pathway)	Germany	Ethyl acetate extraction	GC-MS	12.5-22.5mg/L	https://doi.org/10.1016/j.ymben.2022.10.004
<i>Saccocalyx saturoioides</i> Coss et Durieu	Algeria	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	0.30%	10.1002/ffj.1661
<i>Salvia amplexicaulis</i>	Lithuania	Simultaneous distillation/extraction	GC-MS, GC-FID	6.9 mg/kg	10.1002/ffj.3389

		in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂			
<i>Salvia argentea</i> L.	Serbia	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	10.70%	10.1002/ffj.989
<i>Salvia austriaca</i>	Lithuania	simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	1.3 mg/kg	10.1002/ffj.3389
<i>Salvia brachyodon</i>	Belgrade	Hydrodistillation using a Clevenger-type apparatus	GC-MS	10.80%	10.1002/ffj.1132
<i>Salvia canariensis</i>	Gran Canaria	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.1% (After flowering) 1.6% (Before) 0.8% (During)	https://onlinelibrary.wiley.com/doi/10.1002/ffj.1504
<i>Salvia chionantha</i> Boiss	Turkey	Hydrodistillation using a Clevenger-type apparatus	GC-MS	4.82%	10.1016/j.jchromb.2006.11.044
<i>Salvia dumetorum</i>	Lithuania	Simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	1.6 mg/kg	10.1002/ffj.3389
<i>Salvia forsskaolei</i>	Lithuania	Simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	23.5 mg/kg	10.1002/ffj.3389
<i>Salvia fruticosa</i>	Israel	Steam distillation for 1 h	GC-MS	3.90%	10.1021/jf901162f
<i>Salvia glutinosa</i>	Lithuania	Simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	30.2 mg/kg	10.1002/ffj.3389
<i>Salvia Glutinosa</i> L	Serbia	Hydrodistillation	GC-MS	4.20%	10.1002/ffj.1291
<i>Salvia guaranitica</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS	1.02-3.32%	10.1002/ffj.1817
<i>Salvia nemorosa</i>	Lithuania	Simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	2.3 mg/kg	10.1002/ffj.3389
<i>Salvia Nemorosa</i>	Serbia	Hydrodistillation	GC-MS	1.90%	10.1002/ffj.1291
<i>Salvia officinalis</i>	Tunisia (Sfax town)	Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS, GC-FID	4.60%	10.1016/j.biopha.2018.09.108
	Tunisia	Hydrodistillation	GC-MS	8.94%	10.1021/jf901877x

	(Kelibia)	using a Clevenger-type apparatus for 3 h			
	Lithuania	Simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	2057.9 mg/kg	10.1002/ffj.3389
	Hungary	Steam distillation using a Clevenger-type apparatus for 3 h	GC-MS, GC-FID	15.1% (<i>Salvia officinalis</i> L), 33.24% (<i>Salvia officinalis</i> cv. 'Purpurascens'), 23.38% (<i>Salvia officinalis</i> cv. 'Tricolor'), 14.55% (<i>Salvia officinalis</i> cv. 'Kew Gold'), 8.52% (<i>Salvia judaica</i> Boiss)	10.1021/jf9005092
	Tunisia	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	4.37%	10.1016/j.fct.2009.08.005
	Serbia, Montenegro	Hydrodistillation using n-hexane	GC-MS, GC-FID	3.35-12.49%	10.1002/ffj.1065
	Portugal	Macerated in 10ml of pentane	GC-MS	7.46% (leaves), 5.23% (stem), 4.31% (flowers)	https://doi.org/10.1021/jf001102b
	Portugal	Hydrodistillation using a Clevenger-type apparatus	GC-MS	6.80%	https://doi.org/10.1021/jf020945v
<i>Salvia officinalis</i> × <i>Salvia fruticosa</i> , cv. Neve Ya'ar No. 4	Israel	Hydrodistillation using a Clevenger-type apparatus for 1.5 h	GC-MS	5.19% (Stem), 3.17% (Mature leaves), 4.96% (Young leaves), 6.59% (leaf primordia in main branch), 6.34% (leaf primordia in secondary branches), 6.34% (leaf primordia in secondary branches), 3.42% (upper shoots), 3.86% (lower shoots)	10.1021/jf9901587
<i>Salvia pratensis</i>	Lithuania	Simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	11.6 mg/kg	10.1002/ffj.3389
<i>Salvia przewalskiimaxim.</i>	Tibet	Hydrodistillation for 3 h, using a Clevenger-type apparatus	GC-MS	0.21% (Leaves) 3.64% (Flowers)	10.1002/ffj.1607
<i>Salvia reflexa</i> Hornem	Serbia	Hydrodistillation	GC-MS	Nil	10.1002/ffj.1291
<i>Salvia santoliniifolia</i>	Iran	Hydrodistillation using a Clevenger-type apparatus	GC-MS	7.80%	10.1002/%28SICI%291099-1026%28199903/04%2914:2%3C77::AID-FFJ726%3E3.0.CO;2-9
<i>Salvia sclarea</i>	Greece	Hydrodistillation	GC-MS	<0.05%	10.1021/jf020422n

		using a Clevenger-type apparatus			
	Lithuania	simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	Nil	10.1002/ffj.3389
	Uruguay	Steam distillation for 2 h at normal atmospheric pressure	GC-MS	0.40%	10.1002/ffj.1282
<i>Salvia verticillata</i>	Lithuania	simultaneous distillation/extraction in a Likens-Nickerson apparatus and supercritical fluid extraction with CO ₂	GC-MS, GC-FID	11.6 mg/kg	10.1002/ffj.3389
	Iran	Hydrodistillation using a Clevenger-type apparatus	GC-MS	Nil	10.1002/%28SICI%291099-1026%28199903/04%2914:2%3C77::AID-FFJ726%3E3.0.CO;2-9
<i>Sambucus ebulus</i>	Iran	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	Nil (control), 5.41% (treated with indole-3-acetic acid), 1.85% (treated with naphthalene acetic acid)	10.4314/tjpr.v13i4.13
<i>Santolina chamaecyparissus</i>	India	Hydrodistillation	Triplicate distillations	0.6% (Jammu), 2.3% (Srinagar) 2.5% (Tissue culture raised foliage)	10.1002/ffj.1440
<i>Satureja spicigera</i> C. Koch Boiss.	Iran	Hydrodistilled using a Clevenger-type apparatus for 4 h	Dried over anhydrous sodium sulphate	0.2%.	10.1002/ffj.1642
<i>Satureja. Macrantha</i> C. A. Mey	Iran	Hydrodistilled using a Clevenger-type apparatus for 4 h	Dried over anhydrous sodium sulphate	0.2%.	10.1002/ffj.1642
<i>Scaligeria tripartita</i>	Turkey	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.2% (fruit)	10.1016/j.jchromb.2006.11.041
<i>Schinus mole</i>	Sardinia	CO ₂ based extraction; Hydrodistilled using a Clevenger-type apparatus for 4 h	GC-MS	0.4% (CO ₂ based extraction) 0.2% (hydrodistilled)	10.1002/ffj.1350
<i>Schinus polygamus</i> (Cav.) Cabrera f. <i>Chubutensis</i>	Argentina	Hydrodistilled in a Clevenger-type apparatus	GC-MS	0.80%	https://onlinelibrary.wiley.com/doi/10.1002/ffj.1270
<i>Scleria hirtella</i>	Brazil	Hydrodistillation for 4 h, using a Clevenger apparatus.	GC-MS	0.10%	10.1002/ffj.1593
<i>Senecio nutans</i> Sch.-Bip.	Peru	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	Nil	10.1002/ffj.1204
<i>Senecio seloi</i> Spreng. DC.	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.6% (aerial plant parts)	10.1590/S1516-05722013000400005

<i>Sephredium brevifolium</i>	Skardu Baltistan, Pakistan	Hydrodistillation using a Clevenger-type apparatus	GC-MS	3%	10.1016/j.bjp.2019.04.013
<i>Seseli andronakii</i> Woron.	Athens	Hydrodistillation using a Clevenger-type apparatus	GC-MS	no trace <0.1%	10.1002/ffj.1572
<i>Seseli petraeum</i> M. Bieb.	Athens	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.00%	10.1002/ffj.1572
<i>Seseli tortuosum</i>	Italy	Hydrodistillation using a Clevenger-type apparatus for 2 h	GC-MS	0.30%	10.1002/ffj.1154
<i>Silphium perfoliatum</i>	Poland	Steam distillation method in Deryng's apparatus	GC-MS	1.4% (Leaf oil) 0.6% (Influorescence oil) 2.9% (Rhizome oil)	10.1002/ffj.1418
<i>Solanum tuberosum</i>	Bonin, Japan	Hydrodistillation using a Clevenger-type apparatus	GC-MS	41.2 ng/cm ²	10.1021/jf040437g
<i>Sphaeranthus africans</i>	Vietnam	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.4%	10.3390/molecules27227961
Spreng (Verbenaceae)	Tanzania	Hydrodistillation using a Clevenger-type apparatus	GC-MS	1.40%	https://dx.doi.org/10.1002/ffj.3625
Spruce <i>Picea orientalis</i> (L.) Link	Belgrade	Boiled in water then mixed with petroleum benzine for distillation	GC-MS	1.02% (Wood extract), 0.18% (needle extract)	10.1002/ffj.1196
<i>Stachys alpina</i> ssp. <i>Dinarica</i>	Bosnia and Herzegovina	Hydrodistillation in a Clevenger-type apparatus	GC-MS	2.80%	10.1002/ffj.1684
<i>Stachys sylvatica</i> L.	Italy	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.1% (inflorescence), 0.6% (leaves)	10.1002/ffj.1308
<i>Styrax japonicus</i>	China	Static headspace solid-phase microextraction	GC-MS	1.57%	10.1002/ffj.3654
<i>Syzygium aromaticum</i>	Madagascar	Clove oil purchased	GC-MS	0.5% (Madagascar) 1.80% (Indian)	10.1080/10611860500422958
	India	NR	GC-MS	3.78%	10.1016/j.jbiosc.2016.09.011
	Iran	NR	GC-MS	1.73%	10.1002/ffj.3595
<i>Syzygium aromaticum</i> (<i>Eugenia caryophyllata</i>)	Italy	Commercial and steam distilled clove oil	HPLC	1.10 ±0.02 g/100ml	10.1002/jssc.200600023
<i>Syzygium coriaceum</i>	Mauritius	NR	GC-MS	0.70%	10.1002/cbdv.202000921
<i>Syzygium jambos</i> (L.) Alston, (Myrtaceae)- rose apple	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS	7.07% (leaves)	https://dx.doi.org/10.1590/S0102-695X2013005000035
<i>Syzygium samarangense</i>	Mauritius	NR	GC-MS	0.30%	10.1002/cbdv.202000921
<i>Syzygium zeylanicum</i> (Myrtaceae)	India	Hydrodistillation 8h Clevenger apparatus, dried with anhydrous Na ₂ SO ₄	GC-MS	37.80%	10.1007/s00436-016-5025-2
<i>Taiwania cryptomerioides</i>	Taiwan	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	0.30%	10.1002/ffj.1685
<i>Tetrataenium lasiopetalum</i>	Iran	Hydrodistillation using a Clevenger-	GC-MS, GC-FID	0.4% (aerial plant parts)	10.1002/ffj.1767

Teucrium Scordium	Sicily	type apparatus Hydrodistillation 3h	Dried over anhydrous sodium sulphate	0.50%	https://www.tandfonline.com/doi/full/10.1080/14786419.2019.1709193
Teucrium fruticans	Sicily and Malta	Hydrodistillation 3h	Dried over anhydrous sodium sulphate	5.6% (Sicily) 3.3%, (Malta)	https://www.tandfonline.com/doi/full/10.1080/14786419.2019.1709193
Teucrium libanitis	Spain	Hydrodistillation using a Clevenger-type apparatus for 2.5 h	GC-MS	Nil	10.1002/ffj.1256
Teucrium royleanum	Pakistan	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.60%	10.1002/ffj.1774
Teucrium siculum	Sicily	Hydrodistillation 3h	Dried over anhydrous sodium sulphate	8.60%	https://www.tandfonline.com/doi/full/10.1080/14786419.2019.1709193
Teucrium turredanum	Spain	Hydrodistillation using a Clevenger-type apparatus for 2.5 h	GC-MS	4.7–10.1%	10.1002/ffj.1256
Thymbra Capitata	NR	Water distillation in a Clevenger-type apparatus	GC-MS	0.10%	10.1007/s00436-010-1800-7
Thymbra spicata L	Turkey	Homogenized plant item was extracted with 250 ml extraction solvent (methanol) for 24 hours.	GC-MS	nil	10.1002/ffj.3636
Thymus cilicicus	Turkey	Homogenized plant item was extracted with 250 ml extraction solvent (methanol) for 24 hours.	GC-MS	0.10%	10.1002/ffj.3636
Thymus citriodorus	Italy	Steam distillation	GC-MS	nil	10.1016/j.resmic.2016.11.004
Thymus vulgaris	Italy	Steam distillation	GC-MS	0.10%	10.1016/j.resmic.2016.11.004
Thymus Zygis sylvestris		Water distillation in a Clevenger-type apparatus	GC-MS	Trace	10.1007/s00436-010-1800-7
Tilapia (Oreochromis niloticus)	Bangladesh	Dynamic headspace sampling method	GC-MS	115 ng/g	10.1021/acs.jafc.7b00497
Triumfetta rhomboideajacq.	Burkina-Faso	Hydrodistillation with a Clevenger-type apparatus for 2h	GC-MS	4.90%	10.1002/ffj.1511 Mevy
Turnera diffusa Willd. var. afrodisiaca(Ward) Urb.	Brazil	Hydrodistillation using a Clevenger-type apparatus for 4 h	GC-MS	0.20%	10.1002/ffj.1155
Turnera subulata Sm.	Brazil	Hydrodistillation using a Clevenger-type apparatus for 3 h	GC-MS	1.30%	10.1590/1983-084X/13_011

<i>Unonopsis guatterioides</i>	French Guyana	Steam distilled 3h	Filtered over anhydrous sodium sulphate	2.5% (Root) 6.3% (Fruit)	10.1002/%28SICI%291099-1026%28199703%2912:2%3C95::AID-FFJ611%3E3.0.CO;2-Z
<i>Valeriana officinalis</i>	United States	3 h of hydrodistillation, using a Clevenger type distillation apparatus	GC-MS	0.68% (Select cultivar) 8.46% (Anthose cultivar)	10.1021/jf0353990
<i>Varronia curassavica</i>	Brazil	Hydrodistillation using a Clevenger-type apparatus	GC-MS, GC-FID	1.36% (Plant subject to 20% light-full sun), 1.24% (Plant subject to 50% light-full sun), 1.14% (Plant subject to 70% light-full sun), 1.58% (Plant subject to 100% light-full sun)	10.1016/j.bjp.2014.10.005
<i>Vernonia brasiliana</i> (L.) Druce	Brazil	Hydrodistillation	GC-MS	8.85%	10.1016/j.biopha.2020.111025
Washington navel-type oranges	Turkey	Peel oil extracted by simple distillation	GC-MS	0.11%	10.1002/ffj.3576
<i>Xylopia rubescens</i> Oliv.	Côte d'Ivoire	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.80%	10.1002/ffj.3155
Ylang-ylang	Comoro Islands	NR	GC-MS, GC-FID	20.9 mg/ml	https://dx.doi.org/10.1002/ffj.3625
	Madagascar	NR	GC-MS, GC-FID	39.9 mg/ml	https://dx.doi.org/10.1002/ffj.3625
<i>Zanthoxylum avicennae</i> (Lam.) DC. (Rutaceae)	China	Hydrodistillation using a modified Clevenger-type apparatus for 6 h	GC-MS	0.07%	10.4314/tjpr.v13i3.13
<i>Zanthoxylum bungeanum</i>	China	Molecularly imprinted solid-phase extraction	GC-MS	1.11%	10.1002/jssc.201701014
<i>Zanthoxylum rhetsa</i> seeds	India	Hydrodistillation using a Clevenger-type apparatus	GC-MS	Trace <0.1%	10.1002/ffj.1598
<i>Zataria multiflora</i>	Iran	Commercial	GC-MS	0.13%	10.1016/j.ijbiomac.2018.12.085
<i>Zataria multiflora</i> Boiss.	Iran	Hydrodistillation using a Clevenger-type apparatus	GC-MS	0.19%	10.1016/j.fct.2010.03.025
<i>Zingiber nimmonii</i>	India	Hydro-distillation in a Clevenger apparatus for 8 h	GC-MS	19.60%	10.1007/s00436-016-4920-x Govindarajan
<i>Zingiber zerumbet</i>	Malaysia	Root dried at 60°C for 24 h. Dried root underwent Soxhlet extraction.	HPLC	60-15,800 µg/g (Plant grown in a variety of growth regulators and elicitors)	10.3390/molecules27154744
<i>Ziziphora clinopodioides</i>	Turkey	Homogenized plant item was extracted with 250 ml extraction solvent	GC-MS	nil	10.1002/ffj.3636

		(methanol) for 24 hours.			
--	--	--------------------------	--	--	--

GC-FID – gas chromatography – flame ionisation detection; GC-MS – gas chromatography – mass spectrometry; HPLC – high-performance liquid chromatography; NMR – nuclear magnetic resonance; NR – not recorded



