EGYPTIAN JOURNAL OF BOTANY (EJBO)

Print ISSN: 0375-9237
Online ISSN: 2357-0350

Chairperson
PROF. DR. MOHAMED I. ALI
Editor-in-Chief
PROF. DR. SALAMA A. OUF

Antioxidant properties of Egyptian Desert-adapted plant essential oils: A mini-review

Mohamed Z. El-Sadek, Ahmed H. Shaaban, Marise Bishay, Nada E. Khamess, Youssef M. Youssef1, Ahmed El-Hussein, Magdi A. El-Sayed

PUBLISHED BY
THE EGYPTIAN
BOTANICAL SOCIETY

Antioxidant properties of Egyptian Desert-adapted plant essential oils: A mini-review

Mohamed Z. El-Sadek[1], Ahmed H. Shaaban[1], Marise Bishay[1], Nada E. Khamess[1], Youssef M. Youssef[1], Ahmed El-Hussein[1,2], Magdi A. El-Sayed[2,3]

[1]*Department of Biology, Faculty of Science, Galala University, Suez 43511, Egypt*
[2]*Department of Laser Applications in Meteorology, Photochemistry and Biotechnology, The National Institute of Laser Enhanced Science, Cairo University, Cairo 11316, Egypt*
[3]*Faculty of Education and Arts, Sohar University, P.O Box 44, P.C. 311 Sohar, Oman*

This review article explores the antioxidant properties of essential oils extracted from desert-adapted plants, focusing on their potential therapeutic applications. Desert plants, known for their resilience in harsh environments, produce essential oils that play crucial roles in plant defense against biotic and abiotic stressors. These oils, rich in diverse bioactive compounds, have demonstrated significant antioxidant activity, which is instrumental in mitigating oxidative stress. This review article delves into various studies that have highlighted the efficacy of these oils in promoting wound healing, exhibiting antimicrobial properties, and offering anticancer benefits. Additionally, it discusses the influence of extraction methods on the oils' antioxidant capacities. Emphasizing the need for further scientific research, this review underscores the therapeutic potential of these natural antioxidants for enhancing health and preventing disease, advocating for more clinical trials to confirm their benefits in human health applications.

Keywords: Desert plants, Essential oils, Antioxidants, Environments, Plant adaptation

ARTICLE HISTORY
Submitted: October 10, 2024
Accepted: January 11, 2025

CORRESPONDENCE TO
Ahmed El-Hussein, Magdi A. El-Sayed,
Department of Biology, Faculty of Science,
Galala University, Suez 43511, Egypt
Email: a.elhusseiny@gu.edu.eg;
magdiel_sayed@gu.edu.eg
DOI: 10.21608/ejbo.2025.327284.3031

EDITED BY: M. Mohamed

INTRODUCTION

In the quest for natural and effective antioxidants, essential oils from various plants have garnered significant attention due to their potential health benefits and roles in disease prevention. The antioxidant properties of essential oils derived from a selected group of plants are known for their traditional medicinal uses and unique chemical compositions (Bolouri et al. 2022). Essential oils are complex mixtures obtained from plants that have been used historically in various cultures for medicinal, therapeutic, and culinary purposes. The interest in these oils has increased due to their bioactive compounds, which can provide natural alternatives to synthetic antioxidants (Do Nascimento et al. 2020). While the antioxidant activities of some essential oils are well-documented, the comprehensive understanding of these properties across a diverse range of plants, especially those less studied, remains a significant gap in ethnopharmacology (Miguel, 2010). This review aims to address this gap by exploring the antioxidant potential of essential oils from selected plants, which are promising but underutilized in modern therapeutic practices. The essential oils from plants like Lavandula species, Artemisia herba-alba, and Thymus capitatus show significant antioxidant activities, which could be effectively harnessed in pharmacological and food industries (Ouahdani et al. 2021). This review will primarily discuss the antioxidant activities of essential oils from selected plants, which were analyzed for their chemical compositions through GC-MS. We will explore the specific antioxidant properties of each plant, highlighting how their bioactive compounds interact synergistically. The review aims also to clarify the potential health applications of these oils, setting the stage for further research into their therapeutic benefits. This focused approach offers a comprehensive examination of each plant's contribution to antioxidant activity, guiding future investigations and practical uses in health and medicine.

Plant Antioxidant Activity

An antioxidant can be a chemical that fights free radicals inside a water-based and a fat-based medium. Additionally, it can suppress or retard the oxidative reaction, thereby protecting other significant molecules from damage. Some compounds present in plant tissues serve as antioxidants, helping to inhibit oxidative stress and protect the body from damage caused by free radicals (Alam et al. 2013). Antioxidant activity plays a critical role in the survival and health of plants, especially those exposed to stressful environments (Ouf et al., 2024). One of the primary functions of antioxidants in plants is to protect against environmental stresses (Moreno-Rojas et al. 2022). Environmental factors such as ultraviolet radiation, temperature fluctuations, and water scarcity can lead to the generation of reactive oxygen species (ROS) (Ohja et al. 2014). These ROS are capable of damaging cellular components, including DNA, proteins, and lipids. The presence of antioxidants helps neutralize these ROS, thus preventing cellular damage and aiding in the plant's survival (Harlev et al. 2012). Moreover, antioxidants are vital for maintaining photosynthetic efficiency. The process of photosynthesis, while essential for plant growth, can itself produce ROS, particularly under conditions of high light intensity. Antioxidants safeguard the photosynthetic machinery from oxidative stress, ensuring that energy conversion remains efficient and effective (Haber & Rosenwasser, 2020). his protection is crucial for the plant's ability to produce energy and sustain its metabolic functions under various environmental pressures. Additionally, antioxidants have been observed to play a role in plant signaling and defense mechanisms. They are involved in the modulation of stress-responsive pathways, helping plants adapt to and survive under adverse conditions (Rajput et al. 2021). This adaptive capacity is particularly important for plants in harsh habitats, such as deserts, where extreme conditions prevail. In summary, the antioxidant systems in the plants are not merely protective measures but are integral to the plant's ability to thrive in challenging environments. They provide a crucial defense against oxidative stress, enhance the efficiency of photosynthesis, and play a significant role in stress signalling and adaptation mechanisms. This comprehensive function underscores the importance of antioxidants in the ecological success and evolutionary adaptation of plants.

Antioxidant Properties of Desert Plant Essential Oils

Antioxidant properties of essential oils derived from desert-adapted plants. These essential oils possess significant antioxidant activity, which is crucial in mitigating oxidative stress. This review highlights various studies that have documented the therapeutic potential of these oils, including their role in promoting wound healing, exhibiting antimicrobial properties, and offering anti-cancer benefits (Fauiod et al., 2024). The authors also emphasize the need for further scientific research to confirm the benefits of these natural antioxidants in human health applications. In this context, extraction methods can influence the antioxidant capacities of these oils. Therefore, Figures 1 and 2 provided in this review illustrate the varying antioxidant capacities of essential oils derived from different plants. Analyzing this information provides insights into the potential therapeutic applications of these oils in human health. These figures underscore the significance of conducting further research to confirm the benefits of these natural antioxidants and optimize their extraction methods. Overall, this context emphasizes the significance of considering the potential therapeutic benefits of essential oils derived from desert-adapted plants in human health applications. In a study by Yousi et al. (2016 the Artemisia herba-alba Asso. essential oil they utilized exhibited significant antioxidant activity in almost all assays. The IC_{50} value for DPPH inhibition test was 50.3 µg/mL, for the β-carotene bleaching assay was 1.58 µg/mL, and for the ferrous chelating assay was 2.3 µg/mL. The reduced ferrous state of the oil was 79 µmol $^{1}Fe^{2+}$/g. The antioxidant activity is attributed to the high concentration of oxygenated monoterpenes in the essential oil, including β-thujone, α-thujone, and camphor. The fundamental underlying factor of such a consequential role is the oil characteristics of strong antioxidants which have been proven in the food, cosmetic, and pharmaceutical industries (Younsi et al. 2016). Moreover, the essential oil extracted from the flowers of *Artemisia judaica* L. ssp. *sahariensis* in Algeria demonstrated notable antioxidant activity. The oil exhibited a 50% inhibition of the DPPH radical at a concentration of 3.94 mg/mL and a 50% reducing power at 0.125 mg/mL.

The dominant component of the oil was piperitone, constituting 71.1% of the total composition. These findings suggest the potential of *Artemisia judacia* essential oil as a natural antioxidant agent in cosmetic formulations (Zeragui et al. 2019). Additionally, as shown by Al Ashaal et al. (2010), the essential oil of *Balanites aegyptiaca* exhibits strong antioxidant potential in the model used for DPPH free radical assay, with a DPPH scavenging potential of 43.75%. The antioxidant properties of oil are attributed to unsaturated fatty acids such as oleic acid (0.22%), and linoleic acid (0.10%) which are its major content, and sterols like β-sitosterol (0.4%). It is, therefore, capable of inhibiting the generation of free radicals and may be employed as a natural antioxidant agent (Ahmed et. 2018). As well as, in research by Kulisic-Bilusic et al. (2010), based on evidence presented, *Capparis spinosa* L. essential oil, predominantly composed of methyl isothiocyanate (92.06%), was analyzed for its antioxidant properties. The oil manifested poor radical-scavenging activity in the DPPH test (16,11% inhibition at 2 mg/L) but significant antioxidant activity in the β-carotene bleaching method (83,16% inhibition at 1 mg/L) and in the TBARS test (59,63% inhibition at 1mg/L. According to the remarkable results, it can be assumed that CSOE (Caper Seed Oil

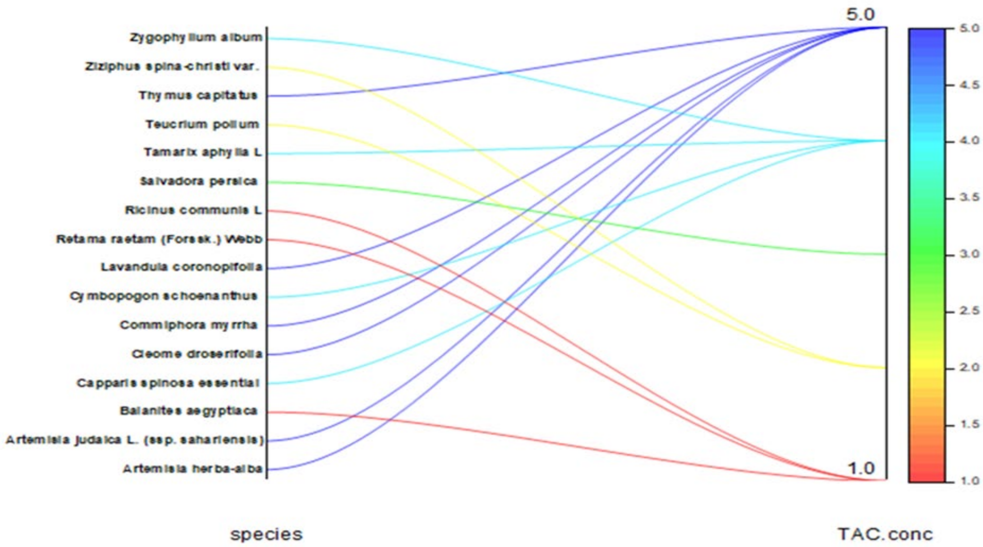

Figure 1. The antioxidant activity of some desert plant species is expressed as total antioxidant capacity (TAC).

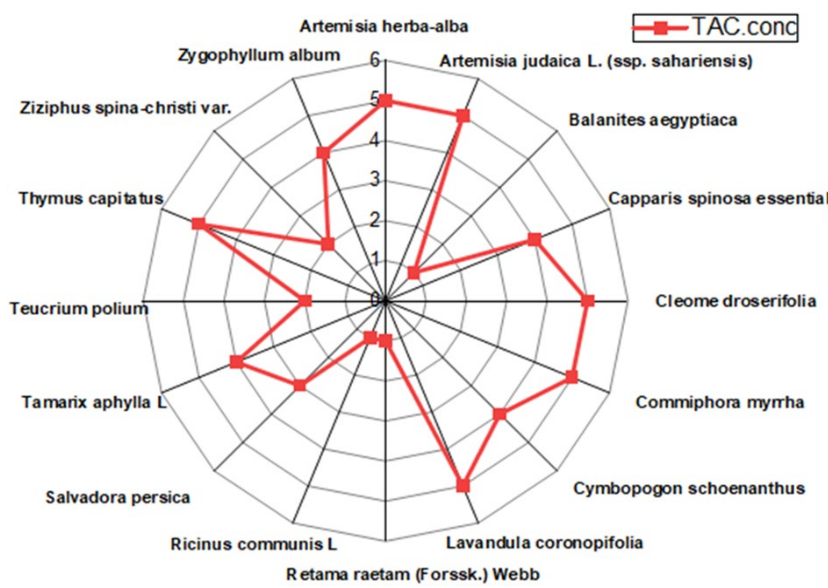

Figure 2. Spider plot of total antioxidant capacity (TAC) concentration of some plant species grown in the Egyptian desert.

Extract) possesses antioxidant ability in emulsion systems used in foods, despite its weak radical-scavenging activity. Scientists need to pay special attention to its use as a natural antioxidant in the food industry due to the deficiency of certain studies. Abd El-Gawad et al. (2018) investigated the antioxidant activity of essential oil extracted from the aerial parts of *Cleome droserifolia* (Forssk.) Delile, an Egyptian ecospecies. The essential oil exhibited significant antioxidant activity, with an IC_{50} value of 976.1 µL/L, as determined using the DPPH free radical scavenging assay. This activity was attributed to the presence of major sesquiterpenes such as cis-nerolidol, α-cadinol, δ-cadinene, and γ-muurolene, which collectively represented 61.97% of the total essential oil composition. These findings suggest that *Cleome droserifolia* essential oil could serve as a natural source of antioxidants. Additionally, Mohamed et al. (2014) evaluated the antioxidant activity of methanol and ethyl acetate extracts as well as the essential oil of *Commiphora myrrha* resin. The methanol extract exhibited the highest antioxidant activity, as demonstrated by its DPPH radical scavenging ability, with an IC_{50} value of 0.32 mg/mL. The ethyl acetate extract and the essential oil showed lower antioxidant activities, with IC_{50}values of 0.93 mg/mL and 11.33 mg/mL, respectively. In the ferrous ions chelating assay, the methanol extract also showed the highest activity, with an IC_{50} value of 0.238 mg/mL, followed by the ethyl acetate extract and the essential oil. Additionally, the essential oil demonstrated superior reducing power compared to the extracts in the ferric-reducing power assay. These findings suggest that the methanol extract of *Commiphora myrrha* resin has the potential to be used as a natural antioxidant source *Cymbopogon schoenanthus* (L.) Spreng. essential oil exhibited antioxidant activity as measured by different tests. The oil has been shown to have the ability to scavenge DPPH radicals with the AM value of 14.61 mg Trolox equivalents/g oil and ABTS radicals scavenge with the AM value of 63.93 mg Trolox equivalents/g oil. With FRAP attacking 101.95 mg Trolox equivalents/g oil and the CUPRAC taking 133.20 mg Trolox equivalents/g oil, FRAP attracted.

Moreover, the oil exhibited a metal chelator, and it gave a maximum value of 31.40 mg of iron. EDTA equivalents/g oil. The outcome of the investigation idnicated the possible use of *Cymbopogon schoenanthus* essential oil as a natural antioxidant by different fields (Yagi et al. 2020). In the same concept, Messaoud et al. (2012) reported a comparative study of the antioxidant activities of essential oils and methanol extracts from three wild *Lavandula* species: *Lavandula coronopifolia*, *Lavandula multifida*, and *Lavandula stoechas* subsp. *stoechas*. The methanol extracts of all three species exhibited significant antioxidant activities, with *L. coronopifolia* showing the highest activity, followed by *L. multifida* and *L. stoechas* subsp. *stoechas*. The antioxidant activities were measured using DPPH free radical-scavenging, ferrous ion chelating, and ferric-reducing power assays. The results suggest that the methanol extracts of these *Lavandula* species could be potential sources of natural antioxidants for use in food, cosmetic, and pharmaceutical industries. Edziri et al. (2010) investigated the antioxidant activity of the essential oil extracted from the flowers of *Retama raetam* (Forssk.) Webb, a wild plant native to Tunisia. The oil exhibited significant antioxidant activity, as demonstrated by the DPPH free radical scavenging assay, with an IC_{50} value of 0.800 mg/mL. The antioxidant potential of the essential oil suggests its potential use as a natural antioxidant agent in various applications Kadri et al. (2011) investigated the *in vitro* antioxidant properties of the essential oil extracted from the aerial parts of *Ricinus communis* L., a member of the Euphorbiaceous family. The essential oil exhibited potential antioxidant activity, as evidenced by three different test systems: the 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay, the β-carotene bleaching test, and the reducing power assay. In the DPPH assay, the oil showed a half antioxidant capacity at a concentration of 300 µg/mL compared to the positive control. In the β-carotene bleaching test, the oil exhibited a lower inhibitory effect on linoleic acid oxidation than the synthetic antioxidant BHT. However, in the reducing power assay, the essential oil demonstrated a higher reducing ability, indicating its potential as a natural antioxidant source for various applications. In another study mentioned before by Noumi et al. (2011), Salvadora persica essential oil, which originated from dried stems, has been shown to possess some antioxidant capabilities. Acetone-acetone dilution of *S. persica* revealed DPPH-free radical scavenging capacity, IC_{50} value of 75 µg/mL, ferric reducing power (FPAP), EC_{50} value of 1940 µg/mL, and total antioxidant capacity (TAC), 0.528 mg GAE/g. This verified *S. persica* essential oil as a natural antioxidant. Nevertheless, its activity was found to be lower than the *Juglans regia* L. deciduous fruits extract in a reference study. Romeilah et al. (2021) evaluated the antioxidant activity of the essential oil extracted from the aerial parts of *Tamarix aphylla* L., collected from the desert region of Ha'il in Saudi Arabia. Antioxidant activity was assessed using DPPH and ABTS assays. The essential oil of *T. aphylla* exhibited IC_{50} values of 134.90 µg/mL for DPPH and 109.23 µg/mL for ABTS, demonstrating moderate antioxidant activity. These findings suggest that the essential oil of *T. aphylla* could be a potential source of natural antioxidants.

Correspondingly, in a study by Bakari et al. (2015), *Teucrium polium* L. essential oil exhibited antioxidant activity, as measured by various assays. The DPPH radical scavenging activity of the essential oil showed an IC_{50} value of 20 µg/mL, indicating its ability to scavenge free radicals. Additionally, the essential oil demonstrated a ferric-reducing antioxidant power (FRAP) with an EC_{50}value of 18 µg/mL, further confirming its antioxidant potential. These findings suggest the potential of *T. polium* essential oil as a natural antioxidant for various applications, attributed to its high phenolic and flavonoid contents. Correspondingly, Goudjil et al. (2020) reported that Thymus capitatus (L.) Cav. essential oil showed significant antioxidant properties. The oil scored the highest DPPH scavenging power with an IC_{50} value of 0.61 mg/mL (foreign), and moderate ferric reducing (FRAP) and total antioxidant power (TAC) with the EC_{50} values of 2.13 and 0.78 mg/mL, respectively. The discovery that ethanol leads to oxidative damage to DNA confirms the possible antioxidant activity of essential oil of *T. capitatus*, which is due to its content of thymol (51.22%), carvacrol (12.59%), and γ-terpinene (10.3%).

In (2020), Papari et al. investigated the antioxidant activity of the essential oil extracted from *Ziziphus spina-christi* var. *aucheri* grown wild in Iran. The antioxidant activity was evaluated using the 1,1-diphenyl-2-picrylhydrazyl (DPPH) assay. The essential oil exhibited antioxidant activity with an IC_{50} value of 53.91 ± 2.431 µg/mL, indicating its potential as a natural antioxidant agent. These findings suggest that the essential oil of *Ziziphus spina-christi* var. *aucheri* could be used in low concentrations for preserving food products. Furthermore, Kchaou et al. (2016) investigated the antioxidant activity of the essential oil extracted from the leaves of *Zygophyllum album*, a shrubby plant native to Tunisia. The antioxidant activity was evaluated using three different assays: 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging, reducing power, and total antioxidant capacity assays. The essential oil exhibited potent antioxidant properties in all three assays, indicating its potential as a natural source of antioxidants for use in the pharmaceutical and food industries. The study suggests that the phenolic compounds present in the essential oil, such as carvacrol and thymol, may contribute to its antioxidant activity.

CONCLUSIONS

This comprehensive mini-review underscores the significant therapeutic potential of essential oils derived from some desert-adapted plants, notably their robust antioxidant properties. The reviewed studies collectively highlight the biochemical complexity and diverse functionality of these oils, which not only confer resilience against harsh environmental conditions but also offer promising avenues for pharmacological and cosmetic applications. The findings from various research methodologies, including advanced analytical techniques like GC-MS, provide compelling evidence of the oils' capacity to scavenge free radicals and inhibit oxidative processes, which are crucial for developing natural antioxidant formulations (Manoto et al. 2021). Despite these promising results, the review also identifies critical gaps in current research, particularly the need for standardized methods to evaluate antioxidant activity and the exploration of synergistic effects among different bioactive compounds. Moreover, while the therapeutic benefits of these oils are evident, there is a pressing need for clinical trials to validate these findings in human health applications.

Future research should focus on expanding the scope of plant species studied, exploring the environmental influences on oil composition, and developing sustainable extraction methods that preserve the bioactive properties of these oils. Additionally, the integration of traditional knowledge with modern scientific approaches could further enhance the understanding and utilization of these potent natural resources.

In conclusion, the antioxidant properties of essential oils from desert-adapted plants represent fertile ground for scientific exploration and application. By bridging the gaps identified in this review and harnessing the full potential of these natural products, we can advance towards innovative solutions for health, cosmetic, and possibly nutritional enhancements, contributing to the sustainable use of biodiversity and the well-being of communities reliant on these ecosystems.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTIONS

Magdi A. El-Sayed and Ahmed El-Hussein: Conceptualization and revised the final version of the manuscript for publication. Mohamed Z. El-Sadek, Ahmed H. Shaaban, Marise Bishay, Nada E. Khamess, Youssef M. Youssef: Contributed equally to this review by collecting data and writing the first draft.

ETHICS APPROVAL

Not applicable

REFERENCES

Abd El-Gawad, A. M., El-Amier, Y. A., & Bonanomi, G. (2018). Essential Oil Composition, Antioxidant and Allelopathic Activities of *Cleome droserifolia* (Forssk.) Delile. Chemistry and Biodiversity, 15(12). https://doi.org/10.1002/cbdv.201800392.

Abdoul-Latif, F. M., Elmi, A., Merito, A., Nour, M., Risler, A., Ainane, A., Bignon, J., & Ainane, T. (2022). Essential Oils of *Tagetes minuta* and *Lavandula coronopifolia* from Djibouti: Chemical Composition, Antibacterial Activity and Cytotoxic Activity against Various Human Cancer Cell Lines. International Journal of Plant Biology, 13(3), 315–329. https://doi.org/10.3390/ijpb13030026.

Abdul-Ghani, R. A., Loutfy, N., & Hassan, A. (2009). Myrrh and trematodoses in Egypt: An overview of safety, efficacy and effectiveness profiles. Parasitology International, 58(3), 210–214. https://doi.org/10.1016/j.parint.2009.04.006.

Ahmed, I., Fang, Y., Lu, M., Yan, Q., El-Hussein, A., Hamblin, M. R., & Dai, T. (2018). Recent patents on light-based anti-infective approaches. *Recent Patents on Anti-Infective Drug Discovery*, 13(1), 70–88.

Al Ashaal, H. A., Farghaly, A. A., Abd El Aziz, M. M., & Ali, M. A. (2010). Phytochemical investigation and medicinal evaluation of fixed oil of *Balanites aegyptiaca* fruits (Balantiaceae). Journal of Ethnopharmacology, 127(2), 495–501. https://doi.org/10.1016/j.jep.2009.10.007.

Alali, F., Hudaib, M., Aburjai, T., Khairallah, K., & Al-Hadidi, N. (2004). GC-MS analysis and antimicrobial activity of the essential oil from the stem of the Jordanian toothbrush tree *Salvadora persica*. Pharmaceutical Biology, 42(8), 577–580. https://doi.org/10.1080/13880200490901834.

Alam, M. N., Bristi, N. J., & Rafiquzzaman, M. (2013). Review on *in vivo* and *in vitro* methods evaluation of antioxidant activity. In Saudi Pharmaceutical Journal (Vol. 21, Issue 2, pp. 143–152). https://doi.org/10.1016/j.jsps.2012.05.002.

Alwasia, A., Alhamrouni, A., Aburas, O. A., Boras, E., Abukhdir, A., & Eljamay, S. M. (2023, July 29). The Gas Chromatography-Mass Spectrometry (GC-MS) Analysis of Seed Oil of Retama Raetam. https://aaasjournals.com/index.php/ajapas/article/view/453.

Bakari, S., Ncir, M., Felhi, S., Hajlaoui, H., Saoudi, M., Gharsallah, N., & Kadri, A. (2015). Chemical composition and *in vitro* evaluation of total phenolic, flavonoid, and antioxidant properties of essential oil and solvent extract from the aerial parts of *Teucrium polium* grown in Tunisia. Food Science and Biotechnology, 24(6), 1943–1949. https://doi.org/10.1007/s10068-015-0256-z.

Bolouri, P., Salami, R., Kouhi, S., Kordi, M., Asgari Lajayer, B., Hadian, J., & Astatkie, T. (2022). Applications of Essential Oils and Plant Extracts in Different Industries. In Molecules (Vol. 27, Issue 24). MDPI. https://doi.org/10.3390/molecules27248999

El-Gawad, A. M. A., El-Amier, Y. A., & Bonanomi, G. (2018). Essential Oil Composition, Antioxidant and Allelopathic Activities of Cleome droserifolia (Forssk.) Delile. Chemistry & Biodiversity, 15(12). https://doi.org/10.1002/cbdv.201800392.

Diass, K., Oualdi, I., Dalli, M., Azizi, S. E., Mohamed, M., Gseyra, N., Touzani, R., & Hammouti, B. (2023). *Artemisia herba alba* Essential Oil: GC/MS analysis, antioxidant activities with molecular docking on S protein of SARS-CoV-2. Indonesian Journal of Science and Technology, 8(1), 1–18. https://doi.org/10.17509/ijost.v8i1.50737.

Do Nascimento, L. D., de Moraes, A. A. B., da Costa, K. S., Galúcio, J. M. P., Taube, P. S., Costa, C. M. L., Cruz, J. N., Andrade, E. H. de A., & de Faria, L. J. G. (2020). Bioactive natural compounds and antioxidant activity of essential oils from spice plants: New findings and potential applications. In Biomolecules (Vol. 10, Issue 7, pp. 1–37). MDPI AG. https://doi.org/10.3390/biom10070988.

Edziri, H., Mastouri, M., Chéraif, I., & Aouni, M. (2010). Chemical composition and antibacterial, antifungal and antioxidant activities of the flower oil of *Retama raetam* (Forssk.) Webb from Tunisia. Natural Product Research, 24(9), 789–796. https://doi.org/10.1080/14786410802529190.

Fauiod, O. G., Fadel, M., El-Hussein, A., & Fadeel, D. A. (2024). Aluminum phthalocyanine tetrasulfonate conjugated to surface-modified iron oxide nanoparticles as a magnetic targeting platform for photodynamic therapy of Ehrlich tumor-bearing mice. *Photodiagnosis and Photodynamic Therapy, 50*, 104356.

Goudjil, M. B., Zighmi, S., Hamada, D., Mahcene, Z., Bencheikh, S. E., & Ladjel, S. (2020). Biological activities of essential oils extracted from *Thymus capitatus* (Lamiaceae). South African Journal of Botany, 128, 274–282. https://doi.org/10.1016/j.sajb.2019.11.020

Haber, Z., & Rosenwasser, S. (2020). Resolving the dynamics of photosynthetically produced ROS by high-resolution monitoring of chloroplastic E GSH in Arabidopsis. https://doi.org/10.1101/2020.03.04.976092.

Hamdoon A. Mohammed, Kamal A. Qureshi , Hussein M. Ali, Mohsen S. Al-Omar, O. K. and S. A. A. Mohammed. (2022). Bio-Evaluation of the Wound Healing Activity of *Artemisia judaica* L . as Part of the Plant ' s Use in Traditional Medicine ; Antibiofilm Properties of the Plant ' s Essential Oils. Antioxidants, 11, 332. https://doi.org/10.3390/antiox11020332. https://doi.org/10.3390/antiox11020332%0AAcademic .

Harlev, E., Nevo, E., Lansky, E. P., Lansky, S., & Bishayee, A. (2012). Anticancer attributes of desert plants: A review. In Anti-Cancer Drugs (Vol. 23, Issue 3, pp. 255–271). https://doi.org/10.1097/CAD.0b013e32834f968c

Hashim, G. M., Almasaudi, S. B., Azhar, E., Al Jaouni, S. K., & Harakeh, S. (2017). Biological activity of *Cymbopogon schoenanthus* essential oil. Saudi Journal of Biological Sciences, 24(7), 1458–1464. https://doi.org/10.1016/j.sjbs.2016.06.001.

Kadri, A., Gharsallah, N., Damak, M., & Gdoura, R. (2011). Chemical composition and *in vitro* antioxidant properties of essential oil of *Ricinus communis* L. Journal of Medicinal Plants Research, 5(8), 1466–1470. http://www.academicjournals.org/JMPR.

Kchaou, M., Salah, H. Ben, Mnafgui, K., Abdennabi, R., Gharsallah, N., Elfeki, A., Damak, M., & Allouche, N. (2016). Chemical Composition and Biological Activities of *Zygophyllum album* (L.) Essential Oil from Tunisia. In J. Agr. Sci. Tech (Vol. 18).

Kulisic-Bilusic, T., Blažević, I., Dejanović, B., Miloš, M., & Pifat, G. (2010). Evaluation of the antioxidant activity of essential oils from caper (*Capparis spinosa*) and sea fennel (Crithmum maritimum) by different methods. Journal of Food Biochemistry, 34(SUPPL. 1), 286–302. https://doi.org/10.1111/j.1745-4514.2009.00330.x

Manoto, S. L., El-Hussein, A., Malabi, R., Kasem, M. A., & Mthunzi-Kufa, P. (2021). Exploring optical spectroscopic techniques and nanomaterials for virus detection. *Saudi Journal of Biological Sciences, 28*(1), 78–89.

Messaoud, C., Chograni, H., & Boussaid, M. (2012). Chemical composition and antioxidant activities of essential oils and methanol extracts of three wild Lavandula L. species. Natural Product Research, 26(21), 1976–1984. https://doi.org/10.1080/14786419.2011.635343.

Miguel, M. G. (2010). Antioxidant and anti-inflammatory activities of essential oils: A short review. In Molecules (Vol. 15, Issue 12, pp. 9252–9287). https://doi.org/10.3390/molecules15129252.

Mohamed, A. A., Ali, S. I., EL-Baz, F. K., Hegazy, A. K., & Kord, M. A. (2014). Chemical composition of essential oil and *in vitro* antioxidant and antimicrobial activities of crude extracts of *Commiphora myrrha* resin. Industrial Crops and Products, 57, 10–16. https://doi.org/10.1016/j.indcrop.2014.03.017.

Moreno-Rojas, J. M., Velasco-Ruiz, I., Lovera, M., Ordoñez-Díaz, J. L., Ortiz-Somovilla, V., De Santiago, E., Arquero, O., & Pereira-Caro, G. (2022). Evaluation of Phenolic Profile and Antioxidant Activity of Eleven Pistachio Cultivars (*Pistacia vera* L.) Cultivated in Andalusia. Antioxidants, 11(4). https://doi.org/10.3390/antiox11040609

Nikpour, H., Mousavi, M., & Asadollahzadeh, H. (2018). Qualitative and quantitative analysis of *Teucrium polium* essential oil components by GC–MS coupled with MCR and PARAFAC methods. Phytochemical Analysis, 29(6), 590–600. https://doi.org/10.1002/pca.2772.

Noumi, E., Snoussi, M., Trabelsi, N., Hajlaoui, H., Ksouri, R., Valentin, E., & Bakhrouf, A. (2011). Antibacterial, anticandidal and antioxidant activities of *Salvadora persica* and *Juglans regia* L. extracts. Journal of Medicinal Plants Research, 5(17), 4138–4146. http://www.academicjournals.org/JMPR

Ojha, N. K., Nematian-Ardestani, E., Neugebauer, S., Leipold, E., & Heinemann, S. H. (2014). Sodium channels as gateable non-photonic sensors for membrane-delimited reactive species. *Biochimica et Biophysica Acta - Biomembranes, 1838*(5), 1412–1419.

Ouahdani, K. El, Es-Safi, I., Mechchate, H., Al-Zahrani, M., Qurtam, A. A., Aleissa, M., Bari, A., & Bousta, D. (2021). *Thymus algeriensis* and *artemisia herba-alba* essential oils: Chemical analysis, antioxidant potential and *in vivo* anti-inflammatory, analgesic activities, and acute toxicity. Molecules, 26(22). https://doi.org/10.3390/molecules26226780.

Ouf, S. A., El-Amriti, F. A., El-Yasergy, K. F., El-Hussein, A., & Mohamed, M. S. M. (2024). Enhancing *Zea mays* L. seedling growth with He–Ne laser-irradiated *Alcaligenes* sp. E1 to mitigate salinity stress. *South African Journal of Botany, 173*, 208–216.

Papari, M., Fard, M., Ketabchi, S., & Farjam, M. H. (2020). Chemical Composition, Antimicrobial and Antioxidant Potential of Essential Oil of *Ziziphus spina-christi var. aucheri* Grown Wild in Iran. In Journal of Medicinal Plants and By-products (Vol. 1).

Rajput, V. D., Harish, Singh, R. K., Verma, K. K., Sharma, L., Quiroz-Figueroa, F. R., Meena, M., Gour, V. S., Minkina, T., Sushkova, S., & Mandzhieva, S. (2021). Recent developments in enzymatic antioxidant defence mechanism in plants with special reference to abiotic stress. In Biology (Vol. 10, Issue 4). MDPI AG. https://doi.org/10.3390/biology10040267.

Romeilah, R. M., El-Beltagi, H. S., Shalaby, E. A., Younes, K. M., Moll, H. El, Rajendrasozhan, S., & Mohamed, H. I. (2021). Antioxidant and cytotoxic activities of *Artemisia monosperma* L. and *Tamarix aphylla* L. essential oils. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 49(1), 1–15. https://doi.org/10.15835/nbha49112233.

Said, A., Fawzy, G., tabl, E. S. A. A., & Tzakou, O. (2010). Volatile constituents of *zizyphus jujuba* aerial parts and *zizyphus spina-christii* fruits from Egypt. Journal of Essential Oil-Bearing Plants, 13(2), 170–174. https://doi.org/10.1080/0972060X.2010.10643807.

Salem, N., Bachrouch, O., Sriti, J., Msaada, K., Khammassi, S., Hammami, M., Selmi, S., Boushih, E., Koorani, S., Abderraba, M., Marzouk, B., Limam, F., & Mediouni Ben Jemaa, J. (2018). Fumigant and repellent potentials of *Ricinus communis* and *Mentha pulegium* essential oils against *Tribolium castaneum and Lasioderma serricorne.* International Journal of Food Properties, 20, S2899–S2913. https://doi.org/10.1080/10942912.2017.1382508.

Tigrine-Kordjani, N., Meklati, B. Y., & Chemat, F. (2011). Contribution of microwave accelerated distillation in the extraction of the essential oil of *Zygophyllum album* L. Phytochemical Analysis, 22(1), 1–9. https://doi.org/10.1002/pca.1236

Yagi, S., Mohammed, A. B. A., Tzanova, T., Schohn, H., Abdelgadir, H., Stefanucci, A., Mollica, A., & Zengin, G. (2020). Chemical profile, antiproliferative, antioxidant, and enzyme inhibition activities and docking studies of *Cymbopogon schoenanthus* (L.) Spreng. and *Cymbopogon nervatus* (Hochst.) Chiov. from Sudan. Journal of Food Biochemistry, 44(2). https://doi.org/10.1111/jfbc.13107.

Younsi, F., Trimech, R., Boulila, A., Ezzine, O., Dhahri, S., Boussaid, M., & Messaoud, C. (2016). Essential Oil and Phenolic Compounds of *Artemisia herba-alba* (Asso.): Composition, Antioxidant, Antiacetylcholinesterase, and Antibacterial Activities. International Journal of Food Properties, 19(7), 1425–1438. https://doi.org/10.1080/10942912.2015.1079789

Zaïri, A., Nouir, S., Zarrouk, A., Haddad, H., Khélifa, A., Achour, L., Tangy, F., Chaouachi, M., & Trabelsi, M. (2019). Chemical composition, Fatty acids profile and Biological properties of *Thymus capitatus* (L.) Hoffmanns, essential Oil. Scientific Reports, 9(1). https://doi.org/10.1038/s41598-019-56580-y.

Zeragui, B., Hachem, K., Halla, N., & Kahloula, K. (2019). Essential Oil from *Artemisia judaica* L. (ssp. sahariensis) Flowers as a Natural Cosmetic Preservative: Chemical Composition, and Antioxidant and Antibacterial Activities. Journal of Essential Oil-Bearing Plants, 22(3), 685–694. https://doi.org/10.1080/0972060X.2019.1649200.

Table S1. Chemical constituents of some Egyptian desert plants essential oils.

Botanical Name	Plant Family	Essential Oil Name	Chemical Constituents	References
Artemisia herba-alba	Asteraceae	White Wormwood oil	Santolinatriene Tricyclene Alpha-Pinene Camphene Cis-Pinen-3-ol Thujene Beta-Pinene 3,3,6-Trimethyl-1,4-heptadien-6-ol 1,2,4-Trimethylbenzene (+)-4-Carene 1-Isopropyl-2-methylbenzene Benzene, 2-ethyl-1,3-dimethyl D-Limonene Eucalyptol Cyclopentene, 3-isopropenyl-5,5-dimethyl Ocimene Cis-3-Hexenyl iso-butyrate 1,5-Heptadien-4-ol, 3,3,6-trimethyl 3,3-Dimethyl-6-methylenecyclohexene Chrysanthone Thujone 1,6-Dimethylhepta-1,3,5-triene Trans-Pinocarveol Camphor P-Mentha-1(7),8(10)-dien-9-ol Santolina epoxide Borneol 4-Carvomenthenol (1R)-(-)-Myrtenal 2-Isopropylidene-5-methylcyclohexanone Bicyclo[3.1.1]hept-2-en-4-ol, 2,6,6-trimethyl-, acetate Trans-alpha-Bergamotene Bornyl acetate 1,3-Cyclopentadiene, 5,5-dimethyl-2-ethyl (1,3-Dimethyl-2-methylene-cyclopentyl)-methanol 3,5-Heptadienal, 2-ethylidene-6-methyl	(Diass et al. 2023)
***Artemisia judaica* L.**	Asteraceae	Judaean wormwood oil	Piperitone, ethyl cinnamate isomer, spathulenol , E-longipinane	(Hamdoon et al., 2022)
Balanites aegyptiaca	Zygophyllaceae	Desert date oil	Undecane Dodecane Tetradecane Pentadecane Hexadecane Heptadecane Octadecane Nonadecane Eicosane Heneicosane Docasane Tricosane Tetracosane Pentacosane Hexacosane Octacosane Cholesterol Campesterol Stigmasterol β-Sitosterol	(Al Ashaal et al. 2010)
Capparis spinose	Capparidaceae	Caper essential oil	methyl isothiocyanate approximately 92.06% of the oil Sec-butyl isothiocyanate Butyl isothiocyanate	(Kulisic-Bilusic et al. 2010)

			Benzeneacetaldehyde (E)-b-Ionone Methyl methylsalicilate Benzyl isothiocyanate Hexenyl benzoate Hexenyl benzoate	
Cleome droserifolia	Cleomaceae	Cleome droserifolia essential oil	N-(4-Methyl-3-pentenyl) pyrrolidine Benzylnitrile Palmitaldehydedibutylacetal Carvotanacetone γ-Muurolene δ-Cadinene cis-Nerolidol α-Cadinol Bis(2-ethylhexyl) phthalate	(Abd El-Gawad, 2018)
Commiphora myrrha ***Cymbopogon schoenanthus***	Burseraceae, torchwood Poaceae	Myrrh essential oil Camel hay (Lemongrass) oil	α-Pinene, Curzerene Furanocudesma-1,3diene, Furanocudesma-1,3-diene, Germacrone, Lindestrene Piperitone Cyclohexanemethanol β-Elemene α-Eudesmol Elemol β-Eudesmol 2-Naphthalenemethanol γ-Eudesmol	(Abdul-Ghani et al. 2009) (Hashim et al. 2017)
Lavandula coronopifolia	Lamiaceae	Lavender oil	cis-Caryophyllene, Dehydronerolidol, Isolongifolanone, Caryophyllene oxide, 10-epi-β-Eudesmol, Humulene.	(Abdoul-Latif et al. 2022)
Retama raetam	Fabaceae	White broom oil	2,7,12,17-Tetrabrom-(all-às) cyclotetrathiophen (2,7,12,17- tetrabromcycloocta[1,2-b:4,3-b':5,6- b'':8,7-b''']tetrathiophen 2-Methylhexadecane 2[3,4Bis(dodecyloxy)phenyl]4,4,5,5tetramethyl1,3,2dioxaborolane 2,4 - Decadienal 3-Methoxy-1-pentene Propanoic acid,2methyl,3hydroxy2,4,4trimethylpentyl ester Phenol,2,4bis(1,1dimethylethyl) Pentadecane Decanoic acid, methylester 2-Naphthalenol, - 8-amino 1,2Benzenedicarboxylicacid, bis(2methylpropyl) ester 1,1,1,2Tetrafluoro2tridecene Dodecanoic acid,3,7,11trimethyl, methylester 1-Octanol 3(5'Formyl2furyl)2propenal Octadecane, 1chloro 9- Octadecenoicacid (Z) 3Undecanol,3ethyl Noreserine Phosphonic acid,dioctadecyl ester 9,12, Octadecadienoic acid (Z, Z), methyl ester 9-Octadecenoic acid (Z), methyl ester (CAS) 2Hexadecen1ol,3,7,11,15tetramethyl, [R[R*, R*(E)]] (CAS) N(2Acetylcyclohexylidene) cyclohexylamine Docosane TransFarnesol 4,5 dihydro [1,2,4] triazolo[3,4d] [1,5] benzoxazepin1(2H) one 17 Octadecynoic acid Cis11Eicosenoic acid, methyl ester 3Pinanemethylisothiocyanate Eicosanoic acid, methylester (CAS) 9-Octadecenoicacid (Z)(CAS) 2,4bis(áchloroethyl)6,7bis[ámethoxycarbonylethyl]1,3,5trimethylporphyrin 3(Benzylthio)acrylicacid, methyl ester 17-Octadecynoic acid Hexadecanoic acid,methyl ester (CAS) ethyl3amino2,5dimethyl1,4,6trioxo1,2,5,6tetrahydro4Hpyrrolo[3,4c] pyridine7caeboxylate 17-Pentatriacontene , 12- Octadecadienoic acid (Z, Z),2,3dihydroxypropylester Squalene Chlorocadmium (1R,19R) 1,2,2,7,7,12,12 Heptamethyl 15 Cyan O19 methoxycarbonyl carrinate 5,10secoCholestan1(10) en3,5dione Stigmasterol 1,5Dimethyl6(1,5dimethylhexyl)15,16epoxy18oxatetracyclo [9.6.1.0(2,10).0(5,9)] octdecane13one (4Bromophenyl) bis(2,4dibromophenyl) amine	(Alwasia et al. 2023)
***Ricinus communis* L.**	Euphorbiaceae	Castor oil	Methyl isobutyl ketone (E)-4-octene	(Salem et al. 2018)

			Hexanal Methyl ethyl disulfide α-Pinene Sabinene β-Pinene 3-Octanol β-Myrcene α-Terpinolene Limonene 1,8-Cineole Benzene acetaldehyde Phenol Linalool Nonanal L-menthone Camphor Isomenthone Isomenthol Isopulegone Neoisomenthol 4-methylene cyclohexane methanol α-Terpineol Pulegone Piperitone Piperitenone Piperitenone oxide Isoquinolinone P- Menth-3-ene β-Caryophyllene α-Humulene Caryophyllene oxide β-Nootkatol 2,4-Diphenyl-4-methyl-2(E)-penten Hexadecanoic acid, methyl ester Phenol, 2-(1,1-dimethylethyl)-4-(1-methyl-1-phenylethyl)- 10,18-Bisnorabieta-8,11,13-triene 2,6-Di-tert-butyl-4-(2,4-dimethyl benzyl) pheno 10-Octadecenoic acid, methyl ester 3,7,11,15-Tetramethyl-2-hexadecen-1-ol Heptacosane Heneicosane Methyl dehydroabietate Octa-2,4,6-triene, 2,7-diphenyl Tetracosane 2,4-Diphenyl-4-methyl-1-pentene Hexacosane Phenol, 2,4-bis(1-methyl-1-phenylethyl) 2,4-Bis(dimethylbenzyl)-6-t-butylphenol Octacosane	
Salvadora persica	Salvadoraceae	Toothbrush Tree oil	a-Pinene b-Pinene p-Cymene 1,8-Cineole Terpinolene Linalool b-Thujone Camphor cis-Pinocamphone Terpin-4-ol a-Terpineol Linalyl acetate a-Caryophyllene b-Caryophyllene Aromadendrene Caryophyllene oxide Unidentified traces Monoterpene hydrocarbon Oxygenated monoterpene Sesquiterpene hydrocarbon	(Alali et al. 2004)
***Tamarix aphylla* L.**	Tamaricaceae	Athel tree oil	α-Pinene β-Pinene 1,8-Cineole o-Cymene γ-Terpinene Terpinolene α-Thujone Trans-pinocarveol Fenchyl alcohol α-Cyclocitral Cis-carveol Carvone Ledene	(Romeilah et al. 2021)

			Dodecanal Neryl acetone Aromadendrene α-Ionone Farenal Tridecanal γ-Cadinene Ledol Viridiflorol Tetradecanal Caryophyllene Farnesal Tetradecanoic acid Farnesoic acid 6,10,14-Trimethyl-2-pentadecanone Farnesyl acetone Hexadecanoic acid Docosan Tricosane Tetracosane Pentacosane Hexacosane Heptacosane Octacosane	
Teucrium polium	Lamiaceae	Cat thyme oil	Methyl-cyclopentane 24-Hexadiene 3-Methyl-butanal 2-Pentanone 2-Methyl-3-hexyne 56-Dimethyl-13-cyclohexadiene 123-Trimethyl-cyclopentene Toluene 3-Methyl-cyclohexene Hexanal Ethyl ester butanoic acid 1,2,4,4-Tetramethylcyclopentene trans-2-Hexenal 7-Methyl −1-octene Sorbaldehyde Isopropylsulfonyl chloride α-Thujene α-Pinen Camphene Sabinene L-β-Pinene 1-Octen-3-ol (3E5E) -26-Dimethyl-1357-octatetraene β-Myrcene 138-p-Menthatriene α-Phellandrene p-Cymene 2-Menthene o-Cymol D-Limonene Ocimene Phenylacetaldehyde p-Mentha-14-dien-7-ol 2-Methylenebornane 5-Isopropyl-2-methylbicyclo [3.1.0] hexan-2-ol 6-Camphenol 4-Isopropyl-1-methyl-2-cyclohexen-1-ol Linalool Nonanal (1R) -endo- (+) -Fenchyl alcohol 1-Octen-3-yl-acetate α-Campholenal Nopinone cis-Verbenol Verbenol 66-Dimethyl-2-methylenebicyclo [3.1.1] heptan-3-one 8-(1-Methylethylidene)bicyclo[5.1.0] octane 4-Methyl-1-(1-methylethyl) -3-cyclohexen-1-ol p-Acetyltoluene p-Cymen-8-ol	(Nikpour et al. 2018)
Thymus capitatus	Lamiaceae	Conehead Thyme oil	α-Thujene α-Pinene Myrcene α-Terpinene p-Cymene γ-Terpinene α-Terpinolene	(Zaïri et al. 2019)

			Linalool	
			Terpinen-4-ol	
			4-Carvomenthenol	
			Geraniol	
			Carvacrol	
			Thymol	
			Eugenol	
			Carvacryl Acetate	
			β-Caryophyllene	
			α-Humulene	
			allo-Aromadendrene	
			α-Bisabolol	
			α-Bisabolol oxide A	
			Hexadecanal	
			1-Hexadecanol	
			Rimuene	
			Hexadecanoic acid	
Ziziphus spina-christi* var. *aucheri	Rhamnaceae	Christ's thorn Jujube oil	Hexanoic acid	(Said et al. 2010)
			Borneol	
			cis-Linalool oxide	
			trans-Linalool oxide	
			(E)-2-Hexenyl butanoate	
			Octanoic acid	
			Myrtenol	
			γ-Terpineol	
			trans-Sabinene hydrate acetate	
			(E)-β-Ionone	
			Dodecanoic acid	
			β-Eudesmol	
			Valerianol	
			Heptadecane	
			Tetradecanoic acid methyl ester	
			Tetradecanoic acid	
			Heptadecanoic acid	
			1-Octadecene	
			Tetradecanoic acid ethyl ester	
			Octadecane	
			Hexahydrofarnesyl acetone	
			Nonadecane	
			Hexadecanoic acid methyl ester	
			Hexadecanoic acid	
			Eicosene	
			Hexadecanoic ethyl ester	
			Eicosane	
Zygophyllum album	Zygophyllaceae	Zygophyllum oil	Carvone	(Tigrine-Kordjani et al.2010)
			α-Terpineol	
			Geraniol	
			Verbenone	
			Linalool	
			Nerol	
			δ-Decalactone	
			Tricosane	
			cis-Linalool oxide	
			Geranial	
			Camphor	
			Heneicosane	
			trans-Linalool oxide	
			Terpinen-4-ol	
			Massoya lactone	
			β-Bisabolene	
			Pentacosane	
			4-Hydroxy-4-methyl-2,5-cyclohexadiene-1-one	
			2,6-di-(tert-butyl)-paraBenzoquinone	
			cis-Megastigma-5,8-diene-4-one	
			Nootkatone	
			1-Oxaspiro [2,5] octane-4,4-dimethyl-8-methylidene	
			2,2,3-Trimethylcyclopent-3-ene-1-ethanol	
			Borneol	