REVIEW DERLEME

DOI: 10.5336/pharmsci.2022-95011

Essential Oil Plants Traditionally Used in Wound Treatment: Systematic Review

Geleneksel Olarak Yara Tedavisinde Kullanılan Uçucu Yağ Bitkileri: Sistematik Derleme

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ABSTRACT Medicinal and aromatic plants such as *Artemisia judaica* L.., *Boswellia papyrifera* (Caill. Ex Delile) Hochst., *Calendula officinalis* L., *Centella asiatica* (L.) Urb., *Lavandula officinalis* Chaix, *Mentha x piperita* L., *Syzygium aromaticum* (L.) Merr. & L.M. Perry were used as treatment for some basic wounds for 6000 years. These plants were utilized by pounding in a mortar, melting with heat, or using with olive oil. On the other hand, these medicinal and aromatic plants are investigated for their wound-healing activity for the treatment of some chronic diseases such as diabetes, reflux, cancer, arthritis, stroke, hypertension, and obesity. Nowadays, many essential oils (lavender oil, clove oil, tea tree oil etc.) and extracts of these plants are studied treatment of diseases, especially skin diseases such as acne, urticaria, psoriasis, vitiligo, rosacea, atopic dermatitis, and wounds (puncture, surgical, incisions, thermal, chemical or electric burns, bites and stings). This review is a non-meta-analysis review, and it is aimed to provide information about medicinal and aromatic plants that carry important essential oils to share information not only about essential oils but also about the important main components in these oils, and to share some *in vitro* and *in vivo* relationships with the wound healing activities of these essential oils. In addition, wound healing studies with volatile components are also briefly mentioned. Plant names are listed in alphabetical order and briefly mentioned about the studies.

Keywords: Essential oil; aromatic plants; natural products; herbal drug

ÖZET *Artemisia judaica* L.., *Boswellia papyrifera* (Caill. Ex Delile) Hochst., *Calendula officinalis* L., *Centella asiatica* (L.) Urb., *Lavandula officinalis* Chaix, *Mentha x piperita* L., *Syzygium aromaticum* (L.) Merr. & L.M. Perry gibi tıbbi ve aromatik bitkiler yaklaşık 6000 yıldır anatomik ve fizyolojik olarak canlı doku bütünlüğünün bozulması olarak bilinen yaraların tedavisinde kullanılmaktadır. Bu tıbbi ve aromatik bitkiler havanda dövülerek, ısı yardımı ile eritilerek veya zeytinyağı ile birlikte bu yaraların tedavisinde kullanılmıştır. Öte yandan diyabet, reflü, kanser, artrit, inme, hipertansiyon ve obezite gibi bazı kronik hastalıkları tedavi etmek için bu bitkilerin yara iyileştirici etkinliği araştırılmıştır. Günümüzde pek çok uçucu yağ (lavanta yağı, karanfil yağı, çay ağacı yağı vb.) ve ekstreler bazı cilt hastalıklarının, özellikle akne, ürtiker, sedef hastalığı, vitiligo, rozasea, atopik dermatit gibi rahatsızlıkların ve yaraların (ponksiyon, cerrahi kesikler, termal, kimyasal veya elektrik yanıkları, ısırıklar ve sokmalar) tedavisi için çalışılmıştır. Bu derleme metaanaliz içermeyen bir derleme olup, önemli uçucu yağlar taşıyan tıbbi ve aromatik bitkiler hakkında bilgi verilmesi, sadece uçucu yağlar değil ayrıca bu yağlarda bulunan önemli başlıca bileşenler hakkında bilgi paylaşılması ve bu uçucu yağların yara iyileştirme aktiviteleriyle ilişkili bazı *in vitro* ve *in vivo* araştırmalar hakkında açıklama yapılması amaçlanmıştır. Ayrıca kısaca uçucu bileşenlerle yapılan yara iyi edici çalışmalardan da bahsedilmiştir. Bitki adları alfabetik olacak şekilde sıralanmış ve yapılan çalışmalardan kısaca bahsedilerek açıklanmıştır.

Anahtar Kelimeler: Uçucu yağlar; aromatik bitkiler; doğal ürünler; bitkisel ilaçlar

More than 50,000 medicinal and aromatic plants are known in the world, these plants possess essential oils that exhibit antimicrobial, antioxidant, and anti-inflammatory properties.[1,2] Treatment in wound healing was utilized ethnobotanically using the ash of *Echium italicium* L. and the roots of *Echium vulgare* L., which were known for their wound healing properties in Türkiye.[3,4] Additionally, *E. vulgare* extract was employed as a skin softener, friction suppressant, aphrodisiac.[5] In 1960s, wounds were treated by Dr.

TO CITE THIS ARTICLE:
Tepe M, Helvacı EZ, Karadağ AE. Essential oil plants traditionally used in wound treatment: Systematic review. J Lit Pharm Sci. 2024;13(1):8-17.

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Peer review under responsibility of Journal of Literature Pharmacy Sciences.

Received: 21 Dec 2022 ***Received in revised form:*** 19 Nov 2023 ***Accepted:*** 07 Dec 2023 ***Available online:*** 05 Jan 2024

Jean Valnet using essential oils such as lemon, clove, and chamomile.[6] Furthermore, various medicinal and aromatic plants including rose, geranium, myrrh aromatic plants, and medicinal chamomile were utilized for treatment in wounds.[7-10] This review aims to give some information and details about aromatic plants and their essential oils utilized for the treatment of wounds.

The number of plants traditionally used in wound treatment is high and in this review, these plants are limited to "essential oil bearing plants". Therefore, if these "essential oil-bearing plants" have ethnobotanical use in wound treatment, or if they gave successful results in wound treatment (extract or essential oil) in experimental studies, they were included in this study. This review excludes meta-analysis, and in this context, the plants that carry essential oil and also their traditional preparation, extract or essential oil are the subject of experimental or ethnobotanical studies are listed below in alphabetical order. The results presented in the study were prepared by compiling previous studies from scientific literature search engines such as PubMed (NCBI, USA), Google Scholar (Google, USA), etc.

IN VITRO AND *IN VIVO* STUDIES RELATED TO WOUND-HEALING PLANTS

The some major compounds of essential oils and medicinal and aromatic plants were given in Table 1 (Figure 1).

TABLE 1: Wound Healing Plants and major compounds into their essential oils.

Plant names	Major compounds of essential oil	References
Anethum graveolens	α-phellandrene, p-cymene and carvone	11
Artemisia judaica L.	Terpinene-4-Ol, α-Thujone, Cis-Ethyl Cinnamate	12
Artemisia absinthium L	*β*-thujone, *α*-copaene, linalool	13
Boswellia papyrifera	Octanol Acetate, 12-Acetoxy-2,6,10-Trimethyl, Nerolidol	14
Cinnamomum verum J. Presl	cinnamaldehyde, eugenol, and linalool	15
Croton adamantinus Müll. Arg.	α-Pinene, Sabinene, β -Caryophyllene	16
Eucalyptus globulus	Eucalyptol, Citronellol, D-Limonene	17
Foeniculum vulgare	Limonene, Trans-Anethole, α-Pinene	18
Helichrysum italicum	Γ-Curcumene, And B-Selinene, α-Pinene	19
Hibiscus rosa sinensis	1 - Iodoundecane, 2, 2, 4-Trimethyl 3-Pentanone, 1,2 Benzenedicarboxylicacid Isodecyl Octyl Ester	20
Hypericum perforatum L.	β-Caryophyllene, Germacrene D, Cis-P-Menth-3-En-1,2-Diol	21
Lavandula officinalis	Linalool, eucalyptol, L-camphor	22
Melaleuca alternifolia	Terpinene-4-ol, γ-terpinene	23
Matricaria chamomillla L.	Menthol, Spathulenol, (E)- β -Farnesene	24
Mentha piperita L.	Menthol, Menthone, Limonene	25
Mentha pulegium	Pulegone and terpinen-4-ol	26
Myrtus communis	Myrtenyl acetate, Linalool and 1,8-cineole or eucalyptol	27
Ocimum grassimum	Linalool, 1,8-cineole	28
Origanum vulgare L.	P-Cymene, Thymol, Carvacrol	29
Pelargonium graveolens	Citronellol, Citronellyl Formate, Γ-Eudesmol	30
Pinus pinaster	α-Pinene, β-Pinene, Trans-Caryophyllene	31
Piper nigrum	Eugenol, Trans-Cinnamaldehyde, Carvacrol	32
Pistacia vera L.	α-Pinene, Hydroxydammarenone, Tirucallol	33
Phlomis rigida	Phlorigidoside A (2-O-acetyllamiridoside), Deoxypulcheloside I, 6-β-hydroxyipolamide	34
Phlomis russeliana	α-Caryophyllene, caryophyllene oxide	34
Syzygium aromaticum	Eugenol, β-Caryophyllene, α-Caryophyllene	35
Tetradenia riparia	Fenchone, α-Cadinol, 14-Hydroxy-9- Epi-Caryophyllene	36
Trachyspermum ammi L.	Terpinene (Γ-), Thymol, Carvacrol	37

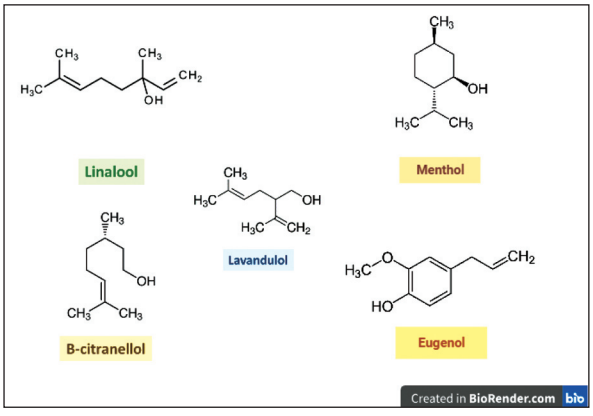

FIGURE 1: The some major compounds of essential oils.

***Anethum graveolens* L.:** This plant is known as a well anti-inflammatory, antimicrobial, antioxidant and wound treatment agent and is used ethnobotanically. An ointment containing *A. graveolens* essential oil was applied for 16 days on an MRSA-infected wound model in a study. For the group that treated with an ointment containing *A. graveolens* essential oil, a significant increase in fibroblast cell count and collagen density was observed compared to the control group. Moreover, a significant degree of re-epithelialization was observed between days 8 and 12 in the wound treated with *A. graveolens* essential oil. By the end of the 16th day period, complete epithelialization was observed in the wound treated with the formulation containing 4% essential oil.[11]

***Artemisia absinthium* L.:** It was reported in numerous ethnopharmacological studies that *A. absinthium* possesses antidiabetic, antihypertensive, and wound healing activity. In a previous study, ointments were prepared using two different concentrations of essential oil obtained from the aerial parts of the *A. absinthium*. The group treated with the ointment containing 10% of *A. absinthium* essential oil exhibited the most favorable results in the wound model. Although no significant difference was observed compared to the control group in terms of healing, the healing rate was better in the *A. absinthium* essential oil -treated group. Furthermore, inflammation decreased rapidly in the wounds treated with *A. absinthium* essential oil.[13]

***Artemisia judaica* L.:** Traditionally, *A. judaica* was utilized for the treatment of skin diseases. Previous *in vivo* and *in vitro* studies demonstrated the wound healing effects of its essential oil. In a study, an ointment containing *A. judaica* was applied to burn wounds in rats for a duration of 21 days. The results of this study revealed a significant increase in the activities of superoxide dismutase (SOD) and catalase (CAT), which are antioxidant enzymes. Additionally, the levels of transforming growth factor (TGF β-1), an anti-inflammation agent, were observed to increase, while the levels of tumor necrosis factor (TNF) levels decreased.[12]

***Boswellia papyrifera* (Caill. ex Delile) Hochst.:** The essential oil of *B. papyrifera* is used ethnobotanically for wound treatment. In a study, nanoparticles of *B. papyrifera* essential oil were prepared and tried for wound treatment. It was reported that the amount of collagen fibers and TGF-β1 were increased, while the level of interleukin-6 level declined. This study demonstrated that inflammation was reduced and tissue epithelization was improved by this essential oil.[14]

***Bursera morelensis* Ramírez:** In the studies, the mechanism of action of *B. morelensis* essential oil in the healing process was determined for migration of fibroblasts to the wound area. In a previous study, the wound healing effect of the essential oil was demonstrated through both *in vitro* and *in vivo* methods.[38]

***Cinnamomum verum* J. Presl:** *In vitro* studies utilizing Cinnamon essential oil demonstrated an increase in cellular proliferation and a reduction in inflammation, indicating its wound healing effect.[39] In another study, ointments containing *C. verum* essential oil at concentrations of 2% and 4% were prepared using soft yellow paraffin. The application of these ointments on wounds resulted in a significant shortening of the inflammatory phase and an increase in collagen accumulation, particularly in the group treated with the 2% ointment compared to the control group. Additionally, the application of the ointments accelerated cellular proliferation, re-epithelialization and keratin synthesis on the wound.[39]

***Citrus reticulata* Blanco:** The wound healing effects of the essential oil obtained from the peel of *C. reticulata* were investigated in animals and an effect

very close to that of the positive control group was observed in the group treated with the essential oil.[40]

***Croton adamantinus* Müll. Arg.:** Traditionally, *Croton* species were used for various diseases including wound healing. In a study, it was demonstrated that the essential oil derived from *Croton* species enhanced tissue epithelization and accelerated wound healing activity. The essential oils of *Croton* were applied to skin wound models in mice. It was observed through this research that wound contraction, epithelization, fibroblast population, and collagen deposition were increased.[16]

***Eucalyptus globulus* Labill.:** In traditional medicine *Eucalyptus* essential oil is used for skin disorders and to expedite wound healing.[41] The wound healing activity of the essential oil of *E. globulus* fruits was investigated in a previous study. The application of the oil on rats with both linear and circular wound models demonstrated its anti-inflammatory and wound healing activities.[42] This previous study showed a significant wound healing activity, as well as a reduction in the level of inflammation in the wounds.[42]

***Eugenia dysenterica* DC.:** In a previous study, it was demonstrated that stimulation for migration in epithelial cells is provided by *E. dysenterica* essential oil. The angiogenic activity of the oil was evaluated using the The Chick Chorioallantoic Membrane. It was found that the essential oil induced skin cell migration in a scratch test at a concentration of 542.2 µg/mL.[43]

***Foeniculum vulgare* Mill.:** In ethnobotanical usage, *F. vulgare* is highly valued for its effectiveness in wound treatment. Fenchone and limonene are the major compounds found in the essential oil of fennel, and these compounds were utilized in this study. The experimental study involved the preparation of four different groups: olive oil group, fenchone group, limonene group, and limonene+fenchone group. Various parameters including epidermal regeneration, granulation tissue thickness, and angiogenesis were evaluated in these groups. On the tenth day of treatment, a significant increase in wound contraction and re-epithelization was observed in the wound models treated with fenchone and fenchone+limonene, as compared to the control group. The fenchone+limonene group also demonstrated anti-inflammatory and antimicrobial activity on the wound.[44]

***Helichrysum italicum* (Roth) G.Don:** Due to its anti-inflammatory, wound healing, and antibacterial properties, *H. italicum* is utilized ethnobotanically for various diseases.[45] In a study, ointment and gel formulations containing *H. italicum* essential oil were applied to rats with streptozotocin-induced diabetic wounds. After 21 days, all groups showed enhanced wound contraction and epithelialization compared to the control group. *H. italicum* essential oil exhibited strong antiproliferative activity in human dermal cells and activated important mediators involved in tissue remodeling and angiogenesis events.[19]

***Hibiscus rosa-sinensis* L.:** In a study, *H. rosa-sinensis* extract was applied to rats with various wound models (excision, incision, and dead space) for a duration of 18 days. The application of *H. rosa-sinensis* extract positively induced wound contraction and epithelialization.[46]

***Hypericum perforatum* L.:** Wound treatment with this plant was practiced ethnobotanically.[47] In a study, the wound healing effects of essential oils extracted from three different *Hypericum* species (*Hypericum empetrifolium* Willd., *Hypericum triquetrifolium* Turra, and *H. perforatum*) were compared. In experiments conducted on hairless SKH-hr1 mice, it was observed that all *Hypericum* species exhibited wound healing effects, with *H. empetrifolium* demonstrating the highest efficacy, while *H. perforatum* and *H. triquetrifolium* were found less effective.[48]

***Lavandula* sp.:** Healing activity in many wounds is exhibited by lavender oil, which is also used ethnobotanically. In a previous study, circular full-thickness skin wounds were created on rats, and *Lavandula angustifolia* Mill. essential oil, as well as a control solution, were applied to the wounds for a duration of 14 days. Approximately 4 days after the application, a significant decrease in the wound area was observed. Furthermore, lavender oil significantly increased the synthesis of Type I and type III collagen, expression of TGF-β, and the number of myofi-

broblasts.[49] *Lavandula stoechas* L. was also studied for its wound healing effect.[50] The essential oil of *Lavandula x allardii* Hy, on the other hand, was investigated in combination with honey in a wound model, and it was revealed that its wound healing effect was quite high.[51] Lavender species and essential oils derived from different species of this genus are widely popular in studies involving wound models. Another species within this genus is *Lavandula aspic* Medik.[52]

***Matricaria chamomillla* L.:** Traditionally, *M. chamomilla* essential oil is utilized for its antiseptic, anti-inflammatory, and wound healing properties.[53] The European Medicines Agency reported that this plant oil is effective in treating minor inflammation in the skin, such as sunburn, and it can be used for superficial wounds and small boils.[54]

***Melaleuca alternifolia* (Maiden & Betche) Cheel:** Traditionally, *M. alternifolia* is used for the treatment of various diseases. Numerous previous studies demonstrated the remarkable wound healing effect of *M. alternifolia* essential oil, which not only reduces the healing time but also exhibits anti-inflammatory properties. In this *in vivo* study, a bicontinuous microemulsion formulation containing *M. alternifolia* essential oil was applied to wound models. After 11 days, complete healing was observed in formulations loaded with 1% and 3.45% *M. alternifolia* essential oil.[55]

***Mentha* x *piperita* L.:** *Mentha*, a medicinal herb widely used in folk medicine, is commonly applied for the treatment of flu, headache, red eyes, fever, and sore throat.[56] In an experimental study, peppermint oil was topically applied to excision wounds in BALB/c mice for a duration of 16 days. By the end of the 16th day, both the mupirocin (positive control) and peppermint oil groups exhibited a decrease in wound area compared to the control group. The peppermint oil groups (4% and 8%) demonstrated lower levels of oedema compared to the other groups. Additionally, the evaluation of epithelization, fibroblast infiltration, and collagen deposition showed the highest levels in the *M. piperita* oil groups (4% and 8%) compared to the control group.[57]

***Mentha pulegium* L.:** *M. pulegium*, traditionally utilized for respiratory diseases, endocrinological wounds, and gastrointestinal disorders, was the focus of this study.[58] Nanostructured lipid carriers loaded with *M. pulegium* essential oil were formulated into a gel. The healing process of cutaneous wounds, including wound contraction, histological parameters, and molecular aspects, was investigated using BALB/c mice. The results demonstrated that the formulated gel shortened the inflammation period and accelerated the proliferation phase in wound healing. The group treated with *M. pulegium* essential oil exhibited higher levels of vascularization and granulation tissue compared to the control group.[59]

***Myrtus communis* L.:** In previous studies, *M. communis* essential oil was observed to stimulate macrophage cells, increase certain protein levels, and reduce inflammation factors.[60] To enhance its delivery and effectiveness, *M. communis* essential oil was microencapsulated by mixing it with maltodextrin and an emulsion. This microencapsulated myrtle essential oil was then administered orally to Wistar rats with acute gastric ulcers at dosages of 250, 500, and 1,000 mg/kg daily for 21 days. Microscopic analyses revealed that the treated group showed no gastric lesions compared to the control group. The percentage of ulceration was the lowest in the group receiving the plant extract with a dosage of 1,000 mg/kg compared to all other groups. Furthermore, the highest percentage of healing was observed in the groups receiving the highest dosage (1,000 mg/kg). It was determined that microencapsulated myrtle essential oil effectively suppressed oxidative damage and could be used as a treatment for acute gastric lesions. Additionally, it significantly reduced gastric acidity and exhibited a potent anti-inflammatory effect by reducing the activity of antioxidant enzymes such as SOD, CAT, and glutathione peroxidase.[27]

***Ocimum gratissimum* L.:** The wound healing activity of *Ocimum* essential oil was investigated in albino rats with excisional wounds for fifteen days, and it was observed that the plant oil-treated group exhibited higher levels of epithelization, anti-inflammatory activity, closure of cutaneous wounds, and antibacterial activity compared to the control group. Based on the results of this previous study, it can be concluded that *Ocimum* essential oil can be utilized for the treatment of wounds.[61]

***Origanum vulgare* L.:** The wound healing activity of *Origanum* essential oil was observed in previous studies, and it is traditionally used to treat several diseases.[62] In one study, the cytotoxic activity of *O. vulgare* essential oil was evaluated in the human keratinocytes cell line NCTC 2544 at 48 and 72 hours. Additionally, wound healing was measured using a scratch assay at 24, 48, and 72 hours. It was found that *Origanum* essential oil effectively promoted cell migration without causing changes in cell morphology. This study concluded that *Origanum* essential oil could be a beneficial treatment for inflammation by supporting cell motility in wounds.[29]

***Pelargonium graveolens* L'Hér.:** The potential treatment of wounds and ulcers using *Pelargonium* essential oil was observed, and it is also used traditionally for this purpose.[63] In a conducted study, a cream formulation containing *P. graveolens* essential oil was applied to a wound model. The results of the experiment showed that there was no significant difference in the antibacterial properties between the positive control group and the group treated with the essential oil. However, in terms of the wound healing process, higher levels of collagen accumulation and tissue granulation were observed in the group treated with the essential oil compared to the positive control.[64]

***Pinus pinaster* Aiton:** The essential oil of *P. pinaster*, containing major compounds such as α-pinene and β-pinene, exhibits good wound healing activity and is used traditionally for this purpose. Essential oil was incorporated into Madecassol (Bayer, Germany) ointment base at a concentration of 1% and formulated as an ointment with propylene glycol and liquid paraffin. Comparisons were made with n-hexane, acetone, and positive control groups. The ointment containing the essential oil extracted from the cones showed the highest wound tensile strength in both linear and circular excision models, surpassing the other groups. Application of the cone essential oil resulted in degeneration of sebaceous glands around hair follicles and increased vascularization. The study concluded that the essential oil derived from the cones was the most effective component for wound healing.[31]

***Piper nigrum* L.:** The essential oil of *P. nigrum*, which is used to treat painful wounds, has been found to exhibit antiproliferative activity on dermal fibroblasts.[65] When dissolved in DMSO, black pepper essential oil (BPEO) was shown to induce tissue formation and promote wound healing activity. The cytotoxic activity of this essential oil was evaluated in primary human neonatal fibroblasts using the sulforhodamine B assay at 24 hours. The results revealed that BPEO had an antiproliferative effect on this cell line. Furthermore, BPEO was found to suppress the synthesis of plasminogen activator 1, indicating its wound-healing activity, as reported in the study.[66]

***Pistacia* sp.:** In the Mediterranean area, the oleoresins of *Pistacia lentiscus* L. and *Pistacia atlantica* Desf. are utilized for their pharmacological effects, including the reduction of blood pressure, anti-inflammatory, antimicrobial, hypoglycemic, wound healing, and analgesic properties.[67-69] In this study, two different ointments were prepared using essential oils from Algerian and Italian *Pistacia* species, which were mixed with petroleum jelly to create Essential Oil Algerian and Italian Ointments formulations [EOAO (5%) and EOIO (5%)]. These ointments were applied to New Zealand albino male rabbits with eye and acute dermal irritations for a duration of 16 days. After treatment, a higher percentage of wound contraction was observed in all essential oil groups and the group treated with reference drugs compared to the control group. Additionally, the rabbits in the essential oil-treated groups exhibited significant collagen deposition and re-epithelization.

***Phlomis rigida* Labill.:** The *Phlomis* genus is traditionally used for the treatment of various conditions, including as a stimulant, diaphoretic, and for wounds, coughs, and colds.[34] In this study, the aerial parts of *P. rigida* were extracted using methanol, and the cell proliferation of RAW 264.7 and L929 healthy mouse fibroblasts was investigated under treatment with *P. rigida* extract for 24 hours. By the 10th day, almost all wounds were healed in the group treated with Madecassol® and *P. rigida* compared to the control group. This study suggests that the extract of this plant plays a role in wound healing.[70]

***Phlomis russeliana* (Sims) Lag. ex Benth.:** Carbopol aqueous gel and hydroxypropyl cellulose gel, mixed with plant extract, glycerin, and isopropyl alcohol, along with a blank gel, were prepared. These gels were applied to BALB-c mice with full-thickness excisional skin wounds for a duration of ten days. Nitric oxide levels and PGE2 were found to decrease in all doses of the gels containing plant extracts compared to the control group. Madecassol® and the gel containing the plant methanol extract were observed to promote wound healing by the end of the ten-day period. Furthermore, the plant gel group exhibited increased angiogenesis, epidermal-dermal regeneration, granulation tissue thickness, and collagen formation compared to the control group.[71]

***Salvia officinalis* L.:** In the study, the healing process was supported by *S. officinalis* essential oil, as the expression of proinflammatory cytokines was reduced and the inflammatory phase was shortened by cellular proliferation stimulation in the proliferation phase. Additionally, it was shown that tissue antioxidant status and angiogenesis could be improved by *S. officinalis*, as it upregulated the expressions of fibroblast growth factor-2 and vascular endothelial growth factor.[72]

***Syzygium aromaticum* (L.) Merr. & L.M. Perry:** *S. aromaticum* is used ethnobotanically to relieve pains and wounds.[73] In the study, the preparation of nanoemulsions using triacetin (oil phase), Tween-80 (surfactant), Labrasol (cosurfactant), and distilled water (aqueous phase) was employed, and a transparent nanoemulsion containing *S. aromaticum* was added. This nanoemulsion, which included clove oil, was applied to four different groups of Albino Wistar rats with full-thickness wounds for ten days, along with pure clove essential oil, nanoemulsion with clove oil, and gentamycin administered orally. The results showed that the contraction of the wound area was higher in the group treated with nanoemulsion containing clove oil and gentamycin compared to the group treated with pure clove oil and the control group. Similarly, the epithelization period was shorter in the group treated with gentamycin and nanoemulsion compared to the group treated with pure clove oil. Fibroblast proliferation, neovascularization, and collagen deposition were enhanced in all treated groups with gentamycin compared to the control group. Among all the treated groups, the group treated with nanoemulsion containing clove oil exhibited the highest inflammatory response. Based on the study, nanoemulsion with clove oil can be utilized for wound healing.[74]

***Tetradenia riparia* (Hochst.) Codd:** In general, this medicinal plant was traditionally used for wound healing in South Africa.[75]

***Trachyspermum ammi* L. :** Although *T. ammi* was not traditionally used in ethnobotanical practices for treating skin diseases or promoting wound healing, various preparations containing the essential oil extracted from this plant have demonstrated wound healing activities. The cytotoxic effects of the essential oil nanofiber mats were assessed on L929 fibroblast cells using the MTT assay for 24 hours. For the wound healing assay, male Sprague-Dawley rats with full-thickness circular wounds infected with *Staphylococcus aureus* were treated with these core-shell essential oil nanofiber mats for a period of 14 days. The essential oil nanofiber mats exhibited the highest antioxidant activity compared to the control group. Furthermore, the percentage of cell viability was found to be the lowest in the essential oil nanofiber mats group at 24 hours, but this cytotoxic activity reduced at 48 and 72 hours. By the end of the 14-day treatment period, complete wound healing was observed in the groups treated with the essential oil nanofiber mats, in contrast to the control group. The results of this study indicate that the wound healing efficiency can be enhanced through the utilization of core-shell electrospun nanofibers containing the essential oil.[37]

CONCLUDING REMARKS AND FUTURE PERSPECTIVES

Wounds become related to out of some physical agents, unless they can't healed, it leads serious problems. Medicinal and aromatical plants and their extracts was utilized for the treatment of these wounds. Nowadays, these plants essential oils can be used in the treatment of wounds such as burns, ulcers, skin disease wounds.

In this review, the records of the wound healing effect of 30 essential oil bearing plants were examined. It can be seen that many "traditional herbal preparations" as wound healing agents in parallel with their traditional use have potential in wound treatment. Since only crude extracts and essential oils were reviewed in this study, the study on pure components may be the subject of a new review. However, it can be said that the effects of all these extracts and essential oils are generally due to their major components. The aim of this review is to share wound-healing plants and their essential oils, and also give some information about recent *in vitro* and *in vivo* studies related to these essential oils.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

All authors contributed equally while this study preparing.

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