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Review article

Burn healing plants in Iranian Traditional Medicine

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Abstract

Burns are known as one of the most common forms of injury with devastating consequences. Despite the discovery of several antiseptics, burn wound healing has still remained a challenge to modern medicine. Herbal products seem to possess moderate efficacy with no or less toxicity and are less expensive compared to synthetic drugs. Burn is a well-known disorder in Iranian Traditional Medicine (ITM). Iranian physicians have divided burns into various types based on the cause and recommended treatment for each type. According to ITM references, herbal therapy was the major treatment prescribed by Iranian physicians for burns. In the present study, seven ancient Iranian medical texts were screened for the herbs with burn healing effects along with their applied dosage forms. The medicinal herbs were listed and scored based on the frequency of their repetition. Moreover, the best scientific name that was suitable for each plant as well as surveying modern studies about their biological effects has been carried out. In our investigation eighteen plants with seven topical application categories have been obtained as the most frequent herbs for burn healing in ITM. Modern studies have revealed that these plants have shown some biological activities such as anti-inflammatory, antimicrobial and antioxidant effects which might establish the relationship between the mentioned activities and burn wound healing property. This list can provide a suitable resource for future researches in the field of burn treatment.

Keywords*:* anti-bacterial, anti-inflammatory, antioxidant, burn healing, Iranian Traditional Medicine

Introduction

Burns are one of the most common and devastating forms of trauma, with outcomes spanning the spectrum from physical impairments and disabilities to emotional and mental consequences [1, 2]. Burn management entails significant duration of hospital stay, expensive medication, multiple operative procedures and prolonged period of rehabilitation [2, 3]. Burn is defined as tissue injury caused by heat, chemicals, electricity, radiation, etc. [4]. Thermal burn and related injuries have remained a major cause of death and disability [5]. According to the depth, burn wounds are classified as first degree (superficial), second

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degree (partial thickness) and third degree (full-thickness). Burn wound healing is a complicated process including inflammation due to disruption of blood vessels and extravasation of blood constituents, re-epithelialization that begins several hours after injury, formation of granulation tissue, neovascularization, migration and mitogenic stimulation of endothelial cells and finally wound contraction as a result of interaction between cells, extracellular matrix and cytokines. Severe burn wounds need to be treated as soon as possible since any delay can postpone the healing process or result in infection [4]. This makes burn care expensive and every effort should be made to provide a shorter treatment period for the burnt patients [3]. Although small burns are not usually life threatening, they need the same attention as large burns, in order to achieve functional and cosmetic outcome. Most of the early treatments include topical application of medicaments, mainly to prevent infections [5]. Healing of burn wounds still remains a challenge to modern medicine, though many antiseptics have been discovered [3]. It may be due to the fact that most of the available products have antimicrobial activity rather than wound healing effect, as well as their probable negative performance and toxicity as in the case of silver sulfadiazine on fibroblasts [4]. Improving the methods of wound healing and tissue repair offers enormous opportunities to enhance the quality of life for trauma and burn patients. It may also help to reduce health care costs. Nowadays, many drugs with natural sources have been retrieved from traditional medical systems [5]. In Iranian Traditional Medicine (ITM), plants have been used to combat various diseases and pathological conditions. Burn is a well-known disorder in ITM and several traditional prescriptions have been recommended for burn healing. According to ITM manuscripts, topical preparations have been considered as the main treatment for burns, though in some cases, phlebotomy was prescribed. ITM scholars believed that there were two stages which should be noticed in burn treatment. The aim of the first stage was prevention of blistering by cooling and non-irritant agents. However, extra cooling should have been avoided due to the heat retention which might lead to tissue decomposition. In this situation, oils were usually useful to remove the heat. In the second stage, if the blister had been formed, detergent and desiccant medications with moderate hot and cold temperament were recommended. Generally, low fat desiccant products were preferred for wet wounds, whereas, wet temperament preparations or oils and waxes were considered as suitable medications for dry wounds [6,7]. Moreover, different dosage forms have been used in ITM for burn healing. The aim of the present study has been introducing some medicinal plants and their dosage forms used in ITM for burn healing.

Methods

Seven ITM texts including *al-Qanun fi al -Tibb* (*Avicenna*) [7], *Al Havi* (*Rhazes*) [8], *Al-abniah An Haghayegh el-adviah* (*Heravi*) [9], *al-jāmi li-mufradāt al-adwiyawa al-aghdhiy* (*Ibn al-Baitar*) [10], *Ekhtiarat-e-Badiee* (*Ansari*) [11], *Tohfat-ul-momenin* (*Mo'men tonekaboni*) [12] and *Makhzan-ul-Adviah* (*Aghili Shirazi*) [13] were studied. The traditional word of "hargh" was considered as the keyword for extracting the plants with healing effect in all kinds of burns. First *al-Qanun fi al –Tibb*, the main text of ITM, was screened using the keyword and the burn healing property of the selected plants was checked in the rest of ITM texts to find the most frequently used plants. In addition to the temperament and used part, different dosage forms of the chosen plants, applied to burns, have been studied. So, the description of the used dosage forms has been investigated [14]. Afterwards, traditional names of the selected plants were matched to the scientific names using botanical text references [15-17]. In the next step, a substantial search has been performed in scientific databases such as ''Google Scholar'' and ''pubmed'' to find the plant biological activities concerning burn healing effect. For this

purpose, the scientific plant names in combination with the key terms including "burn healing", "wound healing", “antioxidant”, “anti-inflammatory and “antibacterial" were used separately and *in vivo*, *in vitro* and clinical trials regarding to the search terms have been screened.

Results and Discussion

Searching ITM references revealed eighteen plants as the most frequently used herbs for burn healing which have been listed in table 1. These plants have been ordered according to their repetition in the references along with their traditional names, family, temperament, used parts, dosage forms and biological effects. The plant parts which had been used for burn healing consisted of leaves, flowers, fruits, seeds, seed oil, roots, bulbs, barks and gum resins while leaves appeared to be the most used parts among others. According to table 1, most of the herbs have hot and dry temperament (>66%) while dryness is the prominent characteristic of the majority of burn healing plants introduced by Iranian scholars (>83%). Different types of dosage forms used in ITM for burn healing have been summarized in table 2. All of the mentioned dosage forms were used topically. Among them “Dohn”, “Marham”, Qeirooti” and “Zemad” (with oily base) could be suitable for dry wounds, whereas, “*Tela*”, “*Natool*”, “*Zaroor*” and “*Zemad*” (without oily base) were useful for wet burns. In addition to the summarized biological effects in table 1, the results of *in vitro/in vivo* tests or clinical trials performed on the plants and the probable mechanisms have been mentioned as follows:

Lawsonia inermis L.

The inhibitory effects of chloroform and aqueous extracts of *L. inermis* leaves on the growth of microorganisms that are involved in burn infections has been proven [18]. The animals treated with ethanol extract of the plant leaves showed reduction in the wound area, therefore, topical formulation of ethanol extract could be successfully used for the wound healing [19,20]. The antioxidant potential of different fractions of *L. inermis* has been demonstrated through DPPH and *β*-carotene-linoleic acid assays as well [21]. The anti-inflammation effects of the plant leaves have been established in a manner that butanol and chloroform fractions exhibited more potent anti-inflammatory effect than aqueous fraction, dose dependently [22].

Hypericum perforatum L.

The healing properties of *H. perforatum* ointment have been evaluated and the histopathological results, along with the wound contraction rate and period of epithelialization, have demonstrated the healing effect of *H. perforatum* ointment in linear incisions, circular excisions and thermal burn wounds [23]. Moreover, a clinical research has shown that applying a specific *H. perforatum* ointment (Gol-Daru company) three times a day for 16 days has significantly improved wound healing and has reduced scar formation compared to placebo [24]. The ethanol extract of the plant has demonstrated anti- inflammatory effects in carrageenan induced pedal edema and cotton pellet induced granuloma model [25]. A flavonoid-rich extract of *H. perforatum* L. has exhibited antioxidant activity as an effective scavenger in quenching DPPH and superoxide radicals [26]. The available literature indicates that different extracts and preparations of *H. perforatum* possess more antibacterial activity against gram-positive than gram-negative bacteria in *in vivo* and *in vitro* tests [27].

Myrtus communis L.

Joursaraei *et al.* have demonstrated that *M. communis* extract could increase revascularization and the number of fibroblasts in second degree burn wounds in rats [28]. Myrtucommulone, a nonprenylated acylphloroglucinol constituent in the leaves of *M. communis*, has exerted potent *in vivo* anti-inflammatory effects [29]. In addition to the protecting effect of *M. communis* fruits against gastric ulcer, the antioxidant activity of the plant

Table 1. The most frequent herbs in ITM for burn healing

No.	Traditional name	phonetics	Scientific name	Family	Temperament	Part used	Dosage form	Biological effects[a]
1	Henna	/hennɑː/	*Lawsonia inermis* L.	Lythraceae	Cold and dry	Leaf	Natool	B [19, 20] , C [22], D [21], E [18]
2	Hiofariqun	/hɪuːfɑːrɪɢuːn/	*Hypericum perforatum* L.	Hypericaceae	Hot and dry	Leaf	Zemad	A [23] B [23, 24] , C [25], D [26], E [27]
3	Ass	/ɑːs/	*Myrtus communis* L.	Myrtaceae	Cold and dry	Leaf/fruit	Dohn, Marham, Qeirooti, Zaroor, Zemad (with olive oil)	A [28] B [30], C [29], D [30], E [31]
4	Khobbazi	/xoʊbbɑːziː /	*Malva sylvestris* L.	Malvaceae	Cold and wet	Leaf	Natool, Zemad (with olive oil)	B [32, 33], C [33, 34], D [35], E [36]
			Malva neglecta Wallr.					B [37], C [39], D [38], E [40]
5	Zaitoon	/zæjtuːn/	*Olea europaea* L.	Oleaceae	Hot and dry (ripe fruits)	Fruit	Zemad	A [41] B [42] , C [44], D [43], E [45]
6	Semsem	/semsem/	*Sesamum indicum* L.	Pedaliaceae	Hot and wet	Seed/seed oil	Zemad	A [46] B [46], C [48] , D [47]
7	Sousan	/suːsæn/	*Iris sp.*	Iridaceae	Hot and dry	Leaf/ bulb	Natool, Zemad (with *Dohn·ul· vard*)[b]	C [50], D [49]
			Lilium candidum L.	Liliaceae				C [52], D [51, 52]
8	Sanoubar	/sænoʊbær/	*Pinus pinea* L.	Pinaceae	Hot and dry	Bark/leaf	Tela, Zaroor	B [53], C [53], D [54], E [54]
9	Selgh	/selɢ/	*Beta vulgaris* L.	Amaranthaceae	Hot and dry	Leaf	Tela	C [56], D [55], E [57]
10	Ghalioon	/ɢɑːliːuːn/	*Galium verum* L.	Rubiaceae	Hot and dry	Flower	Zemad	D [58]
11	Loban (kondor)	/loʊbɑːn/ (/koʊndoʊr/)	*Boswellia carteri* Birdw.	Burseraceae	Hot and dry	Oleogum resin	Zemad (with oily base)	C [60], D [59], E [61, 62]

Table 1. The most frequent herbs in ITM for burn healing (Continued)

No.	Traditional name	phonetics	Scientific name	Family	Temperament	Part used	Dosage form	Biological effects[a]
12	Abou khalsa	/æbuːχælsɑː/	*Arnebia euchroma* (Royle) I.M.Johnst.	Boraginaceae	Hot and dry	Root	Marham, Qeirooti (with olive oil), Tela (with *Dohnˈulˈ vard*)	A [32, 63, 64] B [65], C [64, 67], D [66], E [68]
			Alkanna tinctoria Taush					A [69] B [69, 70], C [73], D [71, 72], E [74]
13	Leblub	/leblʌb/	*Convolvulus arvensis* L.	Convolvulaceae	Dry and hot/cold[c]	Leaf	Natool, Qeirooti Zemad (with *Dohnˈulˈ vard*)	D [75], E [76]
14	Narjes	/nærdʒes/	*Narcissus tazetta* L.	Amaryllidaceae	Hot and dry	Bulb	Zemad (with honey)	E [77]
15	Nil	/nɪl/	*Indigofera tinctoria* L.	Leguminosae	Hot and dry	Leaf	Zemad (with honey)	C [78], D [79], E [80, 81]
16	Zaimeran	/zæjmerɑːn/	*Ocimum basilicum* L.	Lamiaceae	Hot and dry	Leaf	Tela (with rosewater), Zemad	B [82], C [84], D [83], E [85]
			Ocimum minimum L.					B [86], D [87], E [86]
17	Quesus	/ɑesuːs/	*Hedera helix* L.	Araliaceae	Hot	Flower/leaf	Qeirooti (with olive oil), Zemad	C [88, 89], D [90], E [91]
18	Quasab ˈoˈ zarirah	/ɑæsæbooɔzæriːre/	*Acorus calamus* L.	Acoraceae	Hot and dry	–[d]	Zemad (with *Dohnˈulˈ vard*)	B [92], C [92, 93], D [94-96], E [93, 97]

[a]A: burn healing effect; B: wound healing effect; C: anti-inflammatory effect; D: antioxidant effect; E: antibacterial effect
[b]*Dohnˈulˈ vard* : the oily extract of *Rosa damascena* petals
[c]There were different ideas about hot and cold temperament of this plant
[d]Not mentioned in ITM references.

has been revealed by *in vitro* studies [30]. Also, the aqueous leaf extract of *M. communis* has demonstrated an excellent antibacterial activity against *Pseudomonas aeruginosa* [31].

Table 2. Dosage forms used for burns in ITM

No.	Dosage form	Description
1	Dohn (/dohn/)	A dosage form prepared by extraction of the oily constituents of plant by direct compression or indirectly by using other oils especially almond, sesame or olive oil.
2	Marham (/mærhæm/)	A topical preparation consisted of an oil or wax or mixture of them especially applied for injuries and some swellings.
3	Natool (/næt u:l/)	The decoction form of plant material (with or without filtration) poured lukewarmly on the target organ where may be surrounded by a paste.
4	Qeirooti (/ɢeiru:ti/)	A combination of oils and waxes with or without medicinal plants.
5	Tela (/telɑ:/)	A low viscose topical dosage form of the plant material which frequently applied on the body.
6	Zaroor (/zæru:r/)	Dried fine plant powder which sprinkled on the target organ.
7	Zemad (/zemɑ:d/)	A soft and viscose topical preparation which may have oils and waxes and usually dressed on the location.

Malva sylvestris L.

The wound healing activity of *M. sylvestris* has been demonstrated in rat burn model by Pirbalouti *et al.* [32]. In another study, the diethyl ether extract of *M. sylvestris* flowers have effectively stimulated wound contraction and have shown increasing in well-organized bands of collagen, more fibroblasts and few inflammatory cells in the full thickness wounds of alloxan-induced diabetic rats [33]. Moreover, the ethanol extract of the plant leaves have exerted inhibitory effect on croton oil-induced ear edema in mice [34]. The antioxidant activity of *M. sylvestris* has been established by DPPH and *β*-carotene-linoleic acid assays [35]. The chloroform, ethanol and water extracts of the plant have been active against *Staphylococcus aureus* and *P. aeruginosa* [36].

Malva neglecta Wallr.

Aerial parts of *M. neglecta* have demonstrated anti-ulcerogenic activity against the ethanol-induced gastric ulcers in rat model [37]. In *in vitro* studies, hydroalcoholic extract of the plant have shown strong antioxidant activity and reducing power by scavenging the superoxide anion, hydrogen peroxide and free radicals as well as metal chelating property compared to natural and synthetic standard antioxidants such as BHA, BHT and α-tocopherol [38]. The anti-inflammatory effects of the plant extracts have been shown by Vogl *et al.* through *in vitro* studies [39]. Besides, the ethanol extract of *M. neglecta* flowers has exhibited considerable inhibitory effect against *Staphylococcus epidermidis* (MIC: 5 mg/mL) [40].

Olea europaea L.

During an *in vivo* study on full-thickness burns conducted by Edraki *et al.*, the rats treated with sea buckthorn/olive oil mixture have revealed more developed re-epithelialization and continuous basement membrane with a mature granulation tissue and have shown faster wound contraction with no infection [41]. The wound healing activity of the leaves and fruits of *O. europaea* has been studied in incision and excision models in rodents [42]. In addition, the prominent antioxidant properties of the fruit extracts of ten olive tree cultivars have been demonstrated by $ABTS^{+}$ method [43]. The anti-inflammatory effect of *O. europaea* has been investigated and the *n*-hexane extract of the fruits have displayed 12.7–27.8% inhibition in the carrageenan-induced hind paw edema model at 400 mg/kg [44]. Besides, the aqueous fruit extract of *O. europaea* has shown an excellent effect on *S. aureus* growth isolated from burn cases [45].

Sesamum indicum L.

The seeds and oil of *S. indicum* have shown significant reduction in period of epithelization and wound contraction in the excision and burn wound models while in the incision wound model a significant increase in the wound breaking strength has been observed [46]. Free radical scavenging capacity of antioxidants from sesame

extract has been studied in DPPH assay [47]. It has been demonstrated that sesamin, a lipid-soluble lignin isolated from *S. indicum*, has down-regulated NF-κB activation induced by various inflammatory stimuli. In addition, sesamin has inhibited the expression of protein COX-2 closely linked with inflammation [48].

Iris sp.
Evaluation of antioxidant effects of *I. pseudopumila* has demonstrated that in addition to the significant antiradical effect of the methanol and chloroform extracts of the flowers through DPPH assay, the chloroform extract of rhizomes and the methanol extract of the flowers have shown the most considerable activity in lipid peroxidation of liposomes [49]. Moreover, the methanol extract of *I. pseudopumila* has exhibited significant inhibitory effect on NO (an inflammatory mediator) production in macrophages [50].

Lilium candidum L.
The antioxidant capacity of *L. candidum* essential oil has been revealed by photo chemi luminescence (PCL) method [51]. The anti-inflammatory and antioxidant effects of *Pfaffia paniculata/Ptychopetalum olacoides /Lilium candidum* mixture has been measured by quantification of prostaglandin E_2, leukotriene B_4, histamine, and superoxide dismutase levels in an *in vitro* model of human skin culture. The results have shown a dose-dependent decrease in production of inflammatory mediators, concomitant to increased antioxidant enzyme levels under basal and lipopolysaccharide-stimulated conditions [52].

Pinus pinea L.
Süntar *et al.* have demonstrated that the essential oil obtained from the cones of *P. pinea* possessed wound healing activity in linear incision and circular excision wound models. Besides, the anti-inflammatory effect of the plant essential oil was significantly approved by the Whittle method, which is based on the inhibition of acetic acid-induced increase in capillary permeability [53]. In addition to scavenging effect towards DPPH, the oil obtained from the nuts of *P. pinea* displayed inhibitory potentials against the isolated strains of *S. aureus* [54].

Beta vulgaris L.
The antioxidant capacity of a phenolic fraction obtained from *B. vulgaris* hydro alcoholic extract has been reported [55]. The aqueous leaves extract of the plant has shown significant anti-inflammatory activity using carrageenan induced rat paw edema method for acute inflammation and cotton pellet granuloma method for chronic inflammation [56]. Moreover, the ethanol extract obtained from the aerial parts of the plant has exhibited antibacterial effect against *S. epidermidis* and *S. aureus*. [57].
Galium verum L.
Lakić *et al.* have evaluated the antioxidant properties of methanol extract of *G. verum* in four different models and have demonstrated that the extract expressed powerful scavenging activity, reducing the DPPH and OH radical formation and neutralizing H_2O_2, in a dose dependent manner. The examined extract has also showed notable inhibition of lipid peroxidation [58].

Boswellia carteri Birdw.
The essential oil of *B. carteri* has shown strong antioxidant activity by inhibition of linoleic acid peroxidation [59]. Among the pentacyclic triterpenes, some boswellic acids (obtained from *Boswellia* species) are mainly responsible for many of the pharmacological effects which have been revealed to be effective in inhibition of leukoteriene formation [60]. The antimicrobial activity of the essential oil isolated from the oleogum resin of *B. carteri* has been demonstrated against various microorganisms including fungi, gram-positive and gram-negative bacterial strains [61]. Moreover, binary mixture of the methanol extracts of *B. carteri* and

clarithromycine, has shown a potent synergistic effect against *P. aeruginosa* and *S. aureus* [62].

Arnebia euchroma (Royle) I.M.Johst.

The burn healing activity of *A. euchroma* has been revealed by Ashkani-Esfahani *et al*. They have shown that wound closure rate, fibroblast population, volume density of collagen bundles, and length density of vessels have been significantly improved by carboxymethylcellulose (CMC) gels containing *A. euchroma* hydroalcoholic extract at the concentration of 10% and 20% in third-degree burn wounds in rats [63]. In another study, it was also found that the leaves and the root extracts of *A. euchroma* had shown anti-inflammatory effect on second degree burn wounds in rats [64]. Moreover, *in vivo* healing effect of goat lipid containing *A. euchroma* root extract on burns has been demonstrated through increasing the rate of wound contraction and collagen turnover [32]. In another study, a significant wound healing activity has been observed with an ointment containing *n*- hexane root extract of *A. euchroma* (1%) in incision and excision models in mice and rats [65]. The antioxidant activity of the aqueous and methanol extracts of the plant roots has been assessed by several methods while the latter extract has shown to be more powerful in Trolox equivalent antioxidant capacity and reducing power assays [66]. The anti-inflammatory activity of the petroleum ether, chloroform, alcohol and aqueous extracts of *A. euchroma* roots has been evaluated in another research, and the results have demonstrated the prominent edema inhibition property of the extracts against carrageenan-induced rat-paw edema which were comparable to ibuprofen [67]. Besides, the ethanol extract of *A. euchroma* roots has shown interesting minimum inhibitory concentration (8 μg/mL) against *P. aeruginosa* [68].

Alkanna tinctoria Taush

The significant healing effect of an ointment containing alkannin and shikonin (A/S), two enantiomeric naphthoquinones from *A. tinctoria* root extract, has been demonstrated on second intention wounds in dogs [69]. Moreover, several studies have revealed molecular and biological properties of A/S that have improve wound healing [70]. It has been declared that the dichloromethane extract of *A. tinctoria* roots, containing mainly alkannin esters, has demonstrated satisfactory antioxidant activity [71]. Besides, non-aqueous solvents and olive oil extracts of *A. tinctoria* roots with their A/S esters, have exhibited notable radical scavenging activity [72]. The efficient anti-inflammatory effect of these two natural products (A/S) has been revealed in mouse paw edema [73]. Moreover, Shikonin dyed silk exhibited bactericidal effect against *S. aureus* [74].

Convolvulus arvensis L.

A phenolic rich fraction of *C. arvensis* leaves, , has shown antioxidant property by DPPH radical scavenging and inhibiting the oxidation of β-carotene assays [75]. In addition, the antibacterial activity of the aqueous and alcohol extracts of the plant has been demonstrated [76].

Narcissus tazetta L.

The plant aerial parts have shown potential antimicrobial activity against *P. aeruginosa* [77].

Indigofera tinctoria L.

The anti-inflammatory activity of the ethanol extract of *I. tinctoria* leaves has been evaluated by sub-planter injection of carrageenan in Wister albino rats. In this study Tyagi *et al.* has shown that oral administration of the extract, has dose dependently exhibited potent anti-inflammatory activity by reducing the induced paw edema [78]. By employing different *in vitro* assays such as reducing power, DPPH, ABTS, NO and OH radical scavenging methods, the antioxidant properties of different extracts of *I. tinctoria* leaves have been evaluated. All extracts have exhibited reducing power and strong peroxidation inhibition against linoleic acid emulsion system, although the ethyl acetate extract was found to possess more hydrogen donating ability and

higher DPPH and NO scavenging activities [79]. In a study conducted by Selvakumar and Karunakaran, *I. tinctoria* has shown higher antimicrobial activity against *P. aeruginosa*, *S. aureus* and *Bacillus subtilis* compared to penicillin and tetracycline [80]. Moreover, the chloroform extract from the plant leaves has exhibited the broadest and highest antibacterial activity compared to the butanol and ethanol extracts [81].

Ocimum basilicum L.

Using the excision wound model in rats, Salmah *et al.* have reported that the wounds treated with honey in combination with alcohol extract of *O. basilicum* have demostrated considerable signs of dermal healing which has significantly healed earlier compared to those treated with honey alone [82]. The antioxidant property of *O. basilicum* and its effect on nitric oxide (NO) production in lipopolysaccharide-activated macrophages has been revealed [83]. Besides, *O. basilicum* methanol extract has inhibited the pro-inflammatory cytokines and mediators, which accounts for the anti-inflammatory effects [84]. Assessment of the antibacterial effects of the plant has shown that the ethanol extract of *O. basilicum* has been more effective against the pathogens such as *S. aureus* and *P. aeruginosa* when compared to the acetone extract [85].

Ocimum minimum L.

The essential oil extracted from the leaves of *O. minimum* has demonstrated anti-ulcerogenic activity in gastric ulcers induced by indomethacin and ethanol. Moreover, the essential oil has shown antibacterial activity against *S. aureus* using disc diffusion technique [86]. Lukmanul Hakkim *et al.* have revealed the antioxidant activity of the methanol leaves extract of *Ocimum* species including *O. minimum* using iron (III) reduction, ß-carotene–linoleic acid bleaching, DPPH and superoxide anion free radical scavenging assays [87].

Hedera helix L.

In a research performed by Dumitriu *et al.*, "Dermo HdC ", a bioproduct obtained from the leaves of *H. helix*, has inhibited IL6 and IL8 secretion and has blocked the VEGF (Vascular Endothelial Growth Factor) which could stop the inflammation progression from acute to chronic stage [88]. Besides, the anti-inflammatory properties of the ethanol leaves extract of *H. helix* has been demonstrated using formalin-induced paw edema test in Swiss albino mice [89]. α-hederin and hederasaponin-C, two saponins isolated from *H. helix*, have been investigated using different antioxidant tests and have finally exhibited a strong total antioxidant activity [90]. The ethyl acetate extract of the plant has exhibited the maximum inhibitory effect against *Staphylococcus aureus*, *S. epidermidis*, *Escherichia coli*, and *Bacillus subtilis* [91].

Acorus calamus L.

Shi *et al*. have shown that in addition to the inhibitory effect on mRNA expressions of inflammatory mediators, the aqueous extracts from the fresh roots and rhizomes of *A. calamus* could significantly enhance the rate of skin wound-healing in the excisional wounding test in mice [92]. Moreover, the significant carrageenan induced anti-inflammatory property of the plant aqueous extract has been proved by several studies [93]. It has been demonstrated that the ethanol extract of *A. calamus* has exhibited hepatoprotective and antioxidant activities against acetaminophen-induced liver injury in rats which are comparable to the standard drug, silymarin [94]. In addition to the of ethanol extract of *A. calamus* rhizomes [95], the leaf methanol extract has exhibited remarkable DPPH radical-scavenging activity, ability of chelating ferrous ions and reducing power, whereas the rhizome extract has displayed the strongest superoxide anion-scavenging activity as well as radical scavenging ability [95,96]. Besides, the antioxidant activity of *A. calamus* leaves and rhizomes extracts were comparable to the standard antioxidants [96]. The alcohol extract and the essential oil of *A. calamus* have represented potent *in vitro* activity against some pathogenic and nonpathogenic fungi, Gram

negative and Gram positive bacteria specially against *S. aureus* [93]. In addition, the antibacterial effect of the plant leaf extract against *P. aeruginosa* has been demonstrated [97].

Conclusion

Wound healing is a complicated process occurring in injured tissues to restore its construction and return the damaged tissue to its normal situation as soon as possible [98]. The aim of the healing process is prevention of pathogens invasion, confirm the integrity of damaged tissue, and reconstruct the skin physiological function [99]. There are different factors involved in burn healing process; oxidants are considered as inhibitory factors to wound healing so, protecting the tissue from oxidative damage is the important role of antioxidants which leads to survival of ischemic skin flaps or improvement of wound healing [100]. On the other hand, the excessive and unbalanced inflammation could delay healing and enhance scarring which suggests a promising target for future therapeutic interventions or even predisposed tissue to cancer development [101-103]. Therefore, the anti-inflammatory compounds could act as effective agents in wound healing [104]. Despite the natural progression of the burn healing process, infections can delay the process by several mechanisms. Hence, infection is the major complication of burn injuries and antibacterial agents play a critical role in the burn healing process [102,104-107]. Plants have an extensive potential for management and treatment of wounds and burns with their antioxidant, anti-inflammatory and antimicrobial activities due to their phytochemical constituents such as alkaloids, essential oils, flavonoids, tannins, terpenoids, saponins, fatty acids and phenolic compounds [4,106,108]. Low cost, availability and fewer side effects are other advantages of herbal remedies [4]. In the present investigation, we have introduced eighteen plants which were the most frequent herbs in ITM for burn healing. Modern studies have also shown that all of the mentioned plants possessed at least one biological effect corresponding to burn healing activity while antioxidant property was the prominent characteristic of the burn healing herbs. Moreover, among the plants which have been evaluated for wound healing effect, only five plants including “Hiofariqun”, “Ass”, “Zaitoon”, “Semsem” and “Abou khalsa” demonstrated burn healing property. Hence, the rest of the introduced herbs could be appropriate candidates for future burn healing studies and alternative medicaments for management of burn wounds.

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Declaration of interest

The authors declare that there is no conflict of interest. The authors alone are responsible for the content of the paper.

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