ABSTRACT

The complications of diabetes became a heavy burden to the patient as well as physician. Among the various complications, diabetic foot ulcer (DFU) is important since the major deaths in diabetes are due to DFU, which arises as a consequence of complicated and multi-factorial pathologies. The treatments using a single strategy may unlikely less effective and also the overall costs of these therapies are high. From long since, many commonly used herbs and spices are claimed to have wound healing effects with various mechanisms. Hence their application in the treatment of DFU may not only synergize the diabetic wound healing but also reduce the overall cost. This review discusses the possible use of herbs in treating DFUs with their mechanisms.

Key Words: Diabetes Mellitus, Diabetic foot ulcer, Diabetic neuropathy, Herbal.

1. INTRODUCTION

Diabetes mellitus (DM) is the major issue in the world wide and it is the chronic disorder which occurs due to the inadequate amount of insulin uptake (or) release. The occurrence of the DM is increased considerably (Shaw et al. 2010). The main factors for the increasing DM are inactive lifestyle, obesity, ageing and in few cases it was genetical. The negligence of DM condition will result in a number of consequences which include neuropathy, retinopathy, endothelial dysfunction, atherosclerosis, myocardial infarctions, diabetic foot etc., (Bays et al. 2004). This results with many problems in foot such as neuropathy, peripheral arterial disease, DFU, osteomyelitis, gangrene and amputation (Blaktny et al. 2011; Botek et al. 2011; Howell and Goulston, 2011). In the past decade the DM patients with leg complications are increased. A major
Complication of this is diabetic foot having ulcer healing difficulties, which are clinically significant and challenging. It was estimated that approximately 15% of total diabetic patient will be affected by DFU. (Powlson and coll, 2011; Nilforoushzadeh et al. 2012) DM is considered as the major cause of non-traumatic lower extremity amputation that reduces the survival of patient and cause huge burden to the society (Tentolouris et al. 2004). To improve the healing process of a DFU, there are several antibiotics (moxifloxacin, enrofloxacin and Pregabalin), neuropathic drugs (tricyclic anti depressant, anticonvulsant, serotonin reuptake inhibitors) and biomedical devices (epligraft, dermagrafte.tc) are available. The use of oral or I.V antibiotics were found to be resistant to most of the pathogens. Hence this requires repeated and high doses. Medical devices require skilled practitioners and hospitalization of the patient which associated with high cost. Apart from this the treatment of DFU using a single strategy may unlikely less effective since DFU arises as a consequence of multi-factorial pathologies. To overcome these hurdles herbal compounds can be used which are biocompatible, biodegradable and less or non-toxic. Several extracts of plants, minerals and animal origin are described in the traditional texts of Indian systems of medicine like “Ayurveda” for their healing properties under the term ‘Vranaropaka’. Some of these plants have been screened scientifically for the evaluation of their wound healing activity in different pharmacological models and human subjects. However their capacity in treating DFU is remains unexplored (Kumar et al. 2007). Numerous studies have reported the use of herbals in active wound healing but very few explained the herbal products in chronic wound healing. Plant constituents and herbal extracts are known to be the rich source of anti-oxidants to counter act Reactive Oxygen Species (ROS). Hence antioxidants are helpful in treating many diseases such as arteriosclerosis, inflammatory disorders, cancer, coronary disease and DM. Hence natural antioxidants due to their free radical scavenging property gives possible protection against many chronic diseases as well as lipid per oxidation (Ak T et al. 2008). The herbs also enhance the rate of tissue healing by providing different vital substances (vitamins, proteins and minerals) required at different stages of wound regeneration and proliferation. Herbals are also found to be safe and cost effective than allopathic drugs. This review discusses the possible use of herbs in treating DFUs with their mechanisms.

2. HERBAL MEDICINES FOR THE TREATMENT OF DFUs (Figure 1 and Table 1)

![Images of various parts of herbals for treating DFU](https://www.discovery.org.in/md.htm)

<table>
<thead>
<tr>
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<tr>
<td>e. Astragali Radix</td>
<td>f. Rehmanniae Radix</td>
<td>g. Leptospermum scoparium</td>
<td>h. Curculigo orchoides</td>
</tr>
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<td>g. Martyina annua</td>
<td>h. Rosmarinus officinalis</td>
<td>i. Vitis vinifera</td>
<td>j. Actinidia deliciosa</td>
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Figure 1
Images of various parts of herbals for treating DFU
2.1. Turmeric
Turmeric (Curcuma longa) is an herb belonging to the family Zingiberaceae. Since from ancient time it was used as the coloring agent, dietary spice and as antibiotic (Chattopadhyay et al. 2004). Rhizome (root) is the most important part of C. longa which is used as the ancient medicine for several diseases (Chattopadhyay et al. 2004; Patwardhan et al. 2005). The paste of lime mixed with curcumin is used to treat inflammation and wounds, which is known to be one of the popular Indian home remedy (Anamika, 2012). C. longa consists of three principle curcuminoids, among which curcumin (diferuloylmethane 77%) is the major constituent. In more recent times, curcumin has been studied extensively for its use as an anti-cancer (Agrawal and Mishra, 2010; Shehzad et al. 2013), anti-aging (Lima et al. 2011; Bala et al. 2006), diabetic retinopathy (Pathak et al. 2014), anti-infective and wound healing activity (Maheshwari et al. 2006). Curcumin act against and protects the wound tissue from bacterial infections and induces cell proliferation. It reduces inflammation to help in the restoration of damaged tissue (Kulac et al. 2013). It acts as an ideal antioxidant as the free radicals are considered to be the major cause of inflammation during wound healing process of DFUs (Mohanty et al. 2012). The potency of curcumin in wound healing is attributed to its biochemical effects such as anti-infectious (Mun et al. 2013; Singh et al. 2010), antioxidant (Ak T and Gulcin, 2008; Meng et al. 2013) and anti-inflammatory (Liang et al. 2009) activities. Curcumin also improves cutaneous wound healing by involving in the tissue remodeling, collagen deposition, and granulation tissue formation (Joe et al. 2004). The exact mechanisms by which curcumin modulates inflammation is by inhibiting the production of tumor necrosis factor alpha-α (TNF-α) and interleukin-1 (IL-1), two major cytokines released from monocytes and macrophages that play important roles in the regulation of inflammatory responses. Oxidative stress is a significant factor in the chronic wound healing process and generally inhibits tissue remodeling (Thangapazham et al. 2013). As free radicals, ROS result in oxidative damage, DNA breakage and enzyme inactivation, leading to lipid per oxidation all of which inhibit optimum wound healing. ROS is considered to be the major cause of inflammation during chronic wound healing activity (Mohanty et al. 2012). It has been found that anti-oxidants with free radical scavenging potential like curcumin can significantly improve wound healing when applied topically (Martin, 1996). Kant V et al., 2014 studied effect of curcumin (0.3%) in streptozotocin-induced diabetic rats. The results revealed that topical curcumin application increased the wound contraction and decreased the expressions of inflammatory cytokines/enzymes i.e. TNF-α, interleukin (IL)-1β and matrix metalloproteinase-9 (MMP-9). It also has shown increased levels of anti-inflammatory cytokine (IL-10) and antioxidant enzymes (superoxide dismutase, catalase and glutathione peroxidase). Curcumin treated wounds showed better granulation tissue dominated by marked fibroblast proliferation and collagen deposition, and thus wounds were covered by thick regenerated epithelial layer. These findings showed that the anti-inflammatory and antioxidant potential of curcumin caused faster and better wound healing in diabetic rats and they also further confirmed that curcumin could be an additional novel therapeutic agent in the management of impaired wound healing in diabetics (Kant V et al. 2014).

2.2. Avocado
The Persea Americana (P. americana) also known as avocado fruit belonging to the family Lauraceae. The fruit pulp contains monounsaturated fatty acids with the highest content of lutein (70% of the measured carotenoids) (Ortiz et al. 2004; Salazar et al. 2005). These play significant role in reducing the risk of cancer, Wound healing (Nayak et al. 2008) and hepatoprotective action (Kawagishi et al. 2001). It is also a rich source for vitamin A, Vitamin E, phospholipids and glycolipids. Vitamin A is required for epithelial formation, cellular differentiation and immune function, and vitamin E is the major lipid-soluble antioxidant in the skin. Monounsaturated fatty acids, topical and systemic carotenoids and vitamin E promote wound healing. Derivatives of phospholipids and glycolipids also found to have wound-healing properties (Nayak et al. 2008). Phytochemical screening of the P. americana discovered the presence of flavonoids which are helpful in antioxidant property. Extracts of P. americana has shown both antifungal and antibacterial properties (Jacob et al. 1971). Aqueous extract of P. americana reported to have vasorelaxation depending up on the concentration. This vasorelaxant effect may be produced by the inhibition of Ca⁺ mobilization through voltage-dependent channels and to a lesser extent through receptor-operated channels. (Owolabi et al. 2005) P. americana will show anti-inflammatory activity by the inhibition of prostaglandin synthesis in platelets (Adeyemi et al. 2002). Extract of P. americana significantly increases the rate of wound contraction/epithelialisation, and the weight of the granulation tissue. These tissues are mostly composed of fibroblasts, collagen, edema and new small blood vessels. The pro-inflammatory activity of the constituents of P. americana could attract macrophages to the wound site. Macrophages stimulate the chemotaxis and proliferation of fibroblasts and attract endothelial cells to the wound and stimulate their proliferation to promote angiogenesis.

2.3. Aloe vera
Aloe vera is botanical known as Aloe barbadensis (A. barbadensis) belonging to the family of Xanthorrhoeaceae. A. barbadensis gel contains chemical constituents such as saponins, naphthaquinones, anthraquinones, sterols, and triterpenoids. (Rosenthal, 1968) These compounds are useful to show beneficial effects (anti-inflammatory activity) and promote wound healing (Davis et al. 1994). Glucomannan, a mannose-rich polysaccharide, and gibberellin, a plant growth hormone, interact with growth factor receptors of the fibroblast, thereby stimulating their activity and proliferation, which in turn significantly increase collagen synthesis after topical administration of A. barbadensis gel. This gel not only increases collagen content of the wound but also changes collagen composition (type III) and increases the extent of collagen cross-linking. Due to this, it accelerates wound contraction and increases the breaking strength of resulting scar tissue. An increase in the synthesis of hyaluronic acid and dermatan sulfate in the granulation tissue of a healing wound following oral or topical application of A. barbadensis has been reported. The mechanism involved in A. barbadensis in diabetic wound healing (Chithra et al. 1998; Mendonca et al. 2009; Takzare et al. 2009) is by hydrolyzing enzymes like prostaglandin, bradykinin, carboxypeptidase and bardykinase that are hypothesized to reduce inflammation and pain (Steenkamp and Stewart, 2007; Takzare et al. 2009). A. barbadensis derived polysaccharides such as mannose-6-
phosphates has been postulated to be active growth substances, especially in epithelialisation (Davis et al. 1994; Boudreau and Beland, 2006; Steenkamp and Steward, 2007). Acemannan, another polysaccharide in A. barbadensis, has been shown to up-regulate white blood cell activity in the wound healing process (Boudreau and Beland, 2006; Tamura et al. 2009). Anti-bacterial properties of anthraquiones, an organic compound responsible for the natural pigment of A. barbadensis, are beneficial in minimizing infections (Tamura et al. 2009; Kuzuya et al. 2001). Hotkar et al., 2013 have studied the use of A. barbadensis as gel base using Nitroglycerin as active molecule in streptozotocin-induced DFU and rat excision wound models. They found that the wound size in animals of all treated groups was significantly reduced compared with that of the diabetic control and marketed treated animals. They also further conformed that the gel (carbopel 974p (1%) and Aloe vera) treated animals promotes significant wound healing and closure in diabetic rats compared with the commercial product and provided a promising product to be used in diabetes-induced foot ulcer (Hotkar et al. 2013).

2.4. Papaya

Carica papaya (C. papaya) belonging to family Caricaceae (Banerjee et al. 2007). The major phytochemical constituents of this fruit are flavonoids, nicotine, tannins, and terpinenes as well as enzymes such as papain and chymopapain (Brooklehurst et al. 1985; Tona et al. 1998). Traditionally different parts of this plant are used in many treatments. The C. papaya seed extract having effective bactericidal action against the Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, Bacillus cereus and Shigella flexneri (Emeruwa, 1982). The unripe matured C. papaya fruit is reported to have anti diabetic effects and studies are conducted in several animals (Olagunju et al. 1995) and humans (Olapade, 1995; Salau et al. 2003). There is an adequate report on the hypoglycemic and/or antidiabetic effects of the C. papaya seed despite its extensive and historical use in the traditional management of diabetes and obesity. C. papaya is used as the debridement agent and it convert proline to hydro proline and it act as anti bacterial which together enhance wound healing. Nayak et al, 2007 examined the effect of C. papaya in experimentally induced diabetic rats. The reduction of wound area in C. papaya treated animals was reported to be 77% when compared to control which is 59%. The C. papaya treated wound was found to epithelize faster than the control and also a significant increase in wet and dry granulation tissue weight and hydroxyproline content was observed (Nayak et al. 2007).

2.5. Chinese Herbal Medicine

Chinese Herbal medicine contains Astragali Radix (AR) and Rehmanniae radix (RR). AR is extracted from the dried roots of Astragalus membranaceus belonging to the family Leguminosae. The main constituents of AR are polysaccharides, flavonoids, saponins, amino acids and trace elements (Ma et al. 2002; Yu et al. 2007). AR is used as the cardioprotective (Xu et al. 2008; Zhao et al. 2008), immunomodulatory (Zhang et al. 2009; Liu et al. 2010), as well as insulin-sensitizing agent (Xu et al. 2009; Hoo et al. 2010). AR promotes fibroblast proliferation and increasing the rate of diabetic wound healing. RR is extracted from the Rehmannia glutinosa belonging to the family of Scrophulariaceae. RR having wide range of pharmacological actions on the immune system, endocrine system, blood system, cardio vascular system and nervous system (reviewed by Zhang et al. 2008). RR can remove pathogenic heat from blood, nourish and promote production of body fluid. Therefore, it is widely prescribed to relieve febrile diseases, diabetes, epistaxis and skin eruption. AR and RR stimulate fibroblast and inhibit cellular inflammation by synergistic action. Lau et al, 2012 described the synergistic interaction between AR and RR in a chemically induced DFU rat model. Their examination showed that AR and RR as a separate formulation with a clinical relevant dose of 0.98g/kg dose not promote diabetic wound healing. But when they are used as combination a synergistic interaction was demonstrated and reduced the wound area in rats significantly (lau et al, 2012).

2.6. Manuka honey

Manuka honey botanically known as the Leptospermum scoparium belongs to the family Myrtaceae (stephens, 2006). It is also called as Monofloral honey produced from the nectar of the manuka tree. Manuka honey is considered as a medicine in wound healing from the ancient times. In 2007 USFDA has approved Manuka honey for wound management. It act as an antimicrobial, antioxidant and immune modulator with both pro- and anti-inflammatory effects, hence it is used in the treatment of a broad spectrum of wounds. The active constituent present in the Manuka honey is methylglyoxal that show excellent anti-bacterial action (Lo et al. 1994). Methylglyoxal has been reported to react with arginine, lysine and cysteine residues of structural proteins such as collagen giving origin to AGEs that disturb extracellular matrix remodeling, promote fibrosis in chronic tissue infections, impair immune response and microcirculation, promote atherosclerosis and neovascularisation, induce endothelial cell dysfunction and impair wound closure. In a case study conducted by Mohamed H et al., 2013 in a 65 years old female-Egyptian diabetic patient presented with a neuropathic plantar ulcer with honey dressing at 16th week showed complete ulcer healing. Honey used topically has provided antibacterial activity and moisture environment, thereby accelerating tissue repair, less scarring and less pain and no symptoms were reported by the patient which could be attributed to advanced diabetic peripheral neuropathy (Mohamed et al. 2013).

2.7. Curculin

Curculin is botanically known as Curculigo orchioides (C. orchioides) belongs to the family Hypoxidaceae (Singh A and Singh PK, 2009). It is a tiny herbal plant widely distributed in China, Malaysia, Japan, Australia and also in subtropical Himalayas region of India. C. orchioides contains phytoconstituents such as flavonoids, tannins, saponons and phenolic compounds which are important plant metabolites that play prominent role in diabetic wound healing. Tannins act as free radical scavengers, triterpenoids and flavonoids will promote wound healing. But when they are used as combination a synergistic interaction was demonstrated and reduced the wound area in rats significantly (Nayak et al. 2007).
contraction and elevated rate of re-epithelialization. Singh A et al, 2014 found the wound healing activity of standardized extract of C. arboideae in streptozotocin induced diabetic mice. The results showed that the root tubers of C. arboideae are potent source of anti-oxidants. The root tuber of C. arboideae increases the level of superoxide dismutase and nitric acid significantly and decreases lipid peroxidation in granulose tissues of diabetic mice. They also found that the rate of angiogenesis and levels of anti-oxidant enzymes were increased by C. arboideae (Singh et al. 2014).

2.8. Martynia annua
Martynia annua (M. annua) belongs to the family of Martyniaceae (Khare, 2007). M. annua contain phytoconstituents such as glycosides, tannins, carbohydrates, phenols, flavonoids and anthocyanins. Flavonoids are reported to have free radical scavenging effect and anti-bacterial activity. Luteolin exerts a various pharmacological activities including anti-oxidant properties associated with its ability to scavenge oxygen and potent anti-inflammatory (Chatpalliwar et al. 2002) Luteolin is a flavone widely distributed in the plant kingdom, showed a concentration-dependent inhibitory activity in several models of oxidative stress. The anti-oxidant potential of luteolin is twice stronger than that of vitamin E and has strong scavenging properties for superoxide radicals. Lodhi and Singhai, 2013 explored Wound healing effect of flavonoid rich fraction and luteolin isolated from M. annua in streptozotocin induced diabetic rats. The results confirmed that percentage wound contraction was observed significantly (p<0.01) greater in flavanoid fraction and 0.5% w/w of luteolin treatment groups. In their histopathological studies matured collagen fibers and fibroblasts with better angiogenesis were observed possibly due to free-radical scavenging activity of plant (Lodhi and Singhai, 2013).

2.9. Rosmarinus officinalis
*Rosmarinus officinalis* (*R. officinalis*) commonly known as the rosemary belonging to the Family Lamiaceae (al-serelti et al. 1999). It is a perennial herb which is commonly used as the spice and flavoring agent. The major constituent present in the *R. officinalis* are caffeic acid and its derivative rosmarinic acid. *R. officinalis* have a rich source of antioxidants and anti-inflammatory compounds (Takaki et al. 2008) which enhances memory and concentration, neurological protection, prevent brain aging, cancer, protection against macular degeneration. The carnosic acid in *R. officinalis* is able to fight against free radical damage in the wound. Mariam A and Abu-Al-Basal 2010, studied Healing potential of *R. officinalis* on full-thickness excision cutaneous wounds in alloxan-induced-diabetic BALB/c mice. Their study showed reduced inflammation and facilitated wound contraction, re-epithelialization, regeneration of granulation tissue, angiogenesis and collagen deposition were detected in the *R. officinalis* extract treated wounds. This indicates that the extract of *R. officinalis* is more potent in healing diabetic wound (Abu-Al-Basal, 2010).

2.10. Grape seed extract
Grape seed extract (GSE) is botanically known as *Vitis vinifer*. GSE have a high concentration of flavonoids, Vitamin E, linoleic acid and phenolic procyanidins (oligomeric procyanidins). The GSE (proanthocyanidin or condensed tannins) contains poly phenols which are widely distributed throughout the plant kingdom. GSE is an effective hydrophilic peroxyl radical, especially radical scavenger in the aqueous system. The proanthocyanidin were found to be much stronger than the vitamin C and E. GSE is widely used in the treatment of cardiac disorders (atherosclerosis), protective agent for gastric mucosa (gastric ulcer), cataracts, diabetes (diabetic neuropathy) and reduces hypoxic ischemic brain injury. Proanthocyanidins (or condense tannins) and other tannins are well known for their acceleration of wound healing property (Root-Bernstein, 1982; Hupkens et al. 1995). However the mechanism of action is not known (Bagchi, et al. 1997; Bagchi et al. 1999; Ye et al. 1999 Ray et al. 1999). The expected mechanism is found to be anti-oxidant and potentially induced (Vascular endothelial growth factor) VEGF expression in human keratinocytes (Khanna et al. 2001; Sen et al. 2002). It also considerably increase the motor nerve conductive velocity mechanically, superoxide dismutase and reduce the advanced glycation end products (AGEs) and tissue malondialdehyde. It decreases the inflammation and viscosity of the blood to diabetic patient and thereby increases the nutrient supply to wound and accelerate wound healing. It also helps in lowering the blood glucose levels and improves the micro circulation. Alpha-glycosidase, an enzyme in GSE which breaks down carbohydrates into glucose molecule can delay glucose absorption to a greater extent.

2.11. Kiwi Fruit
Kiwi fruit botanically known as *Actinidia delicosa* belongs to the family Actinidiaceae. It is a rich source of vitamin C, E, K and carotenoids, such as provitamin A beta-carotene, lutein and zeaxanthin. It also contains proteolytic enzymes (actinidin) (Low et al. 2004) and ascorbic acid. It is believed that Kiwi fruit contains potent protein-dissolving property that acts as debridement agent. Kiwifruit is probably a rich source of angiogenesis modulators that are commonly required for wound healing. It contains antibacterial (Basile et al. 1997) and scavenger agents in addition to proteolytic enzymes, which may improve the wound healing. Mohajeri et al, 2014 explored the topical use of kiwifruit on neuropathic DFU. They reported a mean reduction in surface area of foot ulcer in kiwifruit treated group when comparing with the control. They also found a significant increase in collagen and granulation tissues similarly higher levels of angiogenesis and vascularization were found in kiwifruit treated patients. Actinidin, a protein dissolving enzyme in kiwifruit have shown improved wound healing property (Mohajeri et al. 2014).
<table>
<thead>
<tr>
<th>Scientific Name of the Plant</th>
<th>Common Name</th>
<th>Family Name</th>
<th>Major Constituents</th>
<th>Mechanism of Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curcuma longa</td>
<td>Turmeric</td>
<td>Zingiberaceae</td>
<td>Curcumin, desmethoxycurcumin and bis-desmethoxy curcumin.</td>
<td>Reduce the activity of NF-(κ)B, TNF-α and IL-1 cytokines. Increase fibroblast proliferation, fibroblast migration, granulation tissue formation and collagen deposition.</td>
</tr>
<tr>
<td>Persea americana</td>
<td>Avocado</td>
<td>Lauraceae</td>
<td>Monosaturated fatty acids, leutin, Vitamin A and E, phospho and glycolipids.</td>
<td>Promotes wound healing by collagen formation at the proliferative stage of wound healing. Vitamins A and E, proteins, beta-carotene, lecithin, fatty acids and potassium which acts as nutrient support in wound healing.</td>
</tr>
<tr>
<td>Aloe barbadensis</td>
<td>Aloe vera</td>
<td>Xanthorrhoeaceae</td>
<td>Saponons, naftoquinones, anthroquinones, sterols and triterpenoids.</td>
<td>Reduce inflammation and pain, Increased blood flow to the wound. Bactericidal and bacteriostatic.</td>
</tr>
<tr>
<td>Carica papaya</td>
<td>Papaya</td>
<td>Caricaceae</td>
<td>Papain, cystatin, chymopapain, tocopherol, flavonoids, cyanogenic glucosides and glucosinolates.</td>
<td>Debridement agent (convert proline to hydro proline) and it act as antimicrobial.</td>
</tr>
<tr>
<td>Astragali Radix and Rehmanniae Radix</td>
<td>Chinese herbal medicine</td>
<td>Leguminosae and Scrophulariaceae</td>
<td>Flavanoids, Saponins, aminoacids and trace elements.</td>
<td>Stimulate fibroblast proliferation and inhibit cellular inflammation.</td>
</tr>
<tr>
<td>Leptospermum scoparium</td>
<td>Manuka honey</td>
<td>Myrtaceae</td>
<td>Methylglyoxal.</td>
<td>Methylglyoxal, effective antimicrobial active against forms of MRSA. Debridement action.</td>
</tr>
<tr>
<td>Curculigo orchoides</td>
<td>Curculin</td>
<td>Hypoxidaceae</td>
<td>Curculigosides Flavanoids, tannins and phenolic compounds.</td>
<td>Free radical scavenger, antimicrobial, decreases lipid peroxidation in granulose tissues.</td>
</tr>
<tr>
<td>Martyina annua</td>
<td>Martynia annua</td>
<td>Martyniaccae</td>
<td>Steroid, palmitic acid, oleic acid, arachidic acid and chlorogenic acid.</td>
<td>Inhibitory activity on oxidative stress. Luteolin have antioxidant potential twice stronger than that of vitamin E and has strong scavenging properties for superoxide radicals.</td>
</tr>
<tr>
<td>Rosmarinus officinalis</td>
<td>Rosemary</td>
<td>Lamiaceae</td>
<td>Carnosic acid and rosmarinic acid</td>
<td>Reduce inflammation and facilitate wound contraction and re-epithelialization, regeneration of granulation tissue, angiogenesis and collagen deposition.</td>
</tr>
<tr>
<td>Vitis vinifera</td>
<td>Grape seed extract</td>
<td>Vitaceae</td>
<td>Oligomeric procyanidins</td>
<td>Oligomeric procyanidins induced vascular endothelial growth factor and accelerated healing of injured skin.</td>
</tr>
</tbody>
</table>
3. CONCLUSION

Treatment and management of DFUs are challenging to medical practitioners till today. Treatment is much costly and most of the ulcers are reluctant to treat with standard wound care. Herbals are better alternatives for the treatment of DFUs because of their safer profiles, low cost, widespread availability, reduced risk of side effects and effective with chronic conditions. Herbal drugs will act by various mechanisms unlikely allopathic drugs and hence synergize the overall wound healing effects. An alternate therapy with herbal drugs will be the best solution to address the complications associated with the treatment of DFUs.

REFERENCES


Kollipara Radhakrishna et al.


