Chapter 3

In Search of Wound Healing Drugs: A Journey Through Ayurveda

Tuhin K. Biswas, Saheli Banerjee, Nandini Poyra,
Srikanta Pandit, Utpalendu Jana,
Shrabana Chakrabarti and Tapan Seal

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/65520

Abstract

Description of wound healing is a recent concern of modern surgery and medical therapeutics, but first evidences are available in ancient Indian system of medicine, namely Ayurveda in the name of *Vrana* (wounds) and *Vranaropaka* (wound healing drugs). It has been reported that in different classical Ayurvedic texts, about 164 medicinal plants, 24 metals and minerals and 18 animal products are described for their wound healing activity. The mechanism of the healing process and the selection of drugs from natural resources are very specific in Ayurveda, and some of these have been scientifically screened. Besides a single component of drug, many classical formulations either in the form of polyherbal or herbo-minerals have been cited in Ayurveda from time to time since pre-vedic era to recent modern time. Many traditional folkloric preparations of India were also later on incorporated in Ayurveda utilizing sources of some pockets of Ayurveda in different parts of the country. Chronological development of these drugs on the basis of physical, molecular and clinical parameters is elaborated vividly with some examples of experimentation like *Curcuma longa, Pterocarpus santalinus, Cynodon dactylon* and a composed formulation named *Kshantak Malam*.

Keywords: wound healing, Ayurveda, *Vranaropaka*, medicinal plants, metals and minerals

1. Introduction

The development of drugs for wound management is a concern of long history in medical science, and probably it was first described in Indian system of medicine, *Ayurveda*. Healing of wound is a natural phenomenon, but the natural way of healing may lack quality, promptness and aesthetics [1]. Biology of wound healing involves a phases like homeostasis and fibrin deposition, inflammation, wound debridement, neoangiognesis, fibroblast proliferation, scar modulation, wound contraction and epithelisation [2]. In recent studies, many drugs and/or agents are reported for management of wounds. Silver is being used since a long back for the management of wounds specially for its antibacterial property [3]. The highly reactive charged silver ion (Ag^{+}) reacts by binding to negatively charged particles such as proteins, DNA, RNA and chloride ions. While this is responsible for its antimicrobial properties, it also complicates delivery as the silver ions are readily bound to proteins and chloride in the wound bed fluid [4]. Acute conditions of wounds are now being treated by non-pharmacological procedures like negative pressure wound device (NPWD) or vacuum assisted closure (VAC) [5] and hydrogel [6]. Several synthetic growth factors like vascular endothelial growth factor (VEGF), platelet derived growth factor (PDGF), epidermal growth factor (EGF), transforming growth factor-β (TGF-β), insulin-like growth factor-I (IGF-I), etc. are reported to have healing properties in specific types of wounds on pre-clinical models [7]. The specific role of EGF is documented as a topical application in cutaneous wounds [8]. These agents performed such activities by stimulating fibroblast proliferation and keratinocytes via transmembrane glycoproteins [9]. The use of NPWD or VAC is limited to stable wounds while hydrogel is applicable in moist wounds. The basic types of fibroblast growth factor (bFGF) is a variety, which stimulates the healing process and inhibits scar formation but may have several side effects like irritation, pain, erythema, pruritis, etc. [10]. However, cost of growth factors therapy in wound healing may not be accessible to common people, and some of the growth factors like recombinant human growth hormone (rhGH) and recombinant human insulin like growth factor-I (rhIGF-I) are reported to have serious side effects like fluid retention, gynecomastia or orthostatic hypotension, specially in elderly patients [11].

In Ayurveda, the Indian system of medicine, elaborative description about the treatment of wounds is mentioned, particularly in the text, *Sushruta Samhita* (ca. 1000 BC), in the name of '*Vrana*' or wounds [12]. In describing the pathogenesis of wound or *Vrana*, three stages are mentioned in Sushruta Samhita as unsuppurtaed (*Ama* stage) wound, early suppurated (*Pachyamana* stage) wound and fully suppurated (*Pakva* stage) wound. Specific symptoms are mentioned for different stages of wounds in this text. A series of 60 steps of treatment for wounds (*Sasti Vrana Upakrama*) is mentioned in Ayurveda, which starts with dissolution of inflammation and ends with correction of deformities in the wound area. Out of these series of 60 steps of treatment, seven steps are most important and one of which is use of plants, minerals and animal products as *Vranaropaka Dravyas* (wound healing agents). This divergence of Ayurvedic drugs definitely excel those of modern remedies for the wounds, but a very few of those have been screened in a scientific way to prove their efficacy. In different classical Ayurvedic texts, about 164 medicinal plants, 24 metals and minerals and 18 animal products are described for their wound healing activity under the term '*Vranaropaka'* [13]. Some of these

http://dx.doi.org/10.5772/65520

agents are already reported for potentiality in management of wounds which are being described in present review.

2. Review of wound healing drugs in Ayurveda

2.1. Plant drugs

Description of wound healing drugs is found in different Ayurvedic texts of different era. It has been observed that there were development in compositions and selection of more specific drugs of natural resources towards specific therapeutic activity, particularly wound healing *per se*, according to chronological changes of different periods. Systemic development of Ayurvedic therapies, particularly with plant origin, is found during sixth century BC to seventh century AD when classical texts like *Charaka Samhita, Sushruta Samhita* and *Astanga Hridaya* were written. The text *Sushruta Samhita* particularly describes the surgical aspects of therapeutics including wound healing through 120 chapters in 5 cantos. However, treatment for wounds in these texts was detailed in the form of multi-ingredient compositions (polyherbal or herbo-mineral). Later on during the period between tenth and sixteenth centuries AD, use of single medicinal plants was emphasized for specific therapeutic purpose like wound healing. The classical text like *Bhavaprakash Nighantu* was written during this period [14]. All these changes from time to time were incorporated owing to the pieces of evidence acquired from the therapeutic experiences by Ayurvedic physicians. In search of this development on wound healing drugs of Ayurvedic origin, a total number of 164 medicinal plants are found to be cited in various classical texts [15]. These medicinal plants are categorized under 73 families with highest number of inclusion under Leguminosae having 20 medicinal plants followed by Compositeae with eight medicinal plants (**Table 1**). Besides families of inclusion, it is also important to know that which part of the plant is responsible for the wound healing property. There is very much specificity of plant parts used for wound healing activity according to variations in plants as described in Ayurveda. It is reported that different plant parts like leaves, root, seed, stem (whole stem, heart wood and stem bark), flowers, fruits (pulp and whole plant), gum, rhizome, latex, filament and whole plants are used for the said purpose owing to specificity of their chemical compositions [15]. Gum and latex may be considered as secondary metabolites of the plants. It has been observed that among 164 medicinal plants described for wound healing, mostly roots (45) are used for therapeutic purpose (**Table 1**). Pieces of scientific evidence of some of these species are being described here for their wound healing properties.

2.1.1. Curcuma longa

The rhizome of *Curcuma longa* L. (family Zingiberaceae), which is commonly known as turmeric, has been widely used for centuries in traditional medicines for several diseases, with the biological actions like antioxidant, anticarcinogenic, anti-inflammatory, antimutagenic, antimicrobial and hypocholesteraemic activities [16]. Most of these biological activities are due

to presence of its main bioactive component curcumin (**Figure 1**). The wound healing property of the plant has been particularly described in the text 'Bhavaprakash Nighantu' [17].

Sl	Family	Total no. of plants cited	Parts of plants used with number distribution										
			Leaves	Stem	Flower	Fruit	Root	Seed	Gum	Rhizome	Latex	Filament	Whole plant
	Acanthaceae	01	01	–	–	–	–	–	–	–	–	–	–
	Algae	01	–	–	–	–	–	–	–	–	–	01	–
	Amaranthaceae	02	–	–	–	–	–	–	–	–	–	–	02
	Anacardaceae	03	01	01	–	–	01	–	–	–	–	–	–
	Anonaceae	01	01	–	–	–	–	–	–	–	–	–	–
	Apocyanaceae	04	01	01	–	–	02	–	–	–	–	–	–
	Araceae	01	–	–	–	–	–	–	–	01	–	–	–
	Aristolochiaceae	01	–	–	–	–	–	–	–	–	–	–	01
	Asclepidiaceae	04	01	–	–	–	02	–	–	–	01	–	–
10	Berberidaceae	01	–	01	–	–	–	–	–	–	–	–	–
11	Bombacaceae	01	–	01	–	–	–	–	–	–	–	–	–
12	Boraginaceae	01	01	–	–	–	–	–	–	–	–	–	–
13	Capparidaceae	02	–	–	–	–	02	–	–	–	–	–	–
14	Celestraceae	01	–	–	–	–	–	01	–	–	–	–	–
15	Combretaceae	03	–	01	–	02	–	–	–	–	–	–	–
16	Compositeae	08	02	01	01	–	03	01	–	–	–	–	–
17	Convolvulaceae	02	–	–	–	-	02	–	–	–	–	–	–
18	Cucurbitaceae	05	02	–	–	–	02	01	–	–	–	–	–
19	Cyperaceae	01	–	–	–	–	01	–	–	–	–	–	–
20	Dipterocarpaceae	02	–	–	–	–	–	–	01	–	01	–	–
21	Euphorbiaceae	05	01	–	–	01	–	01	–	–	01	–	01
22	Gentinaceae	01	–	01	–	–	–	–	–	–	–	–	–
23	Gramineae	06	–	–	–	–	03	02	–	–	–	–	01
24	Gutaceae	01	–	–	–	–	–	–	–	–	–	–	01
25	Gutiferae	01	–	–	01	–	–	–	–	–	–	–	–
26	Hydrophyllaceae	01	–	–	–	–	01	–	–	–	–	–	–
27	Irideae	02	–	01	01	–	–	–	–	–	–	–	–
28	Lauraceae	01	–	01	–	–	–	–	–	–	–	–	–
29	Labiateae	01	–	–	–	–	–	–	–	–	–	–	01
30	Leguminosae	20	02	03	–	–	03	09	01	–	–	–	02
31	Liliaceae	02	–	–	–	–	02	–	–	–	–	–	–
32	Loranthaceae	01	–	–	–	–	–	–	–	–	–	–	01
33	Lytheraceae	01	–	–	01	–	–	–	–	–	–	–	–
34	Malvaceae	03	–	–	–	01	02	–	–	–	–	–	–
35	Meliaceae	01	–	–	–	–	01	–	–	–	–	–	–
36	Menispermaceae	02	–	01	–	–	01	–	–	–	–	–	–

http://dx.doi.org/10.5772/65520

Sl	Family	Total no. of plants cited	Parts of plants used with number distribution										
			Leaves	Stem	Flower	Fruit	Root	Seed	Gum	Rhizome	Latex	Filament	Whole plant
37	Mimosoiodeae	02	–	01	–	–	–	–	–	–	–	–	01
38	Moraceae	05	01	03	–	01	–	–	–	–	–	–	–
39	Moringaceae	01	–	–	–	–	01	–	–	–	–	–	–
40	Musaceae	01	–	01	–	–	–	–	–	–	–	–	–
41	Myricaceae	01	–	01	–	–	–	–	–	–	–	–	–
42	Myrsinaceae	01	–	–	–	01	–	–	–	–	–	–	–
43	Myrtaceae	01	–	01	–	–	–	–	–	–	–	–	–
44	Mertyneaceae	01	–	–	–	01	–	–	–	–	–	–	–
45	Nyctaginaceae	01	–	–	–	–	–	–	–	–	–	–	01
46	Nymphaeceae	04	–	01	–	–	03	–	–	–	–	–	–
47	Oleaceae	03	01	–	01	01	–	–	–	–	–	–	–
48	Orchidaceae	01	–	–	–	–	01	–	–	–	–	–	–
49	Papavaraceae	01	–	–	–	–	–	01	–	–	–	–	–
50	Papilionaceae	01	–	01	–	–	–	–	–	–	–	–	–
51	Pedaliaceae	01	–	–	–	–	–	01	–	–	–	–	–
52	Pinaceae	02	01	–	–	–	–	01	–	–	–	–	–
53	Piperaceae	04	–	–	–	03	01	–	–	–	–	–	–
54	Plumbaginaceae	01	–	–	–	–	01	–	–	–	–	–	–
55	Polypoidiaceae	01	01	–	–	–	–	–	–	–	–	–	–
56	Rannunculaceae	01	–	–	–	–	–	–	–	–	–	–	01
57	Rosaceae	03	–	01	–	–	01	01	–	–	–	–	–
58	Rubiaceae	04	–	02	–	–	01	–	–	–	–	–	01
59	Rutaceae	04	02	–	–	01	01	–	–	–	–	–	–
60	Salicaceae	01	–	01	–	–	–	–	–	–	–	–	–
61	Santalanaceae	01	–	01	–	–	–	–	–	–	–	–	–
62	Sapotaceae	02	–	01	–	–	–	–	–	–	–	–	–
63	Scrophulariaceae	01	–	–	–	–	–	–	–	01	–	–	–
64	Simaronbaceae	01	–	01	–	–	–	–	–	–	–	–	–
65	Solanaceae	02	01	–	–	–	01	–	–	–	–	–	–
66	Symplocaceae	01	–	01	–	–	–	–	–	–	–	–	–
67	Thymelaceae	01	–	–	–	–	–	–	01	–	–	–	–
68	Tiliaceae	01	–	01	–	–	–	–	–	–	–	–	–
69	Umbeliferae	02	–	–	–	01	01	–	–	–	–	–	–
70	Valerianaceae	01	–	–	–	–	01	–	–	–	–	–	–
71	Verbenaceae	04	02	–	–	01	01	–	–	–	–	–	–
72	Zingiberaceae	06	–	–	–	–	01	02	–	03	–	–	–
73	Zygophyllaceae	01	–	–	–	01	–	–	–	–	–	–	–
Total	164	22	31	05	13	45	21	04	05	03	01	14	

Table 1. Categorisation of medicinal plants reported in classical Ayurvedic texts for wound healing activity.

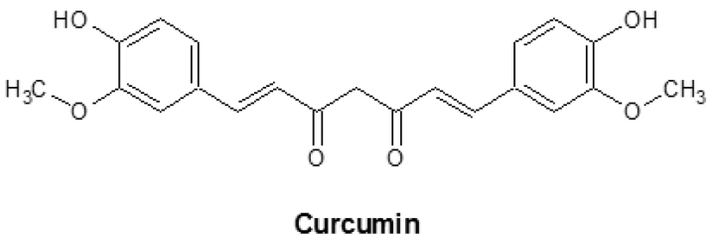

Figure 1. Chemical structure of curcumin.

Pre-clinical investigation of this plant was performed for wound healing activity in a rabbit model in comparison with honey. Significant ($p < 0.01$) improvement of the tensile strength and wound contraction (mm^2) was observed with *C. longa* within a period of 14 days to heal a rectangular full thickness wound measuring 10 × 4 cm^2 area. The result was further evaluated on the basis of the histopathological parameters revealing well-organized remodelling of collagen, reticulin and elastin fibres as well as appearance of epithelialisation and neovascularisation [18]. It has been postulated that the cross linking of collagen for the purpose of wound healing with curcumin is due to its antioxidant properties [19].

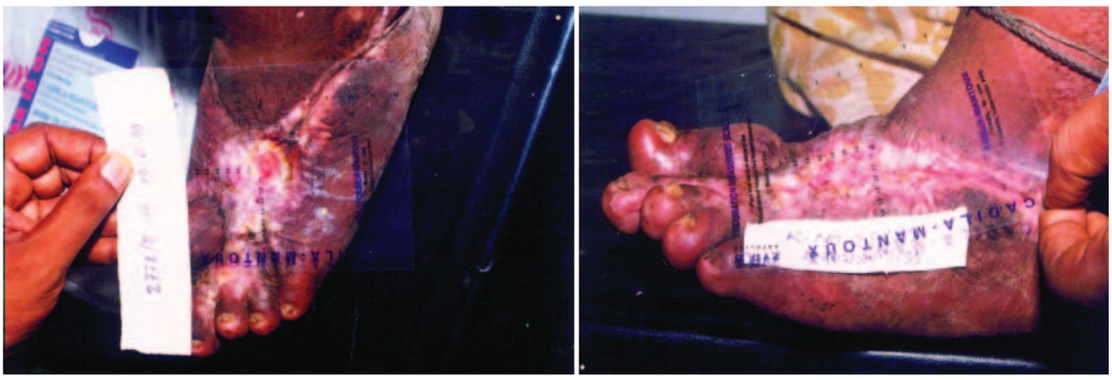

Figure 2. Patient of lower extremity wound before (a) and after (b) 15 days treatment with 15% *P. santalinus ointment*.

2.1.2. Pterocarpus santalinus

The heartwood of the plant *Pterocarpus santalinus* L. (family Papilionaceae), commonly known in the name of red sandal wood, is described in Ayurveda for wound healing property [20]. A detailed wound healing study in the pharmacological model on Charles Foster strain rats was performed on 8 mm full thickness punch, burn and streptozotocin-induced wound models. Significant ($p < 0.001$) results were observed on the basis of the wound contraction size, tensile strength, tissue DNA, RNA, protein and collagen (hydroxyproline as a marker) synthesis, tissue remodelling as observed by histological studies on collagenesis, angiogenesis and epithelialisation [21]. The results were finally quantified by PAGE study with estimation of protein synthesis in which it was found that proteins with different molecular weight on the variations in different days were synthesised indicating its potentiality in triggering the cell

http://dx.doi.org/10.5772/65520

signalling system for successful healing of the wounds. A pilot clinical study on selected six patients of lower extremity wounds was evaluated with 15% paste of the drug under ointment base and significant ($p < 0.01$) improvement was observed (**Figure 2**) on the basis of the granulation and epithelialisation [22]. The drug has been patented officially and now being marketed either as single ingredient or in combined form for the purpose of wound healing.

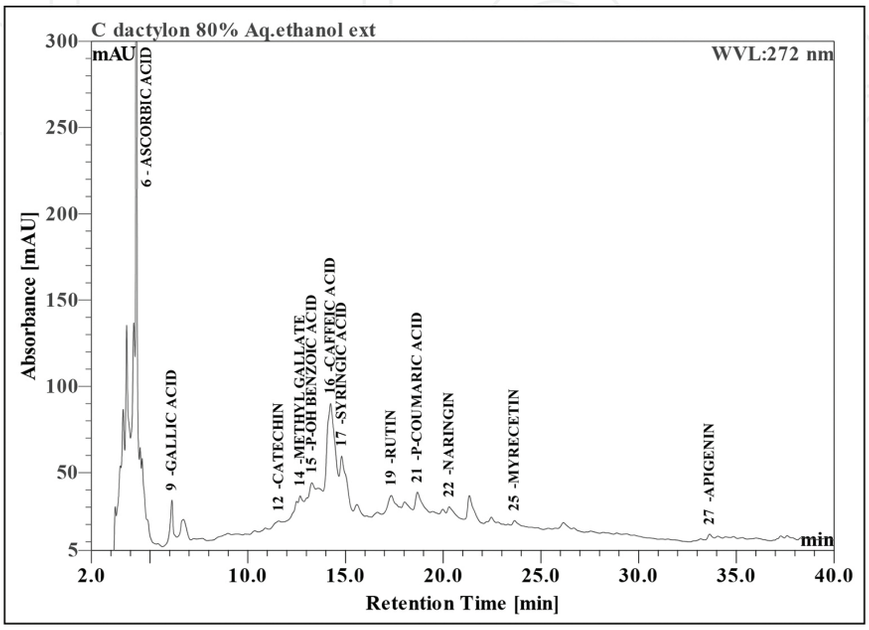

Figure 3. HPLC chromatogram of 80% aq. ethanol extract of *C. dactylon*.

2.1.3. Cynodon dactylon

Cynodon dactylon (Linn.) Pers (Family Gramineae) is a medicinal plant categorized in Ayurveda for its wound healing activity. In *Charaka Samhita*, one of the oldest classical text of Ayurveda, the plant is described in different names for different activities such as '*Sita*' and '*Lata*' for its role to improve body complexion, '*Satavirya*' and '*Sahasravirya*' for its fertility promoting activity, etc. and '*Durva*' for use as fresh juice in the treatment of wounds (*Vrana*) in particular [23]. A detailed chemical, pharmacological and clinical study of 80% aqueous ethanol extract of the plant was performed by the authors for wound healing activity. Chemical study with HPLC revealed that the extract of the plant was found to contain total phenol (23.98 ± 0.16 mg/g GAE), flavonoid (5.79 ± 0.14 mg/g rutin equivalent) and flavonol (14.84 ± 0.17 mg/g quercetin equivalent) (**Figure 3**). The plant also showed antiradical activity by scavenging DPPH (IC_{50} 2.29 ± 0.13 mg/g) and ABTS radical (IC_{50} 0.40 ± 0.001 mg/g). The HPLC analysis of the crude ethanol extract of the plant under investigation showed the presence of ascorbic acid (7.66 ± 0.05 mg/g), phenolic acids namely gallic acid (0.44 ± 0.01 mg/g), *p*-hydroxy benzoic acid (0.06 ± 0.009 mg/g), caffeic acid (2.20 ± 0.01 mg/g), syringic acid (2.78 ± 0.02 mg/g), *p*-coumaric acid (0.44 ± 0.006 mg/g), flavonoids like rutin (0.88 ± 0.01 mg/g), naringin (0.14 ± 0.003 mg/g), myricetin (0.08 ± 0.002 mg/g), apigenin (0.05 ± 0.0009 mg/g) and catechin (0.58 ± 0.006 mg/g) (**Tables 2** and **3**). The phenolic acids and flavonoids present in the plant can react with the

reactive oxygen species and act as free radical scavengers leading to healing of wounds [24]. Detailed experimental study on an 8 mm full thickness punch wound in CF rats showed that the 5% ointment prepared with aqueous ethanol extract of the plant could significantly be able to contract the wounds within a very short period of 10 days and could generate tissue protein, DNA, RNA, protein and hydroxyproline, which were significantly ($p < 0.05–0.01$) better than standard comparator framycetin topical antibiotic ointment or vehicle control petroleum jelly (**Table 4**). The pharmacological study thus conspicuously mimics the chemical analysis of the plant. The drug, thereafter, clinically evaluated by selecting 12 patients of non-healing wounds dividing into two groups comprising equal number (6) of patients treating with 5% ointment prepared with aqueous ethanol extract of the plant and standard comparator framycetin topical antibiotic ointment continuously applied for 21 days. Physical examination on the basis of wound contraction (mm^2) and appearance of granulation and epithelialisation showed significant improvement ($p < 0.05$) in *C. dactylon* treated group than the comparator (**Table 5**).

Name of the plant	Total phenolic content mg/g dry extract (GAE equivalent)	Total flavonoid content mg/g dry extract (rutin equivalent)	Total flavonol content mg/g dry extract (quercetin equivalent)	Reducing power mg/g dry extract (AAE equivalent)	DPPH radical scavenging activity IC_{50} mg/g dry extract	ABTS radical scavenging activity IC_{50} mg/g dry extract
C. dactylon	23.9 ± 0.16	5.79 ± 0.14	14.84 ± 0.17	12.96 ± 0.68	2.29 ± 0.13	0.40 ± 0.001

Each value in the table was obtained by calculating the average of three experiments and data presented as mean ± SEM.

Table 2. Total phenolic, flavonoid, flavonol content, reducing power and radical scavenging activities of 80% aq. ethanol extract of *C. dactylon*.

Ascorbic acid/phenolic acids/flavonoids in *C. dactylon*	Amount in mg/g dry extract (mean ± SD)
Ascorbic acid	7.66 ± 0.05
Gallic acid	0.44 ± 0.01
Catechin	0.58 ± 0.006
Methyl gallate	0.12 ± 0.01
p-Hydroxy benzoic acid	0.06 ± 0.009
Caffeic acid	2.20 ± 0.01
Syringic acid	2.78 ± 0.02
Rutin	0.88 ± 0.01
p-Coumaric acid	0.44 ± 0.006
Naringin	0.14 ± 0.003
Myricetin	0.08 ± 0.002
Apigenin	0.05 ± 0.0009

Table 3. Quantification of ascorbic acids, phenolic acids and flavonoids in the 80% aq. ethanol extract of *C. dactylon*.

Physical and biochemical parameters	*C. dactylon* (*n* = 6)	Framycetin (*n* = 6)	Petroleum jelly (vehicle) (*n* = 6)
Wound contraction (mm^2)	2.04 ± 0.48*	2.64 ± 0.70	3.33 ± 0.31
Healing period (days)	10.00 ± 0.97*	12.00 ± 0.63*	15.83 ± 0.93
Tensile strength (g)	421.50 ± 32.84*	410.41 ± 34.57	301.12 ± 24.08
DNA (mg/g)	2.02 ± 0.05*	2.49 ± 0.02*	1.11 ± 0.06
RNA (mg/g)	1.92 ± 0.03*	2.13 ± 0.02*	1.01 ± 0.02
Protein (mg/g)	22.73 ± 0.06**	25.16 ± 0.10**	12.30 ± 0.15
Hydroxyproline (mg/g)	4.69 ± 0.06**	3.72 ± 0.07**	1.99 ± 0.05

Results are expressed in mean ± SEM.
*$p < 0.05$.
**$p < 0.01$.

Table 4. Physical and biochemical assessment of 5% *C. dactylon* ointment with respect to vehicle control and framycetin in punch wound model in rat.

Parameters	Time interval (*n* = 6)	*C. dactylon* (*n* = 6)	Framycetin (*n* = 6)
Wound area (mm^2)	0 day	25.58	15.00
	21 day	0.37	0
	d ± SE	25.06 ± 5.25*	15.00 ± 2.83*
Granulation/epithelialisation	0 day	1.11	1.00
	21 day	4.96	1.33
	d ± SE	3.86 ± 0.08*	0.33 ± 0.23

Results are expressed in mean differences (d) ± SE.
*$p < 0.05$.

Table 5. Physical evaluation of 5% *C. dactylon* ointment in comparison with framycetin treated group in patients of chronic non-healing wounds.

2.1.4. Polyherbal formulation

Most of the drugs in Ayurveda are used in the polyherbal form for different diseases. These formulations were standardized in the composition and preparation technique according to the clinical experiences obtained from time to time as well as experiences gained from one group of Ayurvedic School to other. A classic example is also applied in designing wound healing drugs of polyherbal composition developed by Bengal school of Ayurveda. The unique preparation is commonly known in the local name of '*Kshatantak Malam*' (wound healing ointment), prepared with leaves of *Achyranthesaspera* L. (Amaranthaceae), onion juice (*Allium cepa* L., Lilliaceae) and leaves of *Cannabis sativa* L (Cannabaceae) under the base of butter. The whole preparation is placed in a decanted tender coconut and covered well with clothes and mud. The preparation when dried is put in a pit and fired by natural way with cow dung cakes (**Figure 4a–d**). The ointment thus obtained was chemically screened by gas liquid chromatog-

raphy (GLC), which showed presence of palmitic acid, oleic acid and polyunsaturated fatty acids. It was rendered for detailed pharmacological screening through the standard protocol after initial acute and chronic toxicity studies in the mice model, revealing safe in use. Pharmacologically the drug showed very significant ($p < 0.05$) wound healing activity when screened on the basis of the physical parameters like wound contraction size, wound index, healing period, tensile strength; biochemical marker evaluation like tissue DNA, RNA, protein, hydroyproline and PAGE study and histological findings [25]. A multidimensional *modus operandi* is proposed for wound healing activity of this formulation. The formulation is composed with *Acyranthes aspera*, *Allium cepa* and *Cannabis sativa. A. aspera* is earlier reported for potent activity in diabetic, burn and immune compromised wounds. *A. cepa* is reported to be active against several micro-organisms like *Streptococcus aureus, Bacilus subtilis* and *Pseudomonas aeruginosa* supporting its anti-bacterial. Butter is used as a good homogenous substance. *C. sativa*, on the other hand, has capability to repair tissues due to its anti-inflammatory property [25].

2.2. Metals and minerals

Metals and minerals are used in Ayurveda to combat several diseases. However, there is description of the technical procedure for purification of these components before therapeutic use. *Jasada bhasma*, an Ayurvedic preparation of zinc, is used for the treatment of wounds. In a pre-clinical study, 10 and 20% ointment of *Jasad Bhasma* was screened both in incised and excised wounds, which showed increased wound contraction and tensile strength, decreased period of re-epithelization and scar area along with proliferative activity on fibroblasts. It is proposed that the functional role of zinc in repair systems is provided by demonstration of zinc metalloenzymes like alkaline phosphatase, RNA and DNA polymerases and metalloproteinases [26].

a **b** **c** **d**

Figure 4. Steps of preparation of *Kshantak Malam* initiated with decanted tender coconut (a), putting of drug preparation covering with clothes and mud (b), placing on pit with cow dung cakes (c) and firing till the end of reaction (d).

2.3. Animal products

Besides, medicinal plants and metallic drugs, animal products also play an important role in treatment of wounds in Ayurveda. The most important animal products that exhibit wound

http://dx.doi.org/10.5772/65520

healing activity is honey. Several studies are reported for wound healing potential of honey. Honey performed the healing activity due to its anti-oxidant, anti-inflammatory, wound debridement, leukocytic stimulation, cytokine and growth factor releasing as well as osmotic activities probably due to presence of natural phenolic compounds [27].

3. Conclusion

Healing of wounds engrosses a diverse mechanism in the process of cell repair involving multiple biological factors. Ideal healing is demarcated with successful closure of wounds in minimum days without any adverse effect. Ayurveda is one of the best ethnological sources to search natural sources for wound healing property. Many drugs are described in different texts for wound healing property, but only few of them have been scientifically screened which are described in the recent review. The information provided in favour of *C. dactylon*, is purely unpublished and may have potentiality in future. Other drugs of Ayurvedic origin either plants, metals or animal origin already exist in clinical practice for wound healing purpose.

Acknowledgements

Authors are thankful to Professor Biswapati Mukherjee, former Director, S. N. Pradhan Centre for Neuroscience, University of Calcutta for encouragement. Authors are also thankful to the Indian Council of Medical Research for financial support to conduct research on *Kshanatak Malam*.

Author details

Tuhin K. Biswas[1*], Saheli Banerjee[1], Nandini Poyra[1], Srikanta Pandit[1], Utpalendu Jana[1], Shrabana Chakrabarti[1] and Tapan Seal[2]

*Address all correspondence to: biswastuhin@rediffmail.com

1 Research Unit, J. B. Roy State Ayurvedic Medical College and Hospital, Kolkata, India

2 Department of Plant Chemistry, Botanical Survey of India, Howrah, India

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