Evaluation of the wound healing potential of
*Albizia lebbeck* (L.) bark

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Abstract:

The present study was performed to substantiate the traditional claim of the wound healing activity of stem bark of *Albizia lebbeck* Linn. in rats. The effects of aqueous and ethanolic extracts of stem bark of *A. lebbeck* (5% and 10% w/v topically and 250 mg/kg and 500 mg/kg p.o.) on excision, incision and dead space wound model were examined. The extracts were administered orally for 10 days for incision and dead space wound model and for excision model drugs were administered until complete epithelialization. The healing of wound was assessed by the rate of wound contraction and period of epithelialization for excision model, tensile strength and histopathology of the incision wound skin for incision model, dry granulation tissue weight and hydroxyproline content for dead space wound. Treatment of wound with ethanolic extract 10% w/v topically exhibited significant (*p* < 0.01) wound healing activity in all three models as compared to control groups. High rate of wound contraction, decrease in period of epithelialization, high tensile strength, increase in dry granulation tissue weight, elevated hydroxyproline content and increased collagenation in histopathological section were observed in animals treated topically with 10% w/v ethanolic stem bark extract. The ethanolic and aqueous extracts were quantitatively analyzed for alkaloids, flavonoids and phenols, and the contents were found to be greater in ethanolic extract than aqueous extract. Topical application (10% w/v) of ethanolic extract possesses better wound healing property and this activity could be attributed due to presence of alkaloids, phenols and flavonoids.

Keywords: *Albizia lebbeck*; Excision wound; Incision wound; Dead space wound; Hydroxyproline content
Introduction

Wound is a clinical entity and is as old as mankind, often possesses problem in clinical practice. Injury to the skin initiates a series of events including inflammation, new tissue formation, and matrix remodeling. A lot of research has been envisaged to develop the better healing agents and it has been a challenging task to discover healing agents and keep up pace with problems encountered [1]. Medicinal plants have been used since immemorial time for the treatment of various ailments of skin and dermatological disorders especially cuts, wounds and burns [2]. Albizia lebbeck Linn. (Mimosaceae) is a tropical evergreen tree widely distributed in India, South Africa and Australia. Its stem bark has been used for a long time in Southeast Asia as a traditional medicine for toothache, diseases of gum, skin infection, ulcer, piles, dysentery and diarrhea [3, 4]. A. lebbeck contains tannin, flavonoids, steroids, and triterpenoids [5]. The plant is well known for its anti-inflammatory, analgesic, and antioxidant [5], and anti-microbial [6, 7] activities. However, investigation of the wound healing activity has not yet been carried out, therefore, the aim of the present study was to evaluate the wound healing potential of the A. lebbeck stem bark.

Materials and methods

Plant material and chemicals

The fresh stem bark of A. lebbeck Linn. (Mimosaceae) was collected from A.B. Road, Indore (M.P.). The plant was authenticated and voucher specimen (RAJUPALBL3) was deposited at the herbarium of the Botanical survey of India, (Pune) India. All the chemicals and reagent used were of analytical grade, obtained from Kasliwal Brothers, Indore, India.

Extraction procedure

The stem bark of A. lebbeck was shade dried, coarsely powdered and defatted by maceration with petroleum ether for 48 h. For aqueous extract the defatted marc were subjected to hot decoction. The solvent was filtered through muslin cloth. The total aqueous extract was concentrated using rotary evaporator and labeled as ALAE. The extract was stored in tightly closed container and kept in refrigerator at 2-8°C. For the preparation of ethanolic extract the defatted marc was subjected to soxhlet extraction with 95% ethanol (2.5 L) at (60-80°C). The solvent was filtered through Whatman No. 1 filter paper and evaporated to dryness under vacuum at 40°C using rotary evaporator. The ethanolic extract was stored in tightly closed container and kept in refrigerator at 2-8°C until use and labeled as ALEE. The extract was freshly prepared and used within a month.

Phytochemical analysis

The aqueous and ethanolic extracts were tested qualitatively for presence of different phytoconstituents like glycosides, flavonoids, saponins, alkaloids, carbohydrates, sterols, proteins using standard methods and screened quantitatively for content of total alkaloid, total phenols by Folin-Ciocalteu method, and the total flavanoid content.

Determination of total alkaloid content

The sample was ground to fine powder. To each five gram powder 200 mL of 10% acetic acid in ethanol were added. The material was allowed to macerate for 4 h. After 4 h it was filtered and extract concentrated to one quarter of the original volume. The concentrated ammonium hydroxide was then added drop wise until complete precipitation. The alkaloidal precipitate was collected, dried and weighed. Value were expressed as g% of dry weight [8].

Determination of total phenol content

A methanolic solution of the extracts at 1 mg/mL was used in the analysis. The reaction mixture was prepared by mixing 0.5 mL of a methanolic solution of extract, 2.5 mL of 10% Folin-Ciocalteu’s reagent dis-solved in water and 2.5 mL of 7.5% sodium bicarbonate. A blank was prepared concomitantly, containing 0.5 mL methanol. 2.5 mL of 10% Folin-Ciocalteu’s reagent dissolved in water and 2.5 mL of 7.5% sodium bicarbonate. The samples were then incubated at 45°C for 45 min and the absorbance was measured at 765 nm. Quantification was done on the basis of a standard curve of gallic acid [9]. The results
were expressed as gallic acid equivalents (mg of GA/g of extract).

**Determination of total flavonoid content**

A methanolic solution of the extracts at a concentration of 1 mg/mL was used in the analysis. The reaction mixture was prepared by mixing 0.5 mL of the methanolic solution of the extract, 0.1 mL of 10% aluminum chloride, 0.1 mL of 1 M potassium acetate and 2.8 mL of distilled water. The absorbance was measured at 415 nm after 30 min incubation at room temperature. Quantification was done on the basis of a standard curve of quercetin [10, 11]. The results were expressed as quercetin equivalents (mg of quercetin/g of extract).

**Extract formulations**

Two types of formulations were prepared from each of the extracts (ALAE and ALEE). For topical administration suspension were prepared ALAE-T (5% and 10%) and ALEE-T (5% and 10%) w/v in normal saline (0.9%). For oral administration 250 and 500 mg/kg of aqueous and ethanolic suspensions of extracts were prepared by triturating it with sodium carboxymethyl cellulose (0.5%) in glass mortar with gradual addition of distilled water to make the required volume and labeled as ALAE-O and ALEE-O.

**Animals**

The Wistar rats of either sex weighing 150-200 g were used. Animals were housed under standard condition of temperature (25 ± 2°C), 12h/12h light/dark cycle and fed with standard pellet diet (Godrej Agrowet Ltd. Indore, India) and water ad libitum. The animals were allowed to acclimatize for one week before the experiments. All experimental protocols were approved by the Institutional Animal Ethics Committee (IAEC) under the supervision of Committee for the Purpose of Control and Supervision on Experiments on Animals (CPCSEA). The acute toxicity study was carried out for ethanolic and the aqueous extracts by the OECD guidelines no. 425 and 434 [12, 13].

**Animal groupings and treatment**

For excision wound model. Wistar rats were divided into thirteen groups and each group consisting of six animals, where group I was topical control (saline 0.9%), group II as oral control (0.5% sodium carboxy methylcellulose), group III as standard I (povidone iodine ointment, topically), group IV as standard II (turmeric powder 0.5 g/cm², topically), group V as standard III (ascorbic acid 500 mg/kg, p.o.), group VI-VII ALAE-O (250 and 500 mg/kg, p.o.), group VIII-IX ALEE-O (250 and 500 mg/kg, p.o.), group X-XI ALAE-T (5% and 10% w/v, topical), group XII-XIII ALEE-T (5% and 10% w/v, topical). For incision and dead space wound models. Wistar rats were divided into four groups and each group consisting of six animals, where group I served as topical control (saline 0.9%), group II as standard (povidone iodine ointment, topically), group III ALEE-T (5% w/w, topical), and group IV ALEE-T (10% w/w, topical) once per day. Povidone iodine and turmeric were used as standard for topical applications. Drug of investigation is of herbal origin therefore turmeric was used as additional standard along with povidone iodine. Ascorbic acid was given orally in the solution form and was used as standard for oral administrations.

**Excision wound**

The rats were anesthetized by administering ketamine-xylazine in combination (ketamine 60 mg/kg and xylazine 5 mg/kg i.p.). A full thickness of the excision wound of circular area (approximately 500 mm²) was made on the depilated ethanol sterilized dorsal thoracic region of the rats, 30 min later the administration of ketamine-xylazine injection under strict aseptic technique. The wounding day was considered as day 0. The treatment was started as per given treatment schedule. The wounds were monitored and the area of wound was measured on 0, 3rd, 6th, 9th, 12th and 15th post-wounding days. The period of epithelialization was calculated as the number of days required for falling of the dead tissue without any residual raw wound [14, 15].

Wound healing rate was calculated by
% of wound closure = 
\[ \frac{\text{Wound area on day 0} - \text{Wound area on day } 'n' \times 100}{\text{Wound area on day 0}} \] (1)

Where \( n \) = number of days 3\(^{rd} \), 6\(^{th} \), 9\(^{th} \), 12\(^{th} \) and 15\(^{th} \) day.

**Incision wound**

The rats were anesthetized by administering ketamine-xylazine in combination. Incision wounds of about 6 cm in length and about 2 mm in depth were made with sterile scalpel on the shaved back of the rats 30 min later the administration of ketamine-xylazine injection. The parted skin was stitched with sterilized needle at 0.5 cm intervals. The wounds of animals in the different groups were treated as per treatment schedule for the period of 10 days. The wounding day was considered as day 0. When wounds were cured thoroughly, the sutures were removed on the 5\(^{th} \) post-wounding day and the tensile strength of the skin that is the weight in grams required to break open the wound/skin was measured by tensiometer (fabricated In-house) on the 11\(^{th} \) day [16].

Tensile strength was calculated as follows [17]

\[ \text{Tensile strength} = \frac{\text{Breaking strength (g)}}{\text{Cross-sectional area of skin (mm}^2\text{)}} \] (2)

**Dead space wound model**

Dead space wounds were created by subcutaneous implantation of sterilized cotton piths (10 mg) on the right side groin and axilla on the ventral surface of each rat. Treatment was given as per described in treatment schedule. The granulation tissues formed on the cotton piths were excised carefully on the 10\(^{th} \) post wounding day under light ether anesthesia. The tissue was dried overnight at 60°C and the dry granulation tissue weight was recorded on 11\(^{th} \) day. The granulation tissue so harvested was subjected to hydroxyproline estimation [14, 18].

**Statistical analysis**

Data were expressed as mean ± standard error of mean and statistical analysis was carried out employing one way analysis of variance (ANOVA) followed by Tukey’s-Kramer multiple comparison test at \( p < 0.05 \) significance level using “Graphpad Instaté version 3.00 for Windows 95, Graphpad Software, San Diego, California, USA (www.graphpad.com).

**Results**

**Phytochemical analysis**

The percentage yields of the aqueous and ethanolic extracts were found to be 10.3% and 12.4% w/w, respectively. The preliminary phytochemical screening of aqueous and ethanolic extracts revealed the presence of tannins, alkaloids, flavonoids, and saponins. Quantitative tests indicated that the stem bark ethanolic extract is highly rich in flavonoids, tannins, lipid and alkaloids (Table 1).

**Table 1** Quantitative determination of phytoconstituents in aqueous and ethanolic extracts of *Albizia lebbeck*

<table>
<thead>
<tr>
<th>Phytoconstituents</th>
<th>ALAE</th>
<th>ALEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total alkaloids (g %)</td>
<td>2.1 ± 0.2</td>
<td>2.5 ± 0.1</td>
</tr>
<tr>
<td>Total flavonoid content (mg quercetin equivalents/g of extract)</td>
<td>8.2 ± 0.2</td>
<td>12.2 ± 0.3</td>
</tr>
<tr>
<td>Total phenolic content (mg tannic acid equivalents/g of extract)</td>
<td>15.1 ± 0.7</td>
<td>24.6 ± 0.8</td>
</tr>
</tbody>
</table>

ALEE: *Albizia lebbeck* ethanolic extract, ALAE: *Albizia lebbeck* aqueous extract
Excision wound study

The wound healing contracting ability of animals treated with ethanolic extract 5% and 10% topically was found to be significantly higher (p < 0.01) on day 9, 12 and 15 as compared to the control (Table 2). The epithelialization period (complete healing) was also found to be 18.2 ± 0.6 and 16.2 ± 0.5 days in case of animals treated with ethanolic extract (ALEE) topically, 5% and 10% respectively. Povidone iodine (5% w/w) showed epithelialization period 15.2 ± 0.3 days and was significantly reduced (p < 0.01) as compared with control. ALEE-T (10%) epithelialization period was found to be equivalent to the animals treated with povidone iodine. Turmeric powder applied topically showed same epithelialization period (16.8 ± 0.6 days) as that of ALEE 10% topical. Ascorbic acid given orally significantly reduced (p < 0.01) days of epithelialization (18.2 ± 0.6 days) as compared to control. All other treated groups i.e. ALAE (250 and 500 mg/kg p.o.), ALEE (250 and 500 mg/kg p.o.) and ALAE (5% and 10% topical) were found insignificant when compared with control (Table 2).

Incision wound study

In incision wound model, ALEE-T 5% and 10% topical, significantly increased (p < 0.01) the tensile strength on 10th post wounding day (507.9 ± 12.2 and 565.6 ± 9.7 g/mm²) respectively when compared to control (399.5 ± 11.0 g/mm²) (Table 3). Histopathological studies of the granulation tissue of the control group

<table>
<thead>
<tr>
<th>Treatment &amp; doses</th>
<th>Day 3</th>
<th>Day 6</th>
<th>Day 9</th>
<th>Day 12</th>
<th>Day 15</th>
<th>Complete healing days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control -T</td>
<td>9.5 ± 5.9</td>
<td>22.3 ± 7.6</td>
<td>33.6 ± 5.1</td>
<td>52.7 ± 5.2</td>
<td>67.9 ± 3.5</td>
<td>25.4 ± 0.6</td>
</tr>
<tr>
<td>Control -O</td>
<td>11.3 ± 1.2</td>
<td>26.8 ± 4.9</td>
<td>48.9 ± 4.2</td>
<td>65.6 ± 4.4</td>
<td>71 ± 3.6</td>
<td>24.2 ± 0.4</td>
</tr>
<tr>
<td>Std-I (Povidone-iodine)</td>
<td>16.9 ± 2.0</td>
<td>45.5 ± 2.0b</td>
<td>80.8 ± 1.1b</td>
<td>94.1 ± 0.4b</td>
<td>99.2 ± 0.1b</td>
<td>15.2 ± 0.3b</td>
</tr>
<tr>
<td>Std.-II (Turmeric powder)</td>
<td>13.6 ± 2.1</td>
<td>34.6 ± 3.4</td>
<td>70.5 ± 2.4b</td>
<td>88.8 ± 1.8b</td>
<td>98.6 ± 4.3b</td>
<td>16.8 ± 0.6b</td>
</tr>
<tr>
<td>Std.-III (Ascorbic acid)</td>
<td>13.2 ± 2.7</td>
<td>44.4 ± 3.5</td>
<td>71.7 ± 2.1d</td>
<td>83.5 ± 1.8c</td>
<td>91.9 ± 1.1c</td>
<td>18.2 ± 0.6d</td>
</tr>
<tr>
<td>ALAE-O (250 mg/kg)</td>
<td>9.4 ± 1.1</td>
<td>20.7 ± 2.7</td>
<td>31.3 ± 3.3</td>
<td>49.2 ± 1.6</td>
<td>71.0 ± 2.6</td>
<td>23.2 ± 0.6</td>
</tr>
<tr>
<td>ALAE-O (500 mg/kg)</td>
<td>12.8 ± 2.5</td>
<td>31.2 ± 4.6</td>
<td>37.4 ± 3.9</td>
<td>62.8 ± 6.2</td>
<td>70.1 ± 4.6</td>
<td>21.8 ± 0.4a</td>
</tr>
<tr>
<td>ALEE-O (250 mg/kg)</td>
<td>12.1 ± 0.8</td>
<td>25.9 ± 6.1</td>
<td>45.9 ± 3.9c</td>
<td>60.6 ± 7.6</td>
<td>85.2 ± 2.5c</td>
<td>21.0 ± 0.4b</td>
</tr>
<tr>
<td>ALEE-O (500 mg/kg)</td>
<td>10.9 ± 3.6</td>
<td>24.9 ± 3.1</td>
<td>45.9 ± 3.3</td>
<td>61.5 ± 5.1</td>
<td>74.8 ± 3.8</td>
<td>21.2 ± 0.3a</td>
</tr>
<tr>
<td>ALEE-T (5% w/v in saline)</td>
<td>13.1 ± 1.7</td>
<td>25.1 ± 1.8</td>
<td>34.8 ± 1.2</td>
<td>47.9 ± 2.5</td>
<td>64.1 ± 3.7</td>
<td>22.8 ± 0.4a</td>
</tr>
<tr>
<td>ALAE-T (10% w/v in saline)</td>
<td>13.6 ± 3.7</td>
<td>28.4 ± 3.7</td>
<td>42.2 ± 4.4</td>
<td>56.3 ± 3.4</td>
<td>70 ± 1.5</td>
<td>19.8 ± 0.4a</td>
</tr>
<tr>
<td>ALEE-T (5% w/v in saline)</td>
<td>14.8 ± 5.4</td>
<td>44.2 ± 3.7a</td>
<td>70.1 ± 5.8b</td>
<td>84.6 ± 1.4b</td>
<td>90.8 ± 0.9b</td>
<td>18.2 ± 0.6b</td>
</tr>
<tr>
<td>ALEE-T (10% w/v in saline)</td>
<td>15.1 ± 1.8</td>
<td>44.6 ± 2.3a</td>
<td>79.0 ± 5.9b</td>
<td>91.9 ± 2.9c</td>
<td>98.4 ± 2.6b</td>
<td>16.2 ± 0.5b</td>
</tr>
</tbody>
</table>

ALEE: Albizia lebbeck ethanolic extract, ALAE: Albizia lebbeck aqueous extract, T: topical, O: Oral,

Results are expressed as mean ± SEM; n=6 in each group. Data was analyzed by one way ANOVA followed by Tukey Kramer multiple comparison test. *p<0.05, **p<0.01 Vs control-T; *p<0.05, **p<0.01 Vs control-O.
showed more aggregation of macrophages with few collagen fibers (Figure 1). In case of ALEE-T 5% treated group, moderate collagen deposition, macrophages and fibroblasts were noticed, whereas in ALEE-T 10% treated group significant increase in collagen deposition and fibroblast with lesser macrophages was observed.

**Dead space wound study**

In dead space wound study the groups treated with ALEE-T, 5% and 10% w/v topical, significantly increased weight of granuloma by 50.2 ± 3.4 mg and 61.3 ± 1.4 mg, respectively compared to control 30.9 ± 0.9 mg. The hydroxyproline contents with ALEE-T

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**Table 3** Effect of ethanolic extract of *Albizia lebbeck* bark on incision wound and dead space wound model

<table>
<thead>
<tr>
<th>Group</th>
<th>Treatments (topically)</th>
<th>Incision wound</th>
<th>Dead space wound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Tensile strength on $10^{th}$ day (g/mm²)</td>
<td>Granuloma wt. (mg/100 g)</td>
</tr>
<tr>
<td>I</td>
<td>Control-T</td>
<td>399.5 ± 11.0</td>
<td>30.9 ± 0.9</td>
</tr>
<tr>
<td>II</td>
<td>ALEE-T (5% w/v in saline)</td>
<td>507.9 ± 12.2$^\text{a}$</td>
<td>50.2 ± 3.4$^\text{a}$</td>
</tr>
<tr>
<td>III</td>
<td>ALEE-T (10% w/v in saline)</td>
<td>565.6 ± 9.7$^\text{a}$</td>
<td>61.3 ± 1.4$^\text{a}$</td>
</tr>
<tr>
<td>IV</td>
<td>Standard-T (povidone-iodine)</td>
<td>608.7 ± 9.8$^\text{a}$</td>
<td>72.1 ± 3.4$^\text{a}$</td>
</tr>
</tbody>
</table>

ALEE: *Albizia lebbeck* ethanolic extract. T: topical

Results are expressed as mean ± SEM; n=6 in each group. Data was analyzed by one way ANOVA followed by Tukey Kramer multiple comparison test. $^\text{a}$p<0.01 Vs control-T.

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**Figure 1** Histopathological characteristics of tissue on treatment with (a) normal saline (control topical), (b) ethanolic extract of *Albizia lebbeck* topical (ALEE-T 5% w/v), (c) ethanolic extract of *Albizia lebbeck* topical (ALEE-T 10% w/v) and (d) povidone-iodine ointment (standard topical)
5% and 10% w/v topical treatment were $2.7 \pm 0.2$ and $5.0 \pm 0.1$ mg/g tissue, respectively, and were significantly higher ($p < 0.01$) than control group ($1.5 \pm 0.1$ mg/g tissue). The hydroxyproline content with povidone iodine treatment was found to be $5.1 \pm 0.2$ which was found to be similar to the group treated with ALEE-T 10% w/v (Table 3).

**Discussion and Conclusion**

Wound healing is a complex and dynamic process of restoring cellular structure and tissue layers in damaged tissue as closely as possible to its normal state. Wound contracture is a process that occurs throughout the healing, commencing in the fibroblastic stage whereby the area of the wound undergoes shrinkage [19]. In excision wound model ethanolic extract of the *A. lebbeck* bark (ALEE-T) 10% w/v topically showed to possess better percentage of wound closure effect against control and other treated groups on 15th day by enhanced epithelialization. This may show that the plant extract possesses a definite pro-healing action. This may be due to the effect of extract on collagen synthesis. Collagens are an important component in all phases of wound healing. Synthesized by fibroblasts, they impart integrity and strength to all tissues and play a key role in proliferative phases of repair. Collagens act as a foundation for the intracellular matrix formation within the wound. Fibroblast is an important factor in wound healing and repair. The different cell types present after epidermal wounding include fibroblasts, endothelial cells and epithelial cells. The remodeling phase begins as the biologic products of these cells undergo transformation into the soft tissue components responsible for the formation of tissue re-growth [20].

Similarly in incision wound model ALEE-T 10% topical application increased the tensile strength. Significant increase was also observed in skin breaking strength and hydroxyproline content which was a reflection of increased collagen levels by increased cross linking of collagen fibers [21]. The breakdown of collagen liberates free hydroxylproline and its peptides and elevates level of hydroxyproline further supported by increased breaking strength. The ethanolic extract of *A. lebbeck* demonstrated a significant increase in the hydroxyproline content of the granulation indicating increased collagen turnover. The histological examination showed that the original tissue regeneration was much greater in the skin wounds that were treated with ALEE-T 10% and povidone-iodine ointment treated group without any oedema, congestion or inflammatory changes.

In dead space wound model ALEE-T 10% significantly increased weight of granuloma and hydroxyproline content against control. Granulation tissue, found in the final part of proliferative phase, is composed of fibroplasia, collagen synthesis, edema and neovascularization. The increase in dry granulation tissue weight in the test treated animals suggests higher protein content. The increased amount of hydroxyproline content in treated group underlines increased collagen content since hydroxyproline is the direct estimate of collagen synthesis which supports the wound healing activity of *A. lebbeck*. Wound healing activity of plant extract may also be subsequent to an associated antimicrobial effect [6, 7, 22].

Tissue injury initiates the inflammatory phase through the activation of several physiologic cascades. The different inflammatory cascades alter the local environment, produce vasodilatation of adjacent vessels, decrease the pH level and oxygen tension, and increase local lactate concentration. This signals the start of the proliferation phase. Inflammatory cells and macrophages populate the early cellular response, and endothelial cells appear later during healing. This was shown in the histopathology of the granulation tissue of the treatment group i.e, there was reduction in the inflammatory cells and macrophage cells [20].

The process of wound healing is promoted by several herbal extracts, which are composed of active agents like triterpenes, alkaloids, flavonoids, tannins, saponins, anthraquinones, and other biomolecules. Stimulation of fibroblasts is one mechanism by which herbal extracts might enhance the wound repair process [23]. The preliminary phytochemical analysis of the alcoholic bark extract of *A. lebbeck* showed the presence of tannins, alkaloids and flavonoids. Recent activity has
shown that phytochemical constituents like flavonoids are known to promote the wound healing process mainly due to their astringent and antimicrobial properties, which appears to be responsible for wound contraction and increased rate of epithelialization [24]. The wound healing property of *A. lebbeck* may be attributed to the phytoconstituents present in the plant and the quicker process of the wound healing could be function of either individual or additive effect of phytoconstituents [25]. Any of the observed phytochemical constituents present in *A. lebbeck* may be responsible for wound healing activity.

The present study has demonstrated that topical application of the ethanolic bark extract of *A. lebbeck* has properties that render it capable for promoting wound healing activity. However, further phytochemical studies are needed to isolate the active compound(s) responsible for the said activity.

**Conflicts of interest**

The authors report no conflicts of interest

**Acknowledgment**

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**References**


