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Antibacterial Activity of *Croton bonplandianum* (Bail.) Against Some Bacterial Isolates from Infected Wounds

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Authors' contributions

This work was carried out in collaboration between both authors. The first author VV performed the research work and wrote the initial draft of manuscript. The corresponding author RU designed the research problem and corrected the final format of manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: The antibacterial activity of medicinal plants against human pathogens has been evaluated by a number of studies. However, a few research works have been done on pus cell pathogens. So this research work was aimed to determine the antibacterial effect of *Croton bonplandianum* against bacterial isolates from pus cells causing wound infections and to compare the antibacterial effect of various solvent extracts of different parts of *Croton bonplandianum* with streptomycin against the isolated bacterial pathogens from wounds.
Study Design: *In vitro* assay of antibacterial activity
Place and Duration of Study: Post Graduate and Research Department of Biochemistry at Government Arts College (Autonomous), Kumbakonam, Tamilnadu, India, between January to June, 2011.
Methodology: The isolated bacterial pathogens such as *Pseudomonas aeruginosa*,

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Staphylococcus aureus, Enterococcus faecalis, *Enterobacter aerogenes* and *Escherichia coli* were used for the evaluation of antibacterial activity of *C. bonplandianum* by well diffusion method.
Results: The fresh latex showed highest inhibitory activity against *E. coli* (32 mm) and *E. faecalis* (30 mm) followed by aqueous and ethanol extracts of latex showed highest inhibitory activity against *E. aerogenes* (26 mm) than other solvent extracts. The ethanol and benzene extracts of leaf showed highest inhibitory activity against *S. aureus* (20 mm). The chloroform extract of fruits showed maximum inhibitory activity against *E. coli* (21 mm) when compared to other solvent extracts. The latex extracts of *C. bonplandianum* showed better results as compared to leaf and fruit extracts.
Conclusion: The results of present study supports that the traditional use of *C. bonplandianum* as antimicrobial agent in wound infections.

Keywords: Antibacterial activity; Croton bonplandianum; well diffusion method; leaf; fruits; latex.

1. INTRODUCTION

Skin and soft tissue infections (SSTIs) represent common health care problems that range from simple uncomplicated superficial skin infections such as cellulitis, furuncles, superficial abscesses and wound infections to life threatening infections like necrotizing fasciitis or gas gangrene [1]. Complicated SSTIs that involve deeper skin structures require significant surgical intervention and usually occur in the presence of significant co-morbidities [2]. Certain conditions may influence to complicate SSTIs such as trauma, pre-existing skin conditions, diabetes mellitus, or immune suppression [3,4]. SSTIs in hospitalized patients are associated with considerable patient morbidity, mortality and escalating healthcare expenditures, because of the need for additional surgery, antimicrobial therapy and prolonged hospital stay [5].

Bacteria cause serious infections in human as well as other animals. *S. aureus* cause superficial skin lesion, localized abscesses and food poisoning [6]. *P. aeruginosa* is one of the most commonly isolated nasocomial pathogens accounting for a significant percentage of hospital-acquired infections [7]. The spread of multidrug resistant *P. aeruginosa* is resulting in an increasing trend of nasocomial infections in hospitals and healthcare centers because there are no effective antimicrobial agents against it. Thus, there is a need to find an effective measure of controlling such harmful pathogens.

The indiscriminate use of antibiotics has led to the development of multidrug-resistant pathogens. Around 90 - 95% of *S. aureus* strains worldwide *are* resistant to penicillin [8] and in most Asian countries 70 - 80% of the strains have become methicillin resistant [9]. There are reports on the development of resistance to antibiotic defence, which has led to a search for reliable methods to control vancomycin-resistant enterococci (VRE), vancomycin-resistant *S. aureus* (VRSA) and methicillin-resistant *S. aureus* (MRSA) [10]. The rapid spread of bacteria expressing multidrug resistance (MDR) has necessitated the discovery of new antibacterial and resistance modifying agents.

Phytochemical and pharmacological investigations of several plants have already led to the isolation of some natural antimicrobials such as berberine and harmane whose mechanism of action is attributed to their ability to intercalate with DNA of microbes [11]. The known success of these traditional therapies has guided the search for new chemotherapeutics alternative to fight respiratory and other infections caused by drug-resistance bacteria [12]. Plants have the major advantage of still being the most effective and cheaper alternative source of drugs. One of such with promising medicinal principle is *Croton bonplandianum*, a member of the family Euphorbiaceae is an exotic weed commonly found in the waste lands and commonly known as 'Bantulsi' in Bengali and "Kukka tulsi" in Telugu [13]. The leaf of *C. bonplandianum* is used in the treatment of skin diseases, cuts and wounds have been claimed as antiseptic in nature [14]. This species of Croton is considered as chologogue and purgative [15]. The plant is reported to possess potent hepatoprotective and anti-helmenthic properties [16]. Leaves of this exotic weed are highly medicinal and used for controlling high blood pressure [17] and the leaves infusion is used to cure fever caused due to infection of glands [18]. Latex of the plant has wound healing activity [19,20] and the fresh juice of the leaves is used against headache [21]. Therefore this research was aimed to determine the antibacterial activity of various solvent

extracts of different parts of *C. bonplandianum* against bacteria like *Pseudomonas aeruginosa*, *Staphylococcus aureus, Enterococcus faecalis*, *Enterobacter aerogenes* and *Escherichia coli,* which are isolated from wound infections of hospitalized patients.

2. MATERIALS AND METHODS

2.1 Collection of Bacterial Isolates

The 24 hours grown bacterial isolates were collected from Microbiology Laboratory at SVS Hospital, Tiruchirappalli, Tamilnadu, India. The bacterial isolates from infected wounds like *Pseudomonas aeruginosa*, *Staphylococcus aureus, Enterococcus faecalis*, *Enterobacter aerogenes* and *Escherichia coli* were used in this study and identified by standard microbiological methods [22].

2.2 Standardization of the Test Organisms

A loop full of test organism was inoculated on nutrient broth and incubated for 24 hours. Exactly 0.2 ml of 24 hours grown culture of the organisms was dispensed into 20 ml sterile nutrient broth and incubated for 3 - 5 hours to standardize the culture to a concentration of $1X10^6$ colony forming units per ml (CFU/ml) before use of culture according to Oyeleke et al. [23].

2.3 Collection of Plant Material

Croton bonplandianum (bantulsi) was collected from the waste lands at Mayiladuthurai, Tamilnadu, India, where it was found naturally. The plant was identified by Rev. Dr. John Britto, The Director, Rabinat Herbarium and Centre for Molecular Systematics, St.Joseph's College, Tiruchirappalli, Tamilnadu, India.

2.4 Preparation of Plant Extracts

From the collected plants, the parts like leaf and fruits were separated for further study and the fresh latex was collected separately from the natural source for antibacterial study.

2.4.1 Preparation of leaf and fruit extracts

The harvested leaves and fruits were washed thoroughly using running tap water and were dried under shade and then ground well to fine powder. 30 g of the powdered material was weighed exactly and soaked in 250 ml of different solvents like water, ethanol, acetone, benzene and chloroform and kept in shaker for 72 hours. After 72 hours, the mixture was filtered using a clean muslin cloth and then again filtered through Whatman No.1 filter paper. The filtrate was concentrated in a hot air oven at 40ºC till a sticky mass was obtained and weighed [24,25]. The extracts were stored at 4ºC until further use.

2.4.2 Preparation of latex extracts

The latex was obtained by hand-plucking and the latex extraction with solvents was employed. For extraction, 20 ml of the fresh latex was mixed with 80 ml of each solvents like aqueous, ethanol, acetone, chloroform and benzene separately and kept at shaker for 3 hours and then filtered the filtrates were concentrated in a hot air oven at 40ºC, till a sticky mass was obtained and weighed [26]. The extracts were stored at 4ºC until further use.

2.4.3 Fresh latex

The latex of *C. bonplandianum* plant was obtained as exudates by and plucking of fresh leaves from actively growing plants. The latex was collected into sterile, plastic containers by pressing and squeezing in-between fingers, the apex of the leaves to release as much as possible latex into the containers. After collection, the latex was centrifuged with 5000 rpm for 15 minutes to remove any solid particles appears in it. The latex was decanted off to containers were plugged with cotton and stored at 4ºC until required for use. Collections were made in the mornings during the days of each analysis [27].

2.5 Antibacterial Activity

The antibacterial screening of leaf, fruit, latex extracts and fresh latex of *C. bonplandianum* was carried out in the Department Laboratory, Government Arts College (Autonomous), Kumbakonam – 612 001, Tamilnadu, India by well diffusion method [28]. 10% w/v test solution of leaf, fruit and latex of *C. bonplandianum* were prepared by dissolving 500 mg of each extract separately in 5ml of sterile 10% Dimethyl Sulphoxide (DMSO). From this 25, 50, 75 and 100µl extracts contains 2.5, 5, 7.5 and 10 mg, respectively and fresh latex were taken for the analysis of antibacterial activity. The extracts of leaf, fruit and latex of *C. bonplandianum* were loaded at different concentrations (2.5, 5, 7.5 and

10 mg) in the well on preinoculated Mueller Hinton Agar (MHA) plates with respective bacterial cultures and incubated at 37ºC for 24 hours. Streptomycin (10µg) was used as a positive control and the solvent 10% DMSO was used as negative control for this study. After incubation the diameter of zone of inhibition (mm) around the well was measured using zone reader.

2.6 Statistical Analysis

The results of the present study were subjected to statistical analysis and the results were expressed as mean ± standard deviation (SD).

3. RESULTS

Crude extracts obtained from leaf, fruits and latex of *C. bonplandianum* using different solvents like aqueous, ethanol, acetone, chloroform and benzene were screened for antibacterial activity against bacterial pathogens isolated from wound infections such a *P. aeruginosa*, *S. aureus, E. faecalis*, *E. aerogenes* and *E. coli* by well diffusion method. There was no zone of inhibition in the negative control (10% DMSO). The streptomycin (10 µg) was used as positive control which produced zone of inhibition at different levels against bacterial isolates. The antibacterial efficacy of various solvent extracts of *C. bonplandianum* showed varied level of inhibition against the pathogenic bacteria causing wound infections (Tables 1,2,3).

3.1 Antibacterial Effect of Leaf of *C. bonplandianum*

The antibacterial activity of the various solvent extracts of leaf of *C. bonplandianum* against bacterial isolates showed best results at the concentration of 7.5 mg/75 µl and the results are shown in Table 1. The aqueous leaf extract showed maximum zone of inhibition 15±2mm against *S. aureus* while the minimum zone of inhibition 10±1mm against *P. aeruginosa* when compared to other bacterial isolates. The ethonolic leaf extract showed highest zone of inhibition 22±2mm against *E. aerogenes* and *E. coli* while the lowest zone of inhibition 16±2mm was observed against *E. faecalis* when compared to other bacterial isolates. The acetone extract of leaf showed maximum zone of inhibition 19±2mm against *E. aerogenes* and *E. coli* while the minimum zone of inhibition 10±1mm against *P. aeruginosa*. The chloroform extract of leaf showed 19±2mm inhibition against *S. aureus* and *E. aerogenes* and the benzene extract of leaf showed 20±2mm inhibition against *S. aureus*.

3.2 Antibacterial Effect of Fruit of *C. bonplandianum*

The antibacterial activity of various solvent extracts of fruits of *C. bonplandianum* against bacterial isolates is shown in Table 2. The aqueous fruit extract showed maximum zone of inhibition 14±2mm against *E. coli* and minimum zone of inhibition 10±1mm against *P. aeruginosa*. The ethonolic fruit extract showed maximum zone of inhibition 18±1mm against *E. aerogenes* and minimum zone of inhibition 11±1mm against *P. aeruginosa*. The acetone extract of fruit showed maximum zone of inhibition 18±1mm against *P. aeruginosa* and showed minimum zone of inhibition 12±1mm against *S. aureus* and *E. faecalis*. The chloroform extract of fruit showed 21±2mm zone of inhibition against *E. coli* and 15±1mm zone of inhibition against *S. aureus, E. faecalis* and *E. aerogenes*. The benzene extract of fruit showed 16±2mm zone of inhibition against *E. coli*.

3.3 Antibacterial Effect of Latex of *C. bonplandianum*

Table 3 represented the antibacterial activity of various solvent extracts of latex and fresh latex of *C. bonplandianum* against the bacterial isolates from infected wounds. The aqueous latex extract showed highest zone of inhibition 26±2mm against *E. aerogenes* and the lowest zone of inhibition 15±3mm was observed against *S. aureus*. The ethonolic latex extract showed maximum zone of inhibition 28±1mm against *E. aerogenes* and minimum zone of inhibition 18±2mm against *P. aeruginosa, S. aureus* and *E. faecalis*. The acetone extract of latex showed maximum 26±1mm zone of inhibition against *E. faecalis* and minimum 16±2mm zone of inhibition against *S. aureus*. The chloroform and benzene extract of latex showed no zone of inhibition against all bacterial isolates. The fresh latex showed 32±1mm zone of inhibition against *E. coli* and 20±1mm zone of inhibition against *S. aureus.* In the present study, the extracts of latex and fresh latex showed strong antibacterial activity when compared to the extracts of leaf and fruits.

Table 1. Antibacterial activity of different solvent extracts of leaf of *C. bonplandianum*

Name of the solvent extracts	Volume of the extract	Diameter of zone of inhibition (mm)				
		Name of the bacterial species				
		Pseudomonas aeruginosa	***Staphylococcus aureus***	***Enterococcus faecalis***	***Enterobacter aerogenes***	***Escherichia coli***
Aqueous	25 µl (2.5mg)	—	10±2.0	—	—	10±2.0
	50 µl (5.0mg)	—	10±2.0	—	10±1.0	11±1.0
	75 µl (7.5mg)	10±1.0	15±2.0	—	13±2.0	13±3.0
	100 µl (10mg)	10±1.0	13±1.0	—	11±2.0	12±1.0
Ethanol	25 µl (2.5mg)	12±2.0	15±1.0	9±1.0	16±2.0	14±2.0
	50 µl (5.0mg)	13±1.0	17±3.0	11±1.0	19±2.0	16±3.0
	75 µl (7.5mg)	18±2.0	20±2.0	16±2.0	22±1.0	22±2.0
	100 µl (10mg)	16±2.0	18±2.0	15±3.0	20±1.0	19±1.0
Acetone	25 µl (2.5mg)	—	8±1.0	—	11±1.0	11±1.0
	50 µl (5.0mg)	—	12±2.0	10±1.0	13±2.0	12±2.0
	75 µl (7.5mg)	10±1.0	14±1.0	12±2.0	19±1.0	19±2.0
	100 µl (10mg)	10±1.0	17±1.0	11±2.0	16±2.0	15±1.0
Chloroform	25 µl (2.5mg)	10±1.0	12±2.0	12±2.0	9±1.0	10±1.0
	50 µl (5.0mg)	12±2.0	14±1.0	14±2.0	13±3.0	11±2.0
	75 µl (7.5mg)	17±1.0	19±2.0	18±2.0	19±1.0	13±2.0
	100 µl (10mg)	14±2.0	16±3.0	16±2.0	16±1.0	12±2.0
Benzene	25 µl (2.5mg)	—	11±2.0	—	—	—
	50 µl (5.0mg)	7±1.0	14±1.0	9±1.0	13±2.0	10±1.0
	75 µl (7.5mg)	12±2.0	20±2.0	18±2.0	18±1.0	14±1.0
	100 µl (10mg)	13±3.0	18±1.0	14±2.0	15±3.0	12±2.0
Negative control – DMSO (10%)		—	—	—	—	—
Positive control – Streptomycin(10µg)		19±1.0	20±2.0	17±1.0	20±3.0	21±2.0

Values are expressed as mean ± standard deviation of three replicates

Table 2. Antibacterial activity of different solvent extracts of fruits of *C. bonplandianum*

Name of the solvent extracts	Volume of the extract	Diameter of zone of inhibition (mm)				
		Name of the bacterial species				
		Pseudomonas aeruginosa	***Staphylococcus aureus***	***Enterococcus faecalis***	***Enterobacter aerogenes***	***Escherichia coli***
Aqueous	25 µl (2.5mg)	—	—	10±1.0	8±1.0	10±1.0
	50 µl (5.0mg)	—	—	11±1.0	10±1.0	11±1.0
	75 µl (7.5mg)	10±1.0	—	12±2.0	11±1.0	14±2.0
	100 µl (10mg)	10±1.0	—	11±2.0	9±1.0	12±1.0
Ethanol	25 µl (2.5mg)	—	—	7±1.0	9±1.0	10±1.0
	50 µl (5.0mg)	10±1.0	—	10±1.0	12±2.0	12±2.0
	75 µl (7.5mg)	11±1.0	—	14±1.0	18±1.0	16±1.0
	100 µl (10mg)	10±1.0	—	12±2.0	16±2.0	14±2.0
Acetone	25 µl (2.5mg)	12±2.0	—	10±1.0	9±1.0	7±1.0
	50 µl (5.0mg)	14±1.0	10±1.0	11±1.0	10±1.0	8±2.0
	75 µl (7.5mg)	18±1.0	12±1.0	12±2.0	13±3.0	14±1.0
	100 µl (10mg)	16±1.0	11±1.0	12±2.0	11±1.0	12±1.0
Chloroform	25 µl (2.5mg)	12±2.0	12±1.0	10±1.0	8±1.0	13±2.0
	50 µl (5.0mg)	13±3.0	13±2.0	12±2.0	10±1.0	16±2.0
	75 µl (7.5mg)	16±2.0	15±3.0	15±1.0	15±3.0	21±2.0
	100 µl (10mg)	14±1.0	14±2.0	13±3.0	12±1.0	19±1.0
Benzene	25 µl (2.5mg)	7±1.0	—	10±1.0	8±1.0	12±1.0
	50 µl (5.0mg)	7±1.0	—	12±2.0	10±1.0	14±2.0
	75 µl (7.5mg)	10±1.0	10±1.0	14±1.0	14±2.0	16±2.0
	100 µl (10mg)	11±2.0	10±1.0	13±2.0	12±1.0	15±1.0
Negative control – DMSO (10%)		—	—	—	—	—
Positive control – Streptomycin (10 µg)		19±1.0	20±2.0	17±1.0	20±3.0	21±2.0

Values are expressed as mean ± standard deviation of three replicates

Table 3. Antibacterial activity of different solvent extracts of latex and fresh latex of *C. bonplandianum*

Name of the solvent extracts	Volume of the extract	Diameter of zone of inhibition (mm)				
		Name of the bacterial species				
		Pseudomonas aeruginosa	***Staphylococcus aureus***	***Enterococcus faecalis***	***Enterobacter aerogenes***	***Escherichia coli***
Aqueous	25 µl (2.5mg)	14±1.0	11±2.0	14±2.0	20±1.0	19±1.0
	50 µl (5.0mg)	16±2.0	12±1.0	16±1.0	22±2.0	20±1.0
	75 µl (7.5mg)	22±2.0	13±2.0	21±1.0	26±2.0	24±1.0
	100 µl (10mg)	19±2.0	15±3.0	17±1.0	24±2.0	22±1.0
Ethanol	25 µl (2.5mg)	12±2.0	12±1.0	12±2.0	19±2.0	12±1.0
	50 µl (5.0mg)	14±1.0	14±2.0	14±1.0	20±1.0	14±1.0
	75 µl (7.5mg)	18±2.0	18±1.0	18±2.0	26±1.0	19±1.0
	100 µl (10mg)	16±1.0	16±2.0	16±1.0	24±2.0	16±2.0
Acetone	25 µl (2.5mg)	14±1.0	10±1.0	14±2.0	20±1.0	18±2.0
	50 µl (5.0mg)	16±1.0	12±1.0	18±2.0	21±2.0	20±2.0
	75 µl (7.5mg)	21±1.0	16±2.0	26±1.0	24±1.0	24±2.0
	100 µl (10mg)	17±1.0	14±1.0	22±2.0	23±2.0	22±1.0
Chloroform	25 µl (2.5mg)	—	—	—	—	—
	50 µl (5.0mg)	—	—	—	—	—
	75 µl (7.5mg)	—	—	—	—	—
	100 µl (10mg)	—	—	—	—	—
Benzene	25 µl (2.5mg)	—	—	—	—	—
	50 µl (5.0mg)	—	—	—	—	—
	75 µl (7.5mg)	—	—	—	—	—
	100 µl (10mg)	—	—	—	—	—
Fresh Latex	25 µl	13±2.0	14±1.0	22±1.0	14±2.0	20±2.0
	50 µl	16±1.0	16±2.0	24±2.0	18±1.0	26±1.0
	75 µl	21±1.0	20±1.0	30±2.0	24±1.0	32±1.0
	100 µl	19±2.0	18±1.0	26±2.0	21±1.0	28±1.0
Negative control – DMSO (10%)		—	—	—	—	—
Positive control – Streptomycin (10 µg)		19±1.0	20±2.0	17±1.0	20±3.0	21±2.0

Values are expressed as mean ± standard deviation of three replicates

4. DISCUSSION

Herbal medicine is still main stay of about 75-80% of the whole population in India and the major part of traditional therapy involves the use of plant extracts and their active constituents [29]. Following the advent of modern medicine, herbal medicine suffered a setback, but during last two or three decades advances in phytochemistry and identification of plant compounds effective against certain diseases have renewed the interest in herbal medicines [30].

In the modern world multiple drug resistance has developed against many microbial infections due to the indiscriminate use of commercial antimicrobial drugs commonly used in the treatment of infectious diseases [31]. In addition to this problem, antibiotics are sometimes associated with adverse effects on the host including hypersensitivity, immune suppression and allergic reactions [32]. Given alarming incidence of antibiotic resistance in bacteria of medical importance, there is a constant need for new and effective therapeutic agents [31]. Therefore, there is a need to develop alternative antimicrobial drugs for the treatment of infectious diseases from medicinal plants [33]. So in this study, the antibacterial activity of different extracts of *C. bonplandianum* was determined and the results are showed in Tables 1-3. Bunchu leaf and Oregon grape root ethanolic extracts were more active against pathogenic microorganism [34]. Similar type of results was observed in the present study. In the present study, 7.5 mg (75 µl) of plant extract showed maximum antibacterial activity than 10.0 mg of plant extract (100µl). Ethanol, chloroform and benzene leaf extracts more effective than aqueous and acetone leaf extracts. The maximum antibacterial activity (22±1mm) was observed in ethanolic leaf extract against *E. aerogenes* and *E. coli.* Ethanol, acetone and chloroform fruit extracts showed more antibacterial activity than aqueous and benzene fruit extracts. The highest zone of inhibition (21±2mm) was observed in chloroform fruit extract against *E. coli.* All bacterial isolates were more sensitive to all solvent latex extracts. The maximum antibacterial activity (32±1mm) was observed in fresh latex against *E. coli.* Among the various solvent extracts of different parts tested, the fresh latex and different solvent extracts of latex showed highest inhibitory activity when compared to extracts of leaf and fruits. The antibacterial activity of the latex may be due to the presence of secondary metabolites such as phenolic compounds, tannins, flavonoids and saponins, which are confirmed in our previous study by GC-MS analysis (data not shown). Tannins coagulate the cell wall proteins resulting in bactericidal activity at higher concentrations, while saponins are surface active agents and they alter the permeability of the cell wall thus facilitating the entry of toxic materials or leakage of vital constituents from the cell [35]. Flavonoids are phenolic in nature and they act as cytoplasmic poisons, which inhibit the activity of cytoplasmic enzymes in microbes [36]. The antibacterial activity of the latex seems to be as a result of the combined effects of the metabolites [27]. Next to latex, the leaf extracts showed best inhibitory activity against bacterial isolates and followed by fruit extracts. The activity of the different extracts of *C. bonplandianum* against tested Gram negative and Gram positive bacteria were showed its broad spectrum of antibacterial activity.

However, the antibacterial properties of medicinal plants are being increasingly reported from different parts of the world [37,38]. Several reports indicated that the antibacterial activities of medicinal plants such as *Datura* metel [39], *Acalypha indica* [40], *Mangifera indica* [41] , *Phyllanthus amarus* [42], *Centella asiatica* [43], *Acacia nilotica* [44], *Garcinia nigrolineata* [45], *Artemissia annua* [46], *Geissospermum argenteum* [47], *Peperomia pellucida* [48,49] and *Sena alata* [50]. Similar type of results were observed in the present study and also confirmed that the different parts of *C. bonplandianum* showed antibacterial activity against bacterial pathogens causing wound infections.

The most effective medicinal plant, *C. bonplandianum* is traditionally used by folk healer to treat skin infections, cuts and wounds [14]. It is well-recognized that wound healing process consists of five phases such as cellular phase (collagenation), narrowing of wound area (wound contraction), collagen deposition, epithelial covering (epithelialisation) and scar remodelling (cicatrixisation). The medicinal plant *C. bonplandianum* significantly increased the rate of wound contraction [51]. Similarly, the antimicrobial activity of *C. bonplandianum* against bacterial isolates from the wounds of hospitalized patients was observed. A plant-based remedy should effect on at least two different phases of wound healing before it can be said to have some scientific support for

its traditional use [52]. Although, the antimicrobial activity reported in this study lends some support to the use of this plant in the topical treatment of wounds.

5. CONCLUSION

In conclusion, the results obtained in this study indicated that the traditional plant, *C. bonplandianum* generally used for wound healing and demonstrated broad spectrum antibacterial activity against bacterial isolates of both Gram-negative and Gram-positive bacteria. However, it is in need of further study to isolate the active ingredients that promote wound healing and active principles of the traditional herbal formula should be additionally established. The substantiation of folk remedies for wound infections is extremely important both for the preservation of traditional medical knowledge and the application as alternative health care solutions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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