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# Antibacterial activity of the alcoholic extract of berberine against *Staphylococcus aureus* isolated from burn and wound infections

Ola Abbas Khdhair[1,*], Yazi Abdullah Jassim[2], Noor Abed Alreda Alkremy[1], Taif Hussein Al-Ameedy[1]

[1]Department of Clinical Laboratory Sciences, College of Pharmacy, University of Babylon, Hillah, Iraq
[2]Department of Biology, College of Science, University of Babylon, Hillah, Iraq

***Corresponding author:** Ola Abbas Khdhair, Department of Clinical Laboratory Sciences, College of Pharmacy, University of Babylon, Hillah, Iraq; Tel.: +964-(0)7827225952
E-mail: pharm.ola.abbas@uobabylon.edu.iq

## Abstract
Burns and wounds destroy the physical skin which is the body's natural barrier to the external environment. As a result the burned area is prone to infection and colonization by microorganisms. The most common pathogenic colonizing bacterium is *Staphylococcus aureus*. In order to solve the problem of bacterial resistance to antibiotics, some medicinal plants have been used so as to determine their effectiveness against *S. aureus*. Among these plants, we have herein used the alcoholic extract of berberine. Our results suggest that the alcoholic extract of berberine, at a concentration 250 mg/mL, can exert a high inhibitory efficacy against *S. aureus*.

**KEYWORDS**
*Staphylococcus aureus*, burns, wounds, berberine, infection

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## 1. INTRODUCTION

The incidence of burn wound infections appears to be correlated with both the depth and the size of wound. Moreover, the longer the wound remains open, the higher the chances on infection. Previous studies have shown that there are several bacterial species which are able to readily infect burn wounds. Among these, *Staphylococcus aureus* and *Pseudomonas aeruginosa* have been found to be the most common species. Interestingly, the variation in bacterial flora and the colonization rate changes over time after the initial infection [1].

Medicinal herbs could be the best source for the development of various medicines [2]. Due to their different therapeutic properties, medicinal herbs have been considered by many researchers worldwide [3]. In modern medicine, several studies have been conducted in order to identify the potential effects of various extracts of medicinal herbs that

have a pivotal role in the health of people and animals [4]. Berberine is an isoquinoline quaternary alkaloid (a 5,6-dihydrodibenzo(a,g)quinolizinium derivative) employed in traditional Chinese and Indian medicine for centuries. It has anti-inflammatory and antimicrobial properties, anti-diabetic and antioxidant effects, and multiple other pharmacological properties [5].

## 2. PATIENTS AND METHODS

All samples of the present study were collected after obtaining ethical clearance from the Ethics Committees of the Babylon Health Office and the agreement of the medical management of the Imam Al-Sadiq Hospital Specialized Burn Center in the Medical City of Baghdad and of Kufa. The study was conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki, and it was carried out with the patients' consent. The study's protocol as well as the subject information and consent form were reviewed and approved by a local ethics committee according to the document number M220109 (17-1-2022).

Different concentrations of the alcoholic extract of berberine were prepared by using the serial dilution method. Experiments were carried out by dissolving 1 g of berberine extract in 2 mL of 70% ethanol in four dilutions (500, 250, 125, and 62.5 mg/mL). Subsequently, 100 µL of test isolates were spread onto the surface of Mueller-Hinton agar plates by using a glass spreader, and the wells were filled with 50 µL of the berberine alcoholic extract. The test plates were incubated at 37°C for 24 h, while 70% ethanol was used as a negative control. The antibacterial activity of the alcoholic plant extracts was evaluated by measuring the zone of inhibition in mm [6].

## 3. RESULTS

Our study population included 230 participants with burn wound infections admitted to a burns' unit in the Imam Al-Sadiq Hospital, the Al-Hilla Teaching Hospital, and the Specialized Burn Center in the Medical City of Baghdad and of Kufa from February to September 2022. Burn wound swabs were taken from all patients registered in the study and were immersed in Stuart transport medium. Swabs were collected from infected wounds following cleansing of any remnant ointment. After collection, all swabs were inoculated on nutrient agar, blood agar, and manitol salt agar, and were incubated at 37ºC for 24 h prior to their morphological examination. The colonial morphology, the production of β-hemolysis on blood agar, and the production of pigmentation on the manitol salt agar revealed 63 isolates of *Staphylococcus* that were confirmed to be *S. aureus* by the Vitek 2 Advanced Expert System (bioMerieux, Marcy l'Etoile, France). In the well diffusion method, the alcoholic extract of berberine exhibited inhibitory effects on *S. aureus* isolates in different concentrations. It was found that out of 63 isolates, 15 isolates exposed to a berberine concentration of 250 mg/mL revealed the highest inhibition effectiveness for the alcoholic extract (Table 1).

**Table 1.** Antimicrobial activity of different concentrations of the alcoholic extract of berberine on *Staphylococcus aureus*.

| **Concentration of the alcoholic extract of berberine** (mg/mL) | **N** | **Zone of inhibition** (mm; mean ± SD) | ***P*-value** |
|---|---|---|---|
| 62.5 | 15 | 1.000 ± 2.803 | 0.495 |
| 125 | 15 | 22.930 ± 2.120 | 0.181 |
| 250 | 15 | 31.600 ± 2.501 | 0.064 |
| 500 | 15 | 22.600 ± 2.414 | 0.180 |

## 4. DISCUSSION

Various clinical applications of berberine have been discovered, especially related to its antibacterial activity. Berberine, with a quaternary nitrogen, polycyclic, and planar system, could helpfully increase membrane permeability and strengthen the binding affinities with amino acids in biomolecules [7]. Previous studies have evaluated the antibacterial effects of berberine against clinical isolates of *S. aureus* [8], and have shown that berberine was effective in inhibiting the growth of *S. aureus* biofilms, which are communities of bacteria that can be particularly resistant to antibiotics [9]. The exact mechanism by which berberine exerts its antimicrobial effects on *S. aureus* is not fully understood, but several mechanisms have been proposed. In summary, it is believed that berberine can disrupt the bacterial cell membrane, interfere with DNA replication and protein synthesis, and inhibit enzymes necessary for bacterial survival [10].

In conclusion, our results suggest that the al-

coholic extract of berberine, at a concentration 250 mg/mL, can exert a high inhibitory efficacy against *S. aureus*.

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**CONFLICT OF INTEREST STATEMENT**
The authors declare no conflicts of interest.

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