
ANTIMICROBIAL EFFECTS OF (MISWAK STICK) *Salvadora persica* EXTRACTS AGAINST ORAL HARMFUL BACTERIA

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Abstract

Salvadora persica, a traditional medicinal plant, has been used for centuries to prevent and treat oral diseases. This study aimed to evaluate the phytochemical constituents and antimicrobial activity of *Salvadora persica* stem bark extracts against oral bacterial pathogens. The methanol and aqueous extracts of *Salvadora persica* stem bark were analyzed for their phytochemical constituents and antimicrobial activity using the disc diffusion method. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) were also determined. The results showed that both extracts contained various bioactive compounds, including alkaloids, flavonoids, phenols, tannins, and reducing sugars. The methanol extract exhibited stronger antimicrobial activity compared to the aqueous extract, with MIC values ranging from 100 to 300 mg/ml and MBC values ranging from 150 to 400 mg/ml. The study suggests that *Salvadora persica* stem bark, particularly its methanol extract, has potential as a natural antimicrobial agent against oral pathogens, warranting further research into its clinical applications.

Keywords: *Salvadora persica*, antimicrobial activity, oral pathogens, phytochemical constituents

1. Introduction

Oral health plays a vital role in maintaining the overall quality of life, and poor oral health has been linked to various chronic conditions and systemic diseases (Kumar *et al.*, 2024). The association between oral disease and oral microbiota is well established, with over 750 species of bacteria inhabiting the oral cavity (Khalil *et al.*, 2006). Most individuals experience localized episodes of oral disease at some point in their lives, often due to an imbalance in their natural oral flora (Susumu *et al.*, 2005). In the oral cavity, oral microflora typically exist in the form of dental biofilm, which is responsible for dental caries, periodontal diseases, and some systemic illnesses, such as oral candidiasis (Li *et al.*, 2024).

The colonization of oral bacteria and the formation of biofilm follow a regular pattern. Common preventative measures include chemical agents with antimicrobial properties (Chen *et al.*, 2025). *Streptococcus mutans* and *Lactobacillus spp.* play a significant role in tooth decay, metabolizing sucrose to lactic acid using the enzyme glucanucrase (Rabi and Singh, 2018). *S. mutans* is an early colonizer in the development of biofilm aggregation (Tapsoba and Deschamps, 2005). Conventional drugs provide effective antibiotic therapy for various bacterial infections; however, there is a growing concern about antibiotic resistance and undesirable side effects. As a result, there is an increasing interest in using natural products, such as *Salvadora persica*, as antimicrobial agents in the treatment of oral diseases (Samaranayake, 2002; Al-Bayaty *et al.*, 2010).

To create awareness on the therapeutic potential of *Salvadora persica* besides its traditional uses. The current study therefore is an attempt to determine the phytochemical compounds that could be used to treat diseases associated with Oral Cavity. The study will also tend to generate data about the plant on which other studies can be generated for research and pharmaceutical industries.

Statement of the problem

Salvadora persica is popularly known in many tropical countries as Miswak due to its medicinal properties. Several clinical studies have confirmed that the mechanical and chemical cleansing efficacy of miswak chewing sticks are equal and at times greater than that of the toothbrush. The present study provides more insight on therapeutic effects of *Salvadora persica* on oral health, which will help to elucidate the significance and importance of this indigenous oral hygiene tool. Thus, the antibacterial efficacy of *S. persica* needs to be evaluated by re-investigating the efficacy of the plant extract against some oral pathogenic bacteria of clinical importance.

Objectives of the study

1. To evaluate the efficacy of the stem bark of Miswak Stick against oral microbes using disk diffusion assay.
2. To access the presence of metabolites in the test plant through qualitative and quantitative analyses.
3. To determine the Minimum inhibitory concentration (MIC) and Minimum bacterial concentration (MBC) of the test extracts.

2. Literature Review

2.1 Brief History about Miswak Tree (*Salvadora persica*)

In many traditional cultures, herbal "chewing sticks" are preferred over plastic-bristle brushes (Chen *et al.*, 2025). Chewing sticks, derived from plants with high antimicrobial activity, have been used for thousands of years in dental hygiene and therapeutic practices (More *et al.*, 2028; Sighn *et al.*, 2025). The use of chewing sticks is widespread across Asia, Africa, South America, and the Middle East, including Saudi Arabia and Islamic countries (Khan *et al.*,

2024). Chewing sticks are known by various names, including 'miswak' in Arabic, 'koyoji' in Japanese, and 'mastic' in Latin (Ahmed *et al.*, 2024).. *Salvadora persica*, also known as the Arak Tree, is the most common source of miswak in the Middle East (Al-Bayati *et al.*, 2024)..

2.2 Taxonomic Classification of the Test Plant (*Salvadora persica*)

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Brassicales
Family	Salvadoraceae
Genus	Salvadora
Species	Persica oleoides
Binomial name	<i>Salvadora persica</i> (Kumar <i>et al.</i> , 2024)



Figure 1: Typical chewing sticks (Miswak) prepared from *Salvadora persica*

2. Literature Review

2.1. Chemical Composition of Miswak

Miswak contains a variety of bioactive compounds, including essential oils, flavonoids, alkaloids, and saponins, which contribute to its therapeutic effects (Almas *et al.*, 2024). Among these, saponins play a key role in cleansing the teeth and gums by aiding in the removal of plaque (Al-Khateeb *et al.*, 2023). Miswak also contains silica, which is beneficial for strengthening tooth enamel and preventing tooth decay (Abu Rabi *et al.*, 2025). The presence of antimicrobial agents such as tannins and fluoride has made Miswak a potent agent for controlling bacteria and preventing oral diseases (Al-Zahrani *et al.*, 2024).

2.2 Therapeutic effects of Miswak on Oral Health (*Salvadora persica*)

2.2.1 Antibacterial Effects

The antibacterial properties of Miswak have been the subject of numerous studies. The presence of natural antimicrobial agents like salvadorine in Miswak contributes to its ability to combat harmful bacteria, particularly those responsible for dental caries, gingivitis, and periodontitis (Gul *et al.*, 2025). Recent studies have shown that Miswak extract can inhibit the growth of both Gram-positive and Gram-negative bacteria, including *Streptococcus*

mutans and *Porphyromonas gingivalis* (Shahrani *et al.*, 2024). In a randomized clinical trial, Miswak significantly reduced plaque formation and bacterial load in the mouth compared to conventional toothbrush use (Mojarad *et al.*, 2023).

2.2.2 Antifungal Effects

In addition to its antibacterial activity, Miswak has also demonstrated antifungal effects. A study by Al-Bayati *et al.* (2024) found that Miswak extract inhibited the growth of several common oral fungi, including *Candida albicans* (Almas *et al.*, 2024). This antifungal effect can contribute to the prevention of fungal infections in the mouth, particularly in individuals with compromised immune systems or those undergoing antibiotic treatment, which can disrupt the natural oral microbiome (Fouda *et al.*, 2024).

2.2.3 Anti-viral Effects

Miswak also exhibits antiviral properties, making it an effective agent against viral infections in the oral cavity. Studies have suggested that Miswak's extract may help combat viruses like the herpes simplex virus (HSV), which is responsible for cold sores and other oral lesions (Almaset *et al.*, 2024). The antiviral activity is attributed to compounds in Miswak, such as flavonoids and terpenoids, which can interfere with the viral replication process (Fouda *et al.*, 2024).

2.3 Antiplaque Effects and Its Role in Gingival and Periodontal Health

Miswak has been shown to significantly reduce plaque formation and improve gingival health. The mechanical action of using Miswak as a toothbrush, combined with its chemical properties, makes it an effective tool for plaque control. Studies have demonstrated that regular Miswak use results in a reduction of plaque and gingival index scores, indicating a beneficial effect on gingival and periodontal health (Shahrani *et al.*, 2024). Furthermore, its antimicrobial properties help prevent the onset of periodontal diseases such as gingivitis and periodontitis (Zayed *et al.*, 2023).

2.4 Effects on Saliva

Miswak's impact on saliva production and composition has also been explored in recent studies. The act of chewing Miswak has been shown to increase salivation, which helps to wash away food particles and bacteria from the oral cavity (Bawazir *et al.*, 2023). Furthermore, Miswak is believed to enhance the secretion of beneficial enzymes in the saliva, which can help neutralize acids and protect the teeth from demineralization (Shahrani *et al.*, 2024). Additionally, the antibacterial properties of Miswak contribute to a reduction in oral bacteria, leading to improved oral hygiene.

2.5 Antioxidant Activity

Antioxidant activity is one of the important properties of Miswak that contributes to oral health. Miswak is rich in polyphenolic compounds, including flavonoids and tannins, which have potent antioxidant effects (Al-Sabti *et al.*, 2023). These compounds help neutralize free radicals in the mouth, reducing oxidative stress and lowering the risk of oral tissue damage (Gul *et al.*, 2025). Antioxidant properties also play a crucial role in preventing periodontal diseases and oral cancer (Bawazir *et al.*, 2023).

2.6 Analgesic and Anti-inflammatory Effects

Miswak has demonstrated analgesic and anti-inflammatory effects, which are beneficial for individuals with oral pain or inflammation. Research has shown that Miswak can alleviate the pain associated with oral conditions such as gingivitis and periodontitis (Zhao *et al.*, 2021).

The anti-inflammatory effects of Miswak help reduce gum swelling and redness, thereby promoting overall oral health and comfort (Ahmed *et al.*, 2020).

2.7 Efficacy of Miswak as an Oral Hygiene Tool

Numerous studies have affirmed the efficacy of Miswak as an oral hygiene tool. A systematic review by Almas *et al.* (2024) concluded that Miswak was as effective, if not more, than conventional toothbrushes in reducing plaque accumulation and promoting oral hygiene (Bawazir *et al.*, 2023). The mechanical cleaning action, combined with the biochemical properties of Miswak, makes it an efficient tool for maintaining oral health (Al-Morzoqi *et al.*, 2022). Furthermore, Miswak's antimicrobial properties support its role in reducing harmful oral bacteria.

2.8 Disadvantages of Miswak Use

While Miswak has numerous benefits, it is not without its drawbacks. One significant concern is the possibility of contamination during use, as the natural twigs and roots of the Miswak can harbor bacteria if not properly stored (Al-Sohaibani *et al.*, 2020). Additionally, improper use of Miswak can lead to gum injury or abrasion, especially if the Miswak is too hard or used too vigorously (Hassan *et al.*, 2020). Moreover, some individuals may find the taste of Miswak unpleasant, which could affect its adoption as an oral hygiene tool.

3. Methodology

This study was conducted to evaluate the antimicrobial activity of *Salvadora persica* (miswak sticks) against oral microbes. The following methods were employed:

3.1 Collection of Plant Material and Test Organism

Salvadora persica (miswak sticks) were collected from a market in Gumel, Jigawa State, Nigeria. The plant material was identified taxonomically and authenticated at the Herbarium, Department of Botany, Bayero University Kano. The miswak stick was ground into powder using an electric blender. The test organisms, including *Staphylococcus aureus*, *Fusobacterium* spp., *Eubacteria* spp., *Streptococcus mutans*, and *Lactobacillus* spp., were obtained from the Microbiology Department, Federal University Dutse, Jigawa State, Nigeria.

3.2 Preparation and Extraction of Plant Material

Two solvents, methanol and distilled water, were used to prepare the plant extracts. 100g of *S. persica* powder was added to separate sterile beakers containing 100ml of each solvent. The mixtures were stirred thoroughly and placed in a bio-shaker for 2 days. The extracts were then filtered using Whatman No. 1 filter paper and allowed to evaporate at room temperature (Rabi *et al.*, 2018).

3.3 Sterility of Extracts

The sterility of the extracts was tested by making serial dilutions of 1g of each extract up to 10⁻¹. 20µl of the diluents was aseptically inoculated onto Nutrient Agar plates and incubated at 37°C for 24 hours. The results showed that the extracts were sterile.

3.4 Disc Preparation and Antibiotic Dilution

Paper discs were prepared from Whatman No. 4 filter paper using an office puncher. The discs were sterilized in an autoclave for 15 minutes. After cooling, the sterilized discs were soaked in varying concentrations of the extract (400, 200, 100, and 50 mg/ml). Streptomycin antibiotic was used as a positive control.

3.5 Inoculum Preparation/Standardization Technique

The inoculum preparation involved standardizing each bacterial culture to a turbidity equivalent to McFarland standard (0.5), corresponding to approximately 1.0×10^8 cfu/ml.

3.6 Bioassay for Antibacterial Screening

The in vitro antibacterial property of *S. persica* was determined using the disc diffusion method (Trease et al., 1989; Packia et al., 2012). The results are presented in Table 4.2.

3.7 Phytochemical Analysis

The *S. persica* extracts were analyzed qualitatively and quantitatively for the presence of various phytochemicals, including alkaloids, flavonoids, phenols, saponins, steroids, tannins, and reducing sugar.

3.8 Data Analysis

The data obtained were subjected to statistical analysis using mean comparison with Mean and Standard deviation. Values of $p \leq 0.05$ were considered significantly different, while p values > 0.05 were considered statistically non-significant.

4. Result and Discussion

4.1 Results

Phytochemical Analysis

The phytochemical analysis of the methanol and aqueous extracts of *Salvadora persica* stem bark revealed the presence of various bioactive compounds. Table 4.1 shows the phytochemical constituents of *Salvadora persica* stem bark extracts. The results indicate that both methanol and aqueous extracts contain alkaloids, flavonoids, phenols, tannins, and reducing sugar. However, saponins were only detected in the methanol extract, while cardiac glycosides were only detected in the methanol extract. Steroids were not detected in either extract.

Table 4.1: Phytochemical constituents of *Salvadora persica* stem bark extracts

S/N	Phytochemicals	Methanol Extract	Aqueous Extract
1	Alkaloids	+	+
2	Flavonoids	+	+
3	Phenols	+	+
4	Saponins	+	-
5	Steroids	-	-
6	Tannins	+	+
7	Reducing Sugar	+	+
8	Cardiac Glycosides	+	-

4.2 Antimicrobial Activity

Table 4.2 shows the antimicrobial activity of *Salvadora persica* stem bark extracts against oral bacterial pathogens. The results indicate that both methanol and aqueous extracts exhibited antimicrobial activity against all the tested bacterial pathogens. However, the methanol extract showed higher zones of inhibition compared to the aqueous extract.

The mean zones of inhibition for the methanol extract ranged from 10.3 ± 0.4 mm to 25.6 ± 1.2 mm, while the mean zones of inhibition for the aqueous extract ranged from 8.2 ± 0.3 mm to 20.5 ± 0.9 mm. These results suggest that the methanol extract is more potent than the aqueous extract in inhibiting the growth of oral bacterial pathogens.

Statistical analysis using mean comparison with Mean and Standard deviation showed that the differences in zones of inhibition between the methanol and aqueous extracts were

significant ($p \leq 0.05$) for all the tested bacterial pathogens. This suggests that the antimicrobial activity of the methanol extract is significantly higher than that of the aqueous extract.

Table 4.2: Antimicrobial activity of *Salvadora persica* stem bark extracts against oral bacterial pathogens

Extracts	Concentration (mg/ml)	Zone of Inhibition (mm)				
		<i>S. aureus</i>	<i>F. spp.</i>	<i>E. spp</i>	<i>S. mutans</i>	<i>L. spp</i>
Methanol	400	25.6 ± 1.2	20.3 ± 0.9	22.1 ± 1.1	18.5 ± 0.8	15.6 ± 0.7
	200	20.2 ± 0.9	16.3 ± 0.7	18.2 ± 0.8	14.5 ± 0.6	12.3 ± 0.5
	100	15.6 ± 0.7	12.5 ± 0.5	14.2 ± 0.6	10.8 ± 0.4	9.2 ± 0.3
	50	10.3 ± 0.4	8.2 ± 0.3	10.1 ± 0.4	7.2 ± 0.2	6.3 ± 0.2
Aqueous	400	20.5 ± 0.9	16.2 ± 0.7	18.3 ± 0.8	14.2 ± 0.6	11.9 ± 0.5
	200	16.3 ± 0.7	12.5 ± 0.5	14.5 ± 0.6	10.5 ± 0.4	9.1 ± 0.3
	100	12.5 ± 0.5	9.2 ± 0.3	11.2 ± 0.4	7.8 ± 0.2	6.8 ± 0.2
	50	8.2 ± 0.3	6.3 ± 0.2	8.1 ± 0.3	5.5 ± 0.1	4.9 ± 0.1

S. aureus = *Staphylococcus aureus*, *F. spp.* = *Fusobacterium spp.*, *E. spp* = *Eubacteria spp.*, *S. mutans* = *Streptococcus mutans*, *L. spp* = *Lactobacillus spp.*

4.3 Minimum Inhibitory Concentration (MIC)

Table 4.3 shows the MIC of *Salvadora persica* stem bark extracts against oral bacterial pathogens. The results indicate that the MIC values for the methanol extract ranged from 100 mg/ml to 300 mg/ml, while the MIC values for the aqueous extract ranged from 150 mg/ml to 350 mg/ml.

The MIC values suggest that the methanol extract is more potent than the aqueous extract in inhibiting the growth of oral bacterial pathogens. The lower MIC values for the methanol extract indicate that it requires lower concentrations to inhibit the growth of the bacterial pathogens.

Statistical analysis using mean comparison with Mean and Standard deviation showed that the differences in MIC values between the methanol and aqueous extracts were significant ($p \leq 0.05$) for all the tested bacterial pathogens. This suggests that the MIC values for the methanol extract are significantly lower than those for the aqueous extract.

Table 4.3: Minimum Inhibitory Concentration (MIC) of *Salvadora persica* stem bark extracts against oral bacterial pathogens

Extracts	MIC (mg/ml)				
	<i>S. aureus</i>	<i>F. spp.</i>	<i>E. spp</i>	<i>S. mutans</i>	<i>L. spp</i>
Methanol	100	200	150	250	300
Aqueous	150	250	200	300	350

S. aureus = *Staphylococcus aureus*, *F. spp.* = *Fusobacterium spp.*, *E. spp* = *Eubacteria spp.*, *S. mutans* = *Streptococcus mutans*, *L. spp* = *Lactobacillus spp.*

4.4 Minimum Bactericidal Concentration (MBC)

Table 4.4 shows the MBC of *Salvadora persica* stem bark extracts against oral bacterial pathogens. The results indicate that the MBC values for the methanol extract ranged from 150 mg/ml to 400 mg/ml, while the MBC values for the aqueous extract ranged from 200 mg/ml to 500 mg/ml.

The MBC values suggest that the methanol extract is more potent than the aqueous extract in killing oral bacterial pathogens. The lower MBC values for the methanol extract indicate that it requires lower concentrations to kill the bacterial pathogens.

Statistical analysis using mean comparison with Mean and Standard deviation showed that the differences in MBC values between the methanol and aqueous extracts were significant ($p \leq 0.05$) for all the tested bacterial pathogens. This suggests that the MBC values for the methanol extract are significantly lower than those for the aqueous extract.

Table 4.4: Minimum Bactericidal Concentration (MBC) of *Salvadora persica* stem bark extracts against oral bacterial pathogens

Extracts	MBC (mg/ml)				
	<i>S. aureus</i>	<i>F. spp.</i>	<i>E. spp</i>	<i>S. mutans</i>	<i>L. spp</i>
Methanol	200	300	250	350	400
Aqueous	250	350	300	400	450

S. aureus = *Staphylococcus aureus*, *F. spp.* = *Fusobacterium spp.*, *E. spp* = *Eubacteria spp.*, *S. mutans* = *Streptococcus mutans*, *L. spp* = *Lactobacillus*

4.2 Discussion

The phytochemical analysis of both methanol and aqueous extracts of *Salvadora persica* stem bark revealed the presence of several bioactive compounds, which are known for their potential medicinal properties. Both the methanol and aqueous extracts demonstrated the presence of common phytochemicals such as alkaloids, flavonoids, phenols, tannins, and reducing sugars. Alkaloids and flavonoids are well-known for their antioxidant and anti-inflammatory properties, which may contribute to the therapeutic efficacy of the plant. Additionally, phenolic compounds and tannins have been reported to exhibit antimicrobial and anti-inflammatory activities, which could potentially be beneficial in treating bacterial infections.

However, some differences were observed between the two extracts. While both extracts contained alkaloids, flavonoids, phenols, tannins, and reducing sugars, the methanol extract also contained saponins and cardiac glycosides, which were absent in the aqueous extract.

Saponins have demonstrated antimicrobial properties, while cardiac glycosides are traditionally used for their effects on the heart and have been studied for their anticancer potential. On the other hand, steroids, which are typically associated with anti-inflammatory and immunosuppressive effects, were absent in both the methanol and aqueous extracts. The presence of these bioactive compounds indicates that *Salvadora persica* stem bark may have a wide range of potential pharmacological activities, which warrants further investigation.

On the other hand, the antimicrobial activity of both methanol and aqueous extracts of *Salvadora persica* stem bark against oral bacterial pathogens was evaluated through the measurement of the zone of inhibition, as shown in Table 4.2. The results indicate that the methanol extract exhibited stronger antimicrobial activity compared to the aqueous extract, as evidenced by the larger zones of inhibition at all concentrations. For example, at a concentration of 400 mg/ml, the methanol extract demonstrated inhibition zones ranging from 15.6 mm against *Lactobacillus spp.* to 25.6 mm against *Staphylococcus aureus*. The aqueous extract, while still active, showed smaller inhibition zones, ranging from 4.9 mm against *Lactobacillus spp.* to 20.5 mm against *Staphylococcus aureus*.

Furthermore, the activity of the methanol extract was dose-dependent, with higher concentrations yielding larger zones of inhibition. At the lowest tested concentration of 50 mg/ml, the methanol extract produced inhibition zones ranging from 6.3 mm against *Lactobacillus spp.* to 10.3 mm against *Staphylococcus aureus*. The aqueous extract also showed a similar pattern, with activity increasing with concentration. These results suggest that both extracts possess significant antimicrobial properties, although the methanol extract is more potent overall.

Notably, both extracts demonstrated activity against a broad spectrum of oral bacteria, including *Staphylococcus aureus*, *Fusobacterium spp.*, *Eubacteria spp.*, *Streptococcus mutans*, and *Lactobacillus spp.*, which are common contributors to oral infections and dental diseases. This broad-spectrum activity underscores the potential of *Salvadora persica* stem bark as a natural remedy for oral infections.

Moreover, The Minimum Inhibitory Concentration (MIC) of the methanol and aqueous extracts of *Salvadora persica* stem bark was determined to evaluate the lowest concentration required to inhibit bacterial growth. The MIC values, as presented in Table 4.3, show that the methanol extract had lower MIC values compared to the aqueous extract, indicating a stronger antimicrobial potency.

For instance, the methanol extract inhibited *Staphylococcus aureus* at 100 mg/ml, while the aqueous extract required a higher concentration of 150 mg/ml for the same bacterium. The methanol extract was also more effective against *Fusobacterium spp.*, *Eubacteria spp.*, and *Streptococcus mutans*, with MIC values of 200 mg/ml, 150 mg/ml, and 250 mg/ml, respectively. In contrast, the aqueous extract required 250 mg/ml, 200 mg/ml, and 300 mg/ml for inhibition of these pathogens.

These results suggest that the methanol extract has a higher antimicrobial potency compared to the aqueous extract, requiring lower concentrations to inhibit bacterial growth. This observation aligns with the zone of inhibition results, further supporting the superior antimicrobial activity of the methanol extract.

In addition, the Minimum Bactericidal Concentration (MBC) was also determined for both extracts, providing insight into the concentration required to kill the bacteria rather than just inhibiting their growth. The MBC values, as shown in Table 4.4, demonstrate that the

methanol extract generally required lower concentrations to achieve bactericidal effects compared to the aqueous extract.

For example, the methanol extract had an MBC of 200 mg/ml against *Staphylococcus aureus*, while the aqueous extract required 250 mg/ml. Similarly, for other pathogens like *Fusobacterium spp.*, *Eubacteria spp.*, and *Streptococcus mutans*, the methanol extract achieved bactericidal effects at lower concentrations, suggesting that it not only inhibits bacterial growth but also has a stronger bactericidal effect. The findings indicate that the methanol extract is more effective in both inhibiting and killing oral bacterial pathogens than the aqueous extract.

Several recent studies have investigated the antimicrobial activity of *Salvadora persica* extracts against various microorganisms. For example, a study by Khan *et al.* (2022) found that the methanol extract of *Salvadora persica* exhibited antimicrobial activity against *Staphylococcus aureus*, *Escherichia coli*, and *Candida albicans*, with MIC values ranging from 62.5 to 125 µg/mL. Furthermore, a study by Al-Marzoqi *et al.* (2022) found that the aqueous extract of *Salvadora persica* exhibited antimicrobial activity against *Streptococcus mutans* and *Lactobacillus acidophilus*, with MIC values ranging from 125 to 250 µg/mL. In addition, a study by Riaz *et al.* (2022) found that the ethyl acetate extract of *Salvadora persica* exhibited antimicrobial activity against *Porphyromonas gingivalis* and *Fusobacterium nucleatum*, with MIC values ranging from 31.25 to 62.5 µg/mL.

However, the results of the current study differ from those of Ahmed *et al.* (2020), who found that the methanol extract of *Salvadora persica* exhibited antimicrobial activity against *Staphylococcus aureus*, *Bacillus subtilis*, and *Escherichia coli*, with MIC values ranging from 50 to 100 µg/mL. Nevertheless, the current study found that the methanol extract was more effective than the aqueous extract against all five oral bacterial pathogens. Moreover, a study by Singh *et al.* (2020) found that the aqueous extract of *Salvadora persica* exhibited antimicrobial activity against *Streptococcus mutans*, *Lactobacillus acidophilus*, and *Candida albicans*, with MIC values ranging from 100 to 200 µg/mL.

The results of the current study are similar to those of recent studies in that they demonstrate the antimicrobial activity of *Salvadora persica* extracts against various microorganisms. However, there are some differences in the specific microorganisms tested, the extracts used, and the MIC values obtained. For instance, the current study used both methanol and aqueous extracts, while recent studies used methanol, aqueous, or ethyl acetate extracts. Additionally, the current study tested the antimicrobial activity of the extracts against five oral bacterial pathogens, while recent studies tested the antimicrobial activity of the extracts against a wider range of microorganisms, including bacteria, fungi, and viruses.

One contrasting finding is that the current study found that the methanol extract was more effective than the aqueous extract against all five oral bacterial pathogens, while Al-Marzoqi *et al.* (2022) found that the aqueous extract was more effective than the methanol extract against *Streptococcus mutans* and *Lactobacillus acidophilus*. However, this discrepancy may be due to differences in the extraction methods, the specific microorganisms tested, or the experimental conditions used.

The findings of the current study and recent studies suggest that *Salvadora persica* extracts have antimicrobial potential against a wide range of microorganisms, including oral bacterial pathogens. Furthermore, the results of the current study highlight the importance of using both methanol and aqueous extracts to evaluate the antimicrobial activity of *Salvadora*

persica. In addition, the study suggests that the methanol extract may be more effective than the aqueous extract against oral bacterial pathogens.

5.2 Conclusion

The results of the phytochemical, antimicrobial, MIC, and MBC analyses clearly show that *Salvadora persica* stem bark, particularly its methanol extract, exhibits significant antimicrobial activity against a variety of oral pathogens. These findings suggest that *Salvadora persica* could serve as a promising natural alternative for the treatment of oral infections, warranting further research into its bioactive components and their clinical applications. Furthermore, the phytochemical constituents identified in the extracts provide a strong basis for the observed antimicrobial activity, suggesting that the bioactive compounds, such as alkaloids, flavonoids, and tannins, may contribute to the plant's therapeutic potential.

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