The Saudi Dental Journal (2012) **24**, 63–69

King Saud University

**The Saudi Dental Journal**

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REVIEW ARTICLE

# A review on miswak (*Salvadora persica*) and its effect on various aspects of oral health

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Received 13 June 2011; revised 21 October 2011; accepted 20 December 2011
Available online 28 January 2012

**KEYWORDS**

Antimicrobial agent;
Toothbrushing;
Dental caries;
Aqueous extract;
*Salvadora persica*

**Abstract** Plants have been used for centuries to improve dental health and to promote oral hygiene, and this practice persists in several communities throughout the world. "Miswak" is an Arabic word meaning "tooth-cleaning stick," and *Salvadora persica* miswak has a wide geographic distribution. It was used by ancient Arabs to whiten and polish the teeth. This review discusses the history and chemical composition of *S. persica* miswak and its influence on oral health, including the advantages and disadvantages of its use.



**Contents**



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1013-9052 

Peer review under responsibility of King Saud University.
doi:10.1016/j.sdentj.2011.12.004

**Production and hosting by Elsevier**

## 1. Introduction

Good oral health has a major influence on one's general quality of life and well-being. Several chronic and systemic diseases have been attributed to poor oral health. With the increasing incidence of oral diseases, the global need for alternative prevention and treatment methods and safe, effective, and economical products has expanded. The maintenance of oral health can be achieved mainly by mechanical and chemical means. The use of a tooth brush in combination with dentifrices is one of the most common methods of cleaning teeth.

The evolution of the modern toothbrush may be traced to chewing sticks that were used by Babylonians as early as 3500 BC, and to toothpicks that were chewed onto help clean the teeth and mouth and were discussed in ancient Greek and Roman literatures (Wu et al., 2001). Chewing sticks are prepared from a variety of plant species and are customarily used for cleaning teeth in Asia, Africa, South America, and the Middle East (Elvin-Lewis, 1980). Western travelers and explorers described the use of chewing sticks by men and women in the Sahara region and Sudan (Bos, 1993). The inhabitants of these regions would clean their teeth diligently whenever they had a chance to sit down for social gatherings. Chewing sticks are known by different names in different cultures: "arak" or "miswak" in Arabic, "koyoji" in Japanese, "qesam" in Hebrew, "qisa" in Aramaic, and "mastic" in Latin (Bos, 1993). The availability, low cost, simplicity, and religious and/or traditional associations of chewing sticks have made them popular through modern times. Chewing sticks may play a role in the promotion of oral hygiene, and further evaluation of their effectiveness is warranted, as stated in the 2000 World Health Organization (WHO) Consensus Report on Oral Hygiene (WHO, 2000).

"Miswak" (synonyms in different Arabic dialects and countries include "miswaak," "misswak," "miswaki," "meswak," "mswaki," "sewak," "siwak," and "siwaki") is an Arabic word meaning tooth-cleaning stick (Hattab, 1997). The spread of Islamic culture had a significant influence on the propagation and use of miswaks, which was a pre-Islamic practice, in different parts of the world (Bos, 1993). Among at least 182 plant species suitable for preparing toothbrushing sticks, miswak harvested from *Salvadora persica,* are used most extensively (Elvin-Lewis, 1982). The roots, twigs, and stems of this plant have been used for oral hygiene (Elvin-Lewis, 1980) and small *S. persica* sticks have been used as toothpicks (Ezoddini-Ardakani, 2010). *S. persica* has a wide geographic distribution ranging from Rajasthan (India), Nepal, and Malaysia in the east through Pakistan, Iran, Iraq, Saudi Arabia, and Egypt to Mauritania in the west, and from North Africa through Sudan, Ethiopia, and Central Africa to southwestern Africa (Khoory, 1983; Wu et al., 2001). Taking into account the historical importance of the use of *S. persica* miswak in the field of oral hygiene, the present review is an attempt to remind readers of the enormous contributions that this practice has made to dentistry, with an input from the most recent literature, and to describe the major aspects of its influence on oral health, including its disadvantages.

## 2. Chemical composition

Chemical analysis of *S. persica* miswak has demonstrated the presence of β-sitosterol and m-anisic acid (Ezmirly et al., 1979; Ray et al., 1975); chlorides, salvadourea, and gypsum; organic compounds, such as pyrrolidine, pyrrole, and piperidine derivatives (Galletti et al., 1993); glycosides, such as salvadoside and salvadoraside (Kamel et al., 1992); and flavonoids, including kaempferol, quercetin, quercetin rutin, and a quercetin glucoside (Abdel-Wahab et al., 1990). The roots and bark of the *S. persica* tree are composed of 27% ash; a high ratio of alkaloids, such as salvadorine and trimethylamine; chlorides and fluorides; moderate concentrations of silica, sulfur, and vitamin C; and small quantities of tannins, saponins, flavonoids, and sterols (Akhtar and Ajmal, 1981; Al Lafi and Ababneh, 1995; Farooqi and Srivastava, 1968). High amounts of sodium chloride and potassium chloride were noted, along with other sulfur-containing organic substances (salvadourea and salvadorine) (Dorner, 1981).

*S. persica* miswak contains nearly 1.0 μg/g of total fluoride and was found to release significant amounts of calcium and phosphorus into water (Char et al., 1987). Repeated chewing of *S. persica* miswak was found to release fresh sap, which may have an anticariogenic effect (Almas and al-Lafi, 1995).However, another study noted that a negligible amount (0.07 μg/ml) of fluoride was released when *S. persica* miswak was soaked in water (Hattab, 1997). Farooqi and Srivastava(1968) isolated benzylisothiocyanate (BITC) from *S. persica* roots, and Ezmirly and El-Nasr (1981) demonstrated that BITC is an end-product derived from the enzymatic hydrolysis of the glucosinolate present in the plant. BITC is a chemopreventive agent that is thought to prevent cariogenic and other genotoxic compounds from reaching or reacting with target sites on the treated tissue (Al-Dosari et al., 1992; Benson and Barretto, 1985; Benson et al., 1980; Wattenberg, 1977). At a concentration of 133.3 μg/ml, BITC was found to have virucidal activity against Herpes simplex virus 1 (al-Bagieh, 1992). In addition, BITC has exhibited broad-spectrum bactericidal activity (Pulverer, 1969) and was found to inhibit the growth and acid production of *Streptococcus mutans* (Al-Bagieh and Weinberg, 1988).

Other components of *S. persica* also have beneficial effects on oral health. The sulfur content in the ash of *S. persica* roots was found to be as high as 4.73% (Galletti et al., 1993). Sulfur has a bactericidal effect (Abo Al-Samh, 1995) and vitamin C was found to help in tissue healing and repair (Almas, 1993). Silica acts as an abrasive and was found to help in removing stains from tooth surfaces (Al Lafi and Ababneh, 1995; Khoory, 1983). The astringent effect of tannins may help to reduce clinically detectable gingivitis. Tannins were found to inhibit the action of glucosyltransferase, thereby reducing plaque and gingivitis (Gazi et al., 1992). Resins may form a layer on enamel that protects against dental caries (Al Lafi and Ababneh, 1995). Salvadorine, an alkaloid present in *S. persica* miswak, may exert a bactericidal effect and stimulate the gingiva (Almas, 1993). The mildly bitter taste of the essential oils in *S. persica* miswak stimulates the flow of saliva, which acts as

a buffering agent. High concentrations of chloride inhibit the formation of calculus (Akhtar and Ajmal, 1981) and aid in removing stains from tooth surfaces (Almas, 1993). Saturation of calcium in saliva due to the use of chewing sticks was found to promote enamel remineralization (Gazi et al., 1992).

## 3. Influence of miswak on oral health

### 3.1. Antimicrobial effects

An *in vitro* study showed that the aqueous extract of *S. persica* miswak had an inhibitory effect on the growth of *Candida albicans* that may be attributed to its high sulfate content (al-Bagieh et al., 1994). AlLafi and Ababneh (1995) investigated the derivatives of *S. persica* miswak using three different laboratory methods, and demonstrated strong antimicrobial effects on the growth of *Streptococcus* sp. and *Staphylococcus aureus*. In addition, Almas et al. (1997) showed that *Enterococcus faecalis* is the most sensitive microorganism affected by the use of *S. persica* miswak, and noted no significant difference in the antimicrobial effects of freshly cut and 1-month-old miswak. A comparison of the alcoholic and aqueous extracts of *S. persica* miswak revealed that the alcoholic extract had more potent antimicrobial activity than did the aqueous extract (Al-Bagieh and Almas, 1997).

Almas (1999) showed that *S. persica* miswak extracts had antimicrobial effects on *Streptococcus mutans* and *E. faecalis*. Elvin-Lewis et al. (1980) and Almas (1999) suggested that this effect may be due to the interaction with bacteria, which prevents their attachment on the tooth surface. Almas and Al-Bagieh (1999) also noted significant differences in the antimicrobial activities of the pulp and bark extracts of *S. persica* miswak.

Research has identified several anionic components of *S. persica* miswak that are known to have antimicrobial effects (Darout et al., 2002).Darout et al. (2000b) hypothesized that these components had potent promoter effects on salivary peroxidase thiocyanate and hydrogen peroxidase antimicrobial systems. Furthermore, Darout et al. (2002)examined the salivary levels of 25 oral microorganisms in a study conducted among Sudanese adults, and suggested that *S. persica* miswak may have a selective inhibitory effect on the levels of certain bacteria. They observed that miswak users had significantly lower numbers of cariogenic bacteria, except *Streptococcus mutans*, in their saliva, whereas toothbrush users had lower salivary levels of periodontal pathogens. *Aggregatibacter actinomycetemcomitans*, a predominant periodontal pathogen, and other bacterial species were found to be present in significantly higher numbers in the saliva of miswak users than in that of tooth brush users (Darout et al., 2002). Furthermore, another study reported that miswak users harbored significantly higher plaque levels of *Staphylococcus intermedius*, *A. actinomycetemcomitans*, *Veillonella parvula*, *Actinomyces israelii*, and *Capnocytophaga gingivalis* and significantly lower levels of *Selenomonas sputigena*, *Streptococcus salivarius*, *Streptococcus oralis*, and *Actinomyces naeslundii* than did toothbrush users (Darout et al., 2003).

In a single-blind, randomized, crossover study involving 15 Saudi Arabian volunteers, Al-Otaibi et al. (2004) demonstrated that the effect of chewing miswak on the levels of subgingival plaque microbiota was similar to that of regular toothbrushing without toothpaste, and that the level of *A. Actinomycetemcomitans* was significantly more reduced by using miswak than by toothbrushing. Almas and Al-Zeid (2004) investigated the immediate antimicrobial effects of *S. persica* miswak and its extract on *Streptococcus mutans* and *Lactobacillus*, and found a significant decrease in *Streptococcus mutans* count, but not in *Lactobacillus* count, in miswak users.

Based on the results of their experimental research, Poureslami et al. (2007) recommended the use of *S. persica* miswak extract in mouthrinses and toothpastes due to its remarkable antimicrobial effects. This research comprised three *in vitro* studies that tested the effect of *S. persica* miswak extract on selected bacteria, compared the paraclinical effects of Iranian toothpaste containing *S. persica* miswak extract and placebo toothpaste on dental plaque, and compared the antibacterial effect of the Iranian toothpaste with that of a Swiss toothpaste on dental plaque and also with penicillin. The results of all three studies showed the positive paraclinical effects of *S. persica* miswak extract on dental plaque.

An investigation of whole (unextracted) *S. persica* miswak pieces embedded in agar or suspended above the agar plate revealed strong antibacterial effects against oral microorganisms associated with periodontitis and dental caries (Sofrata et al., 2008). Fluoride, which is a component of *S. persica* miswak, showed a possible interaction with bacterial glycolytic enzymes and their acids. Moreover, in an earlier study, the BITC component of *S. persica* miswak was suggested to be a bacterial growth inhibitor (Farooqi and Srivastava, 1968).

Al-Bayati and Sulaiman (2008) investigated the aqueous and methanol extracts of *S. persica* miswak for antimicrobial activities against seven isolated oral pathogens (*S. aureus*, *Streptococcus mutans*, *Streptococcus pyogenes*, *E. faecalis*, *Lactobacillus acidophilus*, *Pseudomonas aeruginosa*, and *Candida albicans*) using two methods. Both antimicrobial assays showed that the aqueous extract inhibited all isolated microorganisms and was more efficient than the methanol extract, which was resisted by *L. acidophilus* and *P. aeruginosa*. The strongest antibacterial activity was shown by the aqueous extract against *E. faecalis*. Turbidity tests showed that both extracts had equal antifungal activity against *C. albicans*. The derivatives of *S. persica* miswak are reported to have pronounced antimicrobial activity, and these heterogeneous components can be extracted using different chemical procedures (Akhtar et al., 2011).

### 3.2. Anticariogenic effects

Many epidemiological studies revealed that *S. persica* miswak had strong anti-decay effects. In a dental health survey conducted in Sudan, Emslie (1966) reported a lower caries prevalence among miswak users than among toothbrush users. Subsequent studies (Baghdady and Ghose, 1979; Sathananthan et al., 1996; Younes and El-Angbawi, 1982) found similar lower caries incidences among school children using miswak.

Olsson (1978) reported that chewing sticks reduced dental caries more effectively than did conventional toothbrushes. Despite the carbohydrate-rich diet traditionally consumed in Ghana, the incidence of caries and other dental diseases was low among Ghanaian chewing-stick users (Elvin-Lewis et al., 1980). A cross-sectional pilot study among adults in West Africa (Norton and Addy, 1989) also reported a decreased rate of caries and plaque in miswak users in comparison with non-users.

The pungent taste and chewing effects of miswak may increase saliva secretion in the mouth, thereby increasing its buffering capacity (Hattab, 1997).In an *in vivo* study, Sofrata et al. (2007) found that rinsing with *S. persica* miswak extract stimulated parotid gland secretion, thereby raising the plaque pH; this effect can potentially prevent dental caries by reversing the acid challenge of cariogenic bacteria. In Zanzibar, the caries prevalence rate was found to be lower in rural areas, where miswak use was customary, than in urban areas (Petersen and Mzee, 1998).

A comparative study found that the aqueous extracts of miswak and derum (different type of chewing stick obtained from walnut tree *Juglans regia*) were both able to significantly inhibit the growth of cariogenic bacteria (Darmani et al., 2006). The large amounts of fluoride present in miswak maybe a contributing factor to this effect (Ezoddini-Ardakani, 2010). However, an earlier study found that this potential contribution of fluoride was doubtful, due to the negligible total soluble content of fluoride in *S. persica* miswak soaked in water (Hattab, 1997).

### *3.3. Effects on dental plaque, gingival health, and periodontal status*

Many reports have revealed that *S. persica* miswak effectively reduced gingivitis and dental plaque. Studies among Ethiopian school children (Olsson, 1978) and Saudi Arabian dental students (Char et al., 1987) showed that miswak removed plaque more effectively than did toothbrushing. The study involving schoolchildren required the provision of instructions and supervision because most children were unfamiliar with the proper technique of miswak use. Olsson (1978) recommended the use of miswak in preventive dental programs because it is economical and familiar to older people. Moustafa et al. (1987) reported 75% plaque reduction after the use of *S. persica* miswak for 8 days. A study conducted among two groups of students in Kenya (Danielsen et al., 1989) reported that no additional method was required to remove dental plaque in the group that used toothpaste in combination with chewing sticks.

Although miswak may effectively remove dental plaque, an association between excessive miswak use and gingival recession was demonstrated in Saudi schoolchildren (Younes and El Angbawi, 1983). Eid et al. (1991) also reported many cases of gingival recession among miswak users, which may be due to mechanical trauma. An earlier study by the same investigators (Eid et al., 1990a) found no significant difference in gingival indices or bleeding between miswak and toothbrush users. However, Gazi et al. (1990) found gingival indices to be significantly lower following the use of *S. persica* miswak in comparison with the use of a conventional toothbrush without toothpaste.

Several toothpastes containing *S. persica* miswak extract are commercially available (Al Sadhan and Almas, 1999; Guile et al., 1996). One such toothpaste was found to be significantly more effective in removing dental plaque when compared with Oral-B toothpaste (Hattab, 1997). The combined effect of mechanical cleansing and enhanced salivation achieved with the proper use of *S. persica* miswak was found to be more efficient than toothbrushes in removing dental plaque (Wu et al., 2001).

In a randomized crossover study among 15 Saudi Arabian male volunteers, Al-Otaibi et al. (2003) found that miswak use significantly reduced plaque and gingival indices and was more effective than toothbrushing when preceded by professional instruction regarding its correct application. Rinsing with a slurry of toothpaste containing *S. persica* miswak has been shown to reduce gingival inflammation and bleeding on probing. In comparison, chlorhexidine was found to reduce plaque more effectively than *S. persica* miswak, and the anti-plaque effects of both products suggested no definite advantage in using *S. persica* miswak over chlorhexidine (Gazi et al., 1987). In a similar study investigating a commercial herbal mouthwash containing *S. persica* miswak extract, significant reductions in gingival bleeding were observed in both test and placebo subjects. However, a significant reduction in the load of cariogenic bacteria was observed only in the test subjects (Khalessi et al., 2004).

The efficacy of chewing sticks has been challenged in several studies. Norton and Addy (1989) reported more plaque formation and gingival bleeding in persons using chewing sticks than in toothbrush users. Habitual users of miswak had a significantly higher prevalence of gingivitis than did toothbrush users (Eid et al., 1990b; Norton and Addy, 1989). Gazi et al.(1990) indicated that miswak sticks were less effective than toothbrushes in cleaning interproximal dental areas and lingual surfaces.

Low levels of tooth loss in adults have been found in countries where miswak is widely used (Elvin-Lewis et al., 1980). Epidemiological studies (al-Khateeb et al., 1991; Younes and El-Angbawi, 1982) suggested that miswak use had beneficial effects on the prevalence of periodontal diseases and caries. Furthermore, al-Khateeb et al. (1991) and Guile (1992) reported low periodontal treatment needs among Saudi adults who used miswak. An epidemiological study conducted among certain nomadic groups of the Kaisut Desert region of Kenya showed that dental caries and advanced periodontal disease were rare among miswak users under the age of 50 years (Carl and Zambon, 1993). However, a retrospective study conducted in Saudi Arabia showed conflicting results; miswak users had deeper periodontal pockets and a higher prevalence of periodontal diseases (Eid and Selim, 1994) than did non-users. In a study performed at a medical campus in Sudan, Darout et al. (2000a) reported that the periodontal status of habitual miswak users was similar to or slightly better than that of toothbrush users.

### *3.4. Oral hygiene*

The value of *S. persica* miswak is due primarily to its mechanical cleaning action (Akpata and Akinrimisi, 1977). Gazi et al. (1990) reported significantly lower plaque scores following the proper use of miswak as an oral hygiene aid in comparison with the use of conventional toothbrushes. Miswak is generally used for a longer period of time than a toothbrush, and the buccal/labial surfaces of the teeth can be reached more easily than can the lingual and proximal surfaces (Eid et al., 1990b). Despite the longer duration of miswak use, Eid et al. (1990a) found no significant difference in buccal/labial plaque scores between miswak and toothbrush users in Saudi Arabia.

In many developing countries, chewing sticks are often used as the sole oral cleaning device. Oral hygiene maintenance through the regular removal of dental plaque is an essential factor in the prevention of dental caries and periodontal disease. Several explanations for the cleansing effectiveness of

*S. persica* miswak have been put forward, including (a) the mechanical effects of its fibers, (b) the release of favorable chemicals from the chewing stick while in use, or (c) a combination thereof. However, the lack of studies reporting the time, duration, and frequency of *S. persica* miswak use prevents meaningful assessments of its mechanical cleaning effects on oral health (Hardie and Ahmed, 1995).

In a 2005 survey, the majority of Jordanians believed that using a toothbrush and a miswak was most effective for optimal oral health (Tubaishat et al., 2005). *Salvadora persica* miswak is considered to be an affordable and readily available oral hygiene device that can be used by the vast majority of people (Hooda et al., 2010).

## 4. Disadvantages of chewing sticks

Although *S. persica* miswak is considered to be an essential aid in maintaining oral hygiene, certain disadvantages are associated with its use. Its bristles lie in the long axis of the stick, whereas those of a toothbrush are placed perpendicular to the handle. Thus, it is difficult to reach the lingual surfaces of the dentition with a miswak. Another disadvantage is related to the habitual use of miswak for a prolonged period (Hollist, 1981). Khoory (1983) reported that chewing-stick users may excessively scrub the anterior teeth, which are located in the area of primary concern, while ignoring the posterior teeth. Other studies have considered the use of miswak to be one of the possible etiological factors in gingival recession (Eid et al., 1991). These disadvantages may be overcome with a dentist's provision of precise instructions on the acceptable methods and duration of miswak use.

Mohammad and Turner (1983) evaluated the cytotoxic potential of the *S. persica* plant and its diffusible components on oral tissues using the tissue culture agar overlay method. Their results demonstrated no cytotoxic effect of freshly cut *S. persica* miswak, but showed that the same plants contained harmful components if used after 24 h. A study of the effect of the direct administration of high doses of *S. persica* miswak extract to mice revealed some minor side effects on male and female reproductive systems and fertility (Darmani et al., 2003). However, an earlier study reported that neither aqueous nor ethanolic *S. persica* miswak extract was toxic to mice at doses of up to 1200 mg/kg (Ezmirly et al., 1979).

## 5. Conclusion

Our literature review revealed that the use of *S. persica* miswak as an oral hygiene aid is effective. Descriptive and experimental studies have provided considerable evidence that the *S. persica* plant and its extracts exert beneficial effects on the oral tissues and help to maintain good oral hygiene. It is encouraging to note the large number of studies and clinical trials that have examined the effects of *S. persica* miswak and the value that people have attached to it since ancient times. The use of *S. persica* miswak alone or in combination with conventional toothbrushes, when performed judiciously, will result in superior oral health and hygiene. Thus, *S. persica* miswak may be recommended for regular use, given its favorable effects on oral health, low cost, ready availability, and simplicity of use.

## Ethical Statement

There is no ethical issue regarding this study.

## Conflict of interest

No conflict of interest declared.

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