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Review Article

THE NATURAL TOOTHBRUSH “MISWAK” AND THE ORAL HEALTH

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Oral hygiene measures have been practiced by different populations and cultures around the world since the antiquity with evidence for various oral hygiene products including toothpicks and toothpowders dating back to 4000 BC. Ancient Greek and Roman literature discusses toothpicks that were chewed on to help clean the teeth and mouth. The evolution of the modern toothbrush has its origin in chewing sticks that were used by the Babylonians as early as 3500 BC. Miswak or siwak (tooth cleaning stick) for mechanical tooth cleaning can be traced back at least to pre-Islamic times. Currently, many of the world populations still use chewing sticks as the only method for tooth cleaning. It has been estimated that between 21%-70% of adults in India and Pakistan use miswak, especially in the rural areas. Its use is also very common in Arab countries and most of the Muslim world. Chewing sticks are also the predominant tools that are used for oral hygiene procedures among African populations. Reasons for continuing the use of traditional tooth cleaning methods include low cost and availability. Customs and religious reasons because toothbrushes are not acceptable to all Muslims as an alternative or substitute for miswak during some months (Holy months) of a year. Therefore, chewing sticks have continued to be important for oral hygiene in these communities.

Keywords: Miswak cleaning sticks, Oral hygiene practice, Manual toothbrush

INTRODUCTION

Miswak (miswaak, misswak, miswaki, meswak, mswaki, sewak, siwak and siwaki are all synonyms used in different Arabic dialects and countries) is an Arabic word meaning tooth cleaning stick (Hattab, 1997; Al Sadhan and Almas, 1999). In English, miswak has been mentioned as the “natural toothbrush”. In geographical regions in which the Arak (synonymous with Araak) tree grows, miswak is interpreted as tooth sticks prepared from the Arak tree. Salvadora persica L (family: Salvadoraceae) is the botanical name of the Arak tree. It is a small upright evergreen tree or shrub with white branches and aromatic roots, seldom more than 30 cm in diameter and three meters in height (Kassas and Zahran, 1965). It is known in English as the “toothbrush tree”, the “toothbrush tree of the Orient” or the “Persian toothbrush tree”.

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Geographically, *S. persica* is widely distributed: from Rajasthan (India) in the east (Gupta and Sakena, 1968) through Southern Arabia, Iran, Iraq, Israel, Egypt to Mauritania in the west, and from North Africa in the north through Sudan, Ethiopia, Central Africa to South West Africa in the south (Engler and Prantl, 1942). The roots, twigs and stems of *S. persica* have been used for many centuries as oral hygiene tools (Elvin, 1980) and are today commonly used as tooth and tongue cleaning sticks by Muslims in the Middle East as well as in Asian and various African countries (Raied et al., 1999; Corbet et al., 2000).

**PREPARATION OF MISWAK STICK**

Most chewing sticks share a common design and method of preparation. Pencil-sized sticks 15-20 cm long with diameter ranging from 1.0 cm to 1.5 cm are prepared from the root, stem, twigs or bark of the Arak tree. The stick is chewed or tapered at one end until it becomes frayed into a brush (Figure 1). Soaking in water for a few hours will soften the natural fibers helping them to separate while tapering or chewing. The term “chewing stick” may therefore be misleading since the stick is chewed only briefly to fray its fibers before its common use as a toothbrush. When the mouth cleaning procedure that includes brushing of teeth, gums (Figure 2) and tongue is completed, the chewing stick is removed from or may be left in the mouth for some additional time. Left in the mouth, the miswak will stimulate salivation and thus there will be a better cleansing effect. After having been used several times, the chewing stick is either replaced by a new one or its bristles are cut off to expose a fresh end at which new bristles are prepared by further chewing or tapering.

**CHEMICAL COMPONENTS**

Chemical analysis of *S. persica* root extracts demonstrated the presence of β-sitosterol, *m*-anisic acid (Ray et al., 1975) and elemental sulphur as well as substantial amount of silica (Ezmirly et al., 1979). Chlorides, salvadourea and...
high content of gypsum have been found in the stem (Porters, 1974; Massassati et al., 1981; Galletti, 1983). Organic compounds identified in S. persica included pyrrolidine, pyrrole and piperidine derivatives (Kamel et al., 1992); glycosides such as salvadoside and salvadoraside (Abdel et al., 1990); flavonoids such kaempferol, quercetin, quercetrin, rutin, and a quercetin glucoside (Abdel, 2003); and sugar terpenoids, alkaloids, esters of fatty acids and of aromatic acids, and fats (Almas and al-Lafi, 1995).

**BIOLOGICALLY ACTIVE COMPOUNDS**

The substantial amount of silica detected in S. persica ashes has been thought to contribute to miswak’s mechanical action in plaque removal (al-Bagieh, 1992). Benzylisothiocyanate is a component exhibiting antiviral and antimycotic activity of miswak extracts but its mode of action was not clearly delineated (al-Bagieh, 1994). Dorner (1981) has speculated that the high amount of NaCl and KCl, sulphur-containing organic substances (salvadourea and salvadorine), and an alkaloid yielding trimethylamine on hydrolytic cleavage might somehow be responsible for the observed antibacterial and gum stimulating effect. Decoction of S. persica has been used for the treatment of spleenomegaly, rheumatism, tumors, and renal stones in humans by folk medicine practitioners (Harfi, 1997). It was also shown to possess hypoglycemic effects and an incremented oral-glucose tolerance in normal rats, and to enhance plasma immunoreactive insulin level (Trovato et al., 1998).

A protective action of S. persica decoction against ethanol and stress-induced ulcers has been observed in rats (Sanogo et al., 1999). Extracts from the roots and stems of S. persica have been used for treatment of oral infections in animals (Sulaiman et al., 1986). In humans, miswak extracts have been shown to induce morphological changes in tissue culture using L929 cells (Abo Al-Samh et al., 1997) and IgE-mediated allergic reactions in humans (Mohammad and Turner, 1983). However, fresh plant materials from S. persica demonstrated no cytotoxic effect in a mammalian monolayer cell culture while cytotoxicity was demonstrated after 24 h (Babay and Almas, 1999). Recent studies showed that aqueous and ethanol extracts of S. persica were able to remove the smear layer from dentin surfaces and occlude dentine tubules (Almas, 2001; Lafi and Ababneh, 1995).

**ANTIMICROBIAL ACTIVITY**

Some in vitro studies have shown that S. persica extracts inhibited growth of various oral aerobic and anaerobic bacteria as well as Candida albicans (Almas K, al-Lafi, 1995; Al-Bagieh, 1994). Inhibition of in vitro plaque formation, growth and acid production of various cariogenic bacteria by such extracts have also been demonstrated (Almas and al-Bagieh, 1999). Almas and al-Bagieh (1997) found that aqueous extracts of S. persica bark, pulp as well as whole miswak were effective against various bacteria including Streptococcus mutans, and noted some differences in antimicrobial activities between the pulp and bark extracts. S. persica alcoholic extracts were more antimicrobial potent than water extracts (Almas and al-Bagieh, 1997).

Regarding the effect of storage on the activity of miswak extracts, there was no noticeable
difference in antimicrobial effect between fresh and one-month-old miswak. When extracts prepared from *S. persica* and *Azadirachta indica* (neem) chewing sticks were compared, both were able to suppress growth of *S. mutans* and *Streptococcus faecalis* at 50% concentration, only the *S. persica* extract was reported to be more effective at lower concentrations (Almas and al-Bagieh, 1997). Recently, AbdElRahman et al. (2002b) using various *S. persica* extracts showed *in vitro* that root alcoholic extracts were more antimicrobially potent against *S. mutans* whereas *Lactobacillus acidophilus* was the least susceptible one and that minimum inhibitory concentration values for the various *S. persica* extracts ranged from 100 mg/mL to 300 mg/mL indicating moderate to weak antimicrobial activity. Another recent study Al-Mohaya (2002) showed that renal transplant patients that used miswak had significantly lower prevalence of oral candidiasis than had such patients using modern toothbrush.

**COMPARATIVE EFFICACY OF MISWAK AND TOOTHBRUSHES**

**Development of the Modern Toothbrush**

The earliest trace of an implement remotely similar to today’s toothbrush was 1000 AD in China with horse hair set in ivory handles (Kimery and Stallard, 1968). Brushes more similar to those of today were hogs bristles set in Ox bone dating back the 14th century, again in China. The bristle brush appears to have been reinvented in the 18th century, although cost limited its widespread use. The nylon toothbrush with a plastic handle was developed in the 1930s and being relatively inexpensive had the potential for universal ownership. Thus, the Workshop on Dental Plaque Control and Oral Hygiene Practices 1985 concluded that toothbrushing with toothpaste was arguably the most common form of tooth cleaning practiced by individuals in developed countries (Fradensen, 1986).

**Mechanical Efficiency**

Mechanical cleaning procedures are reliable means of controlling dental plaque, provided cleaning is sufficiently thorough and performed at regular intervals (Loe, 2000). In developed countries, this is achieved by tooth brushing with a manual or electric toothbrush in combination with dentifrice or toothpowder. Chewing sticks are often used as the sole cleansing agent in developing countries. Since most studies on chewing sticks lack specific details concerning the duration and frequency of miswak use, it has been difficult to assess the effect miswak practice has on oral health (Hardy, 1995). For example, Eid et al. (1990a) reported a range of frequency of miswak use from one or two times per day to weekly or irregular use. Gazi et al. (1990), concluded that miswak had to be used five times per day in order to significantly decrease plaque accumulation.

Various explanations for the cleansing efficacy of miswak have been offered including: (i) the mechanical effects of its fibers, (ii) its release of beneficial chemicals; or (iii) a combination of (i) and (ii) (Hardy and Ahmed, 1995). The miswak is generally used for a longer period of time than is the modern toothbrush, the cleaning is usually implemented for 5 to 10 min each time and the plant fibers remove plaque and simultaneously massage the gum. Unlike a modern toothbrush, the bristles of the miswak are situated along the long axis of its handle (see, Figures 1 and 2).
Consequently, the facial surfaces of the teeth can be reached more easily than the lingual surfaces or the interdental spaces. Eid et al. (1990) reported that the majority of miswak users applied the miswak to both aspects of their teeth and no significant differences in facial plaque scores were noted between the miswak and toothbrush users. Additional studies suggested miswak efficacy to be comparable with that of the conventional toothbrush (Olsson, 1978) or demonstrated plaque scores to be significantly lower following the use of miswak as compared with the conventional toothbrush used without toothpaste (Eid et al., 1990).

Clerehugh et al. (1995) reported relatively high mean plaque scores among 14-year-old Ghanaian schoolchildren and no significant differences among the three groups using chewing sponge, chewing stick or toothbrush for tooth cleaning. A few other studies suggested that chewing sticks could be as efficient as the conventional toothbrush if proper instruction and supervision were given to the children (Van, 1992).

Comparative Oral Health Status of Miswak and Toothbrush Users

Dental Caries

In a dental health survey in the Sudan, Emslie (1966) reported for the first time less caries in people using chewing sticks than in those using a toothbrush. In a controlled clinical study Baghdady and Ghose (1979) compared the caries prevalence between Iraqi and Sudanese schoolchildren using the WHO DMFT (diseased, missing, filled teeth) index (WHO, 1979). They reported that Sudanese schoolchildren showed lower caries prevalence due to the use of miswak and their diet. Similar results were noted in Saudi children aged 13 to 15 years when compared with children in western countries (Younes and El-Angbawi, 1982). Again, the main preventive factor reported was miswak use by these children. Carl and Zambon (1993) reported that dental caries was relatively rare among Kenyan primary school children who were using only miswak as an oral hygiene tool. The authors concluded that caries in adults was mostly in older persons and usually involved the maxillary and mandibular second and first molars, which are difficult to reach for cleaning with the miswak. It has also been demonstrated that users of chewing sticks other than those prepared from S. persica had low caries prevalence compared to modern toothbrush users (Sathananthan et al., 1996).

Periodontal Status

Low periodontal treatment needs have been reported among Saudi adults who used miswak (al-Khateeb et al., 1991; Guile, 1992). Furthermore, Gazi et al. (1990) compared habitual miswak users and toothbrush users on periodontal status and showed that the former had lower gingival bleeding and interproximal bone height than the toothbrush users. The authors also indicated that there were no significant differences in plaque scores and pocket depths between the two groups. In the northern Kenya, Carl and Zambon (1993) suggested that advanced periodontal disease was very rare among persons over the age of 50 years who used miswak for teeth brushing. The authors concluded that absence or presence of periodontal disease seemed to go hand in hand with the use or misuse of miswak. Eid et al. (1990a) reported that there were no significant differences in gingival or bleeding indices between miswak and toothbrush users.
GENERAL DISCUSSION

Resources for oral health care are limited in many developing countries and the need to explore and test easily available and inexpensive traditional preventive tools is recognized and supported WHO (1987). This is also in line with a recent consensus statement (2000) stating that “chewing sticks may have a role to play in the promotion of oral hygiene” and that “evaluation of their effectiveness warrants further research”. Compared with the modern toothbrush, which is principally developed from chewing sticks, the latter have a very long tradition, being economical, more ecological, readily available, and can be used without dentifrice.

It has been demonstrated that miswak users had significantly lower numbers of sextants with dental calculus in the posterior sextants than had the modern toothbrush users (Darout et al., 2000). Almas and al-Lafi (1995) indicated that miswak chemical components contribute to its mechanical action in dental calculus removal. Miswak extracts contained high amounts of chloride and substantial amounts of silica (Darout et al., 2000). Recently, it has been shown that the commercially available dentifrice (Whitening Toothpaste) which contains 10% of silica is efficacious for control of supragingival calculus formation (Sowinski, 2002). Furthermore, miswak is generally used for a longer period of time than is the modern toothbrush, the cleaning is usually implemented for 5 to 10 min each time (Akhtar and Ajmal, 1981), and the plant fibers remove plaque and simultaneously massage the gum. It has been suggested that the level of supragingival calculus is a fairly good measure of the oral hygiene level and the frequency of professional dental care in a population (Mandel and Gaffar, 1986). Calculus promotes and retains dental plaque on its outer surface and consequently is an important risk factor of progression of attachment loss (Albandar et al., 1998).

Gazi et al. (1990) demonstrated that there were no significant differences in plaque scores and periodontal pocket measurements between habitual miswak and toothbrush users. Eid et al. (1990) also indicated that there were no significant differences in plaque scores and attachment loss between habitual miswak and toothbrush users.

Miswak users have lower caries experience than toothbrush users (Darout et al., 2002). The lower caries experience in the miswak users may be due to its thiocyanate (SCN–) contents. Tenovuo et al. (1981) showed in vitro that acid production by Streptococcus mutans in human dental plaque was almost totally inhibited when supplementing saliva with SCN– and hydrogen peroxide. This is also in agreement with observations by Lenander-Lumikari et al. (1992).

The finding of lower caries experience of miswak users can also be explained by the cleansing effect of miswak. When the mouth cleaning procedure is completed, miswak is often left in the mouth for some additional time. Left in the mouth, it will stimulate salivation and thus promoting a better cleansing and anti-cariogenic effect.

It has also demonstrated that the type of oral hygiene had a significant effect on the salivary levels of 19 out of the 25 bacterial species investigated, and that the type of effect also depended on the type of bacteria. Thus, 10 of these species were present in significantly higher
numbers, and 9 were found in significantly lower numbers in the saliva of miswak users than of toothbrush users. These microbial differences may be due to release of antimicrobial substances of miswak (69). Four out of the six Streptococcus spp. examined were detectable in significantly lower levels in the miswak group which can be explained by the results reported in Darout et al. (2003). Several of the anionic components detected in miswak are known to have antimicrobial effects. Silva Mendez et al. (1999) reported that nitrite exerted in vitro inhibitory effects against cariogenic bacteria including S. mutans, Lactobacillus casei and Actymices naeslundii at acidic pH. The authors also demonstrated that the ability of these bacteria to recover from nitrite exposure was markedly affected by nitrite concentration. At acidity levels below pH 7, low concentrations of nitrite (0.2 mM) caused complete killing of the test bacteria. Gazi et al. (1990) demonstrated that the use of miswak significantly decreased salivary pH due to its high chloride content. This condition may increase the bactericidal effect of nitrite leaching from miswak in the mouth. Moreover, the bactericidal effect of nitrite is significantly enhanced by SCN- (Xu et al. (2001).

The higher levels of some periodontal pathogens in the saliva of miswak users may be due to a microbial shift from more streptococci to more periodontitis-associated species (Darout et al. (2002). If so, this would be in line with the ecological plaque hypothesis (Marsh, 1994 and 1991). Also, Hillman et al. (1985) and Socransky et al. (1988) reported an antagonistic interrelationship between streptococci species and periodontitis-associated species. Thus, it has been suggested that growth of Aggregatibacter actinomycetemcomitans was inhibited by the potentially beneficial species such as Streptococcus sanguis. The groups of periodontal pathogens that include Tannerella forsythia, Fusobacterium spp, Porphyromonas gingivalis, Prevotella intermedia and Peptostreptococcus micros are considered a causal factor in therapy-resistant periodontitis (Edwardsson, 1999). Presumably these pathogens are present in saliva in the presence (Kononen et al., 2001) or absence (Srinian et al., 2002) of periodontal disease.

Data on the active ingredients in miswak extracts responsible for inhibition of growth and/or virulence factors of oral pathogens is lacking. Although the likely effects in the mouth are difficult to extrapolate from in vitro results, these data may partly explain the low prevalence of dental caries and periodontal disease among miswak users. Darout et al. (2000) used capillary electrophoresis as an analytical technique to show that miswak aqueous extracts contained potentially antimicrobial anionic components including Cl-, SO42-, NO3– and SCN–. The finding of Cl- in S. persica root and stem extracts is consistent with observations of Farooqui and Srivastava (1968). SO42- and SCN in S. persica root and stem water extracts are released from hydrolysis of glucosinolates by myrosinase enzyme in the plant tissue (Darout et al., 2000). Certain isothiocyanates under neutral conditions and in the presence of the enzyme myrosinase may decompose into their respective alcohol derivatives and SCN- (Luthy and Benn, 1977). Darout et al. (2000) indicate that the root and stem of S. persica are rich in SO42-. The presence of SO42- compounds in S. persica root and twigs has previously been reported. Chemical analysis
of air-dried *S. persica* stem extract showed high \( \text{SO}_4^{2-} \) content.

Antibacterial and weak anti-inflammatory effects of *S. persica* root and twig extracts have been attributed to their content of beta-sitosterol, \( \text{SO}_4^{2-} \) compounds and Cl. In addition, Cl leaching into saliva from miswak while in the mouth may mediate the innate host defense systems in human saliva. Cl, I and SCN (pseudohalides) are substrates for salivary peroxidase and/or the myeloperoxidase hydrogen peroxide antimicrobial system. The peroxidase-hydrogen-peroxide-chloride system is a part of the innate host defense that is mediated by polymorphonuclear leukocytes in humans (84). It has been shown that the latter system was more bactericidal against *A. actinomycetemcomitans* than with the myeloperoxidase-thiocyanate and hydrogen peroxide system (Ihalin *et al*., 1998). Recently, Ihalin *et al*. (2001) indicated that the oxidation product of lactoperoxidase and myloperoxidase with I and/or Cl was bactericidal against *P. gingivalis, Fusobacterium nucleatum* and *S. mutans*. \( \text{NO}_3^- \) in *S. persica* root and stem water extracts may be released from the residual nitrate ions taken up by the *S. persica* plant or from the oxidation of ammonia and other nitrogen compounds. Nitrate, nitrite and nitrosamines have been demonstrated to occur naturally in vegetables (Silva *et al*., 1999). The antimicrobial agent nitric oxide (NO) is formed in the mouth and its concentration is directly related to salivary nitrite, which in turn is related to dietary nitrate intake (Silva *et al*., 1999). It has been demonstrated that nitrite, upon its ingestion and mixture with gastric acid, is a potent bacteriostatic and/or bactericidal agent. Acidified nitrite is bactericidal against gastrointestinal, oral, and skin pathogens.

Recently, Allaker *et al*. (2001) reported that acidified nitrite exhibited growth-inhibitory effect on *F. nucleatum Eikenella corrodens* and *P. gingivalis*. Furthermore, it has been shown that the salivary nitrite exerted bactericidal effect on several pathogens such as *Escherichia coli, Salmonella typhimurium, Yersinia entrocolitica, Shigella sonnei* and *C. albicans* at acidic pH. The bactericidal effect of acidified nitrite is due to the production of nitrogen oxide (NO) and nitrogen dioxide (\( \text{NO}_2^- \)). However, the real mechanisms of the bactericidal action and the chemistry of acidified nitrite are still unclear. Another possibility is that nitrite, in synergy with acid in the stomach, mouth, or skin may be an element of innate immunity. The salivary generation of nitrite is accomplished by a symbiotic relationship involving nitrate-reducing bacteria on the tongue surface, which are designated to provide a host defense against microbial pathogens in the mouth and lower gut via NO production.

**CONCLUSION**

Resources for oral health care are limited in many developing countries and the need to explore and test easily available and inexpensive traditional preventive tools is recognized and supported by W.H.O. This is also in line with a recent consensus statement stating that “chewing sticks may have a role to play in the promotion of oral hygiene” and that “evaluation of their effectiveness warrants further research”. Compared with the modern toothbrush, which is principally developed from chewing sticks the study finds:

1. Similar periodontal status of miswak users to that of the toothbrush users, suggesting that the efficacy of miswak use for oral hygiene was comparable to that of the modern toothbrush.
2. Miswak may have a selective inhibitory effect on the level of certain bacteria in saliva, particularly several oral *streptococcus* species (spp.).

3. The type of oral hygiene used had a significant effect on the levels of 11 out of the 28 species investigated. This effect was dependent on the type of bacteria and probing pocket depths.

4. The results showed that miswak extracts contained potential antimicrobial components including Chlorides, Sulphates, thiocyanate, and nitrate oxides.

5. The results also show for the first time that free and bound thiocyanate exist in miswak root and stem extracts.

6. Demonstration of high levels of thiocyanate in aqueous miswak extracts complies with this hypothesis concerning antimicrobial effect of miswak which may be due to its thiocyanate content.

**REFERENCES**


