

Role of *Salvadora persica* chewing stick (miswak): A natural toothbrush for holistic oral health

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ABSTRACT

From an ancient tool to a modern way of improving oral health, miswak (chewing stick) has proven to be an effective tool for oral health. The miswak removes the bacterial plaque by mechanical and chemical actions. It provides a cheap and easily accessible way of improving oral health of the individuals and populations. The use of miswak was promoted centuries ago by Prophet Muhammad (Peace be Upon Him). In the modern era, the beneficial role of using miswak such as antiseptic, antimicrobial, anticariogenic and analgesic effects have been proven scientifically. This article reviews the various oral health benefits of miswak in the light of religious, scientific and social evidences.

Key words: Caries, chemotherapy, oral hygiene, periodontal health

INTRODUCTION

Different oral hygiene methods have been used to overcome widely endemic diseases such as dental caries and oral infections. Due to Increasing awareness and expected evolving population; the use of safe, effective and economical products have expanded drastically. Both chemical and mechanical ways are being used in achieving good oral hygiene.^[1] However; mechanical cleaning using the toothbrush plays the most vital role. The advancement of the modern tooth brushes can be traced back to chewing sticks used by the Babylonians (the Greek and Romans) 7000 years ago.^[2] The use of miswak becomes very popular in

the Muslim world including several African and Arab countries. It is widely known as the chewing stick or natural tooth brush and holds great importance for oral hygiene and has also been recommended by the World Health Organization.^[3]

Miswak is an Arabic word in origin that describes the chewing stick prepared from the root, stem, twigs or bark of a tree and used for cleaning the oral cavity. Conventionally, it is a 15–20 cm long penciled stick [Figure 1] holding a diameter of 1–1.5 cm.^[4,5] For an affective functioning, it is supposed to be

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Figure 1: Types of chewing sticks used as an oral hygiene aids

frayed into brush by the act of chewing. In addition to removing the bacterial plaque mechanically, it prevents the growth of oral microbes and dental plaque.^[6] Similarly, it possesses the antimicrobial property that ceases the process of tooth decay and inhibiting the growth capability of several cariogenic microorganisms. Considering the therapeutic benefits, miswak is commonly being used by populations of many developing countries. It is also helpful to counteract an increased level of resistance developed by pathogenic microorganisms to commercially available antimicrobial drugs being advised in every community.^[7] A number of manufacturers have used the extracts of miswak as an active toothpaste component. A few examples are Sarkan toothpaste (UK), QualiMeswak toothpaste (Switzerland) Epident toothpaste (Egypt), Siwak-F toothpaste (Indonesia) and various herbal mouthwashes. A typical miswak stick is shown in Figure 1.

The most commonly used plant for miswak is *Salvadora persica*.^[8-11] Antimicrobial extracts are obtained from different parts of *S. persica*. It has been proven scientifically that these extracts are equally effective compared to the efficacy of oral disinfectants including chlorhexidine gluconate. Chlorhexidine gluconate has antifungal, antiplasmodial and antibacterial effects when used at an optimal concentration.^[12,13] *S. persica* as a root canal irrigant has better antimicrobial properties when compared to chlorhexidine gluconate and sodium hypochlorite.^[8,10,11]

RELIGIOUS ASPECTS

The use of miswak dates back to ancient times however its importance was highlighted by Prophet Muhammad (Peace be Upon Him [PBUH]) during the early days of Islam. The religion Islam has stressed on the importance of maintaining good overall body as well as oral hygiene. It has been advised to the followers to keep in practice the use of chewing stick (miswak) for keeping the oral cavity clean and minimizing

halitosis. The Prophet Muhammad (PBUH) preached Islam not just by his words but also through his actions by showing and observing practically. The sayings of the Holy Prophet Muhammad PBUH described and stressed on the importance of various plant species amongst which miswak tops the list.^[14] Following are some hadiths in which The Prophet Muhammad (PBUH) emphasized on the use of Miswak; Jabir Bin Abdullah (RA) relates that prophet Muhammad (PBUH) said "The black colored Kapas (fruit of *Salvadora*) is the finest one."^[15] Hazrat Aisha (RA) narrates that Muhammad (PBUH) said "Miswak purifies the mouth and is a cause of Allah's pleasure."^[15] Furthermore, Abu-Hizat-us-Sabahi (RA) described that Muhammad (PBUH) gave him a twig of *Salvadora* and said, "Use it as miswak."^[14]

TYPES OF CHEWING STICKS

There are more than 180 plant species that can be used as a natural toothbrush. These species differ from each other on the basis of appearance, scent, texture and taste. Some of the most commonly practiced species are *S. persica* (Peelu), *Azadirachta indica* (Neem), *Olea europaea* (Zaitoon), *Acacia arabica* (Kikar), *Glycosmis pentaphylla* (Ban), *Capparis aphylla* (Khiran).^[16] Most of these sticks are easily available in different parts of Pakistan, Middle East and African countries. Arak (*S. persica*) is the most commonly used miswak in Saudi Arabia while litmus and orange tree are common in West Africa.^[8,17] *S. persica* obtained from Arak tree is the most popular having spongy characteristics and stem that can easily be crushed between teeth. The stick is widely accepted by people around the world due to its pleasant flavor, texture and its effectiveness in maintaining oral hygiene.^[8,18,19]

HOW TO USE MISWAK EFFECTIVELY?

Miswak has its own unique aspects that must be adapted prior to use for the best results. The functional end of a thin bark piece is striped off followed by chewing. Chewing of miswak separates fibers and giving it a brush like appearance that helps in cleaning the teeth easily. The recommended length for a stick is about 15 cm so that it can easily be grasped along with ease to carry around, whereas, the diameter is preferred to be <1 cm.^[6]

There are two methods documented to hold the miswak. One is the three finger grip technique and the other is five finger grip technique [Figure 2a].

The aim of both techniques is to make sure that all surfaces of the teeth are accessible and cleaned with convenience and controlled movements of the stick in the oral cavity. In order to clean the tooth surfaces, the fibers of miswak should be held perpendicular to the tooth surface and gently moved in up and down motions, directed away from the gingival margins on both the buccal and lingual surfaces [Figure 2b].^[20,21]

THERAPEUTIC EFFECTS OF MISWAK ON ORAL AND GENERAL HEALTH

Chemistry of miswak

Different evidences and researchers have suggested that miswak contains more than 10 natural occurring constituents essential for maintaining good oral and general health [Table 1]. *S. persica* (miswak) has a number of numerous oral health benefits. Upon chewing, it releases antibacterial extracts and improves primary and secondary dental development.^[26]

Table 2 demonstrates different therapeutic effects of miswak on the oral cavity. Its antimicrobial action lowers the proportion of oral candidiasis in patients with renal transplant. The antiplasmodial content in miswak is used to treat malaria and the seed oil is used for the treatment of joints and skin diseases.^[38,39] Use of miswak is also found to regulate peristaltic movements, lowers high-density lipoprotein cholesterol and improves appetite.^[27,34]

TOOTHPASTE AND MOUTHWASH

The utmost and primary method of plaque removal and to maintain good oral hygiene is to remove plaque mechanically using brushing and flossing.^[40,41] A variety of *S. persica* toothpastes are readily available in the market, i.e., Dentacare Miswak (Saudi Arabia)

and Fluorosiwak (Pakistan) and have proved a high efficacy in bacterial plaque removal. Further, *S. persica* mouthwashes have found to be effective to inhibit the colonization of *Streptococcus mutans* bacterial strains on orthodontic rings. Lower plaque formation has been reported on tooth surfaces after using miswak mouthwashes. Unfortunately, no commercial availability of miswak mouth wash exists in the market at present.^[42,43]

ANALGESIC EFFECTS

Miswak has analgesic, astringent and anti-inflammatory properties, making it an effective treatment for primary periodontal diseases.^[20,44] Evidences suggested miswak being affective against thermal stimuli compared to chemical ones. Focusing on the physiology, the responses of the thermal stimuli are via skin pain receptors whereas the chemical stimulus has its response via the visceral receptors. Thus it was found that miswak responds to the peripheral pain and not the visceral. Hence, if applied to the oral mucosa it sets a relief in the oral pain.^[45,46] Experiments on mice in a laboratory proved miswak has a moderate analgesic effect that is related to interaction with the peripheral opiate system.^[47] In addition, it has been noted that patients practicing miswak regularly had a low incidence of toothache compared to toothbrush users.^[2]

ANTIPLAQUE EFFECTS

The main cause of gingivitis and other periodontal conditions is the accumulation of bacterial plaque; hence it is of great importance to avoid plaque accumulation and maintaining good oral hygiene. Miswak is practiced by rubbing it on the surface of the teeth and thus is an effective mechanical tool for reducing the level of daily plaque accumulation.^[48]

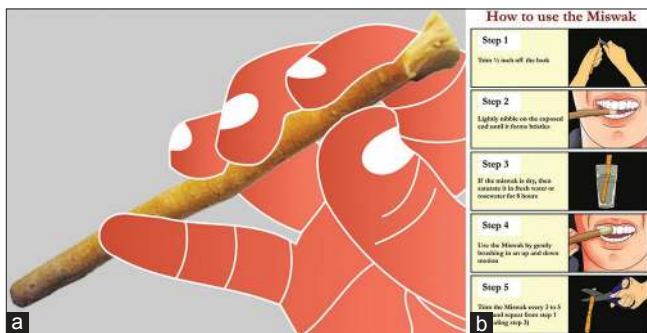


Figure 2: Manipulation of miswak for oral hygiene maintenance, (a) Palm grip for holding, (b) schematic presentation of various steps for using miswak

Table 1: Chemical analysis of various components of miswak (*Salvadora persica*)

Chemical substance	Reference
B-sitosterol and m-anisic acid	[22]
Chlorides, salvadora and gypsum; organic compounds, such as pyrrolidine, pyrrole, and piperidine derivatives	[23]
Flavonoids, including kaempferol, quercetin, quercetin rutin, and a quercetin glucoside	[24]
Glycosides, such as salvadoside and salvadoraside	[25]
Sodium bicarbonate	[26]
Resin large amounts of salts containing chlorine	[27]
Trimethylamine, an alkaloid, chlorides, high amounts of fluoride, silica, sulfur, Vitamin C	[28]

Table 2: Beneficial role of various chemicals present in miswak (*Salvadora persica*)

Chemical substance	Mode of action	Beneficial role	Reference
Fluoride	Antimicrobial	Prevent caries	[29,30]
Vitamin C	Healing/repair	Healing of oral tissues	[27,31]
Silica	Abrasive	Removes stains and plaque	[27,32]
Tannic acid	Antifungal	Reduces <i>Candida albican</i>	[32,33]
Sulphur	Bactericidal	Reduces bacterial count	[34,35]
Sodium bicarbonate	Abrasive	Used as dentifrice	[30,36]
Calcium	Inhibits demineralization and promotes remineralization	Buffering role in the oral cavity	[30,33]
Alkaloid (salvadorine)	Bactericidal	Stimulatory effect on gingiva	[28]
Essential oils	Antiseptic	Disinfects the oral cavity	[27,34]
Benzylisothiocyanate	Preventive agent	Prevents against genotoxic and carcinogenic compounds	[30,37]
Resins	Forms a layer on enamel surface	Makes teeth resistant to caries attack	[32]
Chloride	prevents calculus deposition on teeth surfaces; inhibits demineralization and promotes remineralization	Buffering role and maintains favorable pH of the oral cavity	[27,31]

Numerous studies have identified that silica in miswak possesses plaque inhibiting properties, plays vital role in caries prevention and helps maintaining normal pH after acidogenic attacks chemically.^[5,49,50] The presence of calcium and chlorides in miswak inhibit the bacterial attachment on to the enamel surface hence providing a protective medium.^[33] In addition, miswak has an ability to remove plaque from the interproximal sites as well. This is due to better mechanical cleaning action of its fibers compared to fibers of conventional synthetic toothbrushes.^[6,33,51]

CYTOTOXICITY AND ROOT CANAL IRRIGATION

Irrigation is considered to be of prime importance in root canal therapy as it aids in flushing, debridement, cleaning and dissolution of necrotic tissues in the root canal. Miswak, besides being used in practices such as (mouthwashes and toothpastes), is also used as a root canal irrigant. Recent studies and evidences have suggested that *S. persica* has good antimicrobial activity with a low level of cytotoxicity and causing no significant damage to the host cells at an optimal therapeutic concentration.^[35,50] *S. persica* (15%) exhibited an effective antimicrobial activity against aerobic and an-aerobic organisms. Further, a recent study by Almas compared cytotoxicity of chlorhexidine gluconate and miswak extracts on mouse fibroblasts. The miswak extracts was less cytotoxic and cells viability with miswak extracts was greater than chlorhexidine gluconate.^[8] These evidences altogether supported the idea of using miswak extracts as an endodontic irrigation solution.^[10] Further research is required to evaluate the cytotoxic effects of miswak extracts and chlorhexidine on macrophages, epithelial cells and osteoblasts

ANTIMICROBIAL ACTIVITY

Miswak has been endowed with the property of ceasing growth potential of bacteria causing periodontal disease and dental caries. The antimicrobial effects of miswak is more pronounced against *Enterococcus faecalis*, *Porphyromonas gingivalis*, *Actinobacillus*, *Haemophilus influenza*, *S. mutans* and limited against *Lactobacillus*.^[50] Furthermore, extracts obtained from the root of miswak have better antimicrobial property compared to miswak from other parts of the tree.^[47] The incidence of caries is notably low in miswak users owing to the presence of a strong antimicrobial thiocyanate agent, accompanied by other chemicals such as sodium chloride, potassium chloride, saponin, tanins.^[12,52] The extracts of miswak showed significant reduction in the growth of cariogenic bacteria.^[53] The miswak soaked in 0.1-0.5% NaF solutions help to reduce the cariogenic bacterial count and dental decay.^[12,52] Fluoride is well known for antimicrobial activates in the oral cavity.^[54,55]

ACCUMULATIVE HEALTH BENEFITS OF MISWAK ON PERIODONTAL TISSUES

The main etiological factor for gingival recession and bone loss is bacterial plaque. The calcified mass deposits are mechanical irritants and act as potential retentive areas for the accumulation of bacterial plaque.^[56] The frequent use of miswak helps in reduction of plaque accumulation thus leading to a better oral hygiene. According to a study conducted in Kenya, miswak users (50 or over) had a very low incidence of periodontal diseases.^[2] Active miswak users reported better periodontal health, less gingival bleeding and interproximal bone loss compared to

toothbrush users. Comparatively reduced gingival bleeding and low gingival indices score were observed in miswak users.^[57] Similar results were reported in a randomized control trials conducted by Al-Otaibi *et al.* A significant reduction in plaque score, gingival inflammation and bleeding of gums was observed in miswak users. Further, less tooth loss cases were reported in subjects who used miswak.^[52] Periodontal pathologies such as gingival recession, tooth wear and severe periodontal pockets have been reported in miswak users however, it may be due to excessive use of miswak, faulty technique or due to other etiological factors.^[44,58,59]

ANTIFUNGAL EFFECTS

Recent studies have endorsed the fact that *S. persica* has antifungal properties.^[60] Recently, Alili *et al.* compared antifungal property of solid miswak with grounded miswak particles against different strains of *Candida*. It was concluded that solid miswak exhibited strong antifungal property while pulverized miswak presented no antifungal property.^[60,61] Similarly, an *in vitro* study by Naeini *et al.* explored that alcoholic extracts of *S. persica* showed antifungal properties against all strains of *Candida* except *Candida parapsilosis* and *Candida krusei*.^[60,62] Furthermore, the hexane components in the roots of miswak was found robust against *Candida albicans* and *E. faecalis*.^[63]

ANTIOXIDANT EFFECTS

Antioxidants are substances that shield the body against free radical induced oxidative stress. Current literature has proved antioxidant properties are present in the miswak. A study by Mohamed and Khan concluded that antioxidant enzymes in miswak (catalase, peroxidase, polyphenols oxidase) attribute to antioxidant property of *S. persica*. Thus, synergistic effect of antioxidant compounds and enzymes makes miswak a good oral hygiene maintaining tool.^[64] Another study by Ibrahim *et al.*^[65] showed that antioxidant property, content of flavonoid and phenolic was more in miswak from southern region compared to the central region of Saudi Arabia. Gupta *et al.* performed antioxidant and phytochemical study on *S. persica* and reported that the chloroform extract from miswak showed most antioxidant effect *in vitro* followed by ethanolic extract.^[66] Based on all these findings and evidence it can be positively inferred that *S. persica* is a potential source of antioxidant compound and can be used in medicinal preparation to tackle oxidative stress related disorders.^[65,67]

SALVADORA PERSICA AS A POTENTIAL FOOD BIO PRESERVATIVE

In recent years, customers have developed extra awareness regarding processed foods. Synthetic preservatives in canned and processed foods may lead to hazardous health effects.^[67] Since the roots of *S. persica* contain antimicrobial, antifungal and antioxidant properties, it can be used as a potential food preservative with no side effects. A recent study by Zaid *et al.*^[68] concluded that adding aqueous extract of *S. persica* as a natural food preservative in chicken burgers improved the shelf life. The aqueous extract showed the strongest inhibitory effects against (*Streptococcus mitis*, *Streptococcus salivarius*, *S. mutans*, *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Salmonella typhimurium*, and *C. albicans*) after 48 h. Based on these results *S. persica* can be recommended as a safe and economical natural food and pharmaceutical preservative^[68] however further research is needed on this aspect.

MISWAK VERSUS TOOTH BRUSHES FOR DENTAL CARE

Is using miswak as effective as the tooth brush? It is a very common question and discussed frequently among health professionals and general public. Miswak and tooth brush both serve the same function, i.e. maintenance of good oral hygiene but both these oral hygiene tools vary in certain aspects [Table 3].

Table 3: Salient difference between miswak and toothbrush

	Miswak	Toothbrush
Source	Natural	Synthetic
Dentifrice needed	No	Yes
Cost ^[2]	Cheap	Can be expensive (for public)
Efficiency ^[20,69]	Good	Good
Gingival recession	No if correct technique is used ^[70,71]	Yes ^[72]
Tooth abrasion ^[70,73]	No if correct technique is used	Yes
Disinfection needed	No (as it has disinfectant property itself) ^[69]	Yes ^[71,74]
Saliva stimulation	Yes ^[33]	No ^[51]
Sterility ^[36,70]	Sterile if cut daily	Bacterial growth after 24 h of use
Side effects	Nil (as it is natural)	Fluoride poisoning cases reported due to fluoride toothpaste ^[75]
General body effects ^[20]	Yes	No

A recent study by Malik *et al.* proposed that miswak (*S. persica*) has comparable or at times greater chemical and mechanical capability in plaque removal.^[76] On the basis of the conclusion of this study, advocacy should be planned for miswak promotion as oral hygiene tool replacing nylon filament tooth brushes in developing countries where there exist economic restrains, high unmet needs and restricted dental care for general public.^[76]

SALVADORA PERSICA AND CULTURAL IMPLICATIONS IN PROMOTING ORAL HEALTH

Factors such as needs, customs and traditions along with cultural diversity and variations amongst public constrains, dental care professionals have to gain and develop patient trust along with providing dental care with efficacy. Similarly, in case of miswak (*S. persica*), where dental care providers need to overcome these barriers and must educate along with implication of miswak use amongst patients for better oral health and thus maximizing plaque removal.^[77] Farsi *et al.* assessed the behavior, attitude and knowledge in relation to periodontal health status in school going pupils. It was revealed that private school going pupils were more inclined towards the use of tooth brushes whereas governmental school going students used miswak as a main tool for maintaining oral health.^[78] Another study by Wagner and Redford-Badwal identified low cultural knowledge among dental graduates.^[79]

To overcome this cultural barrier it is recommended to train dental care providers who are culturally and linguistically competent, well versed in cultural practices, mature and sensitive enough to understand practices, traditions and beliefs of different cultures.^[77] Building an instructive framework which is acceptable by dental care professionals based on the expectations of rural communities ingrained in cultural and religious foundations will assist in reducing oral disparities and inequalities. Miswak aids as a model to instruct culturally insensitive dental care providers worldwide.^[77]

Limitation of miswak

Although miswak (*S. persica*) is considered as an inexpensive, cheap and affordable method of maintaining good oral as well as general health, however there are a few limitations. Fibers of miswak are present in long axis making it difficult for the users to access the lingual surfaces of tooth.^[20] Hollist

and Khoory claimed that excessive scrubbing of miswak on the anterior teeth by permanent miswak users compromised the aesthetic zone and resulted in severe attrition of the anterior teeth.^[80,81] Eid *et al.*^[58] claimed miswak as one of the etiology of gingival recession^[58] as a relatively high incidence of gingival recession has been linked to miswak users compared to toothbrush users.^[4,5] It has been demonstrated that freshly cut miswak has no cytotoxic effect on oral health. But same miswak used after 24 h contained toxins harmful for the oral and general health.^[36] All the above mentioned limitations can easily be overcome by understanding and adapting the proper technique and method of use of miswak as it is a technique sensitive oral hygiene tool.^[4] A dried out miswak can be extra hard and abrasive to oral tissues that may result in an excessive wear and damage to the teeth. Oral hygiene instructions should be given for using freshly cut miswak that is flexible, easily chewable and full of natural ingredients. Any damages such as gingival recession, tooth wear and severe periodontal pockets in miswak users are mainly linked to aggressive, excessive and improper use of miswak,^[44,58,59] hence can be controlled by educating patients for using proper technique carefully.

CONCLUSIONS

Evidence suggests that *S. persica* is a miraculous stick for oral health care along with being a cost-effective solution to improve and maintain good dental care. In certain developing countries where use of toothbrush is still considered expensive, miswak is an ideal alternative oral hygiene tool. Its recommendation is also dependable with the notion of the primary healthcare approaches that focus on prevention, community participation, and the use of appropriate technology. Due to its enormous medicinal and therapeutic properties, it is highly commended in oral care but being technique sensitive its method of use and handling must first be adapted for best results. It is permitted to use toothbrush in combination with miswak for superior oral hygiene and more possibilities should be explored to use miswak extracts in mouthwash and root canal irrigants.

It is hoped that the review would help general dental and medical professionals to know about the scientific, cultural and religious importance of miswak use in various populations. It would also help to improve not only the quality of oral health but also the quality of life of populace. Further research is needed for unwarranted oral health care products containing

miswak extracts or powders, available in markets, claiming clinical efficacy of those products.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Muhammad S, Lawal M. Oral hygiene and the use of plants. *Sci Res Essays* 2010;5:1788-95.
- Wu CD, Darout IA, Skaug N. Chewing sticks: Timeless natural toothbrushes for oral cleansing. *J Periodontol Res* 2001;36:275-84.
- Bairwa R, Gupta P, Gupta VK, Srivastava B. Traditional medicinal plants: Use in oral hygiene. *Int J Pharm Chem Sci* 2012;1:1529-38.
- Darout IA, Skaug N. Comparative oral health status of an adult Sudanese population using miswak or toothbrush regularly. *Saudi Dent J* 2004;16:29-38.
- AbdElRahman HF, Skaug N, Francis GW. *In vitro* antimicrobial effects of crude miswak extracts on oral pathogens. *Saudi Dent J* 2002;14:26-32.
- Batwa M, Bergstrom J, Batwa S, Al-Otaibi MF. The effectiveness of chewing stick miswak on plaque removal. *Saudi Dent J* 2006;18:125-33.
- Van Vuuren S, Viljoen A. The *in vitro* antimicrobial activity of toothbrush sticks used in Ethiopia. *S Afr J Bot* 2006;72:646-8.
- Almas K. The effect of *Salvadora persica* extract (miswak) and chlorhexidine gluconate on human dentin: A SEM study. *J Contemp Dent Pract* 2002;3:27-35.
- Almas K, Al-Bagieh NH. The antimicrobial effects of bark and pulp extracts of miswak, *Salvadora persica*. *Biomed Lett* 1999;60:71-5.
- Nawal A, Sabawi A, Khalik A, Sheikh A, Mahmoud Y. The antimicrobial activity of *Salvadora persica* solution (miswak-siwak) as root canal irrigant (a comparative study). *Univ Sharjah J Pure Appl Sci* 2007;4:69-91.
- Al-Bayaty FH, Al-Koubaisi AH, Ali NA, Abdulla MA. Effect of mouth wash extracted from *Salvadora persica* (miswak) on dental plaque formation: A clinical trial. *J Med Plants Res* 2010;4:1446-54.
- Al-Bayati FA, Sulaiman KD. *In vitro* antimicrobial activity of *Salvadora persica* L. extracts against some isolated oral pathogens in Iraq. *Turk J Biol* 2008;32:57-62.
- Rizvi A, Zafar MS, Farid WM, Gazal G. Assessment of antimicrobial efficacy of MTAD, sodium hypochlorite, EDTA and chlorhexidine for endodontic applications: An *in vitro* study. *Middle East J Sci Res* 2014;21:353-7.
- Farooqi I. *Ahadith mein mazkoor nabatat, adwiya aur ghizain. ???*. IIm-o-Irfan Publishers; Lahore, Pakistan;1998. p. 38.
- A'zami M. Tafheem al-bukhari Urdu translation of al-sahih al-bukhari. Dar-ul-Isha't. Maulavi Musafir Khana, Urdu Bazar Karachi, Pakistan 1985;1:869.
- Almas K. The antimicrobial effects of seven different types of Asian chewing sticks. *Odontostomatol Trop* 2001;24:17-20.
- Lewis WH, Elvin-Lewis MP. *Medical Botany. Plants affecting man's health*. New York, USA: John Wiley and Sons; 1977. p. 515.
- Sukanya S, Sudisha J, Hariprasad P, Niranjana S, Prakash H, Fathima S. Antimicrobial activity of leaf extracts of Indian medicinal plants against clinical and phytopathogenic bacteria. *Afr J Biotechnol* 2009;8:6677-82.
- Al-Otaibi M, Zimmerman M, Angmar-Månsson B. Prevailing oral hygiene practices among urban Saudi Arabians in relation to age, gender and socio-economic background. *Acta Odontol* 2003;61:212-6.
- Dahiya P, Kamal R, Luthra R, Mishra R, Saini G. Miswak: A periodontist's perspective. *J Ayurveda Integr Med* 2012;3:184.
- Almas K, Al-Lafi TR. The natural toothbrush. *World Health Forum* 1995;16:206-10.
- Ezmirly ST, Cheng JC, Wilson SR. Saudi Arabian medicinal plants: *Salvadora persica*. *Planta Med* 1979;35:191-2.
- Galletti GC, Chiavari G, Kahie YD. Pyrolysis/gas chromatography/ion-trap mass spectrometry of the 'tooth brush' tree (*Salvadora persica* L.). *Rapid Commun Mass Spectrom* 1993;7:651-5.
- Abdel-Wahab S, Selim M, El-Fiki N. Investigation of the flavonoid content of *Salvadora persica* L. *Bull Fac Pharm Cairo Univ* 1990;28:67-70.
- Ohtani K, Kasai R, Yamasaki K, Tanaka O, Kamel M, Assaf M, *et al.* Lignan glycosides from stems of *Salvadora persica*. *Phytochemistry* 1992;31:2469-71.
- Attar Z. The miswak-nature's toothbrush. *Bull Hist Dent (Batavia NY)* 1979;27:39-41.
- Akhtar MS, Ajmal M. Significance of chewing-sticks (miswaks) in oral hygiene from a pharmacological view-point. *J Pak Med Assoc* 1981;31:89-95.
- El Mostehy M, Al-Jassem A, Al-Yassin I, Al-Gindy A, Shoukry E. Miswak as an oral health device. Preliminary chemical and clinical evaluation. *Hamdard* 1983;26:41-50.
- Hattab FN. Miswak: The natural toothbrush. *J Clin Dent* 1997;8:125-9.
- Benson AM, Hunkeler MJ, Talalay P. Increase of NAD (P) H: Quinone reductase by dietary antioxidants: Possible role in protection against carcinogenesis and toxicity. *Proc Natl Acad Sci U S A* 1980;77:5216-20.
- Almas K. Miswak (chewing stick) and its role in oral health. *Postgrad Dent Middle East* 1993;3:214.
- Al lafi T, Ababneh H. The effect of the extract of the miswak (chewing sticks) used in Jordan and the Middle East on oral bacteria. *Int Dent J* 1995;45:218-22.
- Gazi MI, Davies TJ, al-Bagieh N, Cox SW. The immediate- and medium-term effects of Meswak on the composition of mixed saliva. *J Clin Periodontol* 1992;19:113-7.
- Alali F, Hudaib M, Aburjai T, Khairallah K, Al-Hadidi N. GC-MS analysis and antimicrobial activity of the essential oil from the stem of the Jordanian toothbrush tree *Salvadora persica*. *Pharm Biol* 2005;42:577-80.
- Al-Samh A, Dua'a A, Al-Nazhan S. *In vitro* study of the cytotoxicity of the miswak ethanolic extract. *The Saudi Dental Journal* 1997;9:125-32.
- Mohammad AR, Turner JE. *In vitro* evaluation of Saudi Arabian toothbrush tree (*Salvadora persica*). *Odontostomatol Trop* 1983;6:145-8.
- AlDosari A, Kafrawy A, Standish S. The effect of benzylisothiocyanate on epithelial changes induced by trauma and DMBA in the hamster tongue. *Saudi Dent J* 1992;4:4-10.
- Ali H, König G, Khalid S, Wright A, Kaminsky R. Evaluation of selected Sudanese medicinal plants for their *in vitro* activity against hemoflagellates, selected bacteria, HIV-1-RT and tyrosine kinase inhibitory, and for cytotoxicity. *J Ethnopharmacol* 2002;83:219-28.
- Ahmed SS, El-Gengaihi SE, Ibrahim M, Schnug E. Preliminary phytochemical and propagation trial with *Salvadora persica* L. *Landbauforschung Volkenrode* 2008;58:135.
- Bajaj N, Tandon S. The effect of triphala and chlorhexidine mouthwash on dental plaque, gingival inflammation, and microbial growth. *Int J Ayurveda Res* 2011;2:29-36.
- Koban I, Holtfreter B, Hübner NO, Matthes R, Sietmann R, Kindel E, *et al.* Antimicrobial efficacy of non-thermal plasma in comparison to chlorhexidine against dental biofilms on titanium discs *in vitro*-proof of principle experiment. *J Clin Periodontol* 2011;38:956-65.
- Saffari F, Danesh Ardakani M, Zandi H, Heidarzadeh H, Moshafi MH. The effects of chlorhexidine and persica mouthwashes on colonization of *Streptococcus mutans* on fixed orthodontics O-rings. *J Dent (Shiraz)* 2015;16:54-7.
- Moustafa MH, Abd el-All MM, Abo el-Fadl KM. Reduced plaque formation by miswak-based mouthwash. *Egypt Dent J* 1987;33:375-84.
- Eid MA, Selim HA. A retrospective study on the relationship between miswak chewing stick and periodontal health. *Egypt Dent J* 1994;40:589-92.
- Sulaiman M, Al-Khateeb T, Al-Mazraoo A. Analgesic effects of miswak. *The Saudi Dental Journal* 1996;8:140-4.
- Farooqi M, Srivastava J. The tooth-brush tree (*Salvadora persica*). *Pharm Biol* 1968;8:1297-9.
- Hayes AG, Tyers MB. Determination of receptors that mediate opiate side effects in the mouse. *Br J Pharmacol* 1983;79:731-6.
- Rahmani ME, Radvar M. The antiplaque effects of *Salvadora persica* and padina essential oil solution in comparison to chlorhexidine in human gingival disease; a randomized placebo-controlled clinical trial. *Int J Pharmacol* 2005;1:311-5.
- Manson JD, Eley BM. *Outline of Periodontics*. Dunfermline, United Kingdom: Butterworth-Heinemann; 2000.

50. Sofrata A, Lingström P, Baljoon M, Gustafsson A. The effect of miswak extract on plaque pH. An *in vivo* study. *Caries Res* 2007;41:451-4.
51. Tubaishat RS, Darby ML, Bauman DB, Box CE. Use of miswak versus toothbrushes: Oral health beliefs and behaviours among a sample of Jordanian adults. *Int J Dent Hyg* 2005;3:126-36.
52. Al-Otaibi M, Al-Harthy M, Söder B, Gustafsson A, Angmar-Månsson B. Comparative effect of chewing sticks and toothbrushing on plaque removal and gingival health. *Oral Health Prev Dent* 2003;1:301-7.
53. Darmani H, Nusayr T, Al-Hiyasat AS. Effects of extracts of miswak and derum on proliferation of Balb/C 3T3 fibroblasts and viability of cariogenic bacteria. *Int J Dent Hyg* 2006;4:62-6.
54. Zafar MS, Ahmed N. Therapeutic roles of fluoride released from restorative dental materials. *Fluoride* 2015;48:184-94.
55. Zafar MS. Effects of surface pre-reacted glass particles on fluoride release of dental restorative materials. *World Appl Sci J* 2013;28:457-62.
56. Armitage GC, Cullinan MP. Comparison of the clinical features of chronic and aggressive periodontitis. *Periodontol* 2000 2010;53:12-27.
57. Gazi M, Saini T, Ashri N, Lambourne A. Meswak chewing stick versus conventional toothbrush as an oral hygiene aid. *Clin Prev Dent* 1990;12:19-23.
58. Eid MA, Selim HA, al-Shammery AR. The relationship between chewing sticks (Miswaak) and periodontal health 3. Relationship to gingival recession. *Quintessence Int* 1991;22:61-4.
59. Johansson A, Fareed K, Omar R. Analysis of possible factors influencing the occurrence of occlusal tooth wear in a young Saudi population. *Acta Odontol Scand* 1991;49:139-45.
60. Haque MM, Alsareii SA. A review of the therapeutic effects of using miswak (*Salvadora persica*) on oral health. *Saudi Med J* 2015;36:530-43.
61. Alili N, Türp JC, Kulik EM, Waltimo T. Volatile compounds of *Salvadora persica* inhibit the growth of oral *Candida* species. *Arch Oral Biol* 2014;59:441-7.
62. Naeini A, Naderi NJ, Shokri H. Analysis and *in vitro* anti-Candida antifungal activity of *Cuminum cyminum* and *Salvadora persica* herbs extracts against pathogenic *Candida* strains. *J Mycol Med* 2014;24:13-8.
63. Balto H, Al-Howiriny T, Al-Somily A, Siddiqui YA, Al-Sowaygh Z, Halawany H, *et al.* Screening for the antimicrobial activity of *Salvadora persica* extracts against *Enterococcus faecalis* and *Candida albicans*. *Saudi Med J* 2013;5:486-92.
64. Mohamed SA, Khan JA. Antioxidant capacity of chewing stick miswak *Salvadora persica*. *BMC Complement Altern Med* 2013;13:40.
65. Ibrahim MM, Al Sahli AA, Alaraidh IA, Al-Homaidan AA, Mostafa EM, El-Gaaly GA. Assessment of antioxidant activities in roots of miswak (*Salvadora persica*) plants grown at two different locations in Saudi Arabia. *Saudi J Biol Sci* 2015;22:168-75.
66. Gupta A, Verma S, Kushwaha P, Srivastava S, Rawat A. Phytochemical and antioxidant studies of *Salvadora persica* L. stem and twig. *Indian J Pharm Educ Res* 2015;49:71-5.
67. Anand S, Sati N. Artificial preservatives and their harmful effects looking toward nature for safer alternatives. *Int J Pharm Sci Res* 2013;4:2496-501.
68. Zaid A, Elbandy M, Nadir A. Miswak (*Salvadora persica*) roots as antibacterial agent and a potential food bio preservative. *J Endod* 2015;4:2288-93.
69. Al-Otaibi M, Al-Harthy M, Gustafsson A, Johansson A, Claesson R, Angmar-Månsson B. Subgingival plaque microbiota in Saudi Arabians after use of miswak chewing stick and toothbrush. *J Clin Periodontol* 2004;31:1048-53.
70. Costa M, Marcantonio RA, Cirelli J. Comparison of manual versus sonic and ultrasonic toothbrushes: A review. *Int J Dent Hyg* 2007;5:75-81.
71. Efstratiou M, Papaioannou W, Nakou M, Ktenas E, Vrotsos IA, Panis V. Contamination of a toothbrush with antibacterial properties by oral microorganisms. *J Dent* 2007;35:331-7.
72. Rosema NA, Adam R, Grender JM, Van der Sluijs E, Supranoto SC, Van der Weijden GA. Gingival abrasion and recession in manual and oscillating-rotating power brush users. *Int J Dent Hyg* 2014;12:257-66.
73. Teche FV, Paranhos HF, Motta MF, Zaniquelli O, Tirapelli C. Differences in abrasion capacity of four soft toothbrushes. *Int J Dent Hyg* 2011;9:274-8.
74. Mehta A, Sequeira PS, Bhat G. Bacterial contamination and decontamination of toothbrushes after use. *N Y State Dent J* 2007;73:20-2.
75. Bentley EM, Ellwood RP, Davies RM. Fluoride ingestion from toothpaste by young children. *Br Dent J* 1999;186:460-2.
76. Malik AS, Shaukat MS, Qureshi AA, Abdur R. Comparative effectiveness of chewing stick and toothbrush: A randomized clinical trial. *N Am J Med Sci* 2014;6:333-7.
77. Aboul-Enein BH. The miswak (*Salvadora persica* L.) chewing stick: Cultural implications in oral health promotion. *Saudi J Dent Res* 2014;5:9-13.
78. Farsi JM, Farghaly MM, Farsi N. Oral health knowledge, attitude and behaviour among Saudi school students in Jeddah city. *J Dent* 2004;32:47-53.
79. Wagner JA, Redford-Badwal D. Dental students' beliefs about culture in patient care: Self-reported knowledge and importance. *J Dent Educ* 2008;72:571-6.
80. Hollist NO. The technique and use of chewing stick. *Odontostomatol Trop* 1981;4:171-4.
81. Khoory T. The use of chewing sticks in preventive oral hygiene. *Clin Prev Dent* 1983;5:11-4.