

Review Article

Ethnobotany, Pharmacology and Chemistry of *Salvadora persica* L. A Review

Hilal Ahmad^{1*}, Nizar Ahamed², John Mohamad Dar³, Umargani Jammal Mohammad⁴

¹Dept. of Biotechnology, Sharmilla Institute of Medicinal Products Academy, Thanjavur

²Department of Information Technology, Periyar Maniammai University. Thanjavur, TN India

³Kashmir Tibiya College, Research center and hospital, Srinagar, India

⁴Department of Nuclear and Regenerative Medicine, Apollo hospital, India

*Corresponding author email: hhiillaallbiotech@gmail.com

Salvadora persica L., commonly known as the miswak tree, occurs in shrub savannah from northwestern India to Africa. This review discusses the current knowledge of traditional uses, chemistry, and biological effects of this species. The ethno botanical literature reveal it as a versatile medicinal plant used to treat different human and livestock ailments. Several different classes of compounds were previously isolated from various parts of *S. persica* of which the main groups are Tri-Methyamin, Salvadrin, Chloride, Fluoride, Silica, Sulfur, Mustard, Vitamin C and a small amount of Saponine Tanin. Various types of preparations, extracts and individual compounds derived from this species have been found to possess a broad spectrum of pharmacological effects as well as on different biochemical processes and physiological functions including hypoglycemic, hypocholesterolemic, and sedative, and effects in addition to be against gingival irritation. Moreover, the extracts and preparations from the plant, which are hopefully safe, exhibited various additional biological effects e.g. antimicrobial, antioxidant, antifever, anti-ulcerogenic, anti-caries, anti-periopathic activities. The results of data analysis on the chemical, pharmacological and toxicological characteristics of *S. persica* support the view that this species has beneficial therapeutic properties and indicate its potential as an effective adaptogenic herbal remedy.

In the world today, an herbal drug is defined as a remedy derived from plants (roots, leaves, flowers, fruits, seeds) and/or other natural sources which can be used for therapeutic purposes and its active chemical constituents provide the basis for pharmaceutical synthesis. Thus confirming the economic values of various medicinal plants used in different traditional systems of medicine (Sher et al., 2010a). Ethno pharmaceutical studies have become increasingly valuable in the recent past and medicinal plants are now part of health care

system. The medicinal plants conservation programs and their sustained supply are part of global health strategy (Sher and Hussain, 2009; Sher et al., 2010c). Furthermore, recent reports suggested that in some cases, synthetic antibiotic are no more effective to treat some infectious diseases because of bacterial resistance. Some drug products were found to cause health hazards if used in higher dose range. The observed bacterial resistance and undesirable side effect of certain antibiotics, led scientific community to find new antibacterial compounds from

medicinal plants or to prepare synthetic and semi-synthetic antibacterial drug products with low toxicity (Marchese and Shito, 2001; Poole, 2001). In several studies, medicinal plant extracts, plant products, and isolated phytochemical constituents showed highly significant antimicrobial activity which added more to encourage research on such potential natural drugs (Amani et al., 1998; Salvat et al., 2001).

Meswak is a product of the plant *Salvadora persica* which grows in different areas of the world including the middle east and Africa (Elvin-Lewis, 1980; Eid et al., 1990). The Miswak (*S. persica* L.), also known as tooth brush tree 4–6 m tall with a short trunk, white bark and smooth green leaves, with a life span of 25 years, belonging to the Salvadoraceae family, has been used as a brushing stick for more than 1,300 years. Because these natural tooth brushes are so commonly used in different areas of the world by millions of people, a variety of studies have been performed on the antimicrobial effect of these sticks (Al-Bagieh et al., 1994; Al-lafi, 1995).

Pharmacological studies indicated that *S. persica* L. plant possess anti-microbial, anti-plaque, aphrodisiac, alexiteric, analgesic, anti-inflammatory, anti-pyretic, astringent, diuretic and bitter stomachic activities (Galletti and Chiavari, 1993). It has great medicinal use in the treatment of nose troubles, piles, scabies, leucoderma, scurvy, gonorrhea, boils and toothache, to treat hook worm, venereal diseases, for teeth cleaning, in rheumatism, cough and asthma, to lower cholesterol plasma levels, reestablishment of the components of gastric mucosa, and as a laxative (Alali et al., 2004; Khalessi et al., 2004). It contains important phytoconstituents such as vitamin C, salvadorine, salvadourina, alkaloids, trimethylamine, cyanogenic glycosides, tannins, saponins and salts mostly as chlorides (Alali et al., 2004; Almas, 2002; Almas et al., 2005; Rajesh et al., 2009). *S.*

persica seed contains about 40% oil with a fatty acid composition (lauric -20%, myristic -55%, palmitic 20% and oleic -5%) which can make an excellent soap. Radical reactions in vivo can damage life essential molecules such as nucleic acids and proteins Saez TG et al. (1994). Phenolic compounds, particularly flavonoids, have been shown to possess an important antioxidant activity towards these radicals, which is principally based on their structural characteristics (number and position of phenolic hydroxyls, other groups, conjugation) Bors W. et al. (1990). The history and the use of miswak (tooth stick) as an oral tool as well as the biological effects of *S. persica* extracts are reviewed. Besides medicinal claims, various parts of this plant are of great ethno botanical importance and play a vital role in the livelihood of local communities (Ghazanfar, 2007; Abuzinada et al., 2005; Sher et al., 2004).

Ethnobotanical Importance

Miswak (*Salvadora persica*) is one of the most commonly used medicinal plants for oral hygiene among global Muslim community (Sher et al., 2010c). The traditional medicinal use of *S. persica* as antimicrobial toothbrush stick for oral hygiene, and to treat gum inflammation, is a centuries old practice and a part of Greco-Arab system of medicine (Al-Otaibi et al., 2004; Zakaria et al., 1998; Sher et al., 2010c). *S. persica* is harvested as wild, rather than cultivated, and about 80% world population use it as a natural remedy for the treatment of different diseases (Noumi et al., 2010; Sofrata et al., 2007; Monforte et al., 2002). According to Sofrata et al. in 2007, the fruits of *S. persica* are eaten in raw, cooked, or dried by the inhabitants of the sites where *S. persica* grow in abundance. Similarly, the local folks cook the leaves as a sauce and eat it with couscous or as green vegetables. The flowers of *S. persica* are found to be a good source of nectar; therefore, it is used as a honey bee plant. The local Bedouins were

found to have strong belief that the honey of *S. persica* had high medicinal value as compared to honey from other plant regions (Sofrata et al., 2007). It is worth mentioning that the leaves and young shoots of *S. persica* are used as fodder for camels, cows, goats and sheep. *S. persica* leaves make good fodder because of the high water content (15 to 36%). Moreover, it was confirmed that the leaves of this popular medicinal plant were used in animals to increase lactation in cows and improve general body weight of all animals. (Sofrata et al., 2007). Ethno-botanical evaluation of *S. persica* also reveal its significant pharmaceutical importance. Studies described that toothbrushes made from roots and small branches have been in use for over thousands of years, and currently the use of *S. persica* is more popular among

Islamic communities of the world (Azaizeh et al., 2003). Toothbrushes prepared from the roots and small branches of *S. persica*, to be highly useful as maintainer of teeth (Noumi et al., 2010; Al- Khteeb et al., 1991). In Arab traditional medicine teeth cleaning with *S. persica* sticks were found to provide relief from toothache and gum inflammation, and the decoctions of *S. persica* leaves and root were successfully used as mouthwash, and in the cure of tooth/gum problems and as a remedy for joint pain, thus supporting the reports of earlier researchers (Al-Sadhan et al., 1999). It is interesting to note that decoction of *S. persica* root besides using to treat epilepsy, have been used to cure gonorrhea and skin diseases, spleen troubles, and stomach ulcer (Sanoqo et al., 1999).

Table 1. Traditional use of different parts of *Salvadora persica*

Plant Part	Nature	Traditional Use	References
Leaves	Bitter in taste, corrective, deobstruent, astringent to the bowels, tonic to the liver, pungent	Preparation of sauce, and salad, diuretic, analgesic, anthelmintic, useful in ozoena and other nose troubles, piles, scabies, leukoderma, lessening inflammation, and strengthening the teeth, scurvy and rheumatism.	(Khatak M et al.,2010, Farooqi and Srivastava, 1968).
Fruits	Sweet and edible	Fermented drinks, deobstruent, carminative, diuretic, lithontriptic, and stomachic , biliousness, rheumatism and snake bites.	(Khatak M et al.,2010).
Root / Root bark	Bitter	Tooth cleaning stick, diuretic,Vesicant, amenorrhea, stimulant, emmenagogue, gonorrhea, vesical catarrh, spleen trouble and general stomach-ache	(Khatak M et al.,2010, Abdelrahim and Jurner 1983; Attar, 1979, Kokwaro, 1976, Ezmirly et al., 1979)
Stem Bark	Bitter	Ascarifuge, and gastric troubles	(Khatak M et al.,2010).
Seeds	Sitter and sharp	Purgative, diuretic and rheumatism	(Atassi F.,2002; Bukar A et al.,2004).

Biological activities

As is summarized below, the experimental pharmacological and clinical investigations carried out during the last 32 years have shown that extract and individual compounds isolated from different parts of the plant have specific biological effects

indicating it has marked adaptogenic properties including hypoglycemic effects, eliminating free radicals to prevent oxidizing pathology, and other activities. previous studies demonstrated the anti-ulcerogenic (Galati et al., 1998), hypoglycemic (Trovato et al., 1998), hypocholesterolemic (Galati et al.,

1999) and sedative (Forestieri et al., 1997) activities of *S. persica* aqueous extract. Many studies have demonstrated the antibacterial, anti-caries, anti-periodopathic, and antifungal properties of aqueous extracts of various chewing sticks (Almas, 2002).

Antimicrobial activities

Previous studies showed that *Persica* extracts have antibacterial activity against cariogenic and periodontopathic bacteria and can develop periodontal health. moreover the World Health Organization recommends and

encourages the use of chewing *Persica* sticks (miswak) as an effective oral hygiene procedure in areas where its use is traditional. WHO(1987). Several studies have described the antibacterial effects of *Persica* extract on cariogenic bacteria and on periodontal pathogens and a number of microbial species including bacteria, fungi, and even anti-viral testes have also been evaluated till now. A list of such microbial studies is given in Table 2.

Table 2. Reviewed list of different microbes tested for their sensitivity to *S. Persica* extract

Microbes tested using <i>s. Persica</i> extracts.	References
Gram positive bacteria; <i>Staphylococcus aureus</i> ATCC 25923, <i>Staphylococcus pidermidis</i> CIP 106510, <i>Micrococcus luteus</i> NCIMB 8166.	Emira Noumi et al.(2011)
Gram-negative bacteria: <i>Pseudomonas aeruginosa</i> ATCC 27853, <i>Salmonella typhimurium</i> LT2 and <i>P. ruginosa</i> .	
Fungi; <i>Candida albicans</i> , <i>C. dubliniensis</i> , <i>C. glabrata</i> , <i>C. parapsilosis</i> , <i>C. krusei</i> , <i>C. famata</i> , <i>C. kefyr</i> , <i>C. sake</i> , <i>C. holmii</i> , <i>C. lusitaniae</i> , <i>C. intermedia</i> , <i>C. atlantica</i> , <i>C. maritima</i> , <i>Pichia guilliermondii</i> and <i>Pichia jardinii</i> <i>Streptococcus mutans</i> , <i>P. aeruginosa</i> and <i>Streptococcus faecalis</i> .	Salehi and Momeni, (2006), Al-Bayati and Sulaiman (2008), Almas and Stakiw (2000).
<i>E. coli</i> , <i>S. aureus</i> , <i>B. subtilis</i> , and <i>P. aeruginosa</i> . <i>Staphylococcus aureus</i> , <i>S. mutans</i> , <i>actobacillus acifophilus</i> , and <i>Pseudomonas aeruginosa</i> .	Alali (2004). Hassan Sher(2011).
<i>S. mutans</i> and <i>S. aureus</i> . <i>S. pyrogenis</i> , <i>S. faecalis</i> , <i>P. aeruginosa</i> , <i>Lactobacillus acidophilus</i> , <i>Candida albicans</i>	Hussein (1992); Saleh et al., (2006). Suffredini et al., (2004), Al-Sabawi et al., (2007), Al-Bayati et al. (2008). Zafar Ahmed et al.(2010).
<i>Staphylococcus aureus</i> . <i>Actinomyces viscosus</i> , <i>Streptococcus mutans</i> , <i>Streptococcus sobrinus</i> , <i>Lactobacillus fermentum</i> , <i>Lactobacillus casei</i> and <i>Eikenella corrodens</i> . <i>S. mutans</i> and <i>E. corrodens</i> .	Vahabi S et al.(2011). Abdeirahman et al., (2002).
<i>Staphylococcus aureus</i> , <i>Pseudomonas aeruginosa</i> , <i>Escherichia coli</i> and <i>Candida albicans</i> .	Ashraf Taha Khalil(2006).
Herpes simplex virus, <i>Streptococcus mutans</i> , and <i>Candida albicans</i> .	Al-Bagieh, (1992), (1998); Al-Bagieh and Weinberg, (1988).
<i>Haemophilus influenza</i> . Aggregatibacter actinomycetemcomitans.	Abier Sofrata et al (2011). Al-Otaibi et al., (2004).
<i>Streptococcus mutans</i> , <i>Streptococcus mitis</i> and <i>Staphylococcus</i> .	Chawla.(1983)
<i>Streptococcus</i> and <i>staphylococcus aureus</i> .	Al-lafi, T. and Ababneh, H. (1995).
<i>Streptococcus mutans</i> and <i>lacto bacilli</i> .	Almas K, Al-Zeid Z (2004).

Hypoglycemic effect

A. Trovato et al (1998) saw hypoglycemic effects, an increase in plasma immunoreactive insulin (IRI) and an incremented oral-glucose tolerance in normal rats when treated with stem decoction of *S. persica*. In addition to the hypoglycemic effect, the decoction caused a significant decrease in mean body weights, without drastic reduction in food consumption. They hypothesized that the decoction decreases absorption from the lumen of the small intestine. Which makes it possible that the weight decrease and the hypoglycemic effect are produced by different mechanisms. According to them The ability of decoction to improve the utilization of glucose following a glucose load, may clarify the possible mechanism of hypoglycemic activity of this drug, which further may facilitate peripheral utilization of glucose, either by direct stimulation of glucose uptake or by enhanced insulin secretion. This latter effect may play a significant role in the adipose tissue.

Antiplatelet aggregation effect

The in vitro inhibitory effects of compounds butanediamide, ~, N4-bis(phenylmethyl)-2(S)-hydroxy-butanediamide (1), and N-benzyl-2-phenylacetamide (2), against human platelet aggregation induced by thrombin (0.1 U/mL) and collagen (10 µg/mL) was found by Ashraf Taha Khalil (2006). Their results showed that compound 2 exhibited a significant inhibitory effect on platelet aggregation induced by collagen. They suggested the contribution of compound 2 to the anti-inflammatory action of the crude remedy (Glitz et al., 1997) and providing a rationale for its traditional use.

Antiulcer activity

Sanogo et al. in 1999 confirmed the antiulcer activity of *S. persica* decoction using optical microscopy. Moreover, they concluded that the drug had an anti-inflammatory and

antiulcer activity and the action on the surface epithelium which was cell-mediated fibroblast growth with production of collagen fibres. According to their study *S. persica* appears to strengthen the mucosal barrier which is the first line of defense against endogenous and exogenous ulcerogenic agents. They categorised it as a cytoprotective agent. They suggested that the gastric protective effect of *Salvadora* was due partly to an enhancement in the production of mucus.

Anti-oxidative property

Antioxidants are vital substances which possess the ability to protect the body from damages caused by free radical induced oxidative stress. Radical reactions in vivo can damage lifeessential molecules such as nucleic acids and proteins (Saez TG, et al 1994). Phenolic compounds, particularly flavonoids, have been shown to possess an important antioxidant activity towards these radicals, which is principally based on their structural characteristics (number and position of phenolic hydroxyls, other groups, conjugation) (Bors et al 1990). Abdalbasit Adam Mariod , et al (2001) investigated the antioxidant activity of the bark, leaves and the seed cake phenolic extracts of *S. persica* using the b-carotene-linoleic acid assay. they found two dominant tocopherols as γ-tocopherol, and α-tocopherol in the seed oil of *S. persica*. These compounds display antioxidant properties and are active as vitamin E, which makes them particularly important for human health (Ramadan & Morsel 2004). Among the other anti oxidants γ-tocotrienol, β-sitosterol followed by campesterol and stigmasterol were found by them. Among the different phytosterols, sitosterol had been most intensively investigated with respect to its beneficial and physiological effects on health. (Yang B et al 2001).

Chemical composition

Several different classes of compounds were previously isolated from various parts of *S. persica*. The plant has proved to contain trimethylamine, related to urea alkaloids, sulphur monocline, organic sulphur compounds β -sitosterol and small amounts of saponins (Ezmirly et al., 1979; Hegnauer, 1973; Mansour et al., 1986; Oliver Bever, 1986; Robinson, 1983). Five lignane glycosides were isolated from stems of *Salvadora persica* (Kamel et al., 1992). One of the earlier photochemical reports reveal that its seed contains 40% oil with a fatty acid composition (lauric -20%, myristic -55%, palmitic 20% and oleic -5%) which can make an excellent soap.

Three lignan glycosides were isolated from the stems of this species (Kamel et al., 1992). Whereas an indole alkaloid was reported in the leaves (Malik et al., 1987). Salvadoreurea, (m-MeOC₆H₄CH₂NH)₂CO, has been reported in the roots (Ray et al, 1975). Moreover It contains important phyto-constituents such as, vitamin C, salvadorine, salvadoreurea, alkaloids, trimethylamine, cyanogenic glycosides, tannins, saponins and salts mostly as chlorides (Alali et al., 2004; Almas, 2002; Almas et al., 2005; Rajesh et al., 2009). A partial review of the list of chemicals extracted by different researchers is given in Table-3.

Table 3. Review of compounds/metals extracted from *S. persica*.

Compound/metal	Plant parts	References
N t,N4-Bis(phenylmethyl)-2(s)-hydroxy.butanediamide , N-Benzyl.2.phenylacetamide, N-Benzylbenzamide, Benzyl urea	stem	Ashraf Taha Khalil (2006)
octacosanol, 1-triacantanol, β -sitosterol, and β -sitosterol-3-O- β -d-glucopyranoside	stem	Jain M. et al (2004)
Cu, Ni, Mn, V, Ti, and Mo	leaf	Raj KP et al (1979), Almas K.(2001)
α - and β -thujones, camphor, cineole, β -cymene, limonene, β -myrcene, borneol, linalool, and bornyl acetate and nonvolatile fraction contained humulene, caryophyllene, β -santalol, and farnesol	seed	Hyson JM (2003)
Benzyl isothiocyanate , benzyl nitrile , carvacrol, benzaldehyde , aniline and naphthalene.	Stem,root	Emira Noumi.et al.(2011), Al-Bagieh et al., (1992)
Benzyl Nitril, Isotymol, thymol ,eugenol , β -caryophyllene , eucalyptol, and isoterpinolene	stem	Alali and Al-Lafi (2003)
1,8-cineole , α -caryophyllene , β -pinene and 9-epi-(E)- caryophyllene.	stem	Alali et al (2004).
Rutin and Quercetin	Root	Abdel-Wahab et al., (1990)

Conclusion

Literature review revealed that a great number of pharmacological and phytochemical studies carried out during last 32 years have demonstrated the vast medicinal potential of *S. persica*, especially its marked adaptogenic effect. Various types of preparations, extracts and individual compounds derived from this species have been found to possess various pharmacological effects on several organs such as the teeth, blood, and reproductive

systems (Darmani.et al. 2003) as well as on different biochemical processes with some other biological actions e.g. antioxidant, Antiplatelet aggreation effect, and anti-ulcer activities, indicates marked adaptogenic properties of the plant. Moreover, some other biological activities including antimicrobial, and antiplaque effects have been reported for extracts or individual compounds of *S. persica*. Among several classes of biologically active compounds identified in *S. persica*, Cl- (Chloride), SO₄²⁻ (Sulphate), SCN-

(Thiocyanate) and NO⁻ (Nitrate). are assumed to be its main active principle, responsible for the majority of the pharmacological effects. However, other components described in this review such as volatile oils, flavonoids, alkaloids, steroids, terpenoids, saponins, and carbohydrates (Abdillahi et al., 2010; Garboui et al., 2009; Kamil et al., 1999) may, to some degree, augment the pharmacological effects of the plant. The data summarised above, together with the low toxicity potential of the plant, strongly support the view that the *S. persica* has beneficial therapeutic properties indicating its potential as an effective adaptogenic antiseptic herbal remedy. However, further studies are needed to understand the complex pharmacological action and full phytochemical profile of the plant. Clarification of the chemical composition and biological actions of the essential oil, together with verification of inconsistent results regarding reproduction and sexual function (Darmani et al. 2003) and detailed investigation of the anti-microbial and anti plaque property, antioxidant potential, hypoglycemic effects or Antiulcer activity suggest the most up-to-date challenges for the future research of *S. persica*.

References

- Abd EL, Rahman HF, Skaug N, Whyatt A (2003). Volatile compounds in crude *Salvadora persica* extracts. Pharmaceut. Biol., 41: 399- 404.
- Abdalbasit Adam Mariod, Bertrand Mattha"us, I. H. Hussein.(2009), Chemical Characterization of the Seed and Antioxidant Activity of Various Parts of *Salvadora persica*. J Am Oil Chem Soc 86:857-865
- Abdeirahman HF, Phil M, Skaug N, Francis GW (2002). *In vitro* antimicrobial effects of crude Miswak extracts on oral pathogens. D.
- Abdel-Wahab, S. M., Selim, M. A., and El-Fiki, N. M., Investigation of the flavonoid content of *Salvadora persica* L. Bull. Fac. Pharm. (Cairo Univ), 28, 67-70 (1990).
- Abderahim, M. and Jurner, J. E.: In vitro evaluation of Saudi Arabian tooth tree (*Salvadora persica*). *Odontostomatological Trap.* 613: 145 -148,1983.
- Abdillahi HS, Stafford GI, Finnie JF, Staden JV (2010). Ethnobotany, phytochemistry and pharmacology of *Podocarpus sensus latissimo* (S.I) South Afr. J. Bot., 76(1): 1- 24
- Abier Sofrata, Fernanda Brito, Meshari Al-Otaibi, Anders Gustafsson.(2011). Short term clinical effect of active and inactive *Salvadora persica* miswak on dental plaque and gingivitis . Journal of Ethnopharmacology 137 (2011) 1130- 1134.
- Abuzinada AH, Al-Wetaid YI, Al-Basyouni SZM (2005). The National Strategy for Conservation of Biodiversity in the Kingdom of Saudi Arabia. Prepared and issued by: The National Commission for Wildlife Conservation and Development. Conservation of Biological Diversity, Riyadh, Saudi Arabia.
- Al-Bagieh, N. H., Antiherpes simplex virus type 1 activity of benzylisothiocyanate. Biomed. Lett., 47, 67-70 (1992).
- Alali F, Hudaib M, Aburjai T, Khairallah K, Al-Hadidi N (2004). GC-MS Analysis and Antimicrobial Activity of the Essential Oil from the Stem of the Jordanian Toothbrush Tree *Salvadora persica*. Pharmaceut. Biol., 42(8): 577-580.
- Al-Bagieh NH, Iodow A, Salako NO (1994) Effect of aqueous extract of miswak on the *in vitro* growth of *Candida albicans*. Microbios 80: 107-113
- Al-Bagieh, N.H., 1992. Antiherpes simplex virus type 1 activity of benzylisothiocyanate. Biomedical Letters 47, 67-70.
- Al-Bagieh, N.H., 1998. Effect of benzylisothiocyanate on the growth and

- acid production of *Candida albicans*. Biomedical Letters 58, 139-145.
- Al-Bagieh, N.H., Weinberg, E.D., 1988. Benzylisothiocyanate: a possible agent for controlling dental caries. Microbios Letters 39, 143-151.
- Al-Bayati FA, Sulaiman KD (2008). *In Vitro* antimicrobial activity of *Salvadora persica* L. extracts against some isolated oral pathogens in Iraq. Turk. J. Biol., 32: 57-62.
- Al-Khteeb TL, O'Mullane DM, Whelton H, Sulaiman MI (1991). Periodontal treatment needs among Saudi Arabian adults and their relationship to the use of the miswak. Commun. Dent. Health, 8(4): 323-328.
- Al-lafi T, Ababneh H (1995) The effect of the extract of the Miswak (chewing sticks) used in Jordan and the Middle East on oral bacteria. Int Dent J 45: 218-222
- Al-lafi, T. and Ababneh, H. (1995) The effect of the ex-tract of the Miswak (chewing sticks) used in Jordan and the middle east on oral bacteria. *International Dental Journal*, 45(3), 218-222.
- Almas K (2002) The Effect of *Salvadora persica* extract (Miswak) and chlorhexidine gluconate on human dentin: a SEM study. J Contemp Dent Pract 3:027-035
- Almas K, Al-Zeid Z. The immediate antimicrobial effect of a toothbrush and miswak on cariogenic bacteria: a clinical study. Journal of Contemporary Dental Practice 2004;5:105-14.
- Almas K, Skaug N, Ahmad I (2005). An *in vitro* antimicrobial comparison of miswak extract with commercially available non-alcohol mouth rinses. Int. J. Dent. Hyg., 3(1): 18-24.
- Almas K, Stakiw JE (2000). The effect of miswak extract from *Salvadora persica* stored for 18 years on microbes in vitro. Egypt. Dent. J., 46(1): 227-230.
- Almas K. The antimicrobial effects of seven different types of Asian chewing sticks Odontostomatol Trop 2001;24:17-20.
- Almas, K (2002). The effect of *Salvadora persica* extract (miswak) and chlorhexidine gluconate on human dentin: A SEM study. J. Contemp. Dent. Prac., 3: 27-35.
- Al-Otaibi M, Al-Harthy M, Gustafsson A, Johansson A, Classon R, Angmar-Mansson B (2004). Subgingival plaque microbiota in Saudi Arabians after use of miswak chewing stick and toothbrush. J. Clin. Periodontol., 31(12):1048-1053.
- Al-Otaibi, M., Al-Harthy, M., Gustafsson, A., Johansson, A., Claesson, R., Angmar-Mansson, B., 2004. Subgingival plaque microbiota in Saudi Arabians after use of miswak chewing stick and toothbrush. Journal of Clinical Periodontology 31, 1048-1053.
- Al-Sabawi AK, Al-Sheikh-Abdal AKK, Taha MY J (2007). The antimicrobial activity of *Salvadora persica* solution (Miswak-Siwak) as root canal irrigant (A comparative study). Univ. Sharjah J. Pure Appl. Sci., 4(3): 69-91.
- Al-Sadhan R, Almas K (1999). Miswak (chewing Stick): A Cultural and Scientific Heritage. Saudi Dental J., 11(2): 80-87.
- Ashraf Taha Khalil (2006), Benzylamides from *Salvadora persica*. Arch Pharm Res Vol 29, No 11, 952-956.
- Atassi F. Oral home care and the reasons for seeking dental care by individuals on renal dialysis. J Contemp Dent Pract 2002;3:31-41.
- Attar, A. Z.: The miswak. Natur's toothbrush. *Bulletin of the History of Dentistry* 271: 39 - 40 (1979).
- Bors W, Hellers W, Michel C, Saran M (1990) Radical chemistry of flavonoids antioxidant. In: Emerit (ed) Antioxidants in therapy and preventive medicine, vol 1. Plenum, New York, pp 165-170.
- Bukar A, Danfillo IS, Adeleke OA, Ogunbodede EO. Traditional oral health

- practices among Kanuri women of Borno State, Nigeria. *Odontostomatol Trop* 2004;27:25-31.
- Emira Noumi, Mejdí Snoussi¹, Najla Trabelsi, Hafedh Hajlaoui, Riadh Ksouri, Eulogio Valentin and Amina Bakhrouf..Antibacterial, anticandidal and antioxidant activities of *Salvadora persica* and *Juglans regia* L. extracts. (2011) *Journal of Medicinal Plants Research* Vol. 5(17), pp. 4138-4146
- Farooqi, M. I. H. and Srivastava, J.: The tooth tree (*Salvadora persica*). *Quart. J. Crude Drug Res.* 81: 1297, 1968.
- Hegnauer, R.: *Chemotaxonomie der Pflanzen* – Birkhauser Verlag, Basel und Stuttgart 6: 259 - 261, 1973.
- Hyson JM. History of the toothbrush. *J Hist Dent* 2003;51:73-80
- Kamel, M. S., Ohtani, K., Assaf, M. H., Kasai, R., El-Shanawani, M. A., Yamasaki, K., Ali, A. A., and Tanaka, O., Lignan glycosides from stems of *Salvadora persica*. *Phytochemistry*, 31, 2469-2471 (1992).
- Khatak M, Khatak S, Siddqui AA, Vasudeva N, Aggarwal A, Aggarwal P. *Salvadora persica*. *Phcog Rev* 2010;4:209-14
- Kokwaro, J. O.: *Medicinal plants of East Africa*. East African Literature Bureau, Kampala, Nairobi, Dar Es Salaam, 1976.
- Malik, S., Ahmad, S. S., Haidar, S. I., and Muzaffar, A., *Salvadoricine*, A new alkaloid from the leaves of *Salvadora Persica*. *Tetrahedron Lett.* , 28, 163-164 (1987).
- Rajesh V, Suresh P, Anil B, Brijesh K, Priyanka P (2009). *Salvadora persica* L (Tooth Brush Tree): A Review. *J. P.R.*, 2(12): 1809-1812.
- Ramadan MF, Morsel JT (2004) Oxidative stability of black cumin (*Nigella sativa* L.), coriander (*Coriandrum sativum* L.) and niger (*Guizotia abyssinica* Cass.) crude seed oils upon stripping. *Eur J Lipid Sci Technol* 106:35-43.
- Ray, A. B., Chand, L., and Dutta, S. C., *Salvadourea*. new urea derivative from *Salvadora Persica*. *Chem. Ind.*, 12, 517-518 (1975).
- Robinson, T: *The organic constituents of higher plants*. Cordus Press, North Amherst, MA, 335, 1983.
- Saez TG, Oliva MR, Muniz P, Valls V, Iradi A, Ramos M (1994) Oxidative stress and genetic damage. In: *Health and orange*, Valencia, Spain: Fundacion Valenciana de Estudios Avanzados, pp 51-60
- Saez TG, Oliva MR, Muniz P, Valls V, Iradi A, Ramos M (1994) Oxidative stress and genetic damage. In: *Health and orange*, Valencia, Spain: Fundacion Valenciana de Estudios Avanzados, pp 51-60
- Salehi P, Momeni Danaie SH (2006). Comparison of the antibacterial effects of persica mouthwash with chlorhexidine on *Streptococcus mutans* in orthodontic patients. *DARU*, 14: 178-182.
- Sanoqo R, Monforte MT, Daquino A, Rossitto A, Maur DD, Galati EM (1999). Antiulcer activity of *Salvadora persica* L.: structural modifications. *Phytomedicine*, 6(5): 363-366.
- Sher H, Al-Yemeni MN, Yahya SM, Arif HS (2010c). Ethnomedicinal and Ecological Evaluation of *Salvadora persica* L: A threatened medicinal plant in Arabian Peninsula. *J. Med. Plants Res.*, 4(12): 1209-1215.
- Sher H, Hussain F, Sher H (2010a). *Ex-situ* management study of some high value medicinal plants species in Swat, Pakistan. *J. Ethnobot. Res. Appl.*, (8): 17-24.
- Sher H, Khan ZD, Khan AU, Hussain F (2004). Ethnobotanical study on some plants in village Tigdari, district Swat, Pakistan. *J. Acta Botan. Yunnan.*, 10 (5):42-54
- Sofrata A, Lingstrom P, Baljoon M, and Gustafsson A. (2007). The effect of

- miswak extract on plaque pH: An *in vivo* study. *Caries Res.*, 41(6): 451-454.
- Sofrata A, Lingstrom P, Baljoon M, and Gustafsson A. (2007). The effect of miswak extract on plaque pH: An *in vivo* study. *Caries Res.*, 41(6): 451-454.
- Suffredini IB, Sarder HS, Goncalves AG (2004). Screening of antibacterial extracts from plants native to the Brazilian Amazon Rain Forest and Atlantic Forest. *Braz. J. Med. Biol. Res.*, 37: 379- 384.
- Trovato, A., E. M. Galati, A. Rossitto, M. T. Monforte, A. d' Aquino and A. M. Forestieri(1998). Hypoglycemic effects of *Salvadora persica* L. in the rat, *Phytomedicine*, Vol. 5(2), pp. 129-132.
- Trovato, A., Forestieri, A. M., Rossitto, A., Monforte, M. T., d'Aquino, A., Galati, E. M.: Hypoglycaemic effects of *Salvadora persica* L. in rat, *Phytomedicine* 5: 129-132, 1998.
- Vahabi S, Najafi E and Alizadeh S.(2011), *In vitro* antimicrobial effects of some herbal essences against oral pathogens. *Journal of Medicinal Plants Research* Vol. 5(19), pp. 4870-4878.
- Wolinsky, L.E. and Sote, E.O. (1984) Isolation of natural plaque inhibiting substances from Nigerian chewing sticks. *Caries Research*, 18(3), 216-225.
- World Health Organization. Prevention of oral diseases. Geneva: WHO; 1987.
- Yang B, Karlsson RM, Oksman PH, Kallio HP (2001) Phytosterols in sea buckthorn (*Hippophae rhamnoides* L.) berries: identification and effects of different origins and harvesting times. *J Agric Food Chem* 49:5620-5629
- Zafar Ahmed, Shaukat Saeed Khan, Mahnaaz Khan, Arshiya Tanveer and Zahoor Ahmad Lone (2010), Synergistic Effect of *Salvadora persica* Extracts, Tetracycline and Penicillin Against *Staphylococcus aureus*. *African Journal of Basic & Applied Sciences* 2 (1-2): 25-29.
- Zakaria MNM, Islam MW, Radhakrishnan R, Ismail A, Habibullah M, Chan K (1998). Anti-inflammatory properties of *Salvadora persica*. 46th Annual Congress of the Society for Med. Plant Res., 31 Aug-4 Sept., Vienna. Abstract no. J54.