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Oil Pulling: An Ancient Practice for a Modern Time

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Abstract:

The practice of oil pulling or oil swishing is a time-honored Indian folk remedy that involves swishing edible oil in the mouth for oral and systemic health benefits. Oil pulling offers a naturalistic approach to oral health care for a growing body of individuals who desire alternative and complementary medicine. The purpose of this paper was to summarize published research on the effectiveness of oil pulling on oral health. Literature was retrieved from 1992-2011 through databases including Cumulative Index to Nursing and Allied Health Literature (CINAHL), Education Resources Information Center (ERIC), Medical Literature Analysis and Retrieval System Online (MEDLINE), and Google Scholar. To date, studies have assessed the effectiveness of oil pulling on plaque, gingivitis, xerostomia, dental caries and malodor. Within the scope of this review, research suggests that oil pulling may hold certain advantages over other commercially available products in reducing various oral conditions, yet there is insufficient scientific evidence to support its effectiveness.

Keywords: Oil pulling, oil rinses, dental, sesame oil, sunflower oil, and alternative medicine.

Introduction:

Oil pulling has its roots in Ayurvedic medicine (also called Ayurveda), the ancient healthcare system native to India. In the United States Ayurveda is considered a complementary and alternative medicine (CAM) that relies heavily on herbs, plants, oils and spices for medicinal cures. According to the 2008 report by the U.S. Department of Health and Human Services, which used data

from the 2002 and 2007 National Health Interview Survey (NHIS), the use of Ayurvedic medicine has grown to more than 200,000 U.S. adults.[1] The report suggests that although the use of CAM therapies has increased, there is little scientific evidence to support clinical effectiveness.

The Ayurvedic practice of oil pulling consists of rinsing or swishing with edible oil to prevent and manage oral conditions such as tooth decay, halitosis, gingivitis and xerostomia. Refined plant oils such as sunflower, sesame and olive have widespread appeal; however, sesame oil is the most commonly used due to its nutritional qualities, palatable taste and health benefits.[2] Lignans are a diverse group of plant-derived compounds that are known to have antioxidant and antimicrobial activity. Sesame oil contains three lignans: sesamin, sesamolin, and sesaminol. Additionally, sesame oil contains high amounts of polyunsaturated fatty acids and vitamin E. In particular, sesamin aids in the reduction of low-density lipoprotein (LDL) and displays antihypertensive activity.[2,3]

Oil pulling requires placing one tablespoon of oil into the mouth (one teaspoon for children between the ages of five to fifteen), where it is sipped, sucked and swished between the teeth for a period up to fifteen minutes, then expectorated.[2] As the oil moves throughout the mouth it mixes with saliva and turns thin and milky white. During this process, people are cautioned not to swallow due to bacteria and toxins that may be present in the oil. Furthermore, it is recommended that oil pulling be performed in the morning, on an empty stomach, followed by tooth brushing and rinsing with water.[2]

With CAM practices expanding, many consumers and health care professionals are exploring oil pulling therapy. This review sought to provide a summary of research related to the effects of oil pulling on oral conditions such as plaque-induced gingivitis, caries, malodor and xerostomia.

Methodology: Internet Search Strategy:

Relevant articles were retrieved through numerous search engines including CINAHL, ERIC, MEDLINE and Google Scholar. The following search limiters were placed: full text (freely available), English language, and scholarly (peer reviewed) journals. No date range was selected. Key word and category searches were performed at multiple times using the same parameters. Search key words utilized included: oil pulling, oral rinses, oil rinses, cold pressed refined oil, refined oil, almond oil, sesame oil, sunflower oil, vegetable oil, Ayurvedic medicine, alternative medicine, alternative oral health care, dental health, and oral health.

Oil Pulling, Plaque and Gingivitis:

Asokan and colleagues evaluated the effectiveness of oil pulling on plaque-induced gingivitis through clinical and microbiological analysis.[4] Twenty subjects were randomized equally into two groups: experimental sesame oil and 0.12% chlorhexidine (CHX) control. For ten days, both groups rinsed with either CHX for one minute or sesame oil for ten to fifteen minutes, before morning tooth brushing. Participants were advised to brush their teeth only one time a day. Clinical assessments were scored at baseline and day 10 using the plaque index (PI) (Silness and Löe) and the modified gingival index (MGI) (Lobene). Results revealed that there was a statistically significant decline between pre and post-values of PI and MGI scores in both groups (p = 0.001 for both). Microbiological analysis showed a considerable reduction in the total colony count in both groups; however, this was not statistically significant between groups. Although the exact mechanism of action of oil pulling is unclear, researchers suggest that it was as effective as chlorhexidine in reducing plaque-induced gingivitis, without side effects such as staining or altered taste.[4]

The safety, acceptability and effectiveness of oil pulling on plaque and gingivitis was assessed by Amith and colleagues.[5] Ten male subjects were enrolled in a 45 day study. Baseline oral prophylaxis was not performed allowing participants to start with their normal plaque levels. Participants were advised to maintain their usual self-care practices in addition to oil pulling with refined sunflower oil. Subjects were instructed to swish the oil for a period of 8 to 10 minutes and then expectorate. Plaque (PHP) and gingival (GI) indices were scored at baseline, day 15, 30 and 45. Clinical data revealed a net decline in mean plaque scores, 0.81 ± 0.41 ($p<0.01$) and gingival scores, 0.39 ± 0.17 ($p<0.01$), from baseline to day 45. Oral examinations showed no adverse reactions to hard or soft tissues during the study. Acceptability of the oil pulling regimen was evaluated with a self-assessment questionnaire at the conclusion of the study. Eighty percent of participants surveyed were willing to perform oil pulling for the rest of their lives, even though the procedure was difficult to master and time consuming. Researchers suggest that oil pulling should be considered as a supplemental oral hygiene aid because it is easily obtained and economical, yet the disadvantages of compliance and acceptability exist due

to the length of time and dexterity required to perform the procedure.[5]

In a two-phase study, Busscher et al. examined the clinical efficacy and bacterial growth inhibition of a vegetable oil-based oral rinse.[6] Bacterial growth inhibition was studied *in vitro* on microorganisms associated with dental caries and gingivitis. Bacterial strains of *Streptococcus mutans, Streptococcus sanguis, Veillonella alcalescens, Lactobacillus acidophilus,* and *Actinomyces viscosus* were isolated from human subjects, grown overnight in broth and utilized to inoculate a second set of cultures. The concentrated product was then diluted, incubated, and measured with the use of a photospectrometer. Results revealed that two strains generally responsible for dental caries, *S. mutans* and *V. alcalescens,* were strongly inhibited by the vegetable oil-based product. Based on these *in vitro* findings a short clinical study was conducted (N=15). The clinical effectiveness of a vegetable oil-based oral rinse was compared to six commercially available products: Hibident, Prodent, Meridol, Merocet, Veadent, and Listerine. At baseline, plaque (PI) and gingival scores (GI) were obtained. During the two week preparatory phase (day 0-14) subjects were advised to brush with the assigned non-fluoridated dentifrice. No special oral care instructions were provided. At day 14, plaque (PI), gingival (GI) and planimetry plaque (PP) indices were scored. For the next six days (day 14-20) subjects were advised to discontinue all oral hygiene procedures and to use only their assigned rinse, twice a day, for 30 seconds. At day 20, clinical parameters (PI, GI and PP) were again obtained. Results showed that the vegetable oil-based rinse had PI scores similar to Merocet and Veadent; GI scores comparable to Prodent, Merocet, Veadent and Listerine; and PP scores comparable to Prodent and Merocet. Researchers suggest that the almond oil-based mouthrinse holds promise in maintaining low gingival scores comparable to the commercially available products tested, but caution that long-term clinical efficacy has yet to be established.[6]

A variety of studies have been conducted to assess the effects of oil pulling on plaque and gingivitis with varying results (Table 1). Overall, results suggest that oil pulling holds promise in reducing plaque and gingivitis without negative side effects such as staining and altered taste, yet the technique is often difficult to master and is time consuming.

Oil Pulling and Dental Caries:

Research conducted by Anand and colleagues utilized oil pulling with sesame oil to evaluate its effects on *S. mutans* and *L. acidophilus*.[7] Ten subjects were enrolled who presented with dental caries. At baseline participants were instructed to rinse with a saline solution and salivary samples were collected. Samples were serially diluted, plated, and incubated. After 24 hours the total number of colonies contained within 1 ml of saline was calculated. Participants were then instructed to perform oil pulling for 40 days. The salivary collection procedure was repeated and total colony counts were again calculated. Caries susceptibility was determined by the Snyder method and scored accordingly: (negative, slight, moderate, marked) depending on the length of time it took for the medium to turn from green (negative) to yellow (positive). Antibacterial activity of sesame oil against strains of *S. mutans* and *L. acidophilus* was accomplished by the disk diffusion method to assess the zone of inhibition. Results showed that 50 percent of the participants improved from marked to slight caries susceptibility and 50 percent converted from marked to moderate. Data revealed a reduction in the total colony count ranging from 10 to 33.4 percent, with an average reduction of 20 percent. Researchers suggest that sesame oil exhibited moderate inhibitory effects against *S. mutans, L. acidophilus* and total bacteria growth.[7]

The effect of sesame oil on *S. mutans* was compared to chlorhexidine (CHX) in twenty subjects (16-18 years old).[8] Participants were randomized equally to two groups: CHX control or experimental sesame oil. For two weeks, participants rinsed with either the control or experimental rinse. Samples were collected at 24 hours, 48 hours, 1 and 2 weeks. Plaque and saliva samples were obtained on Dentocult SM Strip mutans test strips (Orion Diagnostica, Espoo, Finland). Post incubation the presence of *S. mutans* was evaluated. Results revealed a statistically significant reduction of *S. mutans* in the plaque of the oil pulling group only after 1 and 2 weeks ($p = 0.01$ and $p = 0.008$ respectively); however, the CHX group showed a statistically significant decrease at all four time points ($p = 0.01$, $p = 0.04$, $p = 0.005$, $p = 0.005$ respectively). Saliva samples showed a decline in *S. mutans* in the oil pulling group, but results were not statistically significant. The CHX group showed a statistically significant reduction after 24 hours, 1 and 2 weeks ($p= 0.02$, $p = 0.02$, $p=0.008$, respectively). The authors suggest that oil pulling cannot be recommended as an adjunctive oral care treatment; nevertheless, sesame oil does possess certain positive qualities for home therapy use such as low cost, non-staining, no after taste and non-allergenic.[8]

Research by Aguiar and Saliba tested the effect of an almond oil dentifrice on dental plaque and *S. mutans*.[9] Eighty male subjects were randomized equally to two groups: experimental (Titoil) almond oil dentifrice or a control low abrasive dentifrice. Individuals were instructed to utilize their normal oral hygiene habits during the four week study. Saliva samples and plaque scores were obtained on day 0 and 28. Tests were conducted for salivary flow rate, salivary buffer capacity, dental plaque accumulation, and total colony count of *S. mutans.* Results revealed no significant difference in salivary flow or buffer capacity between groups. Data showed a significant decrease in CFU/ml of *S. mutans* in both groups ($p = 0.01$). There was a significant reduction in dental plaque after tooth brushing with Titoil ($p < 0.01$) and no reduction with the low abrasive dentifrice. Researchers concluded that the Titoil dentifrice did not interfere with salivary flow rate or buffer capacity and had the ability to reduce dental plaque and quantities of *S. mutans* with less abrasion.[9]

Pretty and colleagues evaluated the effects of an olive oil formulation on *S. mutans* in a two-phase study.[10] The bacterial inhibition of *S. mutans* was accessed using test tubes treated with distilled water (control) and olive oil. Olive oil was placed in the tubes, left undisturbed for 60 minutes and the remainder was poured off without rinsing. Test tubes were inoculated with *S. mutans*, incubated, plated and total viable count (TVC) was calculated. Bacterial adherence was tested on microscopic slides treated with distilled water, olive oil or Airlift dentifrice. Slides were immersed in a solution containing *S. mutans*, incubated and TVCs were determined. Results demonstrated that the test tubes treated with olive oil had significant bacterial inhibition ($p < 0.05$) in contrast to the control group. Significant decreases in bacterial growth and adhesion were revealed in the olive oil group. As a result of these findings, researchers concluded that the olive oil may have the potential to inhibit plaque formation and adherence.[10]

In phase-two twenty subjects were randomized to two groups: olive oil containing dentifrice (AirLift, Biocosmetics, Madrid, Spain) and a matched control fluoride paste.[10] On day 1 plaque (PI) was scored, a baseline prophylaxis was provided and product was dispensed. On day 5, PI was again scored, digital photographs were exposed of the maxillary and mandibular anterior teeth for percent plaque index (PPI) and a cross-over prophylaxis was provided. After a 9-day washout period, participants were assigned to the other group and the same process was repeated. Data revealed a significant difference in plaque re-growth between the two products tested ($p < 0.0001$). PPI data revealed a significant reduction of plaque with the olive oil dentifrice in contrast to the control ($p < 0.0001$).[10] Results suggest that the experimental olive oil containing dentifrice may have potential in inhibiting bacterial growth and adherence without the addition of Sodium Lauryl Sulphate (SLS), although longer term studies are needed.

The mechanism of oil pulling was studied by Asokan et al., to evaluate the antibacterial activity of sesame oil and isolated lignans (sesamin and sesamolin) on oral micororganisms and to determine if saponification or emulsification takes place.[11] The antibacterial activity of three sesame oil compounds were tested by agar well diffusion. The compounds were inoculated with *S. mutans, Streptococcus mitis* and *Streptococcus viridians*, plated, incubated and the zone of inhibition was calculated. Results demonstrated that none of the three compounds tested displayed inhibitory activity against the microorganisms evaluated .[11]

In vitro saliva samples were analyzed from four healthy subjects to test for the saponification and emulsification process.[11] Saponification is a chemical reaction that occurs when oils or fats mix with an alkali. Emulsification is the process where insoluble fats are broken down into smaller particles. The titer volume of sodium hydroxide (NaOH) was calculated as an indicator of saponification. Samples analyzed included sesame oil alone, oil and saliva combined, oil and saliva shaken in a flask for a period of 15 minutes and oil swished in the subjects mouth for a period of 15 minutes and expectorated into a flask. Results showed that post oil pulling some component in the saliva reacted with the sesame oil thereby increasing appreciably the amount of NaOH used up, thus verifying that saponification occurred.

After oil pulling for 30 minutes, the emulsification process was studied in salivary samples collected every 5 minutes. Samples were observed under light microscope and Gram stained.[11] Samples were then centrifuged separating the oil, bacteria and sediment. Results determined that the emulsification process begins after five minutes of oil pulling with the size of the oil globules decreasing. As time progressed oil globule size continued to decrease from 15 to 30 minutes and after 25 minutes only isolated bacteria were visible. Researchers suggest that emulsification may affect the adhesion of the bacteria to the surface of the tooth, remove depleted squamous cells and enhance

oral hygiene. The indication of the saponification and emulsification process found during oil pulling may facilitate the oral cleansing action. The authors concluded that more research must be conducted to confirm the antibacterial activity of sesame oil on oral microorganisms, yet they suggest that the "myth" of oil pulling as a placebo has been debunked.[11]

Overall, research exploring the antibacterial effects of oil pulling against dental caries causing bacteria is inconclusive (Table 2). Studies suggest that oil pulling exhibits an inhibitory effect on *S. mutans* without effecting salivary flow rate and buffering capacity. The prospect of using oil in a dentifrice to inhibit plaque formation should be further explored.

Oil Pulling and Oral Malodor:

The effects of an oil mouthrinse on halitosis was studied in 50 participants who were randomized into two groups: experimental 2-phase oil:water mouthrinse containng cetylpyridinium chloride (CPC) (n=26) or essential oil control (n=24).[12] Subjects were instructed to rinse with their assigned product for 30 seconds, morning and evening, over a six week period, while continuing with their usual oral care. Whole mouth malodor and clinical assessments (modified gingival index, plaque index and papillary bleeding index) were scored at baseline and approximately nine hours post rinsing at weeks 1, 3 and 6. Volatile sulphide compounds (VSC) were measured with a sulphide monitor and oral microbial levels were estimated through the use of the Oratest. Organoleptic measurements were assessed by two judges. At six weeks the GI scores were reduced in the oil:water CPC group by 52 percent and the essential oil control group by 49 percent. Both groups showed reduced plaque levels at week six, with a 49 percent mean reduction in the oil:water CPC group compared to 63 percent in the control group. Results suggest that mean whole mouth odors were reduced by 80, 79, and 70 percent in the experimental 2-phase oil:water CPC mouthrinse group, compared to 70, 77, and 59 percent reductions in the control group. Mean VSC decreased by 40% in the experimental oil:water CPC group, and 29% in the control group, but group differences were not significant. The authors suggest that the oil:water CPC mouthrinse was more effective than the control in terms of reducing malodor.[12]

The efficacy of an oil mouthrinse on malodor was studied by Rosenberg and colleagues to evaluate its ability to diminish malodor for time periods greater than 3 hours.[13] Sixty dental students were randomized into three groups: oil formulations containing essential oils and cetylpyridinium chloride (TPM) (n = 22); 0.2% chlorhexidine gluconate rinse (CHM) (n = 19) or placebo rinse (n = 19). Measurements were made in the late afternoon and 8-10 hours post rinsing. Subjects were informed to use their assigned rinse prior to bedtime and in the morning. Volatile sulphide levels (VSC) were measured with a portable sulphide monitor. Microbial quantities were assessed through the use of the Oratest and a single odor judge was used to provide organoleptic ratings. Both TPM and CHM showed significant decreases in VSC in contrast to the placebo group ($p < 0.05$). CHM showed to be more effective than the TPM rinse in all categories; however, the difference was only significant between CHM and TPM with regard to microbial activity ($p < 0.05$). The researchers suggest that oil:water combinations are effective against malodor and have specific advantages over alcohol and chlorhexidine based products such as lack of discoloration, no alterations in taste perception, no irritation to oral mucosa and lack of dehydration.[13]

A randomized controlled study was conducted by Asokan and colleagues in order to assess the effectiveness of oil pulling on halitosis.[14] Twenty adolescents were equally randomized into two groups: I (experimental) performed oil pulling with sesame oil for 10 to 15 minutes in the morning or II (positive control) used 0.2% chlorhexidine for one minute in the morning. Subjects were instructed to brush their teeth once a day using their normal oral hygiene regimens. A baseline prophylaxis was completed on all subjects. Five parameters were evaluated at day 0 and day 14: modified gingival index (MGI), plaque index (PI), organoleptic breath assessment with one judge (ORG 1), self-assessment of breath (ORG 2), and the BANA test for the presence of microorganisms responsible for malodor (BANAMet LLC, USA). The BANA test strips were incubated. The presence of *Treponema denticola*, *Porphyromonas gingivalis or Bacteroides forsythus* turned the test strip blue. Results showed a statistically significant difference in MGI and PI scores ($p = 0.005$ and $p = 0.007$, respectively) in both groups. There was a decrease in the ORG 1, ORG 2 scores, and BANA test score in both groups; however, there was only a statistically significant reduction for ORG 2 scores in the experimental oil group. Data indicated that oil pulling was comparable to chlorhexidine on organisms associated with malodor. While oil pulling cannot be prescribed as an adjunctive treatment at this time, the authors suggest that it holds promise as a preventive therapy, especially in developing countries.[14]

Studies conducted to date suggest that oil pulling had a positive effect on reducing malodor without side effects such as staining, altered taste and high cost (Table 3). Currently, oil pulling cannot be recommended as an effective oral therapy to manage malodor. More research is needed to determine the clinical effectiveness and the exact mechanism of action, which may open more possibilities in the field of CAM.

Oil Pulling and Xerostomia:

Vegetable oil and Xerolube were compared as a therapy for xerostomia in adults with carcinoma of the head and neck.[15] Twenty-nine participants were enrolled in a double-blinded cross-over study. Patients were randomly assigned to two groups: Xerolube (artificial saliva) or vegetable oil for a two week course of treatment. After a two week washout period the groups switched products for another two weeks. Investigators utilized an Oral Assessment Guide (OAG) to objectively measure oral pathology. Participants' subjective experiences of dryness were quantified using a 17-item Mouth Dryness Questionnaire (MDQ). The OAG was completed at enrollment and every two weeks, while the MDQ was assessed on a weekly basis. Data revealed that non-tobacco users improved significantly with the use of oil and stated a greater preference for vegetable oil. No difference was found between groups based on OAG scores (p = 0.88); MDQ scores exhibited no significant differences between the two treatments (p = 0.54). All subjects experienced dryness during washout periods and relief during treatment periods. Researchers concluded that vegetable oil can be considered as an effective and less costly alternative treatment option for patients with radiation-induced xerostomia.[15]

Studies related to oil pulling and malodor and xerostomia are summarized in Table 3. Results suggest that oil pulling is effective in reducing oral malodor and relieving oral dryness in head and neck cancer patients.

Discussion

Oil pulling is described as a natural alternative to traditional oral rinsing. Despite the fact that numerous commercially available mouthrinses exist to manage a variety of oral conditions, there is a growing sector of the population that desires natural products. Oral health care professionals are increasingly faced with questions about natural therapies; consequently, it is important to be knowledgeable about alternative and complimentary products. Furthermore, the concern that surrounds the overuse of antibiotics and antimicrobials has increased the relevance of cost effective substitutes.

Researchers have investigated the use of oil pulling on oral diseases such as plaque-induced gingivitis, dental caries, oral malodor, and xerostomia. Research suggests that oil pulling may have potential in reducing plaque and gingivitis[4-6], caries causing bacteria[7-11], malodor[12-14] and xerostomia.[15] Additionally, oil pulling may improve oral cleansing through the processes of saponification and emulsification, thus enhancing the inhibition of plaque adherence and formation.[11] Literature retrieved related to the effectiveness of oil pulling as an alternative oral care therapy is diminutive and revealed significant study limitations such as: small sample size, lack of controls, insufficient information on methods and materials, lack of blinding, and incomplete results. Consequently, oil pulling or oil swishing cannot be recommended as an effective adjunctive oral care treatment. More long term studies are needed, in larger populations, to assess the wide-ranging effects that oil pulling may have on various oral conditions.

Conclusion:

Ayurvedic medicine has grown successively despite the negligible amount of scientific evidence.[1] The purpose of this paper was to establish an overview of oil pulling in reducing a variety of oral conditions such as plaque-induced gingivitis, dental caries, malodor and xerostomia. Based on the available research, the effectiveness of oil pulling is inconclusive. Assumptions drawn from this review suggest that oil pulling has certain benefits over commercially available mouthrinses such as non-chemical, non-alcoholic, low cost, and non-staining, yet the effectiveness and mechanism of action are unclear. The qualities of oil pulling appeal to certain individuals seeking a natural alternative, on the other hand, minimal scientific evidence exists to support oil pulling therapy as an effective oral care treatment.

Table 1: Oil Pulling, Plaque and Gingivitis

Authors	Study Design	Sample	Results
Asokan et al 2009	Randomized two groups: oil and CHX PI and MGI assessed at baseline and day 10	N = 20	Significant reduction of pre- & post-values of PI and MGI scores in both groups ($p < 0.001$)
Amith et al 2007	One group: oil Patient Hygiene Performance Index (PHP) and GI assessed at baseline, day 15, 30 and 45	N = 10	Significant reduction of PHP & GI scores from baseline to day 45 ($p<0.01$) for both
Busscher et al 1992	*In-vitro & in vivo* Oil compared to six commercially available products: Hibident, Prodent, Meridol, Merocet, Veadent, and Listerine PI, GI and planimetry plaque (PP) indices assessed at baseline, day 14 and 20	N = 15	*S. mutans* and *V. alcalescens* strongly inhibited *in-vitro* PI scores comparable to Merocet and Veadent GI scores comparable to Prodent, Merocet, Veadent and Listerine PP scores comparable to Prodent and Merocet

Table 2: Oil Pulling and Dental Caries

Authors	Study Design	Sample	Results
Anand et al 2008	One group: oil Salivary samples collected at baseline & day 40 Total number of colonies calculated after 24 hours	N = 10	*S. mutans* and *L. acidophilus* were moderately sensitive to sesame oil Total bacteria reduction varied from 10 to 33.4%
Asokan et al 2008	Two groups: oil and CHX Plaque and saliva samples collected at 24 hours, 48 hours, 1 and 2 weeks	N = 20	Oil group showed a statistically significant reduction in *S. mutans* after 1 & 2 weeks (p = 0.01 & p = 0.008) CHX group displayed significant reductions for all 4 time points (p = 0.01, p = 0.04, p = 0.005, p = 0.005)
Aguiar and Saliba 2004	Randomized two groups: experimental (Titoil) almond oil dentifrice and control low abrasive dentifrice	N = 80	No significant difference in salivary flow or buffer capacity between groups Significant decrease in CFU/ml of *S. mutans* in

	Saliva samples and plaque scores obtained on day 0 and 28 Tests for salivary flow rate, salivary buffer capacity, dental plaque accumulation and total colony count of *S. mutans.*		both groups (p = 0.01) Significant reduction in dental plaque after brushing with Titoil (p < 0.01) and no reduction with the low abrasive dentifrice
Pretty et al 2003	*In vitro & in vivo* Test tubes treated with distilled water and olive oil, inoculated with *S. mutans* Two group: olive oil dentifrice and matched control fluoride paste Crossover design PI scored on day 1 and PI and PPI scored on day 5	N = 20	Olive oil showed a significant inhibition of bacterial growth *in-vitro* (p < 0.05) Olive oil group showed a significant reduction of plaque (p < 0.0001) when compared to the control *in vivo*
Asokan et al 2011	*In vitro* Three sesame oil compounds were inoculated with *S. mutans, S. mitis* and *S. viridians*, incubated, and zone of inhibition calculated	N/A	Results revealed that sesame oil displayed no inhibitory activity against the microorganisms tested

Table 3: Oil Pulling, Oral Malodor and Xerostomia

Authors	Study Design	Sample	Results
Asokan et al 2011	Randomized two groups: oil and CHX MGI, PI, ORG and BANA test Data collected at day 0 and 14	N = 20	MGI and PI scores revealed a statistically significant difference (p = 0.005 and p = 0.007) in both groups A decrease in ORG and BANA test scores were found in both groups
Kozlovsky et al 1996	Two groups: oil:water CPC and essential oil control group Malodor, MGI, PI, and BI scored at baseline and nine hours post rinsing Data collected at weeks 1, 3 and 6	N = 50	Malodor reduced over time with 80%, 79%, and 70% decreases in the oil:water CPC group Highly significant reduction over time for MGI and BI in both groups (p = 0.0001) PI reduced in the

			oil:water CPC group by 49% and by 63% in the control group at week 6
Rosenberg et al 1992	Three groups: oil with essential oils and cetylpyridinium chloride (TPM); chlorhexidine gluconate (CHM); and placebo VSC, microbial activity, and organoleptic ratings were obtained Measurements taken in the late afternoon and 8-10 hours post rinsing	N = 60	CHM was more effective than the TPM on VSC, microbial activity, and organoleptic ratings TPM and CHM showed significant decreases in VSC in comparison to the placebo ($p < 0.05$)
Walizer and Ephraim 1996	Crossover two group: vegetable oil and Xerolube OAG (objective assessment of oral pathology) was completed at baseline and two weeks MDQ (dryness) was evaluated weekly	N = 29	No difference between groups based on OAG scores ($p = .88$) and MDQ scores ($p = .54$)

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