



The Potential of *Aloe vera* as an Active Ingredient in Toothpaste Formulations: A Narrative Review

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Received 2021 July 02; Revised 2021 August 04; Accepted 2021 August 09.

Abstract

Context: Tooth brushing is a primary method to prevent the onset of oral diseases. *Aloe vera* is commonly used in dentistry as an herbal alternative due to its anti-inflammatory and anti-microbial actions; recently, it has been used in toothpaste formulations as an active agent. This review aimed to investigate the clinical effects of *A. vera* as an active ingredient in toothpaste formulations.

Evidence Acquisition: The data used in this review was extracted from articles published until 2020. We searched official databases, including Scopus, PubMed, Google Scholar, Embase, and Science Direct, using the “*Aloe vera*”, “dentifrice”, and “toothpaste” keywords. After screening titles and abstracts, relevant studies were used for full-text review.

Results: Although conflicting results have been reported on the usage of *A. vera* toothpaste in different studies, the majority of findings suggest that *A. vera* effectively reduces periodontal indices and removes different organisms, including *Streptococcus mutans*. However, the overall effects of this herbal toothpaste were found to be equal to those of other commercial toothpaste.

Conclusions: *Aloe vera* toothpaste is as beneficial as other kinds of toothpaste. Therefore, it can be used as an adjunct agent in toothpaste due to its established effects on improving periodontal problems and reducing different oral cavity micro-organisms.

Keywords: Dentifrice, Toothpaste, *Aloe vera*, Clinical Effects

1. Context

The oral cavity contains 500 - 1000 different types of bacteria, fungi, and occasional viruses (1). Cleaning the oral cavity is an essential method of preserving oral health due to removing microbial plaques and preventing them from accumulating on gingiva (2). Periodontal diseases can affect almost 90% of the population. Several etiologic factors can lead to periodontal diseases, including the accumulation of dental plaques (3). In addition to periodontal diseases, plaque is a critical factor for the initiation and progression of dental caries (4).

Tooth brushing once a day is almost adequate to remove plaques and prevent the onset of gingivitis and caries (5). However, the average adult population do not adhere to sufficient tooth brushing. Consequently, some

compounds, such as chlorhexidine, have been used as mouth rinses or are added to toothpaste as adjunctives to improve the mechanical plaque removal (6). Toothpaste can efficiently deliver therapeutically active agents like fluoride to the surface of the teeth (7). The success of toothpaste depends on its ability to reduce pathogenic oral microflora (8). Researchers have investigated more appropriate alternatives for traditional dental medicines due to side effects. For instance, the unpleasant taste and staining are the main side effects of chlorhexidine mouthwashes (9).

The use of natural products in the treatment of oral conditions has recently increased. Among these herbal products, *Aloe vera* is a frequently used plant (10). *Aloe vera* is a tropical plant grown in a hot and dry climate.

It is commonly found in the Northeast of Brazil under the name 'Barbosa' (11, 12). *Aloe vera* gel consists of about 98% water. The remaining include active compounds such as carvacrol, thymol, linalool, phenylmethyl ester, normethadone (an anti-inflammatory compound), fenretinide, and other active natural compounds, such as anthraquinones, vitamins, amino acids, saponins, sugars, and lignin (13). One of the advantages of herbal medicines is that their long-term usage decreases the side effects of traditional drugs (14). As mentioned above, *A. vera* contains acemannan and anthraquinone, which are anti-microbial and antiseptic substances. No adverse side effects have been attributed to *A. vera*, making it a suitable alternative for dental plaque control (15, 16). Herbal toothpaste such as *A. vera* have been used for many years due to its effect on oral diseases, including oral cancerous and precancerous lesions (17). The amount of *A. vera* in a dentifrice usually ranges from 0.4 to 10%. It is proven that dentifrices with a higher concentration of *A. vera* have higher anti-microbial effects (18). The advantages of herbal toothpaste include a more pleasant taste, prevention of caries formation, and freshening the breath. Researchers have also reported that *A. vera* toothpaste showed significant improvement in reducing plaque accumulation (15).

The usage of *A. vera* includes evidence-based and tradition-based approaches. The use of this plant for wound healing, mucositis, acne vulgaris, genital herpes, diabetes type II, and HIV infection is considered evidence-based usage; however, the tradition-based usage is not thoroughly tested, and it includes the use of *A. vera* for alopecia, bacterial and fungal skin infections, systemic lupus erythematosus, and arthritis (12).

Studies have reported the effect of *A. vera* mouthwash on plaque formation and gingivitis, and *A. vera* has been suggested as a substitute alternative for chlorhexidine mouthwash (19). The results of a study showed that the anti-microbial activity of *A. vera* toothpaste could inhibit the growth of *Streptococcus sanguinis*. Despite the wide distribution of herbal toothpaste, information about the anti-microbial effects and compounds of different commercial toothpaste is still limited (20). This study aimed to investigate the clinical impact of *A. vera* as an active ingredient in toothpaste formulations.

2. Evidence Acquisition

2.1. Search Strategy

The data used in the present review were obtained from articles published until September 2020. The search was performed using the following keywords: "*Aloe vera*", "toothpaste", and "dentifrice". All the related articles were retrieved from the Google Scholar, Scopus, Ovid, PubMed, and Science Direct databases and documents published from different international institutions. The search was restricted to articles published in English.

2.2. Inclusion and Exclusion Criteria

The inclusion criteria were: (1) English-language articles with detailed information regarding *A. vera* toothpaste and its clinical effects.

The exclusion criteria were: (1) case reports, (2) animal studies, (3) medical record reviews, (4) meeting abstracts, (5) historical articles, (6) editorials, (7) letters, and (8) commentaries.

2.3. Screening and Selection

Out of 15 articles related to the mentioned topic, 12 articles met the inclusion criteria. Topics discussed in this review included health care, *A. vera*, its applications, herbal toothpaste, and their clinical effects. Two reviewers independently screened the titles and abstracts of the related articles, and if determined eligible, the full texts were obtained for further reading.

3. Results

3.1. Study Selection

A total of 383 articles were identified by searching the mentioned databases based on the strategy outlined in the materials and methods section. Duplicate manuscripts were removed. Subsequently, the full texts of 13 articles were reviewed, out of which only one paper was excluded due to inaccessibility through official web pages (21) (Figure 1).

3.2. Features of Included Studies

Out of the 12 studies included, seven studies were clinical trials, three were in vitro, one was in vivo, and one was a systematic review of *A. vera* dentifrices effects on dental plaque and gingivitis.

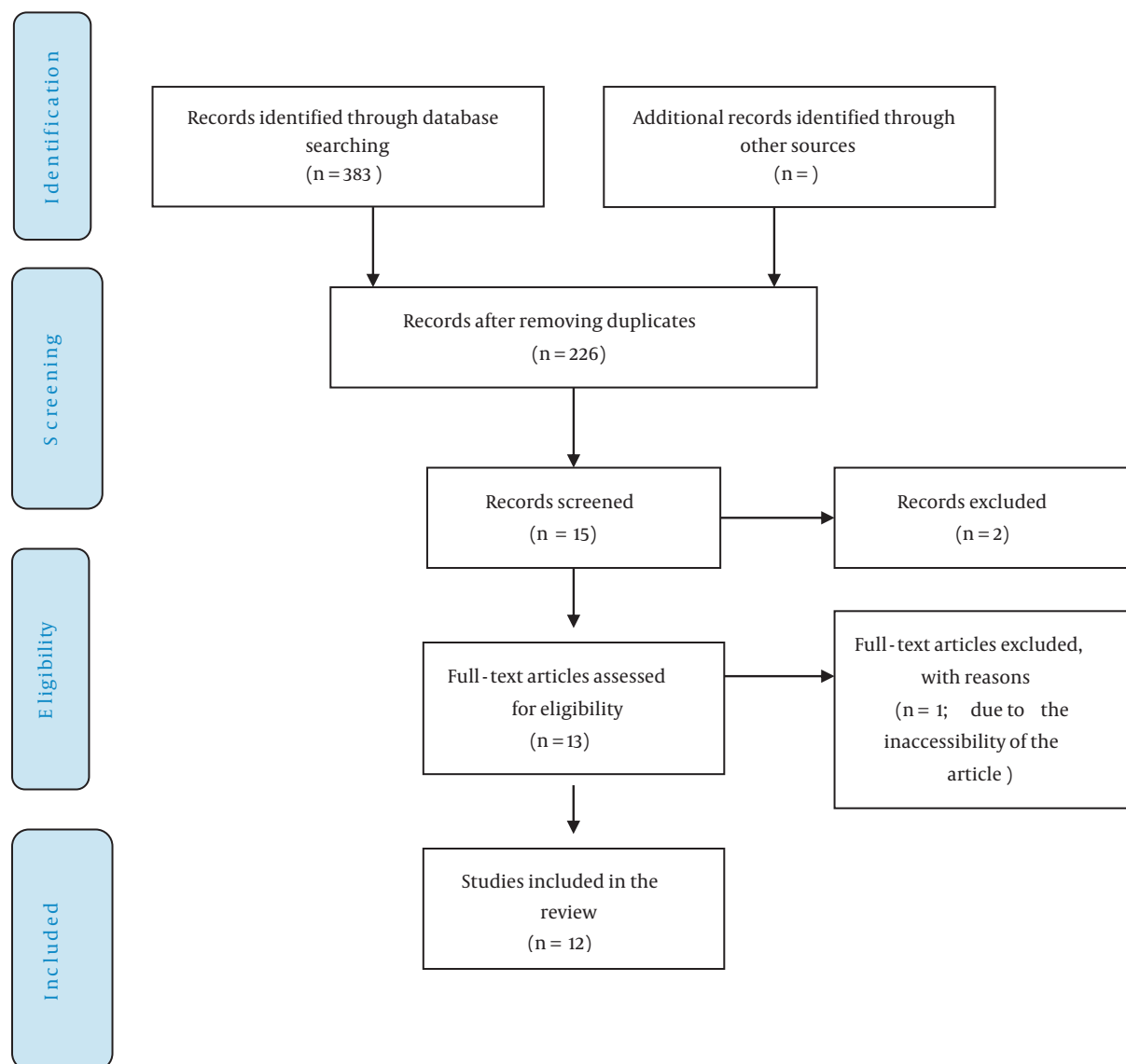


Figure 1. Search and selection of the primary studies

3.3. Clinical Outcomes of Studies Included

3.3.1. Clinical Trials

Among the seven clinical trials, five articles analyzed the effects of *A. vera* on periodontal indices. All these five articles showed that *A. vera* had no additional effects on plaques and gingivitis compared to other control toothpaste mentioned in these trials (15, 22-25). The results of these seven clinical trials are reported in Table 1.

3.3.2. In Vitro Studies

Three in vitro studies related to *A. vera* toothpaste were reviewed in the present literature review. All these three articles analyzed the effect of *A. vera* against *Streptococcus mutans*. Two of them showed that *A. vera* had advantages in decreasing the accumulation of this micro-organism on teeth (20, 28). Still, George et al. concluded that *A. vera* toothpaste had an equal effect in controlling *S. mutans* and other organisms compared to other commercial toothpaste (8). The results are shown in Table 2.

Table 1. Results of Primary Clinical Studies

First Author (Year)	Study Population	Clinical Evaluations	Study Groups	Results
Namirani and Serino (2012) (23)	15 subjects	Plaque Index (PI) and Gingival Index (GI)	In the first six months, the patient's own toothpaste was used. In the second six months, <i>A. vera</i> toothpaste, and in the third six months, the control toothpaste was used.	The use of a toothpaste containing <i>A. vera</i> showed no additional effect on plaques and gingivitis compared to control toothpaste.
Pradeep et al. (2012) (15)	90 subjects	PI and GI and microbiological counts	Group 1: placebo toothpaste; Group 2: toothpaste containing <i>A. vera</i> ; Group 3: toothpaste containing triclosan and fluoride.	There was no significant difference between the <i>A. vera</i> -containing toothpaste and the toothpaste containing triclosan in the reduction of PI and GI indices. Natural herbal preparations in oral health care are still popular, and <i>A. vera</i> dentifrice can be considered a useful adjunct. Its efficacy is comparable to toothpaste containing triclosan.
Garnick et al. (1994) (26)	79 subjects	Changes in root sensitivity	Group 1: placebo toothpaste; Group 2: toothpaste containing <i>A. vera</i> ; Group 3: toothpaste containing allantoin; Group 4: toothpaste containing allantoin and <i>A. vera</i> .	All four kinds of toothpaste reduced root sensitivity, but the difference between the groups was not statistically significant.
Suthar et al. (2017) (25)	60 subjects	PI, GI, SBI, and OHI	Group 1: <i>A. vera</i> toothpaste; Group 2: fluoridated toothpaste (Colgate®).	There was no significant difference between the <i>A. vera</i> and conventional groups. Still, it can be concluded that <i>A. vera</i> toothpaste might be a useful plaque control agent in patients with gingivitis.
Chandru et al. (2020) (27)	60 children	Antifungal activity against <i>Candida albicans</i>	Six groups with six different commercial children toothpaste, including Aloe-dent toothpaste	Among these six kinds of toothpaste, Aloe Dent children's toothpaste® showed the minimum antifungal activity.
de Oliveira et al. (2008) (24)	30 subjects	PI and GBI	The test group used <i>A. vera</i> dentifrice and the control group used fluoridated dentifrice	The dentifrice containing <i>A. vera</i> did not show any additional effects on dental plaque and gingivitis reduction compared to the fluoridated dentifrice.
Kripal et al. (2014) (22)	45 subjects	Probing Pocket Depth (PPD), GI, and PI	Group 1: scaling alone; Group 2: scaling and <i>A. vera</i> toothpaste; Group 3: <i>A. vera</i> toothpaste alone.	There was a significant reduction in the PI and GI indices at the baseline during the fourth and sixth weeks across all the groups. <i>A. vera</i> can be used as an adjunct to scaling (oral prophylaxis) to improve clinical parameters (PI, GI, BOP).

Table 2. Results of in Vitro Primary Studies

First Author (Year)	Study Method	Clinical Evaluations	Study Groups	Results
Korkmaz et al. (2019) (20)	Agar disk diffusion method	Anti-microbial Efficacy against <i>S. mutans</i> and <i>S. aureus</i>	Three herbal toothpastes containing <i>A. vera</i> and strawberry extract	The herbal toothpastes could have advantages in decreasing bacterial accumulation on teeth with additional oral cavity protection.
George et al. (2009) (8)	Freeze-dried stock culture	Anti-microbial Efficacy against <i>S. mutans</i> , <i>S. mitis</i> , <i>Candida albicans</i> , <i>Enterococcus fecalis</i> , and PI	<i>A. vera</i> tooth gel, Pepsodent toothpaste, and Colgate toothpaste	<i>A. vera</i> tooth gel was as effective as two commercially popular toothpaste in controlling all the organisms used in the study.
Bertolini et al. (2012) (28)	15 sterile toothbrushes	The anti-microbial capacity of <i>A. vera</i> and propolis dentifrice against <i>Streptococcus mutans</i> strains in toothbrushes	Five groups including negative control group without dentifrice, fluoridated dentifrice, triclosan dentifrice, positive control without dentifrice and irrigation, <i>A. vera</i> , and propolis dentifrice	After tooth brushing, the <i>A. vera</i> and propolis dentifrice group reduced the contamination of toothbrush bristles by <i>S. mutans</i> , without additional differentiation from the formal chemical agents used in toothpaste.

3.3.3. In Vivo Studies

Among the 12 primary studies in our review, only one study was an in vivo study in which the anti-microbial effect of *A. vera* and two other toothpastes against *S. mutans*

was analyzed by collecting patients' saliva after two days, 15 days, and 30 days of brushing. The saliva specimens were cultured. The results comparing *A. vera* to two other toothpaste were not statistically significant (Table 3) (1).

Table 3. Results of in Vivo Primary Studies

First Author (Year)	Study Population	Clinical Evaluations	Study Groups	Results
Bhati et al. (2015) (1)	60 children	Anti-microbial efficacy using mitis agar for determining <i>S. mutans</i> count	Group 1: control; Group 2: fluoridated dentifrice; Group 3: herbal dentifrice containing <i>A. vera</i> ; Group 4: Herbal dentifrice containing Dabur miswak.	No significant difference was observed in the anti-microbial properties of all the three test dentifrices, but they recommended <i>A. vera</i> as an alternative to fluoridated dentifrice for children.

4. Discussion

This review aimed to compare the effects of *A. vera* as an active ingredient in toothpaste to other kinds of toothpaste. As mentioned above, plaque is a primary risk factor in periodontal diseases, and the removal of plaque can prevent the occurrence of these diseases. The use of mechanical methods and chemotherapeutic agents is the existing ways to maintain oral health (2). Among mechanical methods, brushing and flossing are the most common methods (29). However, nowadays, compliance with plaque control and brushing has decreased. Mechanical methods of plaque control are time-consuming. Some individuals lack the motivation to improve the efficacy of self-performed mechanical procedures; thus, positive changes that may lead to improved daily plaque control seem necessary. Therefore, compounds such as herbal agents have been added to toothpastes (30, 31). Studies report an increasing demand for treatment options for oral diseases using natural products that are safe and effective. Nowadays, bacteria have become resistant to antibiotics. Furthermore, the antibacterial agents commonly used in dentistry have several adverse side effects. Using herbal dentifrices is an alternative option evaluated in clinical trials for controlling dental plaque and periodontal diseases (32, 33). Recently, the use of *A. vera* as a dentifrice has gained importance, and due to its useful properties, it is considered an ideal choice for microbial plaque control (22). Studies have shown that herbal toothpaste exhibit much safer and better anti-microbial activities compared to synthetic ones (34).

Aloe vera is a member of the Asphodelaceae family and has different types, but *A. barbadensis* is mostly used in dentistry due to its medicinal properties (8). The main compounds of *A. vera* are carvacrol, thymol, linalool, phenylmethyl ester, normethadol, and fenretinide. Also, it has different active natural compounds, like anthraquinones, vitamins, amino acids, saponins, sugars, and lignin. Due to the existence of these compounds, *A. vera* has antiviral, an-

tibacterial, and anti-inflammatory activities (12, 20). The level of these compounds differs based on the strain and growth condition of the plant (13).

Aloe vera gel has been used for health care goals due to its anti-inflammatory and anti-microbial effects. *Aloe vera* also contains acemannan, which has anti-microbial and antifungal effects and can stimulate antibody production by the immune system (28).

The present study's findings indicated that *A. vera* dentifrices have anti-microbial effects like other commercial toothpaste. This review showed that *A. vera* is effective in reducing periodontal indices and bacterial accumulation. Seven clinical trials evaluated the potential of *A. vera* toothpaste in the maintenance of oral health, five of which reported that *A. vera* was as effective as other toothpaste they tested and the difference between them was not significant. This finding is inconsistent with the results of an in vivo study conducted by Bhati et al., who showed that herbal toothpaste containing *A. vera* had almost the same anti-microbial effects as fluoridated toothpaste and control toothpaste (1). The other two clinical studies showed different results. Chandhru et al. (27) concluded that although *A. vera* toothpaste has antifungal activity, its antifungal activity was less than other commercial ones used by children. The antifungal activity of *A. vera* toothpaste was due to its active ingredients such as anthraquinone. Still, the reason for its minimal antifungal activity compared to others can be related to inappropriate dilutions and testing methods.

A systematic study by Dhingra investigated two clinical trials reviewed in the present study. They also reported that *A. vera* toothpaste had no significant effects compared to control groups. Still, both of the RCT studies they reviewed reported no adverse effects and had good patient acceptance (35).

The anti-microbial capacity of *A. vera* dentifrice against *S. mutans* inside toothbrush bristles was reviewed in an in vitro study by Bertolini et al. (28). They observed that the dentifrice containing *A. vera* reduced the contamina-

tion of bristles by *S. mutans* but without significant difference compared to the other groups. These results are also consistent with the findings of those five trials mentioned above.

Kripal et al. conducted a randomized clinical trial on the clinical effects of commercial toothpaste containing *A. vera* in 45 subjects. Their results were contrary to other primary studies. They concluded that reduction in periodontal indices, such as bleeding on probing (BOP) and gingival index (GI), were higher in the group that used *A. vera* toothpaste as an adjunctive treatment in addition to scaling (22). A higher concentration of *A. vera* has a better effect as a phytotherapeutic agent (36). Thus, one of the reasons for different results in this study can be the difference in the percentage of *A. vera* in the total formulation of the toothpaste.

Also, the anti-microbial efficacy of *A. vera* dentifrice against *S. mutans* in a culture medium was reviewed in two of the primary studies. The results of these two studies were different. George et al. (8) showed that *A. vera* was equally effective as two other commercial toothpastes, but the *A. vera* toothpaste had an increased antibacterial effect against *S. mitis*. Moreover, this study reported that the anti-microbial effects of commercial toothpaste were due to the fluoride in their formulation. Although *A. vera* dentifrice has no fluoride, it has antibacterial effects against different organisms due to its active compounds, which are equal to other toothpaste. Another in vitro study by Korkmaz et al., which compared an *A. vera* toothpaste and an herbal toothpaste containing strawberry extract by agar diffusion test, reported that the *A. vera* toothpaste had a higher anti-microbial effect against *S. mutans* than the other herbal toothpaste. This study showed that oxygenated monoterpenes such as menthol in *A. vera* are responsible for their anti-microbial activity. They concluded that herbal toothpaste have several advantages in reducing bacterial accumulation (20).

Besides the primary studies' results in this article, *A. vera* gel has been used to heal aphthous ulcers and lichen planus lesions. It has bactericidal effects against *S. mutans* and *Porphyromonas gingivalis* (37). Furthermore, *A. vera* inhibits the formation and accumulation of plaques and the growth of micro-organisms; thus, it is ideal for treating gingivitis and oral infections (1). *Aloe vera* toothpaste can effectively reduce gingival and plaque index (PI) scores. The reduction in PI is due to the antibacterial properties of *A. vera*, and the reduction of GI is attributed

to sterols as anti-inflammatory agents. Further, the carboxypeptidase in *A. vera* inactivates bradykinin and reduces prostaglandin synthesis leading to the reduction of inflammation and pain (25).

This review has some limitations, including lack of sufficient clinical studies, difference in the concentration of *A. vera* in toothpaste formulations, different methods of testing, and various control groups.

Also, most of the studies evaluated periodontal indices and the reduction of organisms, including *S. mutans*. Therefore, it is suggested to conduct further studies on the effects of *A. vera* toothpaste and examine other clinical dental parameters.

5. Conclusions

Aloe vera toothpaste had similar clinical effects compared to other commercial toothpaste. It can be used as an adjunct formulation due to its herbal and medicinal properties and its established effects on improving periodontal problems and reducing different oral cavity micro-organisms.

Footnotes

Authors' Contribution: PN and JMS collected the data, MM performed the interpreted data, and drafted and revised the manuscript for important intellectual content. DP and AMS reviewed the analyses and the final version of the manuscript. JM, PN and AMS revised the manuscript for important intellectual content, and approved the final version. All the authors have read and approved the manuscript.

Conflict of Interests: All the authors declare that there are no conflicts of interest.

Data Reproducibility: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Funding/Support: The current study did not receive funding from any sources.

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