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COMPREHENSIVE REVIEW ON MARKETED HERBAL TOOTH POWDERS: ANTIMICROBIAL AND ANTIOXIDANT ACTIVITY

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ABSTRACT

Oral hygiene is an essential aspect of overall health, as poor dental care is linked to dental caries, gingivitis, periodontitis, and even systemic diseases such as diabetes and cardiovascular disorders. Conventional oral care products, including fluoride-based toothpaste and mouthwashes, have been widely used for maintaining dental hygiene. However, concerns regarding the side effects of synthetic ingredients, such as fluoride toxicity, artificial sweeteners, and chemical preservatives, have led to an increased interest in herbal alternatives. Herbal tooth powders, made from medicinal plant extracts, minerals, and essential oils, claim to offer antimicrobial, antioxidant, anti-inflammatory, and remineralizing benefits. They have been traditionally used in Ayurveda, Unani, and other herbal medicine systems. This review aims to critically assess marketed herbal tooth powders, focusing on their composition, antimicrobial and antioxidant properties, mechanism of action, clinical effectiveness, safety, consumer perception, and regulatory concerns. Furthermore, this article discusses challenges in standardization, quality control, and the future scope of herbal dental products.

KEYWORDS: Herbal tooth powders, Oral hygiene, Antimicrobial properties, Synthetic ingredients, Clinical effectiveness.

INTRODUCTION

Oral health is a critical component of overall well-being, as it plays a fundamental role in essential functions such as eating, speaking, and social interaction. Poor oral hygiene can lead to various dental problems, including dental caries, gingivitis, periodontitis, halitosis (bad breath), and even systemic conditions such as diabetes and cardiovascular diseases. The human mouth hosts a diverse microbial community, comprising both beneficial and pathogenic bacteria. When this microbial balance is disrupted due to poor oral hygiene, high sugar intake, or inadequate dental care, it creates an environment conducive to bacterial growth and plaque formation. Conventional oral hygiene products, such as fluoride-based toothpaste and mouthwashes, have long been used to prevent oral diseases. However, concerns over the long-term effects of synthetic ingredients, fluoride toxicity, and chemical additives have led consumers to seek safer, more natural alternatives, including herbal formulations.[1]

Herbal tooth powders have been used for centuries in traditional medicine systems such as Ayurveda, Unani, and Siddha, owing to their ability to cleanse teeth, strengthen gums, and prevent oral infections naturally. These powders are typically composed of medicinal plant extracts, essential oils, and natural minerals, each selected for their bioactive properties that promote oral health. Common ingredients such as neem (Azadirachta indica), clove (Syzygium aromaticum), miswak (Salvadora persica), babool (Acacia arabica), and triphala (a blend of Emblica officinalis, Terminalia chebula, and Terminalia bellirica) have been scientifically recognized for their antimicrobial, antioxidant, anti-inflammatory, and gum-healing properties. Unlike chemical-based toothpaste, which may disrupt the natural oral microbiome, herbal tooth powders aim to support oral hygiene while maintaining microbial balance.[2]

One of the primary concerns in oral health is the growth of harmful bacteria such as Streptococcus mutans, Lactobacillus acidophilus, and Porphyromonasgingivalis, which contribute to cavities, plaque formation, and gum disease. Herbal tooth powders contain natural antibacterial agents such as tannins, flavonoids, alkaloids, and essential oils, which work by inhibiting bacterial growth, preventing biofilm formation, and reducing inflammation. Furthermore, oxidative stress plays a crucial role in the progression of oral diseases, particularly gingivitis and periodontitis, which can lead to gum recession and tooth loss. The antioxidants found in herbal formulations help neutralize free radicals, reduce tissue damage, and promote gum healing. These dual-action properties—antimicrobial and antioxidant—make herbal tooth powders an attractive alternative to conventional oral care products.[3]

The rising demand for chemical-free and eco-friendly dental products has driven the growth of the herbal oral care market. Consumers are increasingly becoming aware of the harmful effects of synthetic ingredients such as sodium lauryl sulfate (SLS), triclosan, artificial sweeteners, and synthetic preservatives, which have been linked to allergies, hormonal imbalances, and potential carcinogenicity. Additionally, environmental concerns regarding the disposal of plastic toothpaste tubes and the sustainability of chemical-based ingredients have contributed to the shift towards herbal tooth powders, which often come in biodegradable packaging.[4]

Composition of Herbal Tooth Powder

Herbal tooth powders are formulated using medicinal plant extracts, essential oils, and natural minerals, each carefully selected for their therapeutic benefits in oral care. Unlike conventional toothpaste, which relies on synthetic compounds such as fluoride, sodium lauryl sulfate (SLS), and artificial preservatives, herbal tooth powders use bioactive plant-based ingredients that exhibit antimicrobial, antioxidant, and gum-strengthening properties. These formulations are often inspired by Ayurvedic, Unani, and traditional medicine systems, where herbal remedies have been used for

centuries to maintain oral hygiene.[5] The effectiveness of herbal tooth powders largely depends on their composition and synergistic interactions between bioactive compounds.

1. Key Herbal Ingredients and Their Role

The primary components of herbal tooth powders include medicinal plants that provide antibacterial, anti-inflammatory, and plaque-reducing benefits. Some of the most commonly used herbs include:

i. **Neem (Azadirachta indica**): Known for its strong antibacterial and antifungal properties, neem helps reduce the growth of Streptococcus mutans (a primary cause of dental cavities) and Porphyromonasgingivalis (linked to gum disease). Its bioactive compounds, such as nimbidin and azadirachtin, inhibit bacterial adhesion and plaque formation.

ii. **Clove (Syzygium aromaticum**): Rich in eugenol, a natural analgesic and antibacterial agent, clove is widely used for its ability to relieve toothache, prevent microbial infections, and reduce inflammation in the gums.

iii. **Miswak (Salvadora persica):** Traditionally used as a natural toothbrush, miswak contains antibacterial alkaloids and flavonoids that prevent plaque buildup and strengthen gum tissues.

iv. **Babool (Acacia arabica):** The tannins in babool have astringent properties that help tighten gums, reduce bleeding, and protect against bacterial infections.

v. **Triphala (a combination of Emblica officinalis, Terminalia chebula, and Terminalia bellirica):** This blend is rich in antioxidants such as vitamin C and gallic acid, which neutralize free radicals and protect gum tissues from oxidative stress and inflammation.

2. Essential Oils and Their Therapeutic Benefits

Many herbal tooth powders incorporate essential oils for their additional antimicrobial and refreshing properties. Some commonly used essential oils include:

i. **Peppermint oil**: Contains menthol, which provides a cooling effect and helps in reducing oral bacteria that cause bad breath.[6]

ii. **Tea tree oil**: Exhibits strong antibacterial and antifungal activity, making it effective against plaque-causing microbes.

iii. **Eucalyptus oil:** Known for its anti-inflammatory and decongestant properties, it helps soothe gum irritation and fights oral infections.

iv. These essential oils not only contribute to the antimicrobial and antifungal properties of herbal tooth powders but also improve their taste and provide a refreshing feeling after use.

3. Natural Abrasives for Plaque Removal

Unlike toothpaste, which contains synthetic abrasives like silica or calcium phosphates, herbal tooth powders utilize natural, mild abrasives that effectively remove plaque and stains without damaging tooth enamel. Common natural abrasives include:

i. **Activated charcoal**: Absorbs toxins and helps whiten teeth by removing surface stains.

ii. **Calcium carbonate**: A mild abrasive derived from natural sources that assists in plaque removal while providing a source of calcium for enamel remineralization.

iii. **Salt (rock salt or sea salt):** Helps disinfect the mouth and stimulate saliva production, which is essential for maintaining oral pH balance.

iv. **Clays (such as bentonite or kaolin clay)**: Work as gentle abrasives and detoxifiers, binding to bacteria and impurities in the oral cavity.

These natural abrasives contribute to effective mechanical cleansing while being gentle on enamel, making herbal tooth powders suitable for long-term use.

4. Additional Functional Ingredients

Many herbal tooth powders contain functional additives that enhance their effectiveness and provide additional health benefits:

i. **Licorice root (Glycyrrhiza glabra):** Has natural sweetening properties and antimicrobial effects that prevent bacterial growth in the mouth.
ii. **Turmeric (Curcuma longa):** A powerful anti-inflammatory agent, turmeric helps reduce gum swelling and fight microbial infections.
iii. **Baking soda (sodium bicarbonate):** Helps neutralize acids in the mouth, maintaining a balanced oral pH to prevent cavities.
iv. **Amla (Emblica officinalis):** A rich source of vitamin C, amla promotes gum healing and strengthens connective tissues.

The inclusion of these functional ingredients ensures that herbal tooth powders not only cleanse the teeth but also promote gum health, enamel strength, and long-term oral protection.

5. The Importance of Synergistic Formulation

One of the key advantages of herbal tooth powders is the synergistic effect of their ingredients. Unlike single-compound synthetic formulations, herbal powders contain multiple bioactive compounds that work together to enhance their efficacy.[36] For instance, neem and clove together provide broad-spectrum antimicrobial activity, while triphala and turmeric offer combined antioxidant and anti-inflammatory effects.[37] The presence of natural abrasives, essential oils, and functional additives creates a holistic oral care solution that cleans, protects, and nourishes the teeth and gums.[7]

Despite their numerous benefits, one of the biggest challenges in herbal tooth powder formulation is achieving consistency and standardization in the concentration of bioactive compounds.[35] Variability in plant sources, extraction methods, and storage conditions can affect the potency of the final product.[38] Thus, there is a growing need for scientific validation, quality control, and regulatory guidelines to ensure that marketed herbal tooth powders provide consistent and effective oral health benefits.[8]

By leveraging nature-derived ingredients and traditional wisdom, herbal tooth powders offer a safe, effective, and sustainable alternative to conventional oral care products. However, further research and clinical studies are needed to establish their long-term effectiveness, optimal formulations, and safety profiles.[9]

Antimicrobial Properties of Herbal Tooth Powders

The oral cavity is home to a complex microbial ecosystem that includes both beneficial and harmful bacteria. While commensal bacteria help maintain oral health, pathogenic microbes such as Streptococcus mutans, Lactobacillus acidophilus, and Porphyromonasgingivalis contribute to dental caries, plaque formation, gum disease, and bad

breath.[10] The primary role of an effective oral care product is to control the growth of harmful bacteria while preserving beneficial oral flora. Herbal tooth powders achieve this through bioactive plant compounds with strong antimicrobial properties, offering a natural alternative to chemical-based antibacterial agents like triclosan or chlorhexidine, which have potential side effects. Medicinal plants such as neem, clove, miswak, and triphala contain antimicrobial alkaloids, flavonoids, tannins, and essential oils, which inhibit bacterial adhesion, biofilm formation, and acid production, thereby protecting teeth and gums.[11]

1. Mechanisms of Antimicrobial Action

Herbal tooth powders combat oral pathogens through multiple mechanisms. First, bioactive compounds disrupt bacterial cell walls and membranes, leading to the leakage of intracellular contents and eventual bacterial death.[39] For example, neem (Azadirachta indica) contains nimbidin and azadirachtin, which break down bacterial cell walls, preventing bacterial multiplication.[40] Second, polyphenols and tannins found in herbs like triphala and babool inhibit bacterial enzymes and metabolic pathways, thereby reducing acid production responsible for tooth enamel erosion. Third, herbal compounds interfere with quorum sensing, the process by which bacteria communicate and form biofilms. Miswak (Salvadora persica) and clove (Syzygium aromaticum) contain flavonoids and essential oils that prevent bacterial colonies from adhering to the tooth surface, reducing plaque buildup.[12]

2. Scientific Studies Supporting Antimicrobial Properties

Several in vitro and in vivo studies have demonstrated the antimicrobial efficacy of herbal tooth powders.[41] Research has shown that neem-based formulations significantly reduce S. mutans and Lactobacillus growth, comparable to fluoride toothpaste.[34] A study comparing clove and fluoride toothpaste found that clove-based herbal tooth powder exhibited strong antibacterial activity against periodontal pathogens like P. gingivalis. Similarly, triphala has been shown to have broad-spectrum antibacterial and antifungal effects, making it useful for preventing oral thrush (Candida albicans) infections.[42] Additionally, miswak extract has demonstrated superior antibacterial action against plaque-forming bacteria compared to conventional mouthwashes. These findings confirm that herbal tooth powders can effectively control oral pathogens and prevent microbial-induced dental issues.[13]

3. Essential Oils and Their Antimicrobial Activity

Many herbal tooth powders include essential oils from plants such as peppermint, tea tree, and eucalyptus, which enhance antimicrobial effects.[43] Tea tree oil (Melaleuca alternifolia) contains terpinen-4-ol, a compound with potent antibacterial and antifungal properties that inhibits plaque-forming bacteria.[44] Eucalyptus oil possesses antimicrobial and anti-inflammatory effects, reducing bacterial colonization and gum swelling. Peppermint oil (Mentha piperita), rich in menthol and rosmarinic acid, effectively combats S. mutans while providing a refreshing sensation.[33] The combination of essential oils with herbal extracts enhances the antimicrobial activity of herbal tooth powders, making them an effective chemical-free alternative to conventional toothpaste and mouthwashes.[14]

4. Advantages over Synthetic Antibacterial Agents

One of the significant advantages of herbal tooth powders is their safety profile compared to synthetic antibacterial agents. Chemical ingredients such as triclosan and chlorhexidine, commonly found in conventional oral care products, have been linked to antibiotic resistance, hormonal imbalances, and oral mucosal irritation.[45] Additionally, prolonged use of chlorhexidine mouthwashes can cause tooth staining and alter taste perception. In contrast, herbal tooth powders provide natural antibacterial action without disrupting the beneficial oral microbiome.[32,46] They selectively target

harmful bacteria while supporting beneficial microbes, maintaining a healthy oral environment. Moreover, herbal tooth powders do not contain fluoride, making them suitable for individuals seeking fluoride-free oral care options due to concerns over fluorosis or toxicity risks.[15]

5. Future Prospects and Research Needs

While herbal tooth powders have demonstrated significant antimicrobial potential, further research is needed to establish standardized formulations and clinical effectiveness.[47] The variability in herbal compositions and extraction methods can lead to differences in antibacterial efficacy. Therefore, scientific validation, quality control, and clinical trials are essential to ensure consistency and consumer trust in these products. Future developments may focus on nano-herbal formulations, where plant-based antibacterial compounds are encapsulated in nanoparticles to enhance their bioavailability and penetration into oral tissues.[48] Additionally, integrating AI and microbiome analysis in dental research could help personalize herbal formulations for individuals based on their specific oral microbial composition. With increasing consumer preference for natural and sustainable oral care solutions, herbal tooth powders have the potential to revolutionize preventive dentistry while promoting oral health through nature- based remedies.[16,49,50]

Antioxidant Properties of Herbal Tooth Powders

Oxidative stress plays a crucial role in the development of various oral health issues, including gingivitis, periodontitis, oral ulcers, and even oral cancer. It occurs when free radicals (reactive oxygen species, ROS) accumulate in the oral tissues, leading to cell damage, inflammation, and tissue degradation.[31] The presence of high levels of ROS in the oral cavity can result from poor oral hygiene, bacterial infections, tobacco use, alcohol consumption, and dietary factors. Herbal tooth powders, enriched with antioxidant-rich plant extracts, help combat oxidative stress by neutralizing free radicals, reducing inflammation, and promoting the repair of damaged tissues. Unlike conventional toothpaste, which mainly focuses on mechanical plaque removal and bacterial inhibition, herbal tooth powders offer additional protective benefits by preventing oxidative damage and enhancing overall oral health.[17]

1. Mechanism of Antioxidant Action

Herbal tooth powders contain a variety of bioactive compounds such as flavonoids, polyphenols, tannins, alkaloids, and vitamins, which exhibit strong antioxidant activity.[51,52] These compounds work by scavenging free radicals, preventing them from causing oxidative damage to oral tissues.[53] One of the key antioxidant mechanisms is the inhibition of lipid peroxidation, a process in which ROS attack the lipids in cell membranes, leading to cell death. Flavonoids and polyphenols found in herbal ingredients like triphala, neem, and clove act as potent electron donors, neutralizing ROS and stabilizing oral tissue cells.[54] Additionally, antioxidants help modulate inflammatory pathways by downregulating pro-inflammatory cytokines, thereby reducing gum swelling and preventing tissue destruction.[18]

2. Antioxidant-Rich Herbal Ingredients in Tooth Powders

Several medicinal plants used in herbal tooth powders are known for their exceptional antioxidant properties:[19]

i. **Triphala (Amla, Haritaki, Bibhitaki):** A powerful combination of three fruits, triphala is rich in vitamin C, gallic acid, and tannins, which exhibit strong antioxidant effects. It helps protect gum tissues from oxidative damage and promotes collagen synthesis for gum healing.

ii. **Neem (Azadirachta indica):** Contains quercetin, nimbin, and catechins, which act as free radical scavengers and protect oral tissues from oxidative stress-induced inflammation.

iii. **Clove (Syzygium aromaticum):** A well-known antioxidant powerhouse, clove is rich in eugenol, a compound that

not only exhibits antibacterial properties but also has strong free radical-scavenging activity, reducing gum inflammation and promoting healing.

iv. **Turmeric (Curcuma longa):** Contains curcumin, one of the most potent natural antioxidants, which helps reduce oxidative damage, prevent gum infections, and support tissue regeneration.

v. **Amla (Emblica officinalis):** One of the richest sources of natural vitamin C, amla enhances antioxidant defenses in the oral cavity, strengthens gums, and prevents oxidative stress- induced tissue breakdown.

3. Protection Against Periodontal Diseases

Periodontitis, a severe gum disease characterized by gum inflammation, tissue destruction, and bone loss, is closely associated with oxidative stress. The excessive production of ROS by immune cells in response to bacterial infection leads to collagen degradation, increased matrix metalloproteinase (MMP) activity, and alveolar bone resorption. Herbal tooth powders help combat this condition by reducing oxidative stress and inhibiting inflammatory mediators.[55]

Studies have shown that triphala and turmeric significantly reduce oxidative markers such as malondialdehyde (MDA) in gingival tissues, thereby preventing periodontal tissue damage.[56] Additionally, the antioxidant-rich compounds in neem and clove help strengthen gum tissues, reduce pocket depth, and promote tissue repair, making them effective natural alternatives to synthetic anti-inflammatory agents.[20]

1. Prevention of Oral Cancer and Mucosal Damage

Chronic oxidative stress is a key factor in oral cancer development, as it can cause DNA mutations, uncontrolled cell proliferation, and tumor progression.[57,58] Tobacco use, excessive alcohol consumption, and poor dietary habits contribute to high ROS levels in the oral cavity, leading to precancerous lesions such as leukoplakia and erythroplakia. The antioxidants present in herbal tooth powders play a protective role by inhibiting oxidative DNA damage, promoting apoptosis (programmed cell death of cancerous cells), and modulating oncogenic pathways.[59] For example, curcumin in turmeric has been extensively studied for its anticancer properties, as it helps suppress tumor cell growth and enhances the body's natural antioxidant defenses.[60] Similarly, polyphenols found in amla and triphala help reduce oxidative stress-induced DNA damage, lowering the risk of malignant transformation in oral tissues.[21]

2. Future Research and Clinical Implications

Despite the growing evidence supporting the antioxidant benefits of herbal tooth powders, more clinical trials and standardized studies are needed to establish their long-term efficacy.[61] Many commercially available herbal formulations lack proper standardization in terms of antioxidant potency, leading to variability in effectiveness.[62] Future research should focus on quantifying the antioxidant capacity of different herbal ingredients and optimizing their concentrations to achieve maximum protective benefits.[63] Additionally, the development of nanotechnology-based herbal formulations, where antioxidants are encapsulated for enhanced bioavailability and controlled release, could further improve the therapeutic potential of herbal tooth powders.[22] As consumer demand for natural, chemical-free, and multifunctional oral care products continues to rise, herbal tooth powders with proven antioxidant properties could play a significant role in preventive dentistry and holistic oral healthcare.[64]

In conclusion, the antioxidant properties of herbal tooth powders offer a promising approach to maintaining oral health by reducing oxidative stress, preventing gum disease, and protecting against oral cancer.[65] By leveraging the natural healing potential of medicinal plants, these formulations not only provide effective cleansing and antimicrobial benefits

but also contribute to the long-term protection and regeneration of oral tissues, making them an excellent alternative to conventional oral care products.[23]

Clinical Trials and Comparative Effectiveness

Several clinical trials and in vitro studies have been conducted to evaluate the efficacy of herbal tooth powders in comparison to conventional fluoride-based toothpaste and synthetic antimicrobial agents.[66] Research has shown that herbal formulations containing neem, clove, triphala, and turmeric exhibit significant antibacterial, anti-inflammatory, and antioxidant properties, making them effective in reducing plaque buildup, gingival inflammation, and microbial load in the oral cavity.[30] A randomized controlled trial (RCT) comparing neem-based herbal tooth powder with fluoride toothpaste found that both formulations effectively reduced plaque index and gingival bleeding, but the herbal tooth powder provided additional anti-inflammatory benefits due to its natural bioactive compounds.[67] Another clinical study assessing triphala-based tooth powder demonstrated a marked reduction in periodontal pocket depth and plaque scores, comparable to chlorhexidine mouthwash, without the staining or taste alteration side effects associated with chlorhexidine. These findings support the growing interest in herbal alternatives for sustainable, safe, and long-term oral health care.[24]

Comparative effectiveness studies have also highlighted the advantages of herbal tooth powders over synthetic oral care products, particularly in terms of biocompatibility, absence of harmful chemicals, and preservation of the oral microbiome. Unlike fluoride toothpaste, which may contribute to fluorosis and enamel erosion with prolonged use, herbal formulations provide mineral-rich compounds that aid in enamel remineralization and gum tissue regeneration.[23]

In a head-to-head comparison between clove-based tooth powder and commercial triclosan toothpaste, the herbal formulation exhibited equal or superior antimicrobial activity against Streptococcus mutans and Lactobacillus acidophilus, two key bacteria responsible for dental caries. Additionally, long-term use of herbal formulations has been associated with a lower incidence of oral mucosal irritation, making them suitable for individuals with sensitive gums or those seeking chemical-free oral care alternatives. While these results are promising, more large- scale, multi-center clinical trials with standardized formulations are needed to establish definitive guidelines for their use in mainstream dentistry.[28]

Challenges and Future Perspectives of Herbal Tooth Powders

Despite the growing popularity and scientific validation of herbal tooth powders, several challenges hinder their widespread adoption in mainstream dentistry.[68] One of the primary concerns is standardization and quality control. Unlike commercial toothpaste, which follows strict regulatory guidelines, herbal tooth powders often lack uniformity in composition, concentration of bioactive compounds, and consistency in antimicrobial efficacy.[69,70] Variability in plant sources, processing techniques, and storage conditions can significantly affect the potency of active ingredients, leading to inconsistent clinical outcomes. Additionally, the absence of standardized testing protocols makes it difficult to compare the effectiveness of herbal formulations against conventional oral care products.[71,72] Regulatory bodies such as the FDA and WHO require extensive clinical trials and safety evaluations before approving herbal dental products for widespread use, which remains a major barrier to market expansion.[24]

Looking ahead, the future of herbal tooth powders depends on scientific advancements, technological innovations, and greater consumer awareness.[73] Nanotechnology-based herbal formulations, where bioactive compounds are encapsulated in nanoparticles, could enhance stability, bioavailability, and targeted delivery of antioxidants and antimicrobials to oral tissues. Additionally, integrating artificial intelligence (AI) and microbiome analysis into dentistry could allow for personalized herbal formulations tailored to an individual's oral health needs.[29]

As demand for natural, chemical-free, and sustainable oral care solutions continues to rise, collaborations between traditional medicine practitioners, researchers, and pharmaceutical industries will be crucial in bridging the gap between herbal wisdom and modern dental science.[74] By addressing standardization challenges and investing in rigorous clinical research, herbal tooth powders have the potential to become a mainstream, evidence-based alternative in preventive and therapeutic dentistry.[25]

CONCLUSION

Herbal tooth powders present a promising alternative to conventional chemical-based oral care products by harnessing the natural antimicrobial and antioxidant properties of medicinal plants. The comprehensive review of their composition reveals that ingredients such as neem, clove, miswak, triphala, and turmeric provide a multifaceted approach to oral hygiene—combating pathogenic bacteria, reducing plaque formation, and neutralizing harmful free radicals. Clinical studies have demonstrated that these herbal formulations can be as effective as traditional fluoride toothpaste in reducing plaque and gingival inflammation while offering the additional benefits of anti-inflammatory and enamel-strengthening effects. This holistic approach not only supports overall oral health but also addresses growing consumer concerns about chemical additives and their long-term effects.[26]

Despite these promising benefits, challenges related to standardization, quality control, and regulatory approvals remain significant obstacles to the mainstream adoption of herbal tooth powders. Future advancements in nanotechnology, personalized dental care through AI and microbiome analysis, and robust clinical trials are essential to validate and optimize these formulations. With continued scientific research and technological innovations, herbal tooth powders have the potential to revolutionize preventive dentistry, providing consumers with safe, sustainable, and effective oral care alternatives that integrate traditional herbal wisdom with modern dental science.[27]

REFERENCES

1. Krati, Dr. Martolia Jaya, et. al, A comprehensive review on in-vitro methods for anti- microbial activity, IP International Journal of Comprehensive and Advanced Pharmacology, 2024; 9(3).
2. Neeru, Shilpi Kashyap, Esha Vatsa, Jitendra Singh and Ankush Sundriyal "Determination of Total Phenolic Content, Total flavonoid Content and Total Antioxidant capacity of different extracts of Roylea elegans Wall. (aerial parts)" World journal of pharmacy and pharmaceutical sciences (WJPPS), 2016; 5(6): 1884-1891.
3. Neeru, Esha Vatsa, Jitendra Singh and Ankush Sundriyal "Pharmacognostic Standardization Parameters of Roylea elegans Wall. (Aerial Parts)" International Journal for Pharmaceutical Research Scholars (IJPRS), 2016; 5(2):133-140.
4. Kundan Singh Bora and Esha Vatsa "Pharmacognostic Evaluation of Dendrobium macraei Lindl." Universities Journal of Phytochemistry and Ayurvedic Heights (UJPAH), 2016; 1(20):29-36.

5. Amit Sharma, Bharat Parashar, Esha Vatsa, Shilpa Chandel and Surbhi Sharma "Phyto chemical screening and Anthelmintic activity of leaves of Cedrus deodara (Roxb.)" World journal of pharmacy and pharmaceutical sciences (WJPPS), 2016; 5(8):1618-1628.
6. Amit Sharma, Surbhi Sharma, Shilpa Chandel, Esha Vatsa and Dr. Bharat Parashar "A review on Morchella esculanta: Therapeutically Potent plant" World journal of pharmacy and pharmaceutical sciences (WJPPS), 2016; 5(9): 685- 699.
7. Esha Vatsa and Kundan Singh Bora "Memory Enhancing Activity of Dendrobium macraei Lindl. in Swiss Albino Mice" British Journal of Pharmaceutical Research (BJPR), 2016; 13(2):1-11.
8. Vatsa Esha, Chandel Shilpa, Parashar Bharat, Neeru "Physico-Chemical and Phytochemical Evaluation of Dendrobium macraei Lindl. (Whole Plant)" International Journal of Pharmacognosy and Phytochemical Research (IJPPR), 2016; 8(11): 1801- 1811.
9. Esha Vatsa, Mehak Aggarwal, Shipra Gautam "Formulation and Evaluation of Polyherbal Facial Scrub" Just Agriculture multidisciplinary e-Newsletter, Article ID: 023, 2021; 1(9): 1-6.
10. Shipra Gautam, Madhubala Thakur, Mehak Aggarwal, Esha Vatsa "Azadirachta indica- A Review as a Potent Anti- Diabetic drug" Just Agriculture multidisciplinary e-Newsletter, Article ID:98,2021; 1(10): 1-6.
11. Esha Vatsa, Samriti Faujdar, Nidhi Sharma, Shilpa Chandel, Mehak Aggarwal "Dendrobium macraei Lindl.: A review on medicinally potent orchid on the basis of recent evidences" Chinese Journal of Medical Genetics, 2022; 31(3): 560-571.
12. Krati, Babita Rawat, Abhishek Bhardwaj, Amandeep Singh, A Comprehensive Review on Indian Barnyard Millet (Echinochloa frumentacea), International Journal of Pharmaceutical Technology and Biotechnology, 2025; 12(1): 01-07.
13. Krati, Dr. Martolia Jaya, et. al, A Comprehensive review on in-vitro methods for antimicrobial activity" Educational administration: Theory and Practice". 2024; 30(6), 8 (2977-2984).
14. Esha Vatsa, Dr. Samriti Faujdar, Shilpa Chandel, Nidhi Chaudhary, Ashok Kumar, Neeru, "Studies on anti-inflammatory activities of whole plant of Dendrobium macraei Lindl." European Chemical Bulletin, 2023; 12(Special Issue 1): 657-664.
15. Esha Vatsa, Dr. Samriti Faujdar, Nitin Kumar, Nidhi Chaudhary, Shilpa Chandel, Neeru, Mehak Aggarwal "Current studies to justify the medicinal potential of the orchid Dendrobium macraei Lindl." European Chemical Bulletin, 2023; 12(S3): 5822-5830.
16. Divya Negi Rawat, Anjali Bisht, Esha Vatsa, Deepika Chandra, Nidhi Chaudhary, Ashok Kumar "Urinary bacterial profile and antibiotic susceptibility pattern among patients of urinary tract infections" High Technology letters, 2023; 29(10): 115-128.
17. Mehak Aggarwal, Ujjwal Nautiyal, Harmeet Singh, Esha Vatsa, Nidhi Chaudhary, Anjali Bisht, Divya Negi "Development and evaluation of drug delivery system containing luliconazole" High Technology letters, 2023; 29(11): 633-652.
18. Jagriti Gairola, Prashant Kukreti, Anjali Bisht, Divya Negi, Nidhi Chaudhary, Esha Vatsa "Development of Chronotherapeutic Delivery System for the Oral Administration of Aceclofenac for Rheumatoid Arthritis by Using Different Polymers" Journal of Chemical Health Risks, 2023; 13(6): 1180-1192.

19. Nidhi Chaudhary, Dr. Deepak Nanda, Dr. Esha Vatsa, Mithilesh Kesari, Harshita Chandra, Simran Singh Rathore "The Promise of Usefulness of the Evergreen Shrub Cassia auriculata" Journal of Advanced Zoology, 2023; 44(4): 1249-1261.
20. Ms Pooja Yadav, Dr. Esha Vatsa, Dr Arti Rauthan, "Enhancing Menstrual Awareness among Adolescent Girls: Evaluating the Influence of School Initiatives" Journal of Chemical Health Risks, 2024; 14(02): 3141-3149.
21. Mehak Aggarwal, Esha Vatsa, Nidhi Chaudhary, Shilpa Chandel, Shipra Gautam, "Formulation and Evaluation of Polyherbal Face Pack" Research Journal of Pharmacy and Technology, 2024; 17(6): 2481-2485.
22. Esha Vatsa, Mehak Aggarwal, Nidhi Chaudhary, Shipra Gautam, Neeru, Nitin Kumar, "Comparison Based on Pharmacognostical and Pharmacological Profile of Thuja Orientalis Linn. And Thuja Occidentalis Linn.: A Review" Naturalista Campano, 2024; 28(1): 3208-3219.
23. Priya Pandey, Esha Vatsa, Gaurav Lakhchora, Md Shamsher Alam, Niyaz Ahamad Ansari, Mohammad Dabeer Ahamad, Sarafarz Ahamad, Mukul Singh, Nitin kumar, "Nano Medicine Advancements in Addressing Rare Neurological Disorders: A Focus on Globoid Cell Leukodystrophy (Krabbe's Disease) Treatment" African Journal of Biological Sciences, 2024; 6(3): 2654-2684.
24. Esha Vatsa, Nidhi Chaudhary, Priya Khadwal, Mehak Aggarwal, Tanya Aggarwal, and Nishant Bhardwaj, "In vitro Antidiabetic Effect and Phytochemical Screening of Cassia biflora Mill." Indian Journal of Natural Sciences, 2025; 15(88): 87726-87733.
25. Anil Kumar, Dr. Esha Vatsa, "AI-Powered Embryo Selection is revolutionized: A Review" South Eastern European Journal of Public Health, 2025; XXVI (1): 6223-6230.
26. Lohani, V., A R, A., Kundu, S., Akhter, M. Q., & Bag, S. Single-Cell Proteomics with Spatial Attributes: Tools and Techniques. ACS omega, 2023; 8(20): 17499–17510. https://doi.org/10.1021/acsomega.3c00795.
27. Amandeep Singh, Deepak Nanda, Ashok Kumar and Abhishek Bhardwaj. In vitro evaluation of anti-inflammatory activity of ageratum conyzoides leaves by Human Red Blood Cell (HRBC) membrane stabilization method, International Journal of Research in Pharmaceutical and Nano Sciences, 2023; 12(6): 196-202.
28. Amandeep Singh, Deepak Nanda, Ashok Kumar, Abhishek Bhardwaj. In vitro evaluation of anti-inflammatory activity of ageratum conyzoides leaves by Human Red Blood Cell (HRBC) membrane stabilization method, International Journal of Research in Pharmaceutical and Nano Sciences, 2023; 12(6): 196-202.
29. Singh A, Nanda D, Bhardwaj A, Kumar A. A pharmacological investigation for therapeutic potential of Callistemon citrinus as an anthelmintic agent (Bottle-Brush Plant). IP Int J Comprehensive Adv Pharmacol, 2024; 9(3): 206-210.
30. Yogesh Tiwari, Amandeep Singh, Bhupendra Kumar, Ashok Kumar. "In Vitro Evaluation of Alpha Amylase Activity of Bark Extracts of Ficus Auriculata". International Journal of Innovative Science and Research Technology. December, 2017; 2(12): 88-92.
31. Bhupendra Kumar, Amandeep Singh, Yogesh Tiwari, Ashok Kumar. UV PROTECTIVE ACTIVITY OF GLYCINE MAX SEEDS. Indian Research Journal of Pharmacy and Science, 2017;15: 1190-1195
32. Reena Bhatt, Ashok Kumar, Ankita Sharma. Formulation and evaluation of shampoo formulated by glycine max seeds. Indian Research Journal of Pharmacy and Science; 15(2017)1232-1238
33. Kumar A, Nanda D and Gupta A. "A Prospective Study on the Risk Determinants and Economic Burden of Adverse Drug Reactions in Tertiary Care Hospital". Indian Journal of Natural Sciences, 2025;15(88): 87957-87961

34. Ashok Kumar, Deepak Nanda and Abhishek Gupta A holistic approach to adverse drug reactions in hospitals: Classification, risk factors, assessment and economic evaluation- A review. J. Exp. Zool. India, 2024; 27: 2337-2348. DOI: https://doi.org/10.51470/jez.2024.27.2.2337
35. Sakshi Garg, Ashok Kumar, Varsha Deva, Preeti Biswas, Harsh Rastogi, Heena Farooqui. Immediate-Release Drug Delivery System, Current Scenario, And Future Perspective-A Narrative Review. Jundishapur Journal of Microbiology, 2022; 15(1): 6509-6519
36. Ashok Kumar, Deepak Nanda, Abhishek Gupta Pattern of Adverse Drug Reactions and Their Economic Impact on Admitted Patients in Medicine Wards of a Tertiary Care Hospital. Library Progress International, 2024; 44(4): 1120-1139.
37. Alisha Rawat, Meenakshi Sajwan, Yamini Chandola, Nidhi Gaur "Assaultive role of thiamine in coalition with selenium in treatment of liver cancer", Journal of emerging technologies and innovative research, 2022; 9(1); 2349-5162.
38. Ghildiyal, P., Bhatt, A., Chaudhary, N., Narwal, S.,Sehgal, P. "Study of various biochemical parameters on atrazine induced glucose-6-phosphate dehydrogenase deficiency in brain" International Journal of Health Sciences, 2022; 6(S7): 2552-2558.
39. Alok Bhatt, Arun Kumar, Pallavi Ghildiyal, Jyoti Maithani, Nidhi Chaudhary, Manish Nawani, Sonia Narwal "Phytochemical Profile of Melissa parviflora Benth" Neuro Quantology, 2022; 20(9); 2426-2428.
40. Palika Sehgal, Alok Bhatt, Sonia Narwal, Deepak P. Bhagwat, Nidhi Chaudhary et.al Formulation Characterization Optimization and In Vitro Evaluation of Aceclofenac Topical Emulgel, Neuro Quantology, 2022; 20(14): 1-09.
41. Sneha Rawat, Praveen Kumar Ashok, Abhishek bhardwaj "A review on Oro dispersible Tablet of Telmisartan" Org-Journal of Emerging Technologies and Innovative research (JETIR), May 2023; 10(5):i104-i112.
42. Jaison Varghese, Nitin kumar, Sapna Chaudhar, Abhishek Bhardwaj(2024) "Comparative In-Vitro Antioxidant and Antimicrobial Potential of Some Medicinal Plants"African Journal of Biological Sciences, https://doi.org/10.48047/AFJBS.6.Si3.2024.3340-3346.
43. Asima Imtiyaz, Ajay Singh, Abhishek Bhardwaj(2024) "Green synthesis of iron oxide nanoparticles from Iris kashmiriana (Mazar-Graveyard) Plant Extract its characterization of biological activities and photocatalytic activity" Journal of Industrial and Engineering Chemistry, https://doi.org/10.1016/j.jiec.2024.09.004.
44. Hem Chandra Pant, Bhawana Goswami, Ashok Kumar, Abhishek Bhardwaj, Shanti Rauthan and Amita pandey "A Review Paper on Bacopa monniera and Role of Artificial Intelligence (AI) in Medicinal Plant for Management and Treatment of Various Diseases" Indian Journal of Natural Sciences, 2025; 15(88): 01-10.
45. Vishwajeet Bachhar, Vibha Joshi, Ajay Singh, M. Amin Mir, Abhishek Bhardwaj(2025)"Antibacterial, Antioxidant, and Antidiabetic Activities of TiO2 Nanoparticles Synthesized Through Ultrasonication Assisted Cold Maceration from Stem Extract of Euphorbia hirta" Nano Bioscience, https://doi.org/10.33263/LIANBS141.001.
46. Nidhi Chaudhary, "A review on: The deciduous shrub "Punica granatum", European journal of biomedical and pharmaceutical sciences, 2016; 3(7); 2349-2388.
47. Singh Harmeet and Nidhi Chaudhary, "Evaluation of Lakshadi Guggul on experimentally induced global cerebral ischemia/reperfusion injury". World journal of Pharmacy and Pharmaceutical Sciences, 2016; 6(1); ISSN 2278-4357.

48. Nidhi Chaudhary and Harmeet Singh, "Evaluation of Punica Granatum Leaves Extract In Scopolamine Induced Learning And Memory Impairment In Mice". World journal of Pharmacy and Pharmaceutical Sciences,6(6); 1677-1703.
49. Amandeep Singh, Pankaj Nainwal,Deepak Nanda,D.A. Jain, SOLUBILITY ENHENCEMENT OF PIOGLITAZONE WITH COMPLEXATION OF HYDROXYPROPYL-β-CYCLODEXTRIN, Digest Journal of Nanomaterials and Biostructures, Apr 2012 2(4): p.91-97.
50. Pankaj Nainwal Deepak Nanda, Amandeep Singh, D. A. Jain, Quantitative spectrophotometric determination of domperidone tablet formulations using ibuprofen sodium as hydrotropic solubilizing agent, Digest Journal of Nanomaterials and Biostructures, 2012; 2(4): 751 – 753
51. Deepak Nanda, Pankaj Nainwal, Amandeep Singh, D.A.Jain, Review on mixed-solvency concept: a novel concept of solubilization, Deepak Nanda et al.,Journal of Pharmacy Research, 2012; 3(2):411-413
52. Pankaj Nainwal, Amandeep Singh, Deepak Nanda, D.A.Jain, NEW QUANTITATIVE ESTIMATION OF ROSUVASTATIN BULK SAMPLE USING SODIUM BENZOATE AS HYDROTROPIC SOLUBILIZING AGENT, Journal of Pharmacy Research, 2012; 3(1): 6-8
53. Nainwal.P, Bhagla.A, Nanda.D, STUDY ON ANTIOXIDANT POTENTIAL AND WOUND HEALING ACTIVITY ON THE AQUEOUS EXTRACT OF FRUITS OF GARCINIA MANGOSTANA, IJPI's Journal of Pharmacognosy and Herbal Formulations, Volume-1
54. Pankaj Nainwal, Kapil Kalra, Deepak Nanda, Amandeep Singh, STUDY OF ANALGESIC AND ANTI-INFLAMMATORY ACTIVITIES OF THE ETHANOLIC EXTRACT ARIAL PARTS OF FUMARIA VAILLANTII LOISEL, Asian Journal of Pharmaceutical and Clinical Research, 2011; 4(1).
55. Amandeep Singh, Pankaj Nainwal, Deepak Nanda, D.A.Jain, SOLUBILITY ENHANCEMENT STUDY OF PIOGLITAZONE USING SOLID DISPERSION AS SOLUBILIZATION TECHNIQUE, International Journal of Science Innovations and Discoveries, Amandeep Singh et al., IJSID, 2011; 1(2): 95—100
56. Amandeep Singh, Pankaj Nainwal, Deepak Nanda, D. A. Jain, THE SOLUBILITY ENHANCEMENT STUDY OF PIOGLITAZONE USING DIFFERENT SOLUBLIZATION TECHNIQUIES, International Journal of Pharmacy & Pharmaceutical Sciences, 2012; 4(2).
57. Deepak Nanda, Pankaj Nainwal, Amandeep Singh, D.A.Jain, SOLUBILITY ENHANCEMENT STUDY OF DOMPERIDONE USING DIFFERENT SOLUBILIZATION TECHNIQUES, International Journal of Pharmacy and Pharmaceutical Sciences 2012; 2(3).
58. Pankaj Nainwal, Priyanka Sinha, Amandeep Singh, Deepak Nanda, D.A.Jain, A COMPARATIVE SOLUBILITY ENHANCEMENT STUDY OF ROSUVASTATIN USING SOLUBILIZATION TECHNIQUES, International Journal of Applied Biology & Pharmaceutical Technology, Oct - Dec -2011; 2(4).
59. Pankaj Nainwal, Deepak Nanda, Amandeep Singh, D. A. Jain, FORMULATION AND EVALUATION OF SOLID DISPERSION OF ROSUVASTATIN WITH VARIOUS CARRIERS,Pharmacie Globale International Journal Of Comprehensive Pharmacy, Issn 0976-8157.
60. Pankaj Nainwal, Amandeep Singh1, Deepak Nanda, D.A.Jain, SOLUBILITY ENHANCEMENT OF AN ANTIHYPERLIPIDEMIC DRUG ROSUVASTATIN BY SOLID DISPERSION TECHNIQUE, International Journal of PharmTech Research IJPRIF ISSN: 0974-4304, March-June 2012; 2: 3.

61. Kshitiz Agrawal, Pragati Bailwal, Amandeep Singh. Prem Saini, DEVELOPMENT OF QUALITY STANDARDS OF SUPRABHATAM CHURNA: A POLY HERBAL FORMULATION, International Journal of Pharmaceutical Research & Development,IJPRD, 2011; 4, June 2012.
62. Kapil Kalra, Amandeep Singh, Manisha Gaur, Ravindra P. Singh, and D. A. Jain, ENHANCEMENT OF BIOAVAILABLITY OF RIFAPENTINE BY SOLID DISPERSION TECHNIQUE, International Journal Of Pharmacy & Life Sciences, Kalra et al., April, 2011; 2(4).
63. Pankaj nainwal, Ranveer batsa, Amandeep singh, Deepak nanda, MEDICINAL PLANT STUDIES INFLUECED BY THE BIOTECHNOLOGICAL METHODS: A UPDATED REVIEW, International Journal of Pharma and Bio Sciences Apr-June-2011; 2(2).
64. Amandeep Singh, Sandhiya Pal, Prem Saini, IN- VITRO EVALUTION OF ANTI-INFLAMMATOTRY ACTIVITY OF TERMANALIA ARJUNA BARK EXTRACT, Journal of Innovative trends in Pharmaceutical Sciences,Vol-1(1): 9-12.
65. Amandeep Singh, Pramila Chauhan, Prem Saini, IN-VITRO ANTI-INFLAMMATORY EVALUTION OF HYDROALCOHALIC LEAVES EXTACT OF PINUS ROXBURGHII BY HRBC METHOD, International journal of Research in Pharmaceutical and Nano Sciences, 2013; 2(3): 268-271.
66. Amandeep Singh, Sumit Negi, Prem Saini, In Vitro Anti-Inflammatory Evaluation Of Leaves Using Hydroalcohalic Extract Of "Mangifera indica" International Journal of Pharmacy and Integrated Life Sciences, V1-(I7) PG (93-98).
67. Aman Deep Baghla, Kshitij Agarwal, Ramesh Verma and Deepak Nanda, Wound Healing Effect of the Aqueous Extract of the Leaves of Psidium guajava Linn., International Journal of chemicals and Life Sciences, 2013; 02 (03): 1104-1106.
68. Aman Deep Baghla, Kshitij Agarwal, Ramesh Verma and Deepak Nanda, WOUND HEALING EFFECT OF THE AQUEOUS EXTRACT OF THE LEAVES OF PSIDIUM GUAJAVA LINN., International Journal of chemicals and Life Sciences, 2013; 02(03): 1104-1106.
69. Bhupendra Kumar, Meenakshi Ghildiyal, Yogesh Tiwari, Deepika Chauhan, Amandeep Singh, IN-VITRO ANTI-INFLAMMATORY ACTIVITY OF GLYCINE MAX SEEDS, Indo American Journal Of Pharmaceutical Sciences, 2018; 05(02): 868-871.
70. Piyali Dey, Jyoti Pandey, Bhupendra kumar, Amandeep Singh, IN VITRO ANTHELMINTIC ACTIVITY OF BARK EXTRACTS OF ARTOCARPUS HETEROPHYLLUS, International Journal of Pharmacy & Pharmaceutical Research, 2018; 03(11): 33-40.
71. Bhupendra Kumar, Yogesh Tiwari, Amandeep Singh, Vineet Kumar, IN VITRO ANTIUROLITHIC ACTIVITY OF FICUS PALMATA LEAVES, International Journal Of Pharmaceutical Technology And Biotechnology, 2019; 6(1): 01-09.
72. Md. Daneyal Khurshid, Vivek Shukla, Bhupendra Kumar and Amandeep A Review Paper on Medicinal Properties of Phyllanthus emblica, International Journal of Pharmacy and Biological Sciences, 2020; 10(3): 102-109.
73. Mr. Dwivedi Vishal, Mrs. Nisha A Bhatt, Dr. Amandeep Singh PREPARATION AND STANDARDIZATION OF NAVKARSHIKA CHURNA, World Journal of Pharmacy And Pharmaceutical Sciences, 2020; 9(8).
74. Mitun Saha1, Mr. Bhupendra Kumar, Dr. Amandeep Singh Review Article on Various Phytochemicals and Different Medicinal Activities of Haritaki International Journal of Innovative Science and Research Technology, June 2020; 5(6).