Pharmaspire

RESEARCH ARTICLE

Formulation and evaluation of herbal toothpaste

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ABSTRACT

Introduction: Oral hygiene has become increasingly important globally in recent years. In conjunction with utilizing a toothbrush, toothpaste serves to keep the esthetics and dental health. **Scope:** This study examined the global significance of oral hygiene, emphasizing the integral role toothpaste plays in upholding both the esthetic appeal and health of teeth. This investigation extends beyond the conventional focus on plaque and debris removal, considering additional facets, such as combating bad breath and preventing tooth decay and gum disease through active ingredients. **Objective:** The purpose of this investigation was to compare the effects of herbal products on gum health and tooth enamel roughness with those of conventionally formulated toothpaste. The primary objective goal this research was to evaluate the effects of herbal toothpaste on both gum health and the surface roughness of tooth enamel. Herbal toothpastes have garnered public and professional approval due to their positive effects on teeth. **Materials and Methods:** This study employed a comparative approach, juxtaposing the effects of herbal and conventional toothpastes on gum health and tooth enamel roughness. Rigorous experimentation and analysis were conducted to measure and quantify these effects. **Results:** The findings of this study will shed light on the relative effects of herbal and conventional toothpastes on gum health and tooth enamel roughness. Across quantitative data and statistical analyses, this study attempts to offer a thorough grasp of the possible advantages and disadvantages connected with herbal oral care products compared to their traditional counterparts. **Conclusion:** The study came to the conclusion that herbal toothpaste is safer and has less negative effects than synthetic toothpaste, making it more noteworthy and accepted in dentistry research. The toothpaste's formulation has anti-microbial action against pathogens and is effective in maintaining dental and oral hygiene. The preparation of the market in relation to the formulation.

KEY WORDS: Antimicrobial, Cure, Dentrifice, Diseases, Harsh chemicals, Herbs

INTRODUCTION

Herbal products have gained considerable popularity and are experiencing a global resurgence. Compared to synthetic substances, which are often perceived as dangerous for the environment and people, herbal medicines are now viewed as symbols of safety. Botanically, a herb is defined as a plant without woody tissue, that is a characteristic of trees or bushes. Plants are called herbs that utilized for medicinal, flavoring, or fragrance qualities.[1] Herbal extracts have proven successful in dentistry as tooth cleaning and antimicrobial plaque agents, and their global use is growing at a rapid pace. People use herbal items or medications in a variety of contexts as part of their healthcare practices in many different nations.[2] Many applications of herbal extracts in dentistry have been reported, including the reduction of inflammation, antimicrobial plaque agents, histamine release inhibition, antiseptic, antioxidant, antimicrobial, antifungal, antibacterial, antiviral, and analgesic effects. In addition, they promote healing and

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effectively reduce microbial plaques in periodontitis and gingivitis, which boosts immunity.[3]

Herbs are among the remedies that God has provided for afflicted humans, and ancient medical systems, such as Ayurveda, Unani, and Siddha have acknowledged their therapeutic benefits for thousands of years. Of the 2,500 plant species that traditional healers in India employ, 100 are consistently used as sources of medication. Studying medicinal plants and their traditional uses across the world has gained popularity in the past several decades.[4] The World Health Organization estimates that approximately 80% of the global population relies on traditional medicines, including herbal remedies, for primary healthcare. The treatment of various diseases with indigenous medicines, such as medicinal plants, can provide significant economic benefits. In developed countries, approximately one-fourth of the medical drugs are derived from herbal sources.[5,6]

Oral care is often performed using natural toothbrushes made from healed plants. Primitive twig brushes are effective and provide natural bristles with healing ingredients that are incorporated into plants. Herbalist Lesley Tierra recommends using twigs containing volatile oils, tannins, and vitamins to stimulate blood circulation, clean gum tissue, and maintain healthy gums.[7] It is common in Asia to use twigs of the neem tree (Azadirachta indica). Natural dentists' daily oral rinse of healthy gum, formerly known as it has been demonstrated that herbal mouth and gum therapy is excellent for the oral cavity. A number of anti-inflammatory and antimicrobial compounds are naturally present in it, including aloe vera, calendula, Golden Seal, and grapefruit seeds. Using herbal mouth rinses to treat gingivitis, plaque, and periodontitis can improve oral health.[8,9]

The significance of preserving excellent dental health has recently come to the attention of people worldwide. This study aims to investigate the global importance of dental hygiene with a focus on toothpaste's critical role in preserving teeth's health and esthetics. Beyond the usual focus on plaque and particle removal, this study intends to examine additional elements, such as fighting bad breath and avoiding gum disease and tooth decay through the use of active compounds contained in toothpaste formulations. Experts have embraced and utilized herbal toothpastes more commonly due to their purportedly beneficial effects on oral health. Extensive testing and analysis have been conducted to measure and evaluate their effects. By using numerical data and statistical analysis, this study seeks to provide a thorough understanding of the possible benefits and drawbacks of herbal oral care products relative to their conventional equivalents. The results of the study may clarify the relative advantages of conventional toothpastes versus herbs for gum health and tooth enamel roughness, hence promoting advancements in dental research and practice. By focusing on specific aspects of formulation and assessment of herbal toothpaste, this study aims to improve uniformity and clarity. This will make it possible to examine herbal oral care products in more detail and with greater focus.

Herbal toothpaste

Herbal toothpastes are composed of natural ingredients, some of which are certified as organic. An increasing number of consumers have started to use natural toothpaste to get away from the artificial and synthetic tastes that are sometimes included in traditional toothpaste.[10] These natural toothpastes do not contain artificial flavours or chemicals. They are a good choice for individuals allergic to the foaming chemical sodium lauryl sulphate (SLS), which is frequently included in commercial toothpaste brands, or mint.[11]

One herbal toothpaste brand, Vicco, is highly trusted and uses only original herbal ingredients. It is effective in preventing gum diseases and is made from herbal stems and flowers rather than artificial ingredients. Vicco toothpaste also contains Vajradanti, which translates to "diamond teeth," and does not use any sugar.[12]

Diseases of teeth caused by conventional toothpaste

Common dental diseases

The oral cavity harbors a multitude of bacterial cells, comprising both beneficial and detrimental bacterial strains. The latter is principally responsible for a plethora of oral diseases that can affect various areas of the mouth.[13]

Some of the most common dental diseases include but are not limited to

1. Periodontal disease
2. Tooth decay and cavities
3. Mouth abscess
4. Tooth abscess.[14]

Periodontal disease

Commonly referred to as gum disease, this dental condition typically arises from neglect of regular flossing. Over time, the accumulation of bacteria that form plaques leads to the development of gingivitis or periodontitis, which are the initial stages of periodontal diseases.[15]

Symptoms of periodontal disease

Periodontal disease symptoms include bleeding gums during oral care, tender and swollen gums, widening spaces between teeth, and recurrent mouth sores.[16]

Undoubtedly, the most encouraging news is that periodontal disease can be successfully treated within a handful of dental appointments. To eliminate plaque and tartar build-up around the gum line, thorough deep dental cleaning is necessary. While some individuals may experience temporary discomfort during the procedure, it is typically administered in multiple sessions.[17,18]

Tooth decay and cavities

Tooth decay is a prevalent dental condition affecting a significant number of individuals globally, including both children and adults. This condition leads to the formation of cavities, which are brought about by the neglect of tooth brushing following the ingestion of substantial amounts of sugary and acidic foodstuffs and beverages. These substances penetrate the enamel, enabling the growth of bacteria that cause the cavities to thrive.[19,20]

Symptoms of tooth decay

Tooth decay symptoms include sharp localized pain, grey/brown spots on teeth, swollen gums, and difficulty chewing due to sensitivity.

Cavities can be treated by removing bacteria from the surface of the tooth through scraping or drilling and then filling the area with composite or amalgam material to restore the appearance of the natural tooth. In cases in which cavities have progressed to the interior pulp, a root canal procedure performed by an endodontist may be necessary. In severe cases, tooth extraction is the only treatment option.[19]

Mouth ulcers

Canker sores typically manifest as small, painful lesions on the mouth or gums, causing discomfort during eating, drinking, and speaking. Those who are female, young, or have a family history of mouth ulcers are more likely to develop these symptoms.[21]

Symptoms of mouth ulcer

Mouth ulcer symptoms may arise from minor injuries, use of sodium lauryl sulfate in oral care products, sensitivity to acidic foods, deficiencies in vitamins (B-12, zinc, folate, iron), and allergic responses to mouth bacteria.[22,23]

Tooth abscess

Untreated dental cavities, injuries, or previous dental work can lead to the formation of periapical tooth abscesses. Dentists typically treat this condition by draining the abscess and eradicating infection. If left untreated, tooth abscesses can cause severe and potentially life-threatening complications.[24]

Symptoms of tooth abscess

Tooth abscess symptoms encompass a severe, throbbing toothache sensitive to temperatures, pain during chewing, facial swelling, tender lymph nodes, a potential foul-smelling discharge upon rupture, and difficulty in breathing and swallowing.[25]

Diseases caused by oral unhealthy lifestyle

Dental decay

Dental decay is the result of an acid assault that softens a tooth's enamel and dentin. This is usually brought on by consuming sugar-containing meals and beverages. The acid assault causes a hole or cavity in the tooth over time. Dental caries is another name for dental deterioration, commonly referred to as tooth decay.[26]

What causes the dental decay?

Dental decay is the result of plaque acids, which erode the enamel and dentin of teeth over time. This erosion can damage teeth and may even require them to be filled or extracted.

Dental erosion

Tooth enamel can be damaged by acid attacks, resulting in the loss of its hard protective coating. This can expose the sensitive dentin underneath, leading to pain and sensitivity.[27,28]

What causes the dental erosion?

The temporary softening and mineral loss of the enamel on teeth following the consumption of acidic foods or beverages can be attributed to the effects of acidity. Fortunately, saliva eventually neutralizes acidity and restores the natural balance in the mouth. However, frequent occurrences of this process can prevent the enamel from adequately repairing itself, which may result in the loss of small fragments of enamel due to brushing. Consequently, gradual erosion of the surface of the teeth may occur over time.[29,30]

Gum disease

The symptoms of gum disease include inflammation, pain, and infection of the tissues that surround the teeth. Gingivitis and periodontal disease are the two primary types of gum disease.[31]

What is the reason behind gum disease?

Plaques have been linked to every gum disease as they are a result of a bacterial layer that forms on dental surfaces. While many of the bacteria on plaques are not harmful, some have been found to be the main culprits behind gum disease. Plaque is a thin film of bacteria that accumulates on teeth every day. While most bacteria in plaques are harmless, some have been linked to gum disease. Gum disease is caused by the formation of plaques.[32,33]

Sensitive teeth

Sensitive teeth can range from mild to severe discomfort that can last for hours and may also indicate more serious dental issues.

What causes sensitive teeth?

The enamel layer of the tooth protects the underlying dentin, which is softer. The tooth becomes sensitive when dentin is exposed. This commonly occurs when the tooth and gum meet and the enamel layer is thinner. There are several reasons why tooth sensitivity can occur.[34]

Role of herbs

Medicinal plants have considerable significance in the domain of human health, encompassing not only traditional uses but also medicinal properties for the treatment of various ailments. These plants represent promising sources for the identification of bioactive lead compounds, which has been attributed to the growing number of phytochemical and biological investigations.[35] The medicinal plant sector is a valuable resource for discovering novel therapeutic agents.[36]

Medicinal plants contain an extensive array of secondary metabolites with diverse biological activities *in vitro*, providing a source of novel drug candidates. The incorporation of medicinal plant extracts into oral care products is gaining traction worldwide due to their low toxicity and minimal side effects. Adequate dental care is crucial for preventing tooth decay and periodontal diseases.[37] The prevention of dental caries poses a challenge given its high prevalence in the general population, particularly among economically disadvantaged individuals who cannot afford commercial oral hygiene products. Although dental caries is recognized as an infectious disease, its clinical applications have not been fully capitalized on this information.[38]

A plethora of substances, including cetylpyridinium chloride, amine fluorides, triclosan, and chlorhexidine, have detrimental effects on the human body and the ability to discolor teeth.[39] In the field of dentistry, Herbal extracts have been used as antiseptics, antioxidants, antimicrobials, antivirals, and analgesics. They have also been used to diminish inflammation, function as antimicrobial plaque agents, stop histamine production, and more.[40]

Herbs for oral health

Because natural substances are safer than synthetic ones, formulas including them are more accepted. The goal of this study was to create herbal toothpaste with natural components, such as neem bark and stem, clove, rice starch, banyan tree roots, strawberry, and liquorice root, as shown in [Table 1]. The evaluation parameters showed promising results compared to the marketed formulations.[41]

Pharmaceutical aids

Due to the high rate of absorption displayed by the human oral mucous membrane, substances that penetrate the mouth cavity can be absorbed into the circulation. Consequently, denitrifiers employed for daily hygiene purposes must be evaluated as safe for human use. However, many commercially available denitrifiers contain toxic components that can accumulate within the body when utilized twice daily. It is crucial to choose toothpaste carefully because many well-known brands include substances that may be harmful to your health. Applying toothpaste with a toothbrush helps clean and preserve teeth,

Table 1: Common herbs for oral health

Sr. No.	Crude drugs	Biological name	Uses
1	Liquorice	Glycyrrhiza	Foaming agent
2	Strawberry	Fragaria ananassa	Whitening agent
3	Roots of banyan tree	Ficus benghalensis	Anti-inflammatory agent
4	Neem	Azadirachta indica	Antibacterial agent[43,44]

Table 2: Herbal extracts

Ingredients	Quantity
Neem extract	0.05 g
Liquorice	1.3 g
Strawberry extract	0.2 g
banyan extract	0.9 g

encourages good oral hygiene, acts as an abrasive, gets rid of food particles and dental plaque, alleviates halitosis, and delivers active components to prevent tooth decay and gum inflammation.[42]

SLS

SLS and lauryl sarcosinate are common foaming ingredients included in toothpaste that help retain the paste in the mouth and remove oil and debris from teeth. However, these detergents can also lead to sensitization and interfere with taste bud function by breaking up phospholipids. In addition, they can cause irritation in the mouth and lead to issues such as mouth ulcers, gastrointestinal issues, canker sores, and even cancer, per some research. The International Agency for Research on Cancer has designated SLS as a category 2 B carcinogen, meaning that it is a recognized carcinogen with traces of 1,4-dioxane. Moreover, it is also harmful to aquatic life.[45]

Flavouring agents

Strong flavorings and sweeteners included in toothpaste are mostly responsible for its flavor, since they cover over the flavors of other substances and make the product more palatable. Popular fruits and plants, as well as artificial tastes, such as mint, cinnamon, anise, and vanilla, are frequently utilized. Common sweeteners used in toothpastes include sodium saccharin, xylitol, sucralose, and aspartame. Oils, extracts, and synthetic substances are examples of flavor additions that might irritate oral tissues and produce heartburn.[46]

The incorporation of diethylene glycol as a sweetener in certain Chinese-manufactured toothpastes has led to a global uproar and subsequent ban due to its toxic properties. Aspartame, the most commonly utilized artificial sweetener, is metabolized in the body to generate poisonous methanol

and formaldehyde, and it is 200 times sweeter than sugar.[47] Many negative side effects have been associated with aspartame consumption. Moreover, aspartame intake has been connected to the onset of illnesses including fibromyalgia, diabetes, Parkinson's disease, multiple sclerosis, epilepsy, lymphoma, and Alzheimer's disease. Another sweetener found in toothpaste is saccharin, which is 350 times sweeter than cane sugar and is generated from crude oil. It has also been connected to the creation of substances that cause cancer.[3]

Fluoride

Conventional toothpastes sold in the United States generally comprise fluoride, which reinforces tooth enamel and protects it against bacteria-generated acids. Fluoride does, however, have some serious health hazards, especially for young children, who may experience skin rashes, stomach issues, permanent tooth discoloration, and decreased glucose metabolism. The US Food and Drug Administration (FDA) suggests including a warning label on fluoride toothpaste in light of these worries. Fluoride is a poisonous material that builds up in tissues over time and can lead to a number of serious health problems, such as problems with the nervous and endocrine systems. Youngsters are especially susceptible to excessive exposure. Water fluoridation was heralded as a major accomplishment of the 20th century; however, it may react with chlorine in water to create deadly carcinogens, such as chloroform. In addition, toothpaste containing fluoride can be hazardous when used in excess, and dental fluorosis in children older than 12 months is a big worry when toothpaste is used in excess. In addition, using topical fluoride may cause nausea and vomiting.[4]

Anti-microbials

The use of antimicrobial agents in toothpastes is designed to inhibit the growth of oral bacteria. Among these substances were sodium fluoride/monofluorophosphate, triclosan, amylase/glucose oxidase, and hexamidine diisethionate. Colgate Total toothpaste, which has received FDA approval, contains triclosan, an antibacterial ingredient that is used to treat gingivitis. However, concerns have been raised regarding the potential of triclosan to contribute to antibiotic resistance and endocrine disruption. Studies have linked triclosan exposure to various health problems, including breast, ovarian, testicular, and prostate cancers, in addition to low birth weight and preterm infants, females' early puberty, and boys' undescended testicles.[5] Furthermore, it has been demonstrated that triclosan causes abnormalities of the fetal bone in rats and mice, a finding that may be connected to its hormonal effects. Triclosan disrupts the signaling between cells in the heart, brain, and other organs, potentially accelerating the development of breast cancer. Although triclosan was outlawed by the FDA in 2016 for use in soaps, it is still allowed in toothpaste. To cure dental and oral conditions, toothpastes also include a lot of antibiotics. Research has demonstrated that using a mouthwash containing chlorhexidine can effectively reduce plaque and gingivitis.[6]

Abrasives

Commonly used materials for removing surface stains and debris from teeth consist of marble, eggshells, calcium carbonate, calcium phosphate, sodium bicarbonate (baking soda), silica, and alumina. However, these substances can be abrasive to teeth and should be used with caution. In addition, baking soda and calcium are employed as abrasives in toothpastes. During brushing, the baking soda releases carbon dioxide, resulting in the production of additional foam.[7]

Thickening agent

Guar gum, xanthan gum, cellulose gum, and carrageenan are examples of thickening agents used in toothpaste, and gluten contributes to product thickness and consistency. Gluten, although widely used, is a source of concern because it can trigger celiac disease and may induce inflammation in tumors of the colon and intestine. Humectants: sorbitol, propylene glycol, and glycerol, help maintain moisture in toothpaste by preventing water loss. Xylitol, a moisture-providing ingredient, is also better in preventing cavities than fluoride, especially in kids' permanent teeth. Xylitol is effective, yet it doesn't seem to have any negative side effects.[8]

Propylene glycol is a surfactant that is used in toothpaste and other cosmetic and medicinal formulations as dispersion. However, its security in personal hygiene products is debated, as it can irritate the skin, eyes, lungs, and organs, and may cause reproductive issues, cancer, and inflammation of the skin. White pastes typically contain titanium dioxide, which has a white opaque appearance. However, titanium dioxide can be an allergen, and some individuals may experience hypersensitivity to polyethylene glycol, a common dispersant in toothpastes.[9]

Preservative

Toothpastes often contain preservatives, such as sodium benzoate, methylparaben, and ethylparaben. While these parabens are effective in preventing the growth of bacteria and mold, they have been linked to potential health risks such as cancer, reproductive issues, and developmental problems due to their ability to mimic estrogen. Despite this, sodium benzoate is generally considered a safe preservative for use in toothpastes.[10,11]

MATERIALS AND METHODS

Collection

Neem was gathered from plants found in the Guru Gobind Singh College of Pharmacy's medicinal garden campus, which is located in Yamunanagar, Haryana, India.

Some ingredients, such as rosemary oil, olive oil, rose water, $CaCO_3$, clove oil, vegetable glycerin, and rock salt, were purchased from the local market. Some ingredients of rice starch and calcium carbonate were obtained from the College Laboratory Department of Pharmacognosy.

Preparation of plant extracts

All herbal ingredients were dried. The required amount of ingredients was weighed and taken in mortar and pestle neem leaves, roots of banyan tree, liquorice root, and strawberry were extracted with distilled water as shown in Figure 1 and Table 2.

Extraction of maceration process

Fresh neem leaves, liquorice roots, strawberries, and roots of banyan trees were extracted with distilled water using a maceration process for 48 h and filtered. The extract was evaporated above its boiling point. The extracts were stored in a beaker in a refrigerator until further use, as shown in Figure 2.[13]

Morphological evaluation

The morphological evaluation of herbal ingredients was conducted to assess their organoleptic properties, including color, odor, taste, size, and shape.

Chemical composition

The composition of chemicals used in the formulation of herbal toothpaste was determined. This included a variety of oils and extracts, including rice starch, calcium carbonate, citric acid, rosemary oil, mint oil, clove oil, neem oil, liquorice extract, banyan extract, strawberry extract, olive oil, rose water, and vegetable glycerine.

The composition of chemicals is shown in Figure 3 and Table 4.

Preparation of herbal toothpaste

The preparation of gums and humectants resulted in adequate dispersion, followed by the gradual addition of other powdered components to form a mucilaginous mixture through continuous stirring. Subsequently, the aqueous media and extracts were combined and stirred to achieve the desired detergent flavors, with additional ingredients incorporated.[14]

Analysis of toothpaste

The physical examination of the color-formulated toothpaste involved assessing visual color, determining odor through smelling, and manually checking taste by sampling the formulation.

Threading property

The assessment of the threading property of each toothpaste was conducted by squeezing it onto the entire toothbrush and then slowly lifting it up, according to the following criteria- Evaluation criteria of threading property: Toothpaste application varies: Smooth placement on a toothbrush (1), light threading (2), or difficulty due to severe threading.[48]

Moisture content

Weigh 10 g toothpaste in a porcelain dish, dried in an oven at 105°C, and cooled in a desiccator, and the weight loss was recorded.[15]

pH

The pH of the herbal toothpaste formulation was gauged utilizing a pH meter. A 150 mL beaker was filled with 10 g of toothpaste and 10 mL of water that had been boiled and subsequently cooled. The mixture was stirred vigorously to create a suspension.[16]

Homogeneity

Toothpaste is typically dispensed from a collapsible tube or other appropriate container by applying a standard force at 27 ± 20°C. As force was applied, most of the toothpaste contents were squeezed out of the tube and then progressively rolled out.[28]

Determination of anti-bacterial activity

Determination of sharp and edge abrasive particles

Produce 15–20 cm of content on butter paper for at least ten collapsible tubes and then use your fingertip to press down on the entire length of each tube to check for the presence of sharp and hard-edge abrasive particles. It should be noted that toothpaste does not contain these types of particles.

Determination of fineness

Approximately 10 g of toothpaste was combined with 50 mL of water in a 100-mL beaker and stirred for 30 min to ensure complete dispersion. The resulting solution was then moved to a 150-micron IS sieve, washed with a slow stream of tap water, and drained under running tap water. The sieve was subsequently dried in an oven at 105 ± 20°C. Any remaining particles on the sieve were transferred to a watch glass and weighed. The percentage of material retained on the sieve was calculated by dividing the retained mass by the total amount of material taken and multiplying by 100.

Determination of Foaming Power

The foamability of the developed toothpaste formulation was assessed by introducing a small quantity of the formulation mixed with water into a measuring cylinder.

Figure 1: Liquorice root and Strawberry

Figure 2: Calculation of percentage moisture content

Figure 3: Composition of chemicals

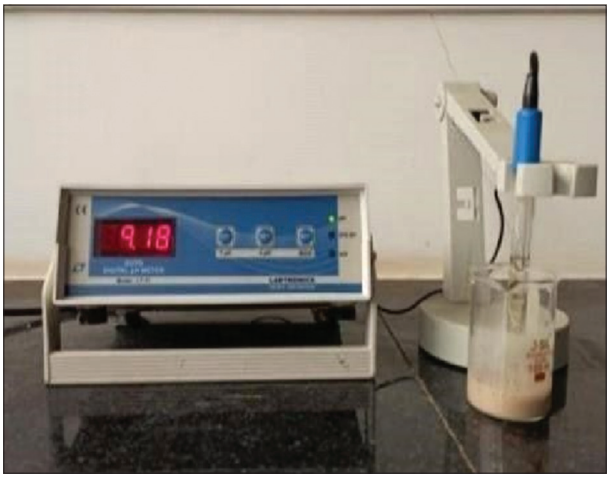

Figure 4: pH meter

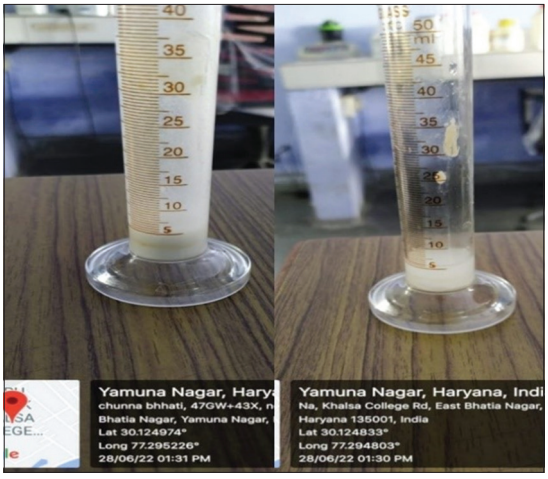

Figure 5: Foamability determination

Figure 6: Determination of antimicrobial potential of formulated toothpaste

The initial volume was observed, the sample was agitated 10 times, and the resulting volume of the foam was documented.[30]

Determination of anti-microbial activity

An *in vitro* antimicrobial study of the formulated paste was carried out using the disc diffusion method on Muller Hinton Agar medium against the pathogenic bacterial strain *Staphylococcus aureus* (MTCC 3160). The bacterial cells were cultured on Muller Hinton agar plates and allowed to multiply. The paste containing the disks was applied to bacterial plates and incubated at 37°C for 24 h. The diameter of the zone of inhibition (ZOI) was measured in millimeters (mm) to ascertain the minimum inhibitory concentration (MIC). MIC was determined as the minimum concentration at which the compound displayed no visible microbial growth. The procedure entailed creating a microbial suspension at approximately 10 colony-forming units per milliliter, applying it to a Petri

Table 3: Morphological evaluation

Organoleptic properties	Roots of banyan	Strawberry	Liquorice roots	Neem leaves	Lemon juice
Color	Brown in color	Rosy red color	Dark reddish, outer surface pale yellow	Green color leaves	Green yellow color
Odor	Delicate and crisp floral	Aroma and sweet	Faint and characteristics	Specific odor	Strong, fragrant aromatic
Taste	Bitter taste	Sweet and sour	Sweet, free from bitterness	Bitter taste	Aromatic and bitter
Size	20–30 meters in length	3–10 cm in length	20–50 cm length and 2 cm in diameter	20–25 cm length	5–12 cm in length
Shape	Elliptical in shape	Oval in shape	Cylindrical pieces which are straight may be peeled or unpeeled	Irregular in shape	Irregular in shape

Table 4: Composition of chemicals

Ingredients	Quantity	Uses
Clove oil	0.02 g	Anti-microbial
Neem extract	0.05 g	Anti-bacterial
Liquorice extract	1.3 g	Foaming agent
Banyan extract	0.9 g	Bleeding agent
Strawberry extract	0.2 g	Whitening agent
Olive oil	2.5 g	Anti-inflammatory
Rose water	q.s	Flavoring agent
Vegetable glycerine	44 g	Humectant
Rice starch	1.2 g	Thickening agent
Calcium carbonate	41 g	Binder and abrasive
Citric acid	0.1 g	Preservative
Rock salt	0.2 g	Anti-cavity
Rosemary oil	1.6 g	Re-mineralising agent
Mint oil	q.s	Cooling agent

dish through serial dilution, and incubating the dish at 37 ± 1°C. The MIC value was ascertained, and the average was computed. Following 15–16 h of incubation, each plate underwent scrutiny for consistent circular and confluent growth patterns. The diameter of the ZOI was subsequently measured, and the findings were interpreted.[18]

RESULTS AND DISCUSSION

Herbs and herbal extracts have been proven to be blessings for mankind. Considering the benefits of herbs in therapeutics, including dentistry, we prepared a herbal toothpaste that is thoroughly composed of natural extracts, which are safe for children as well.

The herbal toothpaste formulation consisted of neem, liquorice, banyan tree root, strawberry, and other natural oils/ingredients. We conducted trial phases of the formulation (i.e. single batch) and performed evaluator tests, including pH, foamability, moisture content, and physical examination. The formulated herbal toothpaste was beige in color, showed good uniformity, good abrasive power, and good antimicrobial activity [Tables 3,5 and 6].

Table 5: Physical evaluation of herbal toothpaste

Sr. No.	Parameter	Observation
1	Color	Beige
2	Odor	Characteristics
3	Taste	Characteristics
4	Threading property	Smooth

Physical examination

Color

The Formulated herbal toothpaste has a brown color, which shows the presence of natural ingredients without any chemical coloring agents.

Odor

The toothpaste has a unique odor that is nice & mild, reflecting the natural smell of its plant ingredients.

Taste

The toothpaste has a unique taste that is acceptable, without the fake sweetness or bitterness found in some synthetic toothpastes.

Threading Property

The threading property of toothpaste is smooth, ensuring an easy & consistent application on the toothbrush & enabling uniform spreading in the mouth.

Evaluation result

pH

The pH of prepared plant toothpaste is 9.18. This basic pH helps in keeping the mouth environment, possibly lowering the chance of acid-related dental problems such as tooth loss and damage.

Homogeneity

The toothpaste shows good homogeneity, suggesting that chemicals are well-mixed and evenly spread throughout

Table 6: Various evaluation parameters of herbal toothpaste

Sr. No.	Parameters	Observation
1	pH	9.18
2	Homogeneity	Good
3	Abrasiveness	Good abrasive
4	Foamability	1.5 cm
5	Moisture content	9.6
6	Fineness	Fine

mixture. This regularity ensures each treatment offers same healing benefits.

Abrasiveness

The toothpaste has good abrasive power, which is important for successfully cleaning teeth plaque and surface spots without causing damage to enamel. This balance is important for keeping mouth health and avoiding tooth caries.

Foamability

The foam height was tested at 1.5 cm. Adequate foamability is important as it helps in the spread of toothpaste throughout the mouth, ensuring all areas of teeth are cleaned effectively.

Moisture content

The moisture content of toothpaste is 9.6%. This amount of wetness ensures that toothpaste stays flexible and easy to apply while also keeping its stability over time.

Fineness

The toothpaste is described as fine, meaning it has a smooth structure without any gritty bits. This quality improves user experience by giving a nice taste and ensuring soft yet effective cleaning.

pH

The pH of the formulated herbal toothpaste was calculated using a pH meter, as shown in Figure 4, and was recorded as 9.18, by simply defining the basic characteristics of the formulation. This basic pH level is beneficial for oral health as it helps reduce acids made by bacteria in the mouth, thereby lowering the risk of tooth loss and enamel damage. Maintaining a basic pH can also support natural remineralization process of teeth and help to general oral health.

Determination of foaming power

The foaming ability of the product was assessed by taking a small amount of water in a measuring cylinder, as shown in Figure 5, and was recorded as 1.5 cm. Sufficient foamability is crucial as it facilitates the mechanical elimination of debris and tartar from teeth and gums. In addition to providing complete cleanliness and freshness, foam helps toothpaste's active components disperse evenly throughout mouth.

Moisture content

The Weight loss of the product was evaluated, as shown in Figure 2, and the percentage of moisture content was recorded as 9.6. Maintaining toothpaste's structure, consistency, and ease of application requires right amount of moisture. Controlled wetness prevents toothpaste from drying out or becoming too runny, ensuring it remains flexible and effective throughout its shelf life.

Anti-microbial activity

The herbal toothpaste demonstrated good antimicrobial activity. This formulation exhibited an impressive ZOI of 12 mm. The combination of herbal toothpaste and its impressive 12-mL ZOI against oral disorders demonstrated excellent antibacterial activity. This antibacterial efficacy is essential for preventing development of harmful oral bacteria and, as a result, lowering risk of periodontal disorders, gingivitis, and tooth decay. Natural antibacterial ingredients, such as licorice and neem enhance toothpaste's capacity to maintain dental health and cleanliness of the mouth.

The study's findings are consistent with recent investigations on efficacy and security of plant-based toothpaste [Figure 6]. According to studies, licorice and neem, two common herbal substances, have strong antibacterial properties make them even more beneficial for dental health. Our mixture's basic pH of 9.18 is consistent with research showing a higher pH helps lower bacterial acidity and promote a healthier oral environment. A previous research that demonstrated balance required in toothpaste formulas to provide efficient cleaning while maintaining tooth health is consistent with excellent abrasion power without harming enamel.

The herbal toothpaste's observed benefits on tooth enamel roughness and gum health may be attributed to synergistic impact of its natural constituents. Because of their well-known antibacterial properties, licorice and neem help prevent infections by reducing bacterial burden. By lowering acids, basic pH preserves enamel and promotes remineralization. Plaque and debris are thoroughly removed from gums while toothpaste is gentle on them thanks to its smooth texture and sufficient moisture content [Figure 6].

DISCUSSION

The toothpaste showed a consistent beige hue, indicating the absence of artificial coloring ingredients, which was a positive outcome. Its flavor and aroma, which came from natural plant elements, were pleasant and subtle. Regular

spreading in mouth was made possible by the smooth stitching quality, which ensured simple and reliable application on toothbrush.

These findings are consistent with recent studies on the efficacy and security of plant-based toothpaste. Research has shown components such as licorice and neem possess strong antibacterial properties, contributing to their effectiveness in dental hygiene. Our product's basic pH aligns with research showing a higher pH helps lower bacterial acidity and promotes a healthier oral environment. A previous research demonstrated balance required in toothpaste formulas to provide efficient cleaning while maintaining tooth health is consistent with excellent abrasion power without harming enamel. The combined activity of natural substances may be attributed to observed benefits on tooth enamel roughness and gum health. The antibacterial properties of licorice and neem are well recognized for reducing bacterial loads and preventing infections. By lowering acids, basic pH preserves enamel and promotes remineralization. Plaque and debris are removed from teeth with ease thanks to toothpaste's smooth texture and ideal moisture content.

To validate these findings and investigate long-term impacts of plant-based toothpaste on oral health, future research should include larger and more varied sample sizes in randomized controlled trials. Important phases will include examining advantageous effects of combined plant elements, enhancing combination for increased efficiency, and determining if large-scale manufacturing is cost-effective. The stability and reliability of plant toothpaste products will also need to be guaranteed by standardized testing procedures and ongoing safety evaluations.

Our findings indicate that plant-based toothpaste has great potential as a superior substitute for synthetic toothpastes, exhibiting potent antimicrobial properties and favorable physical attributes. Nevertheless, to validate these findings and validate plant toothpaste as a dependable option for dental care, further exhaustive research is required.

CONCLUSION AND FUTURE PROSPECTS

The study came to the conclusion that herbal toothpaste is safer and has less negative effects than synthetic toothpaste, making it more noteworthy and accepted in dentistry research. The toothpaste's formulation has anti-microbial action against pathogens and is effective in maintaining dental and oral hygiene. The preparation of the market in relation to the formulation. As a result, it demonstrates the same absorbing enthusiasm as patronizing over the commercial preparations. The developed herbal toothpaste has a bright future in the study of natural therapies and public dental health. Herbal extracts have been used for centuries to prevent and control diseases, due to their interaction with specific chemical receptors in the body and their pharmacodynamic properties. The potency of herbal products can vary; therefore, caution should be exercised when selecting them. In dentistry, herbs such as myrrh, ginger, clove, banyan tree roots, xanthan gum, and neem are useful. Further research is needed to determine whether herbal remedies are effective alternatives to current treatments for oral health problems.

The Formulated herbal toothpaste showed encouraging outcomes in terms of safety and effectiveness, and it could have several benefits over toothpastes prepared traditionally. Our investigation revealed that toothpaste exhibited excellent physical properties, including a uniform beige color, a distinct flavor and odor, and smooth threading ability. It is composed of natural substances such as neem, liquorice, banyan tree root, strawberry, and other natural oils. Upon examining many aspects, the following findings were highlight: The toothpaste's basic pH was 9.18, which is in line with keeping teeth healthy. The product has the right amount of foaming power to clean well, as seen by its 1.5 cm foam height. The paste's consistency and stability were assured at 9.6% moisture content. Strong grinding power is essential for getting rid of tooth plaque and stains, and this combination showed it. In addition, toothpaste showed an impressive 12 mm ZOI, indicating potent antibacterial capabilities to prevent oral infections.

The study was limited to a single batch, and more thorough testing with larger sample quantities is needed to generalize results. In addition, lack of comparison group using synthetic toothpaste and any errors in reviewer testing might affect overall assessment of effectiveness of plant formulation. Future research should focus on conducting randomized controlled trials with a range of demographics, investigating long-term effects of herbal toothpaste on oral health, and analyzing distinct contributions of each herbal ingredient to understand their distinct roles in enhancing dental hygiene in order to verify results.

In conclusion, while plant-based toothpaste has the potential to be a better alternative with beneficial qualities, it is crucial to treat these results with caution. Further investigation is necessary to corroborate these first results and properly establish plant-based toothpaste as a treatment option. Future studies should focus on performing randomized controlled trials with different groups to verify results, examining long-term benefits of herbal toothpaste on dental health, and examining unique impacts of each herbal ingredient to understand their unique roles in improving oral health.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

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ETHIC STATEMENT

Not applicable

CONFLICTS OF INTEREST

The authors declare no conflicts of interest, financial or otherwise.

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