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Natural oral care: Formulation and evaluation of a polyherbal toothpaste

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Abstract

Herbal formulations are increasingly preferred over synthetic alternatives due to their natural origin and minimal side effects. This study aims to develop a safe and effective polyherbal toothpaste using Shikakai (*Acacia concinna*) extract as a natural foaming agent, replacing synthetic surfactants like Sodium Isethionate. The formulation incorporates Neem (*Azadirachta indica*), Clove (*Syzygium aromaticum*), Turmeric (*Curcuma longa*, API: Curcumin), and Aloe Vera (*Aloe barbadensis*), which offer multiple medicinal benefits such as reducing dental plaque, gingivitis, cavities, gum diseases, and mouth ulcers. Calcium Carbonate acts as a mild abrasive, while Menthol and Honey enhance freshness and antimicrobial efficacy.

The surfactant is naturally derived from Shikakai pods, ensuring good foaming ability and optimal cleaning efficiency. The laboratory formulation was evaluated for pH, spreadability, homogeneity, stability, foaming ability, extrudability, and moisture content. In vitro studies assessed its antibacterial activity against both Gram-positive and Gram-negative bacteria, demonstrating significant zones of inhibition. The resulting formulation exhibited a brownish aromatic appearance, effective foaming, and strong antimicrobial potential, making it a safe and efficient herbal alternative for oral hygiene.

Keywords: Polyherbal; Toothpaste; Organoleptic; Turmeric; Sodium isethionate; Antimicrobial

1. Introduction

Toothpaste has played a vital role in oral hygiene from ancient times to modern formulations. It helps maintain dental health by reducing oral diseases when used with a toothbrush. The history of toothpaste dates back over 5,000 years, with early civilizations such as the Egyptians (3000 BC) using a mixture of ox hooves, myrrh, eggshells, pumice, and water as a dental paste. In the late 1800s, the British Dental Association (BDA) approved the first commercial toothpaste in tube form. By the 1850s, American dentist John Harris discovered the benefits of fluoride, while Dr. Washington Sheffield later introduced toothpaste containing soap and salt. Modern oral hygiene practices, including toothpaste, toothbrushes, and floss, became widely adopted in the 1950s. [1]

After 1950, advancements in toothpaste formulation led to the use of various detergents, with sodium lauryl sulfate (SLS) becoming the primary foaming agent. Oral hygiene involves keeping the mouth clean and free from diseases such as cavities, dental caries, ulcers, tooth decay, oral thrush, oral herpes, and gum diseases like gingivitis and periodontitis. Several infections in the mouth can be caused by bacteria, viruses, or fungi, affecting overall dental health.

One common issue is dental plaque, a sticky bacterial layer that forms on teeth, especially when foods rich in sugars and starches are left behind. If not removed, plaque hardens into tartar (calculus), which can only be eliminated through professional cleaning. Canker sores (aphthous ulcers) are another common problem, appearing inside the mouth and

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causing pain while eating or speaking. Unlike cold sores, they are not contagious but can be triggered by irritation or certain chemicals.

Many commercial toothpaste formulations contain sodium lauryl sulfate (SLS) or triclosan, which may cause irritation, dryness, redness, peeling, or sensitivity in some users. This study focuses on developing a natural, herbal toothpaste formulation that effectively addresses dental issues while avoiding the side effects associated with synthetic ingredients. [1, 2]

2. Material and methods

2.1. Chemical

- Calcium Carbonate
- HPMC
- Sodium Saccharin
- Titanium Dioxide

2.2. Preparation of Extract of API (Turmeric - *Curcuma longa*)

The active pharmaceutical ingredient (API) used in this formulation is Turmeric (*Curcuma longa*), with Curcumin as the key bioactive compound. To prepare the extract, fresh turmeric rhizomes are thoroughly washed to remove any impurities and then dried under shade for 7–10 days to preserve their active constituents. Once dried, the rhizomes are finely ground into powder using a mechanical grinder. For extraction, 20 g of turmeric powder is placed in a Soxhlet apparatus, and ethanol (95%) or distilled water is used as the solvent. The extraction process is carried out at 60–70°C for 6–8 hours, allowing the active components to dissolve into the solvent. After extraction, the solution is filtered using Whatman No.1 filter paper to remove solid residues.

The filtered extract is then concentrated using a rotary evaporator or water bath at 40–50°C to eliminate excess solvent, yielding a thick paste or dry extract. The final extract is stored in an amber glass container at 4°C to maintain stability. Before incorporating it into the toothpaste formulation, the extract undergoes standardization by analyzing Curcumin content using UV-Vis Spectroscopy or HPLC to ensure potency. Additionally, it is evaluated for pH, microbial contamination, and stability to confirm its suitability for safe and effective oral care applications. This extraction method ensures a high-yield, potent turmeric extract with antibacterial and antioxidant properties, making it a valuable ingredient in herbal toothpaste formulation.[2, 17]

Figure 1 Extraction of Neem

Table 1 Material

Sr. No.	Ingredient	Botanical Name	Quantity (% w/w)	Parts Used	Category
1	Calcium Carbonate	-	20-25%	-	Mild Abrasive
2	Glycerin	-	10-15%	-	Humectant (Moisture Retainer)
3	Purified Water	-	Q.S. (To 100%)	-	Vehicle (Base)
4	Turmeric Powder	*Curcuma longa*	2-3%	Rhizome (Rootstock)	Antibacterial, Coloring agent
5	Neem Extract	*Azadirachta indica*	1-2%	Leaves	Antibacterial, Antifungal
6	Clove Oil	*Syzygium aromaticum*	0.5-1%	Flower Buds	Antimicrobial, Analgesic
7	Aloe Vera Gel	*Aloe barbadensis*	3-5%	Leaves (Gel)	Gum Healing, Mild Preservative
8	Honey	*Apis mellifera*	2-4%	Extracted from Honeycombs	Sweetener, Antibacterial
9	Menthol Crystals	*Mentha piperita*	0.2-0.5%	Leaves	Cooling Agent, Freshness
10	HPMC (Thickener)	-	1-2%	-	Stabilizer, Thickening Agent
11	Sodium Saccharin	-	0.3-0.5%	-	Sweetening Agent
12	Sodium Isethionate	-	1-2%	-	Foaming/Detergent Agent
13	Titanium Dioxide	-	0.5-1%	-	Whitening Agent
14	Shikakai Extract	Acacia Concinna	1-2%	Pods	Natural Foaming Agent

2.3. Equipment's

Table 2 Equipment's

Sr. No	Equipment	Model No
1	Hot air oven	AI- 7981
2	Digital PH meter	LT – 11
3	Analytical balance	HR – 250A
4	Spreadability meter	-
5	Crimping machine	HX 050

2.4. Formulation of Herbal Toothpaste

The herbal toothpaste is made using natural ingredients that help clean teeth, fight bacteria, and improve oral health. Calcium Carbonate is used as a mild abrasive to remove plaque and stains gently. Glycerin keeps the toothpaste moist and gives it a smooth texture, while Honey acts as a natural sweetener and has antibacterial properties. To give the toothpaste a thick and stable consistency, Hydroxypropyl Methylcellulose (HPMC) is added.

The toothpaste contains Neem (*Azadirachta indica*), which has strong antibacterial effects, and Clove (*Syzygium aromaticum*), which helps reduce tooth pain and keeps gums healthy. Turmeric (*Curcuma longa*) extract is the main active ingredient because of its anti-inflammatory and antioxidant properties, helping to prevent gum diseases and infections. Instead of using artificial foaming agents like Sodium Lauryl Sulfate (SLS), the formulation includes Shikakai (*Acacia concinna*) extract, a natural foaming agent that cleans the teeth effectively. Menthol is added to give a cool and refreshing feel, while Purified Water is used to mix all the ingredients properly.

To prepare the toothpaste, all ingredients are carefully measured and mixed in a specific order. First, the dry ingredients like Calcium Carbonate, HPMC, and herbal powders are blended together. Then, liquid ingredients such as Glycerin, Honey, and Turmeric extract are added slowly while mixing continuously to get a smooth paste. Menthol crystals are dissolved separately and then added to the mixture. The final product is mixed thoroughly until it becomes a smooth and stable toothpaste. After preparation, the toothpaste is tested for pH, texture, foaming ability, stability, and antibacterial properties to ensure its quality. This herbal toothpaste is a safe and effective alternative to chemical-based toothpaste, providing natural oral care without harmful side effects.[17]

Figure 2 Formulation of toothpaste

2.5. Evaluation –

2.5.1. Physical Examination

Colour, odour, taste, smoothness, and relative density all these parameters are evaluated to check the compatibility of the formulation. Colour was tested by the visual observation and odour is determined based upon its smell sensation, the taste was determined by practically tasting the formulation, The density of the substances varies with pressure and temperature so it is necessary to specify the pressure and the temperatures at which the densities and the masses are to be determined.[7,18]

2.5.2. Inertness of tube

The inertness is observed to check whether any sign of deterioration or chemical reactions occurred in the container due to material of the tubes container or ant external atmospheric factor. The container used for herbal toothpaste was not produce any corrosion or deterioration in normal storage conditions such as room temperature ranges around 45 0C for few days. Inertness of tube was checked by cutting the internal surface of toothpaste container and observing whether any sign of chemical reactions such as phot-oxidation, deterioration or other occurred in the container or not upon stable atmospheric conditions. [8, 19]

2.5.3. pH

The aqueous suspension toothpaste was prepared by taking about 10 gm of toothpaste from the container in a 50 mL beaker and add 20 mL of distill water and Stir well and determine the PH of the solution using digital PH meter.

2.5.4. Foaming capacity-

The foam production plays an important role in the cleaning efficacy and its distribution. The optimized foaming behavior leads to a good cleansing effect. The initial volume was noted by taking 2g of formulation with 5ml water in a measuring cylinder and the volume of the liquid was adjusted with the water up to 10 ml the solution was shaken 10 times to produce a foam and the measuring cylinder was covered with a watch glass and allows to stand for 15 minutes and height of the foam produced was measured. The final volume of foam was noted. [9] The foaming ability of herbal toothpaste was determined. Foaming power is calculated by using the following formula

$$\text{Foaming power} = V1 - V2$$

Where, V1 - Volume in ml of foam with water

V2 - Volume in ml of water only

2.5.5. Storage stability

The stability study was carried out for the prepared toothpaste at a temperature of 37 °C for 2 months. The toothpaste was filled in a toothpaste tube for storage and stored for 45 days at room temperature and 45oC. Then the toothpaste tube was cut and whether the liquid component was separated from the toothpaste tube or not. The amount of liquid components separated gives the storage stability evaluation efficacy. [10, 15].

2.5.6. Moisture content

10 g of toothpaste was weighed and taken in a Porcelain dish and dried in the hot air oven at 105 °C then it was cooled in a desiccator to achieve constant weight. The loss of weight will be recorded as a percentage of moisture content and calculated by the given formula. [11]

The formula for calculating moisture content is:

% Moisture = Original sample weight – dry sample weight/ Original sample weight

Moisture Content (%) = Initial Weight−Dry Weight×100

Where:

Initial Weight is the weight of the toothpaste sample before drying.

Dry Weight is the weight of the toothpaste sample after drying.

2.5.7. Net content:

Formula to calculate net content;

Net content = weight of filled tube – the weight of empty tube.

2.6. Antimicrobial activity

The common pathogenic microorganisms were used in the study as test microorganisms, such as gram-positive bacteria like *Staphylococcus aureus* and gram-negative bacteria like *Escherichia coli and Pseudomonas aeruginosa*. [12]

2.7. Disc diffusion method

The disc diffusion method was used to evaluate the antimicrobial activity of the toothpaste. A teste microorganism suspension was prepared. Autoclaved agar media was poured into each Petri plate, then the swabbing of the bacterial colonies from the inoculums of the test microorganisms on prepared media plates with the help of sterile cotton swabs, which was then incubated for 15 min at 37 °C to allow proper adsorption and active growth of the pathogen. [13] Different concentrations of formulated toothpaste are taken such as 100, 250, and 500 mg/ml, and poured into the inoculated agar plates and incubated for 37 ºC for 48 hours. Then the diameter of the zone of inhibition was measured against the tested organisms. The plates were placed on a black surface, upon a non-reflecting background, and illuminated with reflected light to observe the zone of inhibition. [14, 16].

3. Results and Discussion

Table - Organoleptic evaluation of formulated polyherbal toothpaste .

3.1. Organoleptic evaluation Result

Table 3 Organoleptic Properties

Sr.no	Parameters	Result
1	Colour	Yellowish brown
2	Odour	Pleasant
3	Taste	Sweet
4	PH	7
5	Texture	Smooth
6	Moisture content	17.35
7	Storage stability	Stable (separation of a liquid component is observed slightly after two months)
8	Foaming character	10 7.6 ± 0.115 (ml)
9	Viscosity	Slightly viscous
10	Homogeneity	Homogenous
11	Spreadability	Spreadable 6.2 ± 0.115 (cm)
12	Tube Extrudibility	62.67 ± 1.45 (%)

The formulated toothpaste was tested for antibacterial activity against Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa with different concentrations of toothpaste. The potency was qualitatively and quantitatively assessed by the presence or absence of a zone of inhibition and zone diameter values. Different concentrations show different readings in terms of the zone of inhibition. The formulated toothpaste exhibited a highly significant effect on all the tested bacteria, whereas the negative control did not produce an observable inhibitory effect for any of the tested bacteria.

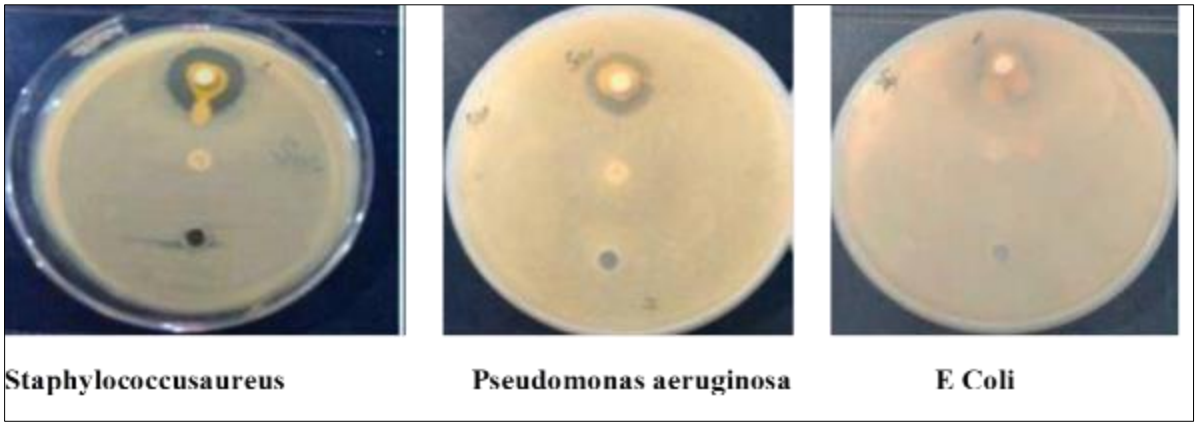

Figure 3 Antibacterial Avtivity

Among all the tested bacteria used Staphylococcus aureus was found to be most sensitive to the formulated toothpaste as seen by a zone of inhibition (10-15 mm) followed by Escherichia coli (9- 12 mm) and Pseudomonas aeruginosa (9-11 mm).

Table 4 Antimicrobial activity of the formulated polyherbal toothpaste

Sr.no	Medium	Zone of inhibition in mm
1	Staphylococcus aureus (gram + positive)	12
2	Escherichia coli (Gram-negative)	10
3	Pseudomonas aeruginosa (Gram-negative)	11

Upon observation, the sodium isethionate has a potential impact on the inhibition of both gram-positive and gram-negative bacteria. The antibacterial activity of the formulated polyherbal toothpaste also showed significant antibacterial activity against all the tested microorganisms. This observation indicates that the activity is due to the presence of large varieties of phytoconstituents present in the extract. Hence, the observed antibacterial activity of the toothpaste was due to the presence of active constituents of the extract. This was a good sign to do further studies on that to make it one of the commercial herbal toothpastes for the treatment of oral bacterial infections.

4. Conclusion

The formulated polyherbal toothpaste was successfully evaluated using different standard parameters including antimicrobial properties. The *Curcuma longa* and *Azadirachta indica* compound showed promising antimicrobial effects against both gram-positive and gram-negative organisms. The formulated toothpaste may be safer compared to fully synthetic toothpaste. Further studies are warranted to prove the in-vivo activity for safety studies and anticancer activity of the formulation to market the formulation for use.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed. The authors declare that there are no conflicts of interest associated with this work.

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