A REVIEW ON FORMULATION AND EVALUATION OF DENTIN-HYPERSENSITIVITY TOOTHPASTE

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ABSTRACT

Dentin hypersensitivity (DH) is a common dental condition characterized by brief, sharp pain caused by exposed dentin and open tubules responding to external stimuli. The hydrodynamic theory explains DH as fluid movement within dentinal tubules stimulating nerve endings. Key causes include enamel erosion, attrition, gingival recession, and dental procedures. Treatment often involves sensitivity toothpastes with agents like potassium nitrate, fluoride, and calcium phosphate, providing affordable relief. Herbal toothpastes containing turmeric, neem, and clove are increasingly popular for their antibacterial and anti-inflammatory properties, appealing due to their natural composition and perceived safety. While desensitizing toothpastes show effectiveness, they may cause side effects such as oral irritation. Further clinical research is needed to optimize formulations and confirm long-term benefits. This review evaluates herbal toothpaste preparations, highlighting their growing acceptance in oral care over synthetic alternatives.

KEY WORDS: Sensitivity toothpaste, Dentin hypersensitivity, desensitizing agents, Sodium Lauryl Sulphate (SLS), hydrodynamic theory, gingivitis, Gluma.

INTRODUCTION

Toothpaste was first developed in India and China between 300 BC and 500 BC. During that time, substances like crushed bones, shellfish, and ground eggshells were used as abrasives to clean teeth. The modern concept of toothpaste began to take shape in the 19th century, when ingredients like chalk and various cleansers were combined to improve its cleaning ability. After 1945, formulations evolved further with the introduction of agents such as Sodium Lauryl Sulphate (SLS), which was added as an emulsifying and foaming agent to enhance the product's effectiveness.

Over time, toothpaste brands have incorporated various active ingredients into their products, tailored to specific purposes such as preventing cavities, reducing plaque and gingivitis, combating bad breath, controlling tartar build-up, and whitening teeth. Additional objectives include the inclusion of more effective agents to relieve pain caused by dentin hypersensitivity (DH) [1].

Anti-sensitivity toothpastes primarily contain desensitizing agents that help reduce sensitivity by protecting exposed root surfaces. These agents are used to treat dentin hypersensitivity—a sharp, often painful reaction in exposed dentin triggered by various stimuli such as chemical, tactile, evaporative, osmotic, or thermal factors.

Epidemiological studies show that the prevalence of dentin sensitivity rises with age, and the issue is most severe among the elderly. Teeth with open dentin tubules were sensitive, whereas the orifices of most tubules in naturally desensitised areas were clogged with mineral crystals. Oxalates can clog dentin tubules, reducing permeability and sensitivity. Calcium phosphate minerals, which make up the majority of the tooth's inorganic composition, effectively block dentin tubules and decrease sensitivity [5].

The growing global demand for sensitivity toothpastes is being driven by rising disposable incomes, increased consumer awareness of oral hygiene, and evolving lifestyle standards. These factors are expected to contribute significantly to market growth in the coming year [2].

According to the hydrodynamic theory, dentin hypersensitivity arises from the rapid movement of fluid within the dentinal tubules. Effective treatment of DH requires addressing the underlying etiological factors contributing to the condition.

Desensitizing therapies include the use of chemical agents, laser irradiation, restorative procedures, and periodontal surgeries, all primarily aimed at controlling the hydrodynamic mechanisms responsible for pain [3].

Dentin hypersensitivity (DH) is characterized by a sudden, sharp pain of brief duration. It is not a standalone condition but rather a common symptom associated with various dental disorders.

Dentin hypersensitivity (DH) negatively impacts oral health-related quality of life. Currently, DH is recognized as a significant oral health issue, drawing increasing attention for its prevention and diagnosis. Multiple factors contribute to DH, including tooth wear, abrasion, and acid erosion, all of which can result in the loss of enamel and cementum, ultimately exposing the dentinal tubules [4].

Currently, various methods are available for treating dentin hypersensitivity (DH), including sodium fluoride varnishes, Gluma desensitizing agents, resin-based sealants, laser therapy, and desensitizing toothpastes. Among these, desensitizing toothpastes are favoured for being convenient, non-invasive, and cost-effective [5].

While substantial clinical research supports the effectiveness of these toothpastes in managing DH, some researchers argue that the overall quality of the evidence is insufficient to draw firm conclusions [6].

Several studies have evaluated iontophoresis and fluoride as desensitising agents. Iontophoresis and fluoride have been associated with decreased sensitivity. Various medicinal plants, such as Kattha, pan leaves, Haldi rhizomes, and Tulsi leaves, have been used to treat sensitivity [36].

Advantages of Sensitivity Toothpaste

- Relieves tooth pain and discomfort
- Provides lasting relief from sensitivity
- Strengthens and re-mineralizes tooth enamel
- Helps protect against plaque build up
- Promotes healthy gums [7].

Disadvantages of sensitivity toothpaste

- **Serious Side Effects**

If you experience any of these, seek immediate medical attention:

- **Burning in your mouth or sore tongue** – Could indicate a chemical burn or allergic reaction.
- **Nausea, vomiting, or diarrhoea** – Common signs of gastrointestinal irritation or systemic toxicity.
- **Vomiting blood** – A potentially life-threatening symptom; may suggest internal bleeding or severe stomach/oesophageal damage.

- **Less Serious Side Effects**

These symptoms are usually manageable but should still be discussed with a healthcare provider if persistent:

- **Stomach cramps** – Caused by irritation or mild reaction.
- **Drooling or increased saliva** – Could result from oral irritation or a reflex response to a noxious substance [8].

PREVALENCE OF DENTIN HYPERSENSITIVITY

Dentin hypersensitivity is a global condition, with reported prevalence rates ranging widely from 3% to 98%. More recent studies suggest that the prevalence typically falls between 4.8% and 62.3%. Research conducted in both the U.K. and South Korea found that dentin hypersensitivity affects various populations, with a higher incidence reported among females compared to males. In a study from the United States, approximately 1 in 8 patients visiting general dental practices experienced dentin hypersensitivity. The condition was described as chronic, with intermittent episodes of low-intensity pain. Individuals affected by dentin hypersensitivity were more likely to be younger and female [9].

Generally, DH is most commonly observed in individuals aged 30 to 50 years, with a higher prevalence among females. Although it can affect all teeth, it is most frequently reported in the canines and premolars. Many patients experience hypersensitivity following procedures such as scaling and root planning. In some cases, sensitivity is triggered by simple stimuli, such as air spray or light probing with a dental instrument. Additionally, procedures like cavity or crown preparation involving vital teeth can cause temporary sensitivity, which typically persists until the final restoration is completed [10].

Patients typically report dentinal hypersensitivity after experiencing a sudden, sharp pain triggered by various external stimuli [11].

Over the years, the prevalence of dentinal hypersensitivity has been reported in various ways: affecting over 40 million people annually in the U.S., 14.3% of all dental patients, between 8% and 57% of the adult dentate population, and up to 30% of adults at some point in their lives [12].

ETIOLOGY AND MECHANISM OF DENTIN HYPERSENSITIVITY

Dentin hypersensitivity has multiple etiologies. It may result from procedures such as scaling, gingival attachment loss, or periodontal surgery. Typically, root sensitivity develops within 1 to 3 weeks following scaling or periodontal treatment and gradually subsides over time. Exposure of dentin due to enamel loss—caused by factors such as tooth wear (attrition), erosion, or parafunctional habits like bruxism—also contributes to hypersensitivity. Dentin hypersensitivity is also a common side effect of gingival recession and tooth whitening procedures. Additionally, acids from food and beverages, as well as gastric reflux, can erode dentin and expose the dentinal tubules, leading to increased sensitivity [13].

Dentin contains microscopic channels known as dentinal tubules, which extend outward from the pulp chamber through the dentin. Each tubule houses Tomes' fibres and odontoblastic processes that maintain a connection with the dental pulp. Two types of nerve fibers are associated with these tubules: unmyelinated C-fibers and myelinated A-fibers. Among these, the A-fibers are primarily responsible for the sharp pain associated with dentin hypersensitivity [14].

According to the hydrodynamic theory, fluid within the dentinal tubules flows outward. When external stimuli are applied to the dentin, they increase this fluid movement, which in turn activates nerve endings in the pulp. Brannstrom and colleagues further proposed that physical stimuli initiate fluid shifts through capillary action, stimulating A-type nerve fibers and thereby causing the characteristic pain of dentin hypersensitivity [14].

CLINICAL SIGNS OF HYPERSENSITIVITY

(a) Gingival recession

(b) Cervical abrasion

(c) Exposed root surfaces.

(a) **Gingival recession:**

Gingival recession (GR), which is frequently brought on by traumatizing brushing, defective dental restorations, or irregular tooth alignment, is the apical movement of the gum edge that exposes the tooth root. An all-encompassing orthodontic-surgical strategy was employed to address GR in a mandibular incisor. In order to align the tooth root within the bone envelope, the initial step was to realign it orthodontically. The second stage involved covering the exposed root and regenerating gum tissue using the V-CAF (Vestibular Incision Sub-Periosteal Tunnel Access with Connective Tissue Graft) surgical procedure [15].

(b) **Cervical abrasion:**

The gradual, non-carious loss of tooth structure at the cement enamel junction as a result of mechanical wear is known as cervical abrasion. It frequently results in dentin hypersensitivity (DH), which is typified by sudden, intense pain in reaction to harmless stimuli such as touch, cold, or sweet foods. When exposed dentin responds inappropriately to stimuli, DH occurs. Because diagnostic criteria are unreliable, its incidence varies greatly (1–98%). Both functional and aesthetic issues are raised by this disorder, which may eventually result in decreased chewing efficiency and turn into a public health hazard [16].

(c) **Exposed root surfaces:**

The exposure of the dentine to the oral environment is linked to tooth hypersensitivity. This exposure may be caused by denudation of the root surface due to gingival recession or periodontal therapies, or it may be the consequence of enamel loss via processes like abrasion and erosion. A negative reaction or discomfort in one or more teeth brought on by a mechanical, chemical, bacterial, or thermal stimuli is known as dentine hypersensitivity. Adult patients frequently have painful symptoms from exposed dentine; up to one in seven patients receiving dental care are said to be affected [17].

MECHANISM OF ACTION

Brannstrom's hydrodynamic theory is widely accepted as the leading explanation for the mechanism behind dentin hypersensitivity. This theory proposes that when external stimuli are applied to dentin tubules—open at both the pulpal and oral surfaces—they cause rapid fluid movement within the tubules. This fluid shift stimulates mechanoreceptors located on nerve endings at the pulpal side, resulting in the sensation of pain.

According to the hydrodynamic theory, any change in the flow of fluid inside the dentinal tubules can activate these receptors and trigger a pain response. Exposure of dentinal tubules may occur due to enamel loss from mechanical wear (attrition), erosion, or abfraction or following gingival recession caused by periodontal disease or surgical procedures.

In vital teeth with exposed dentin, stimuli such as erosion, abrasion, dental manipulation, or structural defects can cause fluid movement within the tubules—either inward or outward—depending on pressure differences in surrounding tissues. Cold stimuli cause the tubular fluid to contract slightly, while heat leads to expansion. Strongly osmotic substances, such as sugary or acidic solutions, draw fluid outward. An air blast can evaporate fluid at the tubule opening, causing a rapid outward flow. Conversely, contact with a dental instrument or certain disinfectants may push fluid inward.

Although the hydrodynamic theory provides a strong framework for understanding dentin hypersensitivity, the exact mechanisms involved remain the subject of ongoing research [18].

ANTISENSITIVE TOOTHPASTE AVAILABLE IN MARKET

- Sensodyne
- RA thermos seal
- Colgate
- Orajel
- Crest

Ingredients Commonly Found in Sensitivity Toothpastes:

- **Desensitizing Agent (Potassium Nitrate)**

The primary desensitizing agent in anti-sensitivity toothpaste is potassium nitrate. It helps block the transmission of signals from nerve endings to the teeth. This works by diffusing through the dentinal tubules and causing depolarization of nerve cells, which makes them less responsive to pain stimuli [19].

- **Abrasive**

Abrasives are substances used to grind, polish, and clean the surface of teeth. They help remove food debris by gently adhering to it without causing scratches, restoring the natural shine of the teeth. The most commonly used abrasive is calcium carbonate, a fine, odourless, microcrystalline white powder that does not dissolve in water [20].

- **Surfactant (Foaming Agent)**

Surfactants in toothpaste help improve cleaning by reducing the surface tension of liquids in the mouth. This allows the active ingredients in the toothpaste to come into better contact with the teeth. Surfactants also break down plaque by penetrating it, making it easier to clean the teeth. The most commonly used surfactant in toothpaste formulations is sodium lauryl sulphate (SLS) [19].

- **Glycerine (Humectants)**

Glycerine, a short-chained polyalcohol, is the most commonly used humectant in toothpaste formulations. It helps prevent water loss and keeps the toothpaste from hardening inside the tube or when exposed to air. Additionally, glycerine gives the toothpaste a smooth and creamy texture [21].

- **Gelling Agent (Binders)**

Gelling agents help prevent the separation of solid and liquid components in toothpaste and give it the right viscoelastic consistency. Carboxymethyl cellulose is the most commonly used binder in toothpaste. It also helps prevent the toothpaste from drying out and influences its dispersion, rinsing, foaming, and other properties during use [21].

- **Sweetener**

Sweeteners are added to toothpaste formulations to enhance the taste, providing a mild and pleasant sweetness [21]. Sodium saccharin is the most commonly used sweetener in toothpaste. Besides improving flavour, sweeteners help mask the bitter taste of other ingredients such as binders or surfactants, making the product more enjoyable and easier to use.

- **Flavouring Agent**

Flavouring agents are added to toothpaste to mask unpleasant tastes and odours from other ingredients, providing a refreshing and cool sensation. These agents are dissolved and evenly distributed throughout the paste with the help of surfactants [21]. Peppermint oil, a volatile edible oil, is the most commonly used flavouring agent.

- **Preservative**

Preservatives are substances that inhibit the growth of microbes and microorganisms in toothpaste. They help maintain the toothpaste’s quality during storage and extend its shelf life. Methyl paraben is the most commonly used preservative [21].

- **Opacifier (Whitening Agent)**

Opacifiers, also known as whitening agents, are included in almost all toothpaste formulations to enhance the toothpaste's brightness and whiteness. Titanium dioxide is the most commonly used opacifier in toothpaste [21].

- **Vehicle (Solvent)**

The vehicle or solvent in toothpaste formulations serves to dissolve the ingredients and help blend them evenly. Purified water is the most commonly used vehicle in toothpaste [21].

Role of herbs in oral health

Medicinal plants play a vital role in oral health by offering traditional and therapeutic benefits. They are rich in bioactive compounds and secondary metabolites with various biological activities. Increasingly used in oral care products, these extracts are valued for low toxicity and few side effects. They offer affordable dental care alternatives, especially for preventing caries in underserved populations.

Table 2 – Herbs used in oral health

SI NO	CRUDE DRUGS	BIOLOGICAL NAME	USES	STUDY OUTCOME
1	Turmeric	Curcuma longa	Antisensitivity agent, antibacterial agent	Curcumin effectively reduces dental sensitivity by inhibiting bacterial activity and pH changes, demonstrating significant anti-caries properties even at low concentrations [22].
2	Clove	Syzygium aromaticum	Antisensitivity agent, anti decay agent	Clove seed n-hexane extract exhibits strong antibacterial properties, making it a promising natural toothpaste ingredient for preventing dental cavities and reducing sensitivity[23] .
3	Propolis (bee resin)	Apis indica	Anti hypersensitive agents	Propolis varnish effectively blocks dentinal tubules, offering a promising natural remedy for dentinal hypersensitivity. Future in vivo studies are needed to compare it with traditional desensitizing agents and confirm its clinical efficacy[24] .
4	Neem	Azadirachta indica	Anti sensitivity agent, Anti-bacterial agent	This study shows that Azadirachta indica herbal mouthwash effectively reduces tooth sensitivity, offering a potential alternative treatment for dentinal hypersensitivity. Further long-term clinical trials are needed to confirm its efficacy[25].

Methods for Preparing Toothpaste

Sensitivity toothpaste can be formulated using either of the following two techniques:

1. **Dry Gum Method**
2. **Wet Gum Method**

Dry Gum Method

The formulation of sensitivity toothpaste using the dry gum method involves the following steps:
i. All solid ingredients such as potassium nitrate, calcium carbonate, methyl cellulose, sodium saccharin, methyl paraben, and titanium dioxide (excluding SLS) are accurately weighed, passed through an 80-mesh sieve, and thoroughly mixed using a dry mixer like an agitator.
ii. Next, the liquid components, including glycerine and purified water, are gradually added to the dry mixture.
iii. The entire blend is then triturated using a mortar and pestle until a smooth and uniform paste is formed.
iv. Finally, sodium lauryl sulphate (SLS) and peppermint oil are incorporated into the homogeneous paste under vacuum conditions to complete the formulation [20].

Wet Gum Method

The preparation of sensitivity toothpaste using the wet gum method involves the following steps:
i. The liquid ingredients, such as glycerine and purified water, are first combined to create the liquid phase.
ii. Methyl cellulose is then slowly added to this liquid while continuously stirring to form a smooth mucilage.
iii. Once the mucilage is formed, the solid ingredients including potassium nitrate, calcium carbonate, sodium saccharin, methyl paraben, and titanium dioxide (excluding SLS) are gradually mixed in using an agitator until a uniform and consistent paste is achieved.
iv. Finally, sodium lauryl sulphate (SLS) and peppermint oil are incorporated into the prepared toothpaste under vacuum conditions to complete the formulation [26].

Toothpaste Manufacturing Techniques

Based on the principles used in the formulation process, the following techniques are commonly employed in the manufacturing of toothpaste:

- **Cold Compression Technique**
- **Hot Liquid Phase Technique**
- **Multiple Liquid Phase Technique**

1. Cold Compression Technique

The preparation of toothpaste using the cold compression method involves the following steps:
i. The process begins by adding humectants such as glycerine or 70% w/v sorbitol into a mixing bowl.

ii. A binder is then gradually sprinkled into the humectant while stirring continuously to ensure uniform dispersion.
iii. In a separate container, other liquid ingredients—including sweeteners, preservatives, and water—are combined to form a separate liquid phase.
iv. If required, active ingredients are added at this stage to the liquid phase.
v. The prepared liquid phase is then slowly added to the binder-humectant mixture in the mixing bowl. The combined mixture is blended for about 5 minutes to eliminate any trapped air and achieve a gelatinous consistency.
vi. Finally, the vacuum supply is cut off once the mixture has reached the desired texture.
vii. Next, the abrasive agent is added to the mixture and stirred thoroughly to ensure complete dispersion.
viii. The vacuum is reapplied, and the mixture is blended for an additional 30 minutes to enhance consistency.
ix. In a separate bowl, the flavouring agent and surfactant are dispersed in a small quantity of humectant (approximately 5%).
x. This mixture is then added to the main batch under vacuum and mixed for another 5 minutes to achieve a smooth, air-free toothpaste.
xi. This technique results in a uniform and high-quality toothpaste with excellent texture and consistency.

2. Hot Liquid Phase Techniqu

The preparation of toothpaste using the hot liquid phase method involves the following steps:
i. First, all dry ingredients—such as preservatives, binders, and abrasives—are thoroughly mixed in a dry mixer to form a uniform powder.
ii. In a separate container, water, sweeteners, and humectants are combined to create the liquid phase, which is then gently heated.
iii. The heated liquid phase is slowly added to the dry powder mixture with continuous stirring to ensure even blending.
iv. The resulting mixture is then processed under vacuum for about 30 minutes to achieve proper consistency.
v. Finally, the surfactant and flavouring agents are added under vacuum and mixed for another 5 minutes.
vi. This method produces a clear, smooth, and homogeneous toothpaste.

3.Multiple Liquid Phase Technique

The formulation of toothpaste using the multiple liquid phase method includes the following steps:
i. The process begins by adding hot water and magnesium aluminium silicate into a mixing bowl.
ii. In a separate container, binders, humectants, preservatives, and flavouring agents are mixed together to form a secondary liquid phase.
iii. This prepared liquid phase is then added to the mixing bowl, and the final volume is adjusted using additional humectants to achieve the desired consistency.
iv. Once the liquid mixture is prepared, vacuum is applied to the mixing bowl to eliminate any trapped air.
v. After the air has been removed, the vacuum is temporarily released.
vi. Abrasive agents are then added to the liquid mixture, and vacuum is reapplied. The mixture is stirred continuously for about 30 minutes to ensure uniform blending.

vii. Finally, the surfactant is incorporated into the mixture and stirred uniformly for an additional 5 minutes.
viii. This technique results in the formation of a clear gel-based toothpaste with smooth consistency.

EVALUATION OF SENSITIVITY TOOTHPASTE

Quality control and evaluation of desensitizing toothpaste are essential to ensure its purity, effectiveness, and consistency. The following tests are commonly performed:

1. Colour Evaluation
The colour of the formulated toothpaste was assessed visually to ensure consistency and appearance.
2. Odour Evaluation
The odour was evaluated by smelling the toothpaste to check for any unpleasant or unusual scent.
3. Taste Evaluation
The taste was assessed manually by carefully tasting a small amount of the toothpaste to determine its palatability.
4. Fragrance Evaluation
The fragrance of the toothpaste was judged based on user acceptability through personal observations. Feedback was collected from five individuals using the following criteria:

- The scent was comparable to that of the reference toothpaste.
- The aroma was acceptable but slightly less pleasant than the reference.
- The aroma was noticeably weaker than that of the standard toothpaste [27].

5. pH Determination
The pH of the toothpaste was measured using a digital pH meter.

- 1 gram of toothpaste was placed in a 150 ml beaker.
- 10 ml of freshly boiled and cooled water (at 27°C) was added.
- The mixture was stirred continuously to form a uniform suspension.
- The pH was measured within 5 minutes using the pH meter, and the values were recorded [28].

6. Abrasiveness Test

To assess the smoothness and safety of the formulated toothpaste, its abrasiveness was evaluated. A strip of toothpaste, approximately 15 to 20 cm long, was extruded onto butter paper from each of 10 collapsible tubes. The strip was checked manually using fingertips to detect any hard edges or sharp particles, which are not acceptable in toothpaste formulations [29].

7. Particle Size Determination

The particle size of the toothpaste was analysed to evaluate its cleansing and abrasive capabilities, which are primarily influenced by the size of the particles used. This evaluation was carried out using either microscopic analysis or the standard sieving method [30].

8. Foamability

The foaming ability of the toothpaste was measured to determine the quantity and stability of the foam produced.

- 1 gram of toothpaste was placed in a stoppered test tube (16 cm tall, 6 mm in diameter).
- Water was added to make up 10 ml total volume.
- The tube was sealed and shaken at a consistent rate (2 shakes per second) for a specific time.
- After standing for 15 minutes, the height of the foam was recorded.

In another method, a 10% solution of toothpaste was prepared by mixing 4 ml of toothpaste with 146 ml of water at 30°C. After shaking for 10 seconds, the solution was transferred into a 100 ml graduated cylinder and allowed to foam. The density and stability of the foam were evaluated by placing a rubber stopper on top and measuring the time it took to sink (typically 40–80 milliseconds). A denser, more stable foam took longer to collapse [27].

9. Stability Testing

The stability of the toothpaste was tested following ICH (International Council for Harmonisation) guidelines. The toothpaste was stored in collapsible tubes under different environmental conditions for 3 months. These conditions included various temperatures (2°C and 25°C) and humidity levels (5%, 60%, and 65%) to assess product stability under stress [29].

10. Homogenicity Test

This test was performed to ensure the uniform texture of the toothpaste. When pressure was applied (at 27°C), the toothpaste was expected to extrude as a consistent, homogeneous mass from its container—whether a collapsible tube or another suitable packaging type. Ideally, the bulk of the paste should begin to emerge from the crimped end of the container as it is gradually rolled [29].

11. Shape Retention

The evaluation of the prepared toothpaste for shape retention was conducted to determine its ability to maintain form after being dispensed. Toothpaste was squeezed completely onto a toothbrush, then left at rest for 10 seconds. The condition of the paste was assessed based on the following criteria:

- The toothpaste should retain its shape on the toothbrush after application.
- The toothbrush should practically maintain its form without the toothpaste spreading or collapsing.
- If the toothpaste fails to hold its shape once applied to the toothbrush, it is considered unsatisfactory.

12. Moisture Content

The moisture content test was performed to measure the amount of volatile matter and water present in the toothpaste formulation.

- 10 grams of toothpaste were weighed and placed in a porcelain dish.
- The sample was dried in a hot air oven at 105°C until completely dry.
- After drying, the toothpaste was cooled in a desiccator.
- The percentage of moisture loss was calculated using the formula:

%Moisture Content = (Weight of Original Sample – Weight of Dry Sample/Weight of Dry Sample) × 100

- The weight loss corresponds to the total moisture content in the toothpaste [31].

13. Study of Rheological Properties

a) **Determination of Spread ability**

Spread ability refers to how well the toothpaste spreads over a surface, which is an important quality parameter.

- 1 gram of toothpaste was placed at the centre of a glass plate (10 cm x 10 cm).
- Another glass plate was gently placed on top.
- A 1 kg weight was applied at the centre to avoid sliding.
- After 15 minutes, the diameter of the spread paste was measured in centimetres.

Spread ability (S) was calculated using the formula:

$$S = m.l/t$$

Where,
S = Spread ability,
m = Weight applied on the upper glass slide,
l = Length moved by the glass slide,
t = Time taken [32].

b) **Tube Extrudability**

In this test, the prepared toothpaste was filled into collapsible aluminium tubes, sealed with a standard cap, and crimped at the end. The ease with which the toothpaste could be squeezed out was then evaluated to determine its extrudability.

The weight of the filled tubes was recorded initially. Each tube was then clamped securely between two glass slides. A 500-gram weight was placed on top of the slides, after which the cover was removed. The toothpaste extruded from the tube under this pressure was collected and weighed precisely. Using this data, the percentage of toothpaste extruded was calculated [29].

c) Viscosity

The viscosity of the toothpaste was measured using a Brookfield Digital Viscometer (model LV DV-II Ultras Programmable, USA) with spindle number 3. Different shear rates were applied to study the flow behaviour of the toothpaste. All measurements were conducted at a controlled temperature of 30°C [33].

14. Microbiological Studies

The antimicrobial effectiveness of the toothpaste was tested by culturing common microorganisms such as *Escherichia coli*, *Candida albicans*, and *Staphylococcus aureus* on agar plates to evaluate microbial inhibition [32].

15. Cleansing Property Test

The cleansing ability of the toothpaste was assessed using both in-vitro and in-vivo methods.

- For the in-vitro test, the toothpaste was applied on a polyester film, and changes in the reflective properties of a lacquer coating were measured.
- In the in-vivo test, participants brushed their teeth with the toothpaste for 14 days. Photographs taken before and after this period were compared to observe any improvements in tooth cleanliness [30].

16. Sensitivity Assessment Using Stimuli

The desensitizing effect of potassium nitrate in the toothpaste was evaluated by applying stimuli to sensitive teeth.

- First, evaporative stimulus was applied by directing cold air from a dental unit syringe (at 20°C ± 3°C and 40-65 psi) from about 1 cm away from the sensitive tooth for 1 second. This helped establish the baseline sensitivity.
- After 5 minutes, thermal stimulus was applied using cold water maintained at 4°C. The response to these stimuli was recorded to assess the toothpaste's effectiveness [34].

17. Limit Test for Heavy Metals

The toothpaste was tested for the presence of harmful heavy metals like arsenic and lead to ensure product safety.

- The limit test for heavy metals was conducted using a setup that generates hydrogen sulphide gas, which reacts with metals to form visible precipitates.
- A standard lead reference was used to compare and detect any lead present in the toothpaste. This helps confirm that heavy metals are within safe limits or absent entirely [30].

Yellow stains appeared on mercuric bromide paper when arsine gas reacted with it. The test stain matched the standard stain, confirming the presence of arsenic in the toothpaste [35].

Conclusion

Dentin hypersensitivity (DH) is a widespread dental issue, causing sharp, short-lived pain in response to external stimuli. This review explores its causes, mechanisms, and available treatments, with a particular focus on sensitivity toothpastes containing desensitizing agents like potassium nitrate, fluoride, and calcium phosphate. These formulations help alleviate discomfort by sealing dentinal tubules or reducing nerve activity, although some may lead to side effects such as oral irritation and digestive disturbances. There is a growing shift toward herbal alternatives incorporating turmeric, neem, and clove, valued for their antibacterial and anti-inflammatory properties. While these natural options show promise, additional clinical research is necessary to confirm their long-term efficacy. Evaluating toothpaste formulations based on key parameters—including pH, viscosity, spreadability, and extrudability—is crucial for ensuring effectiveness and consumer safety. With increasing demand for advanced oral health solutions, continuous research and refinement of sensitivity toothpaste compositions will enhance treatment outcomes and improve overall patient care. A deeper understanding of DH's physiological processes and ongoing efforts to optimize formulations will contribute to more efficient and sustainable management strategies for this condition.

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