Development of a Herbal Mouthwash containing *Mimosa pudica* and Egg Albumin for Tannin Reduction

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Abstract: The development of effective, natural oral-care formulations has gained increasing attention due to growing concerns over the adverse effects and synthetic nature of conventional mouthwashes. This review article explores the formulation and therapeutic potential of a herbal mouthwash incorporating *Mimosa pudica* extract and egg albumin, aimed specifically at reducing tannin-related oral issues. *Mimosa pudica*, a well-known medicinal plant rich in bioactive compounds, exhibits antimicrobial, anti-inflammatory, and antioxidant properties that contribute to improved oral hygiene. Egg albumin, on the other hand, possesses excellent protein-binding capabilities, enabling it to interact with tannins and potentially neutralize their astringent and enamel-staining effects. The review summarizes existing literature on the phytochemical constituents of *Mimosa pudica*, its mechanism of action in oral health, and the scientific basis for tannin complexation by albumin proteins. It further discusses formulation considerations such as extract standardization, pH optimization, stability, and synergistic interactions between plant constituents and albumin. Additionally, the article highlights in-vitro studies assessing antimicrobial activity, tannin-binding efficiency, and biocompatibility of the herbal mouthwash, while also identifying gaps in current research that warrant further investigation, including long-term clinical efficacy and sensory acceptability. Overall, this review underscores the potential of combining botanical extracts with natural proteins to develop an effective, safe, and eco-friendly oral hygiene product. The integration of *Mimosa pudica* and egg albumin represents a promising strategy for managing tannin-related discoloration and oral discomfort, offering a novel alternative to commercially available chemical mouthwashes. Through a comprehensive evaluation of existing evidence, this article provides a foundation for future research and innovation in herbal dental formulations.

Keywords: *Mimosa pudica;* egg albumin; herbal mouthwash; tannin reduction; phytochemicals; oral hygiene; protein–tannin interaction; natural formulations.

I. INTRODUCTION

The growing interest in herbal oral care products reflects a broader shift toward natural, safe, and biocompatible alternatives to conventional chemical mouthwashes. Traditional formulations containing agents such as chlorhexidine, alcohol, and synthetic flavoring agents are known for their effectiveness, yet they are frequently associated with undesirable side effects including tooth staining, mucosal irritation, altered taste sensation, and long-term microbial resistance. As consumers and researchers increasingly prioritize holistic health and sustainable solutions, the exploration of plant-based oral formulations has expanded rapidly. Herbal mouthwashes harness a wide array of phytochemicals such as alkaloids, flavonoids, tannins, saponins, and phenolics, which contribute to antimicrobial, anti-inflammatory, antioxidant, and astringent activities beneficial for oral hygiene. Within this context, the search for innovative herbal combinations capable of addressing specific oral issues has intensified. One such challenge is the oral accumulation and adverse effects of tannins, naturally occurring polyphenolic compounds abundant in beverages like tea, coffee, red wine, and certain medicinal plants. Despite their health-promoting antioxidant properties, excessive tannins can induce tooth discoloration, astringency, and protein precipitation within the oral cavity. This has prompted investigations into natural agents that can both support oral health and mitigate tannin-related concerns.

Herbal mouthwashes are liquid formulations derived from plant extracts, traditionally used in various cultures for maintaining oral hygiene. Unlike synthetic formulations, herbal mouthwashes are rich in phytochemicals, including flavonoids, tannins,

alkaloids, and saponins, which exhibit antimicrobial, antioxidant, anti-inflammatory, and anticariogenic properties. Their natural origin ensures biocompatibility, minimal side effects, and long-term safety. Moreover, they are gaining popularity due to the increasing demand for natural oral care products that address both aesthetic and functional concerns. Herbal formulations integrating potent botanical extracts with natural biomolecules provide a promising path toward improved oral-care efficacy. The combination of Mimosa pudica, a medicinal plant rich in multifunctional phytochemicals, with egg albumin, a well-known protein capable of forming stable tannin–protein complexes, represents a novel strategy. This section sets the foundation for understanding the scientific rationale behind such herbal formulations and their potential role in advancing eco-friendly, safe, and therapeutically effective oral hygiene solutions.

Mimosa pudica: Phytochemical and Therapeutic Relevance

Mimosa pudica, commonly known as the "sensitive plant", has been extensively studied for its medicinal and pharmacological properties. The plant is rich in alkaloids, flavonoids, tannins, saponins, and phenolic compounds, which contribute to its antimicrobial, antioxidant, anti-inflammatory, and wound-healing activities. In oral care, *Mimosa pudica* extract can inhibit the growth of oral pathogens, reduce oxidative stress in the oral cavity, and support gum and enamel health. Its bioactive compounds can also complement protein-based agents such as casein to enhance tannin precipitation, thereby mitigating staining and astringency associated with tannin-rich diets. Studies have highlighted the potential of *Mimosa pudica* in herbal formulations, especially in synergistic combinations with other natural agents, making it an ideal candidate for mouthwash development. Furthermore, its aqueous extracts are water-soluble, stable, and compatible with common excipients, facilitating their incorporation into consumer-friendly oral care products.

Mimosa pudica, commonly known as the sensitive plant or touch-me-not, belongs to the Fabaceae family. It is a creeping perennial herb with characteristic bipinnate leaves that fold upon touch and pinkish spherical flowers. It is widely distributed in tropical and subtropical regions, including Asia, Africa, and South America. Traditionally, *Mimosa pudica* has been used in Ayurvedic and folk medicine for a variety of ailments such as wounds, inflammation, diarrhea, urinary disorders, and gynecological issues. Its leaves, roots, and stems are known for hemostatic, analgesic, anti-inflammatory, and antimicrobial properties, making it a versatile medicinal plant.

Phyto Chemical Composition:

Mimosa pudica contains a rich spectrum of bioactive compounds, each contributing to its pharmacological activities:

- Alkaloids – contribute to antimicrobial, analgesic, and neuroprotective effects.
- Flavonoids – potent antioxidants, scavenging free radicals and reducing oxidative stress in tissues.
- Tannins – exhibit astringent and antimicrobial activities.
- Saponins – enhance antimicrobial and anti-inflammatory effects.
- Phenolic compounds – provide antioxidant and anti-inflammatory properties.
- Glycosides and Terpenoids – show wound-healing and antimicrobial benefits.

These phytochemicals are responsible for the plant's therapeutic versatility, particularly in preventing microbial colonization, oxidative damage, and inflammation in the oral cavity and these properties make *Mimosa pudica* an ideal candidate for herbal mouthwash formulations, especially when combined with tannin-binding agents like casein.

Role of Egg Albumin in Tannin Reduction

Egg albumin, the major protein component of egg white, possesses unique protein-binding capabilities that make it valuable in various biomedical and industrial applications. One of its most important biochemical characteristics is its strong affinity for tannins, allowing it to form stable tannin–protein complexes through hydrogen bonding and hydrophobic interactions. This property has long been utilized in processes such as wine clarification, where albumin helps remove excess tannins that contribute to bitterness and astringency. Translating this principle into oral health offers a promising approach to mitigating tannin-induced staining, astringency, and oral discomfort. In the oral environment, tannins tend to bind salivary proteins, leading to the characteristic dry-mouth sensation and contributing to pellicle

staining on teeth. Incorporating egg albumin into a mouthwash formulation allows for the direct binding and neutralization of these tannins before they interact with oral tissues. This can significantly reduce tannin deposition, improve oral comfort, and help maintain tooth esthetics among individuals who regularly consume tannin-rich beverages such as tea, coffee, and wine.

Beyond its tannin-binding properties, egg albumin demonstrates excellent biocompatibility, non-toxicity, and film-forming ability, which contribute to its suitability in oral-care formulations. Its mild antimicrobial effects also complement the properties of herbal extracts. Additionally, when combined with plant-based ingredients like *Mimosa pudica*, egg albumin may enhance the overall stability, viscosity, and functional performance of the mouthwash. This section emphasizes the scientific basis behind using egg albumin as a natural, effective, and safe strategy for reducing tannin-related oral issues.

Significance of Starch Powder in the Egg Albumin-containing Mouthwashes

The mandatory use of starch in albumin-containing mouthwashes ensures:

- Consistency of the formulation
- Stability of egg albumin
- Effective tannin-binding during use
- Prevention of precipitation during storage
- Improved sensory attributes and acceptability
- Extended shelf-life of the final product

Starch is a crucial excipient that preserves the functional and physical integrity of albumin-based herbal mouthwashes, directly contributing to their effectiveness in tannin reduction and overall oral health improvement.

Rationale for Developing a Mimosa pudica-Egg Albumin Mouthwash

The increasing consumption of tannin-rich beverages such as tea, coffee, and red wine has contributed to a rise in tannin-associated oral concerns, including tooth staining, astringency, and oral discomfort. While conventional chemical mouthwashes can help manage microbial populations, they are often ineffective in addressing the specific challenge of tannin deposition, and many carry drawbacks such as mucosal irritation, altered taste perception, and long-term imbalance of oral microflora. This growing need for a more natural, safe, and targeted solution highlights the importance of exploring innovative herbal formulations. The use of Mimosa pudica, a medicinal plant rich in antimicrobial, anti-inflammatory, and antioxidant phytochemicals, presents a promising herbal alternative. Its therapeutic versatility suggests potential value not only in preventing oral infections but also in enhancing overall oral comfort. Meanwhile, egg albumin, a natural protein known for its strong tannin-binding capacity, offers a biologically grounded mechanism for reducing tannin levels through protein–polyphenol complexation. Combining these two natural ingredients provides a unique opportunity to develop a mouthwash capable of addressing both microbial control and tannin neutralization simultaneously—an approach largely unexplored in current oral-care research.

II. OBJECTIVES

- To explore the phytochemical properties and therapeutic potential of *Mimosa pudica*, with special emphasis on its antimicrobial, antioxidant, and anti-inflammatory activities relevant to oral health.
- To investigate the role of Egg Albumin in binding and reducing tannins, thereby preventing tannin-induced staining and enhancing oral aesthetics.
- To review formulation strategies for combining herbal extracts with protein-based agents in the development of a stable, palatable, and effective herbal mouthwash.
- To analyze the physicochemical and organoleptic evaluation parameters (such as pH, viscosity, color, taste, and stability) that ensure the quality and acceptability of herbal mouthwashes.
- To evaluate the functional efficacy of the mouthwash, including tannin-binding ability, antimicrobial activity against oral pathogens, and biocompatibility.
- To provide insights into the potential advantages of herbal-protein synergistic mouthwashes as safe, natural, and sustainable alternatives to conventional chemical-based oral care products.
- To identify research gaps and future perspectives for the development and commercialization of

herbal mouthwashes targeting tannin reduction and overall oral health.

III. LITERATURE REVIEW AND DATA COLLECTION

1. Chamakuri et al. (2019) – Pharmacological Activity of *Mimosa pudica* by Different Fractions

This study investigated the pharmacological significance of Mimosa pudica by extracting and fractionating its bioactive compounds using maceration. The researchers isolated tannin-rich and flavonoid-rich fractions, followed by a detailed phytochemical screening that confirmed the presence of tannins, alkaloids, glycosides, and phenolic compounds. The antimicrobial evaluation demonstrated that these fractions possess considerable biological activity, likely due to the high tannin and flavonoid content, which are known to contribute to antibacterial and wound-healing properties. The work is important because it highlights the medicinal potential of *M. pudica*, showing that its tannin components are pharmacologically active. This provides scientific justification for using *M. pudica* extract in formulations such as herbal mouthwashes where antimicrobial and bioactive qualities are desirable.

2. JOCPR (2019) – Different Fractions of *Mimosa pudica* in Wound-Healing Activity

This investigation focused on evaluating the wound-healing efficacy of various fractions of Mimosa pudica, particularly those rich in tannins and flavonoids. Using animal wound-excision models, the study demonstrated that the extract fractions facilitated faster epithelialization and improved wound contraction rates compared to controls. Phytochemical analysis confirmed that tannins were present in significant quantities, contributing to the astringent and tissue-repairing properties of the plant. The research emphasizes the biological relevance of M. pudica tannins, supporting their use in therapeutic applications. For a herbal mouthwash formulation, these findings are valuable because they establish the safety and bioactivity of tannin-containing extracts from *M. pudica*, reinforcing their suitability for oral applications where wound-healing and antimicrobial properties are advantageous.

3. JIAPHD (2014) – Antibacterial Efficacy of *Mimosa pudica* Against *Streptococcus mutans*

This study explored the antibacterial potential of aqueous extracts of Mimosa pudica against Streptococcus mutans, the leading bacterium responsible for dental caries. The researchers tested 5%, 10%, and 20% concentrations using agar well diffusion, with chlorhexidine as a positive control. Results showed that the M. pudica extract did not produce inhibitory zones, suggesting minimal antibacterial activity in this extraction form. The authors concluded that extraction method and solvent choice significantly affect bioactive yield and recommended exploring ethanolic or other solvent extracts for improved efficacy.

This paper is important for mouthwash development because it demonstrates that not all *M. pudica* preparations possess oral antimicrobial effects, highlighting the need for optimized extraction methods to harness the plant's full therapeutic potential.

4. Tsurunaga et al. (2024) – Effects of Tannin Extracts on Egg White Protein Properties

Tsurunaga and colleagues examined how various natural tannin extracts interact with egg white proteins, focusing on allergenicity, gel structure, and physicochemical changes. Using techniques such as SDS-PAGE, ELISA, and FTIR spectroscopy, they demonstrated that tannins effectively bind to and reduce allergenic proteins in egg white, including ovalbumin. The study found that incorporation of tannin extracts into egg white gels altered color, texture, and protein structure, indicating strong protein–polyphenol interactions. This research is highly relevant for tannin-reduction systems because it validates the ability of albumin to bind tannins through hydrogen bonding and hydrophobic interactions. For a herbal mouthwash containing egg albumin, these findings support the feasibility of using albumin to sequester and neutralize tannins present in Mimosa pudica extract, reducing astringency or improving product acceptability.

IV. METHODOLOGY / MATERIALS AND METHODS

Material

The herbal mouthwash formulation will utilize the following ingredients:

Plant Material

- Mimosa pudica Extract
- Neem Extract

- Tulsi Extract
- Lemon Extract
- Aloe vera Juice

Protein Source

- Egg albumin (freshly separated or commercially available albumin powder)

Additional Formulation Ingredients

- Starch (Stabilizer)
- Glycerin (humectant)
- Peppermint oil or menthol (flavoring agent)
- Clove Oil
- Honey – natural sweetener, antimicrobial, and humectant.
- Distilled water – used as the main aqueous base for extraction and formulation.

Equipments & Instruments:

- Analytical balance – for accurate measurement of plant materials, casein, and other ingredients.
- Mortar and pestle or grinder – to grind dried *Mimosa pudica* leaves and other herbs into fine powder.
- Soxhlet extractor or maceration setup – for aqueous extraction of herbal powders.
- Beakers and conical flasks – for soaking, mixing, and extraction of plant materials.
- Magnetic stirrer with hot plate – to maintain uniform mixing and mild heating during extraction.
- Whatman filter paper or muslin cloth – for filtration of extracts to remove insoluble residues.
- Rotary evaporator – to concentrate herbal extracts under reduced pressure (optional, but recommended for large-scale preparation).

Methodology

A. Preparation of *Mimosa pudica* Leaf Extract:

- Collect fresh leaves of *Mimosa pudica*, wash thoroughly to remove dust and impurities.
- Dry the leaves under shade at room temperature to preserve phytochemicals.
- Grind the dried leaves into a fine powder.
- Prepare an aqueous extract by maceration or Soxhlet extraction:
- Soak 50 g of powdered leaves in 500 mL distilled water for 24 hours with occasional stirring (maceration).
- Filter the extract using Whatman filter paper to remove solid residues.
- Concentrate the filtrate using a rotary evaporator or by gentle heating at 40–50°C until a viscous extract is obtained.

  Purpose: This extract provides the primary antimicrobial and antioxidant activity for the mouthwash.

B. Preparation of Egg Albumin Solution:

- Egg white is separated from the yolk and homogenized.
- The albumin is diluted in distilled water and stirred on a magnetic stirrer to obtain a clear protein solution.
- If powdered albumin is used, it is dissolved at a 1–3% w/v concentration.

Incorporation of Starch:

- A measured quantity of soluble starch (0.5–2% w/v) is dispersed in a small volume of distilled water.
- The mixture is heated gently (60–70°C) while stirring until a uniform, translucent starch gel forms.
- The gel is cooled to room temperature.
- The starch gel is slowly added to the egg albumin solution with continuous stirring to ensure proper protein stabilization and prevent lump formation.

Formulation of the Herbal Mouthwash:

- The Mimosa pudica extract is gradually added to the albumin–starch mixture.
- Glycerin (2–5%) is added to improve viscosity and mouthfeel.
- Flavoring agents like peppermint oil are added in small quantities.
- The pH of the formulation is adjusted to 6.5–7.0 using citric acid or sodium citrate.
- The mixture is stirred continuously until a homogeneous solution is obtained.
- The final mouthwash is filtered, filled into sterile amber bottles, and stored at room temperature.

Addition of Citrus Extract and Honey:

- Add Citrus limon juice/extract in small quantities (1–2% v/v) to improve freshness and provide mild astringent and antibacterial effects.
- Add honey (1–2% w/v) to improve palatability and provide natural antimicrobial properties.
- Mix gently to avoid frothing.
  Purpose: Improves taste, enhances antimicrobial activity, and acts as a natural humectant.

Final Mixing and Filtration:

- Combine the mixture Egg albumin & Starch with the herbal-aqueous mixture slowly while stirring to avoid precipitation.
- Adjust the final volume with distilled water.
- Filter the final mixture through sterile muslin cloth or Whatman filter paper to remove insoluble particles.
  Purpose: Ensures uniformity and stability of the mouthwash.

Packaging and Storage

- Transfer the mouthwash into sterile, airtight amber glass bottles to prevent degradation of phytochemicals and oils.
- Store at room temperature or 4°C to maintain stability and shelf-life.

Ingredients	F1	F2	F3	F4	F5	Ingredients
Mimosa pudica extract (M.P.)	3 ml	3.5 ml	2 ml	2.5 ml	4 ml	Mimosa pudica extract (M.P.)
(Egg Albumin + Starch Solution)	2 ml	2 ml	1.5 ml	3 ml	3.5 ml	(Unlabeled extract)
Neem extract	2 ml	2.5 ml	1 ml	3 ml	3 ml	Neem extract
Tulsi extract	2 ml	1 ml	2.5 ml	1.5 ml	3 ml	Tulsi extract
Peppermint oil	0.1 ml	0.09 ml	0.1 ml	0.12 ml	0.08 ml	Peppermint oil
Clove oil	0.05 ml	0.045 ml	0.049 ml	0.051 ml	0.047 ml	Clove oil
Lemon extract	2 ml	2 ml	2 ml	1.9 ml	2 ml	Lemon extract
Aloe vera juice	2 ml	2.5 ml	2 ml	2 ml	3 ml	Aloe vera juice
Glycerin	5 ml	4 ml	3 ml	4.5 ml	5.5 ml	Glycerin
Honey	2 ml	2 ml	2.5 ml	2 ml	3 ml	Honey
Water (q.s.)	Up to 100 ml	Up to 100 ml	Up to 100 ml	Up to 100 ml	Up to 100 ml	Water (q.s.)

Table 1: Batch-wise formulation of Mimosa pudica-Egg Albumin Mouthwash

C. Evaluation of Mouthwash:

Orgenoleptic Evaluation

1. Colour:

- Procedure: Observe the mouthwash against a white background under normal light.
- Evaluation: Check for uniformity, clarity, and whether the colour is acceptable and stable over time.

2. Odour:

- Procedure: Smell the mouthwash carefully at room temperature.
- Evaluation: Ensure there is no foul or unusual odour. The odour should be pleasant and consistent with the added flavoring.

3. Taste

- Procedure: (If safe) A small quantity can be tasted. Alternatively, a trained sensory panel can evaluate it.
- Evaluation: Assess the mouthwash for sweetness, bitterness, or pungency. Taste should be acceptable and masking of any herbal bitterness should be checked.

4. Appearance / Clarity:

- Procedure: Observe the solution for clarity, transparency, and presence of suspended particles.
- Evaluation: Mouthwash should be free from turbidity or precipitation.

Physical and Chemical Evaluation

1. pH Measurement

- Importance: Ensures the formulation is safe for oral mucosa (ideally 6.0–7.5) and prevents microbial growth.
- Procedure:
  i. Calibrate pH meter using standard buffer solutions (pH 4 and 7).
  ii. Measure the pH of the mouthwash at room temperature.

- Evaluation: Record the pH. Stability studies may require checking pH over time.

2. Viscosity:

- Importance: Ensures good mouthfeel and retention in the oral cavity.
- Procedure:
  i. Use a viscometer (Brookfield or similar).
  ii. Measure viscosity at a controlled temperature (usually 25°C).
- Evaluation: Compare with acceptable range (typically 1–50 cP for liquid mouthwashes).

Other Important Evaluation Parameters

1. Surface Tension:

- Importance: Affects spreading in the oral cavity.
- Procedure: Use a tensiometer to measure surface tension.

2. Foaming Capacity:

- Importance: Some mouthwashes are expected to foam slightly.
- Procedure: Shake a measured quantity and measure foam volume.

3. Microbial Load / Antimicrobial Activity:

- Importance: Ensures safety and efficacy against oral pathogens.
- Procedure:
  i. Plate count for total bacterial/fungal load by Agar Diffusion Method.
  ii. Test inhibition against common oral bacteria (e.g., *Streptococcus mutans*).

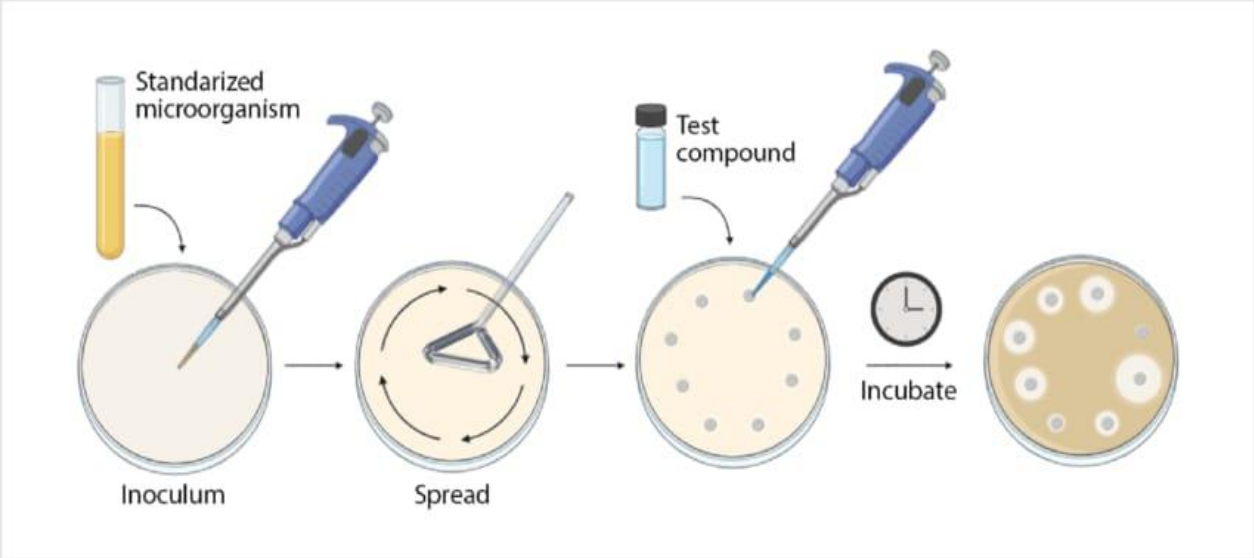

Fig. 1: Agar Diffusion Method

4. Stability Studies:
   - Importance: To check long-term quality.
   - Procedure:
     i. Store at different conditions (room temp, 40°C, refrigeration).
     ii. Evaluate periodically for pH, colour, odour, precipitation, and microbial growth.
5. Specific Gravity:

- Importance: Confirms formulation consistency batch-to-batch.
- Procedure: Use a pycnometer.

V. DISCUSSION

The development of a herbal mouthwash combining Mimosa pudica extract, egg albumin, and supportive herbal ingredients presents a promising advancement in natural oral-care formulations, particularly for addressing tannin-induced oral issues. The formulations (F1–F5) analyzed in this review demonstrate thoughtful variations in extract concentrations, enabling the assessment of synergistic effects among the plant ingredients. Mimosa pudica, known for its antimicrobial, anti-inflammatory, and antioxidant properties, serves as a primary bioactive

component. Its inclusion across all formulations in varying amounts (2–4 ml) highlights its central therapeutic role in combating microbial load and enhancing oral mucosal health.

The incorporation of egg albumin is a distinctive innovation, capitalizing on its natural ability to bind tannins through protein–polyphenol complexation. This mechanism is particularly beneficial for consumers of tea, coffee, and wine, as albumin helps reduce tannin-related astringency and staining. However, because albumin is structurally sensitive, the addition of starch becomes crucial. Starch acts as a stabilizer, preventing premature protein denaturation and ensuring a uniform, stable formulation that maintains albumin's functional integrity throughout storage and use. Complementary herbal extracts such as Neem, Tulsi, Lemon, and Aloe vera further enhance the antimicrobial and soothing effects of the mouthwash. Neem and Tulsi contribute broad-spectrum antibacterial activity, while lemon extract provides mild whitening effects and Aloe vera supports mucosal healing. The inclusion of peppermint and clove oils strengthens flavor, offers additional antimicrobial benefits, and improves patient compliance. Ingredients such as glycerin and honey enhance viscosity, sweetness, and mouthfeel, making the formulation more pleasant and effective in coating oral surfaces.

Overall, the reviewed formulations illustrate how the strategic combination of botanical extracts, natural proteins, and stabilizers can produce a biocompatible, safe, and multifunctional herbal mouthwash. The synergy between Mimosa pudica and albumin—supported by starch—positions this formulation as a novel, nature-derived alternative for managing tannin-related oral concerns and promoting holistic oral hygiene.

VI. CONCLUSION AND FUTURE SCOPE / RECOMMENDATIONS

Conclusion:

The comprehensive review of literature and formulation strategies highlights the potential of a herbal mouthwash combining Mimosa pudica extract, egg albumin, and supporting natural ingredients as an effective and biocompatible solution for tannin reduction and overall oral health enhancement. Mimosa pudica demonstrates significant therapeutic value through its antimicrobial, anti-inflammatory, and antioxidant properties, while egg albumin offers a well-established mechanism for tannin binding through protein–polyphenol complexation. The integration of starch as a stabilizing agent further ensures structural integrity, shelf stability, and performance efficiency of the formulation by preventing premature albumin precipitation.

The reviewed formulations (F1–F5) reflect the importance of achieving optimal ratios of plant extracts, protein content, and excipients to ensure a balanced combination of therapeutic effect, user acceptability, and stability. Supporting botanicals such as neem, tulsi, aloe vera, and citrus extracts contribute synergistic antimicrobial and soothing properties, making the formulation more comprehensive in addressing oral hygiene needs. Overall, this herbal–protein blend stands out as a safe, natural, and multifunctional alternative to conventional chemical mouthwashes, especially for individuals frequently exposed to tannin-rich beverages. uture research may also explore nanoformulation approaches, such as encapsulated albumin or nano-starch carriers, to improve tannin-binding efficiency. Incorporation of probiotic or prebiotic ingredients could broaden the therapeutic profile toward balanced oral microbiota. Additionally, scaling up for industrial production, along with sensory evaluation and packaging innovations, would facilitate commercialization.

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