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**Research Article** 

# **Formulation And Evaluation of Herbal Gel for Dental Caries**

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#### ARTICLE INFO ABSTRACT Published: 28 May 2025 Periodontal diseases such as gingivitis and periodontitis remain widespread oral health Keywords: issues, primarily caused by bacterial plaque accumulation, which leads to inflammation, Herbal Gel, Dental infection, and tissue damage. With growing concerns over antibiotic resistance and the Formulation, Antibacterial demand for safer, natural oral care products, this study aimed to develop and evaluate a Activity, Natural Oral Care herbal-based dental gel with enhanced antibacterial and analgesic properties. The DOI: formulation incorporated Carbopol 980 as a gelling agent, polyethylene glycol and 10.5281/zenodo.15537062 glycerin as solubilizers, and preservatives including methylparaben and propylparaben. Cinnamon and peppermint oils were added to improve flavor, antimicrobial efficacy, and user acceptability. The gel was assessed for key physicochemical parameters such as appearance, pH, Spreadability, homogeneity, texture, and stability. Results indicated that the gel had a smooth, pale-yellow appearance, pleasant aroma, good Spreadability, and a stable pH of 6.32, making it suitable for oral use. The clove oil-based herbal gel demonstrated notable potential in maintaining oral hygiene, relieving dental discomfort, and preventing microbial infections, offering a promising natural alternative to conventional dentifrices.

# **INTRODUCTION**

Currently, dental diseases are emerging as one of the growing health concerns worldwide. These conditions can range from acute to chronic in nature. Effective treatment of dental issues requires the use of potent antibacterial agents and the delivery of adequate drug concentrations directly at the site of action, while minimizing the risk of adverse side effects.[1] Periodontal disease is a significant oral health issue that can affect individuals of any age, gender, or background. It develops when harmful bacteria accumulate around the gums, particularly in the tiny gaps near the teeth. If left untreated, this buildup can cause inflammation, infection, and progressive damage

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to the gums, the underlying bone structure, and surrounding tissues that support the teeth.[2] Periodontal disease includes gum conditions like gingivitis and periodontitis, both caused by plaque buildup. Gingivitis is the early, mild stage, with symptoms like red, swollen, and bleeding gums due to plaque above the gumline. It involves a change in the types of bacteria in the mouth. If untreated, it can lead to periodontitis, a more serious stage where the bone around the teeth starts to break down. Gingivitis and periodontitis are the most common oral health issues.[2] This condition develops as a result of the body's immune response to bacteria interacting with the tissues surrounding the teeth. The toxins and enzymes released by these bacteria damage the periodontium, which includes the structures that support the teeth.[3] Bacteria in the pockets around teeth can protect themselves from antibiotics by forming biofilms, which are sticky layers that help them stick together and to surfaces. Some of these bacteria have special pumps that push antibiotics out of their cells, making them harder to kill. Inside these biofilms, bacteria can also share resistance genes with each other. This helps them survive treatment and can lead to the growth of new types of bacteria that are resistant to antibiotics.[4] Effective and timely management of periodontal disease is essential to stop its progression and prevent further bone loss. Without regular care and treatment, ongoing bone erosion can eventually lead to tooth loss. To address this, mucoadhesive drug delivery systems have been developed. These systems stick to the mucosal lining and slowly release medication over time. One promising form is the mucoadhesive gel. The ideal gel formulation should be easy to apply with a syringe into the periodontal pocket, release the drug in a controlled manner, stay in place without needing to physically attach to the teeth, and be both safe and non-allergenic.[5] Dentifrices are commonly available in the market as pastes, gels, and

powders. These products typically contain a range of ingredients, including flavoring agents, detergents, fluoride, binders, and key components like humectants, desensitizers, and various medications, which can be either herbal or chemical-based. They play an important role in preventing dental issues such as cavities, plaque, and other oral diseases. Recently, herbal-based dentifrices have gained popularity due to their lower risk of side effects.[6] Dental gel is a commonly used oral care product aimed at maintaining oral hygiene. It is a gel-like substance applied to the teeth and gums for various functions, including cleaning, freshening breath, preventing plaque buildup, soothing gum irritation, and delivering active ingredients. Dentists often recommend incorporating them into a daily oral hygiene routine. Chemically, dental gels are semisolid organic or inorganic colloids, which are rich in liquid and consist of hydrated threads or granules of the dispersed phase, closely associated with the dispersion medium.[7]

#### **Product Profile**

Herbal gels are semi-flexible formulations made from natural ingredients that create a stable, threestructure. They offer several dimensional advantages over traditional ointments, including reduced greasiness, better comfort during application, and more effective drug delivery with fewer side effects. Unlike conventional ointments, herbal gels provide a cleaner and more practical alternative, avoiding the oily residue that can be left behind. A key feature of herbal gels is their mucoadhesive properties. These gels contain polymers that attract water, allowing them to adhere more effectively to mucosal surfaces, such as those in the mouth, eyes, or gastrointestinal tract. This increased adhesion prolongs the gel's contact time with the target area, enhancing its therapeutic effectiveness and drug absorption.

This also reduces the need for higher doses. By the specific site of treatment, targeting mucoadhesive gels minimize systemic exposure, lowering the risk of side effects. Overall, herbal mucoadhesive gels provide a promising, efficient, and user-friendly approach to localized drug delivery.[8] The formulated gel was evaluated for key physical characteristics, including spreadability, pH, homogeneity, odor. and appearance. The surface pH was found to be neutral to mildly acidic, indicating that the gel is well-suited for use in the oral cavity without causing irritation. Furthermore, the polymer formulation spreadability was found to be within acceptable ranges.

# **Merits of Dental Gel**

- 1. Targeted Relief Clove oil, rich in eugenol, provides potent analgesic and anti-inflammatory effects directly at the site of pain, such as in cases of toothaches or gum inflammation. This localized action ensures effective relief where it is needed most.
- 2. Rapid Action Clove oil rapidly penetrates the tissues upon topical application, delivering fast-acting pain relief and soothing effects, making it an ideal choice for immediate symptom management.
- **3.** Reduced Systemic Side Effects Due to the localized application of the gel, systemic absorption is minimal, which reduces

the risk of side effects commonly associated with oral analgesics, offering a safer alternative for patients.

- 4. Antibacterial and Antiseptic Properties Clove oil demonstrates strong antimicrobial activity, helping to control oral bacteria that contribute to dental issues such as caries, gingivitis, and other infections, thus supporting oral health.
- 5. Improved Patient Compliance The gel's ease of use, combined with its quick relief of symptoms, encourages patients to adhere more consistently to treatment protocols, leading to better treatment outcomes.<sup>[9]</sup>

# MATERIAL AND METHODS

Table No.1 Materials and their functional roles in				
formulation				

Sr.	Ingredients	Role
No.		
1.	Clove Oil	API (Pain Relief And Antibacterial
		Action)
2.	Carbomer 980	Gelling Agent
3.	Polyethylene	Cosolvent
	Glycol	
4.	Glycerine	Drug Solubilizer
5.	Methyl Paraben	Preservative
6.	Propyl Paraben	Preservative
7.	Cinnamon Oil	Sweetening Agent And Mild
		Antiseptic
8.	Peppermint Oil	Flavouring Agent
9.	Distilled Water	Vehicle





Figure No.1 Material Used

# Clove oil:

• Clove oil is extracted by distilling the dried flower buds of *Syzygium aromaticum* (Linn.) Merrill and Perry, also known as *Eugenia caryophyllus*.

# **Description:**

- Freshly distilled clove oil is a clear, colorless or pale-yellow liquid, but it tends to darken and thicken over time or when exposed to air. It has a characteristic clove-like aroma.
- The oil contains between 85.0% and 95.0% by weight of phenolic compounds, primarily eugenol (C<sub>10</sub>H<sub>12</sub>O<sub>2</sub>).
- Clove oil serves as an active pharmaceutical ingredient.<sup>[10]</sup>

# 1. Carbopol:

• These substances are commonly referred to as carbomers. They are high-molecular-weight polymers made from acrylic acid and are cross-linked with polyalkenyl ethers derived from sugars or polyalcohols.

• Carbomers contain between 56.0% and 68.0% carboxylic acid (-COOH) groups, based on their dried weight.

# **Description:**

- It appears as a white, fluffy powder.
- It easily absorbs moisture from the air.
- It is commonly used as a gelling agent.<sup>[11]</sup>

# 2. Polyethylene glycol:

Polyethylene glycol is a man-made resin produced by polymerizing ethylene glycol, resulting in a series of water-soluble compounds known as oligomers.

# **Description:**

- It is a clear, colourless, or thick (viscous) liquid.
- It functions as a co-solvent, helping to dissolve other substances.<sup>[12]</sup>

# 3. Glycerin:

• Glycerine, also known as propane-1,2,3-triol, has the molecular formula C<sub>3</sub>H<sub>8</sub>O<sub>3</sub>. It contains between 98.0% and 101.0% of C<sub>3</sub>H<sub>8</sub>O<sub>3</sub> when



measured on a moisture-free (anhydrous) basis.

# **Description:**

- Glycerine is a clear, colourless liquid with a thick, syrup-like consistency.
- It is highly hygroscopic, meaning it readily absorbs moisture from the air.
- It is commonly used to help dissolve drugs.<sup>[13]</sup>

# 4. Methylparaben:

- Methyl 4-hydroxybenzoate is another name for methylparaben, which has the chemical formula C<sub>8</sub>H<sub>8</sub>O<sub>3</sub>.
- A minimum of 99.0 percent and a maximum of 101.0 percent of C8H8O3 are present in methylparaben.

# **Description:**

- It appears as a colourless or white crystalline powder.
- It is commonly used as a preservative.<sup>[14]</sup>

# 5. Propyl paraben:

 Propylparaben, chemically known as propyl 4hydroxybenzoate, has the molecular formula C10H12O3. It is required to contain no less than 99.0% and no more than 101.0% of C10H12O3, when calculated on a dried basis.

# **Description:**

- Appears as a white, odourless crystalline powder
- Commonly used as a preservative to enhance product shelf life.<sup>[15]</sup>

#### 6. Cinnamon Oil:

• The volatile essential oil is obtained through steam distillation from the bark or leaves of *Cinnamomum zeylanicum* (Cinnamomum verum), commonly referred to as Ceylon cinnamon, or from other species within the *Cinnamomum* genus. This oil is recognized for its aromatic and medicinal properties.

# **Description:**

- It is a transparent liquid with a colour that varies from yellowish to brownish, possessing a strong aromatic scent and a warm, spicy taste.
- The oil dissolves easily in alcohol.
- Its main active compound is cinnamaldehyde, accompanied by smaller quantities of eugenol, benzaldehyde, and other minor constituents.<sup>[16]</sup>

# 7. Peppermint Oil:

• Peppermint oil is an essential oil extracted by steam distillation from the fresh flowering tops of *Mentha piperita* Linn., a plant belonging to the Lamiaceae family.

# **Description:**

- It appears as a colourless to pale yellow liquid with a strong, penetrating aroma and a cooling taste, primarily due to its high menthol content.
- It has a sharp, pungent flavour followed by a cooling sensation and mainly contains menthol and menthone as its active components. It is also used as a flavouring agent.
- Peppermint oil acts as a mild local anaesthetic and has antipruritic (anti-itching) properties.<sup>[17]</sup>



#### **Steps For Gel Preparation**

- 1. Carbopol 980 was dispersed in distilled water and allowed to soak for 24 hours to ensure complete hydration and swelling of the polymer.
- 2. Accurately weighed amounts of methylparaben and propylparaben were then incorporated into the hydrated Carbopol and mixed thoroughly to ensure uniform distribution.
- 3. The required amount of polyethylene glycol was added gradually, with continuous stirring to maintain consistency and promote proper blending.
- 4. Glycerine was then introduced into the mixture and stirred until it was evenly distributed.
- 5. A pre-weighed quantity of the hydrated Carbopol gel base was carefully added to the formulation to provide the desired gel consistency.
- 6. Clove oil, cinnamon oil, and peppermint oil were added as active and aromatic agents, contributing both therapeutic and sensory qualities to the gel.
- 7. The entire mixture was stirred continuously until a smooth, homogenous gel was formed, ensuring all components were evenly incorporated

# **Composition Of Gel Formulation:**

# Table No.2 Gel Formulation Ingredients and Their Quantities

Sr. No.	Ingredients	Quantity
1.	Clove oil	0.75 ml
2.	carbomer 980	0.9 g
3.	Polyethylene	15 ml
	glycol	
4.	Glycerin	5 ml
5.	Methyl paraben	0.2 g
6.	Propyl paraben	0.002 g
7.	Cinnamon oil	2.25 ml
8.	Peppermint oil	0.45 ml
9.	Distilled water	q.s.

#### **Evaluation of gel formulation:**

#### **1. Physical appearance:**

• Colour:

The color of the formulation was observed by placing it against a white background for better visibility and accuracy.

#### • Consistency:

The consistency of the gel was evaluated by applying it to the skin.

#### • Greasiness:

The level of greasiness was assessed through its application on the skin.

#### • Appearance:

The gel formulations were observed to have a paleyellow colour.

• Odour:

The odour of the gel was evaluated by dissolving the gel in water and assessing the resulting fragrance.

# **Determination of pH:**

The pH of the gel was measured using a digital pH meter by fully immersing the glass electrode into the gel formulation.<sup>[18]</sup>

#### **Determination of Spreadability**

The Spreadability of the gel was evaluated using a glass slide apparatus. A quantity of 2 g of the gel was placed on a clean glass slide, and another slide was carefully positioned over it to sandwich the gel uniformly between the two surfaces. A known weight was placed on the upper slide to facilitate



spreading, after which the slides were pulled apart in opposite directions. The distance the upper slide moved and the time taken were recorded. This procedure was repeated three times, and the average value was considered for analysis.

Spreadability was calculated using the following formula:

$$S = M \times L / T$$

Where:

S = Spreadability M = Weight applied on the upper slide (g) L = Distance moved by the slide (cm)T = Time taken (s)

#### **Determination of Homogeneity**

To assess the uniformity of the gel formulation, the prepared gels were visually inspected after being stored in their respective containers. This evaluation focused on the overall appearance, aiming to detect any visible signs of lumps, aggregates, or phase separation. A smooth, consistent texture without any irregularities was considered an indication of good homogeneity. [19,20]

# Solubility

Solubility describes the capability of a solute to dissolve in a solvent, resulting in a homogeneous solution. Clove oil demonstrates excellent solubility in ethanol and is classified as freely soluble in it.

# **RESULT AND DISCUSSION**



Figure No.2 Prepared Sample of Herbal Tooth Gel

Sr. No.	Test	Result
1.	Colour	Pale Yellow
2.	PH	6.32
3.	Homogeneity	Very Good
4.	Odour	Aromatic
5.	Spreadability	Good
6.	Appearance	Glossy
7.	Stability	Stable
8.	Texture	Smooth

#### Table No.3 Evaluation of gel Formulation



#### DISCUSSION

The physical properties of the formulation were carefully evaluated. The formulations appeared pale yellow in colour, as indicated in Table 3. The pH of the formulation was measured at 6.32, which falls within the normal pH range (6–7) of the buccal cavity, indicating that the gels are likely to be gentle and irritation-free. Additionally, the formulation was evaluated for homogeneity, as shown in Table 3, and it was found to be uniform and free of aggregates.

#### CONCLUSION

In conclusion, the herbal based gel demonstrated effective results. The study indicates that the formulated gel is capable of cleaning teeth, maintaining oral hygiene, and inhibiting the growth of harmful microorganisms in the oral cavity. Additionally, the herbal tooth gel may possess properties such as anti-plaque, antitoothache, and the ability to prevent gum-related issues. The gel also shows superior penetration compared to other oral care products, such as ointments or mouthwashes, with a rapid absorption into the gums that helps reduce inflammation and address other dental concerns.

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