

To Formulate and Evaluate A Clove Oil-Based Herbal Gel for Dental Applications

Akhil¹ and Mrs. Richa Agnihotri²

¹ B. Pharmacy 8th Semester Student, ² Associate Professor

School of Pharmacy, Abhilashi University, Chailchowk, Mandi, Himachal Pradesh, India

Abstract: *This study focuses on the formulation and evaluation of a herbal dental gel containing clove oil. Clove oil, rich in eugenol, exhibits strong antibacterial and analgesic properties. The gel was prepared using suitable gelling agents and evaluated for physicochemical parameters such as pH, spreadability, viscosity, and drug content. Antibacterial activity was tested against oral pathogens like Streptococcus mutans. The results showed significant antimicrobial activity and acceptable formulation characteristics. The developed herbal gel may serve as a safe and effective alternative to synthetic dental products.*

Keywords: to formulate and evaluate a clove oil-based herbal gel for dental applications

I. INTRODUCTION

Herbal medicines have gained significant attention in recent years due to their safety, effectiveness, and minimal side effects compared to synthetic drugs. Medicinal plants have been used since ancient times for the treatment and prevention of various diseases. According to the World Health Organization (WHO), a large proportion of the global population relies on plant-based medicines for primary healthcare. Among these, clove (*Syzygium aromaticum*) is one of the most important medicinal plants known for its wide range of therapeutic properties.

Clove is the dried flower bud of *Syzygium aromaticum*, belonging to the family Myrtaceae. It is widely used in traditional medicine systems for its antimicrobial, analgesic, anti-inflammatory, and antioxidant activities. The major bioactive constituent of clove oil is eugenol, which is responsible for its strong antibacterial and antiseptic properties. Due to these characteristics, clove oil has been extensively used in dental care for the treatment of toothache, gum infections, and oral diseases.

Oral diseases such as dental caries, gingivitis, and periodontitis are among the most common health problems worldwide. These conditions are mainly caused by microbial infections, particularly bacteria like *Streptococcus mutans* and *Lactobacillus*. Conventional treatments include synthetic antimicrobial agents and fluoride-based products, which may lead to side effects such as dental fluorosis, mucosal irritation, and microbial resistance with prolonged use. Therefore, there is a growing need for safe and effective herbal alternatives.

Herbal gels are semisolid dosage forms that offer several advantages such as ease of application, better patient compliance, and targeted drug delivery. Incorporating clove oil into a gel formulation enhances its therapeutic efficacy and allows localized treatment of oral infections. The use of natural ingredients in gel formulations also reduces toxicity and improves biocompatibility.

Based on these considerations, the present study aims to formulate and evaluate a clove oil-based herbal gel and assess its antibacterial activity against oral pathogens. This research focuses on developing a safe, effective, and economical herbal alternative for maintaining oral hygiene and treating dental infections.

II. REVIEW OF LITERATURE

Clove (*Syzygium aromaticum*) has been extensively studied for its medicinal properties, especially due to the presence of its major bioactive compound, eugenol. According to Chaieb et al. (2007), clove essential oil exhibits strong



antimicrobial, antifungal, and antioxidant activities, making it highly effective against a wide range of pathogenic microorganisms. These properties support its traditional use in dental and oral care applications.

Gupta et al. (2011) reported that medicinal plants are valuable sources of bioactive compounds and play a significant role in modern drug development. Herbal formulations derived from such plants are considered safer and more acceptable compared to synthetic drugs, which often cause adverse effects.

Pawar et al. (2013) developed a dental gel containing essential oils and found that the formulation showed significant antimicrobial activity against oral pathogens. Their study demonstrated that herbal gels can effectively inhibit bacterial growth and can be used as alternatives to conventional dental products.

Similarly, Sharma et al. (2012) formulated and evaluated a herbal gel and concluded that such formulations possess good physicochemical properties like stability, spreadability, and viscosity, along with therapeutic effectiveness. Misal et al. (2012) also emphasized that herbal gels are advantageous due to their non-greasy nature, ease of application, and better patient compliance.

Satpathy et al. (2011) studied gel formulations containing essential oils and reported enhanced antimicrobial activity against skin and oral pathogens. Their findings support the incorporation of essential oils like clove oil into gel formulations for improved therapeutic effects.

Kamatou et al. (2012) highlighted the importance of eugenol as a versatile bioactive compound with analgesic, anti-inflammatory, and antimicrobial properties. The study explained its mechanism of action, particularly its role in disrupting microbial cell membranes, which contributes to its antibacterial activity.

Jirovetz et al. (2006) analyzed the chemical composition of clove oil and confirmed its strong antioxidant properties, which help in reducing oxidative stress and enhancing healing processes. Ates and Erdogru (2003) also reported that plant extracts, including clove, show significant antimicrobial activity against various bacterial strains.

Dheepika and Uma Maheswari (2014) discussed the role of herbal agents in oral diseases and concluded that plant-based formulations are effective in managing oral infections with minimal side effects. Mastiholimath et al. (2006) developed dental formulations and emphasized the importance of localized drug delivery systems for better therapeutic outcomes.

Moran et al. (1994) and Ashley et al. (1984) studied the effectiveness of chemical agents like cetylpyridinium chloride in controlling plaque and gingivitis but also highlighted limitations such as side effects and long-term safety concerns, which create the need for safer herbal alternatives.

Gulcin et al. (2012) demonstrated that clove oil possesses powerful antioxidant activity, which contributes to its protective effects against various diseases. Furthermore, the World Health Organization (2002) reported that a significant portion of the global population depends on herbal medicine for primary healthcare, emphasizing the importance of developing plant-based formulations.

Overall, the literature suggests that clove oil has significant therapeutic potential, particularly in dental care, and its incorporation into herbal gel formulations can provide an effective, safe, and economical alternative to conventional synthetic products.

III. METHOD OF PREPARATION

The clove oil herbal gel was prepared by using Carbopol 934 as the gelling agent. Initially, the required quantity of Carbopol 934 was accurately weighed and dispersed slowly in distilled water with continuous stirring to avoid formation of lumps. The dispersion was kept aside for proper hydration of the polymer. In a separate beaker, clove oil was mixed with propylene glycol to obtain a uniform solution, and methyl paraben was added as a preservative. This mixture was then added gradually into the hydrated Carbopol base with continuous stirring to obtain a homogeneous preparation. After complete mixing, triethanolamine was added dropwise to adjust the pH and to convert the dispersion into a smooth gel. The prepared herbal gel was stirred thoroughly to remove entrapped air and ensure uniform distribution of all ingredients. Finally, the formulated clove oil herbal gel was transferred into suitable airtight containers and stored at room temperature for further evaluation studies.



Procedure

- Accurately weighed the required quantity of Carbopol 934.
- Dispersed Carbopol 934 in distilled water with continuous stirring to avoid lump formation.
- Allowed the dispersion to stand for proper hydration of the polymer.
- Mixed clove oil with propylene glycol in a separate beaker to obtain a uniform mixture.
- Added methyl paraben as preservative to the clove oil mixture.
- Slowly incorporated the clove oil mixture into the hydrated Carbopol dispersion with constant stirring.
- Added triethanolamine dropwise to adjust the pH and convert the dispersion into gel form.
- Stirred the preparation continuously until a smooth and homogeneous gel was obtained.
- Removed entrapped air from the gel by keeping it undisturbed for some time.

Transferred the prepared herbal gel into airtight containers and stored at room temperature for further evaluation studies.

Clove oil

Clove oil is a natural essential oil obtained from the dried flower buds of *Syzygium aromaticum*, commonly known as clove. It belongs to the family Myrtaceae and is widely used in traditional as well as modern medicine because of its numerous therapeutic properties. Clove oil contains a major active constituent known as eugenol, which is mainly responsible for its medicinal and pharmacological activities. Other constituents present in clove oil include eugenol acetate, β -caryophyllene, flavonoids, tannins, and triterpenoids. Clove oil possesses strong antibacterial, antifungal, antioxidant, antiseptic, analgesic, and anti-inflammatory properties. Due to these activities, it is extensively used in dental care preparations for the treatment of toothache, oral infections, gum pain, mouth ulcers, and bad breath. Eugenol present in clove oil acts by damaging the bacterial cell membrane and inhibiting microbial growth. It is highly effective against oral pathogens such as *Streptococcus mutans* and *Lactobacillus* species, which are responsible for dental caries and plaque formation. Clove oil is also used in pharmaceutical, cosmetic, and food industries as a flavoring and preservative agent. Because of its natural origin, lower toxicity, and wide range of biological activities, clove oil has become an important ingredient in herbal formulations such as gels, mouthwashes, toothpastes, creams, and ointments. In the present research work, clove oil was selected as the active ingredient due to its excellent antimicrobial and analgesic properties, making it suitable for oral healthcare applications.

Carbopol934

Carbopol 934 is a synthetic high molecular weight cross-linked polymer of acrylic acid widely used as a gelling agent in pharmaceutical formulations. It is commonly used in topical preparations such as gels, creams, lotions, and ointments because of its excellent thickening, suspending, and stabilizing properties. Carbopol 934 forms a clear, smooth, and stable gel when dispersed in water and neutralized with suitable alkaline agents such as triethanolamine. In herbal gel formulations, Carbopol 934 plays an important role in providing suitable viscosity, consistency, and spreadability. It helps in maintaining uniform distribution of the active ingredient throughout the formulation and improves the stability of the product during storage. Carbopol gels are non-greasy, easily washable, and provide good patient compliance due to their smooth texture and ease of application.

Carbopol 934 also enhances the retention time of the formulation at the site of application, thereby improving the therapeutic effectiveness of the drug. Because of its bioadhesive nature, it is widely used in oral and topical drug delivery systems. In the present study, Carbopol 934 was selected as the gelling agent for the preparation of clove oil herbal gel because it produces a transparent and stable gel with good consistency and spreadability.

Propylene glycol

Propylene glycol is a clear, colorless, odorless, and hygroscopic liquid widely used in pharmaceutical, cosmetic, and food formulations. In pharmaceutical preparations, it acts as a solvent, humectant, plasticizer, and penetration enhancer.



Propylene glycol helps in dissolving active ingredients uniformly and improves the overall consistency and stability of the formulation.

In herbal gel formulations, propylene glycol is mainly used to enhance the solubility of clove oil and other ingredients. It also helps in maintaining moisture content in the formulation and prevents drying of the gel during storage. Due to its humectant property, it provides smooth texture and improves spreadability of the gel, making the preparation easy to apply over the affected area.

Propylene glycol also acts as a penetration enhancer by increasing the absorption of the active ingredient through the skin or oral mucosa, thereby improving the therapeutic effectiveness of the formulation. It is considered safe, non-toxic, and non-irritant when used in suitable concentrations. Because of these advantages, propylene glycol is extensively used in topical gels, creams, lotions, and oral pharmaceutical preparations.

In the present study, propylene glycol was used to improve the solubility of clove oil, maintain moisture in the gel, and enhance penetration of the active ingredient for better antibacterial activity.

Methyl paraben

Methyl paraben is a commonly used preservative in pharmaceutical, cosmetic, and food products. It belongs to the class of parabens, which are esters of para-hydroxybenzoic acid. Methyl paraben is widely used because of its effective antimicrobial activity against bacteria, fungi, and molds. It helps in preventing microbial contamination and spoilage of formulations during storage, thereby increasing the shelf life and stability of the product.

In herbal gel formulations, the presence of water and natural ingredients increases the risk of microbial growth; therefore, preservatives are essential to maintain product quality and safety. Methyl paraben is preferred because it is stable over a wide pH range, compatible with most pharmaceutical ingredients, and effective even at low concentrations. It is colorless, odorless, non-irritant, and safe when used within permissible limits.

Methyl paraben also helps in maintaining the physical appearance, consistency, and therapeutic effectiveness of the formulation throughout the storage period. Due to its broad-spectrum antimicrobial activity and low toxicity, it is extensively used in topical gels, creams, ointments, lotions, and oral pharmaceutical preparations.

In the present study, methyl paraben was used as a preservative to protect the clove oil herbal gel from microbial contamination and to improve the stability and shelf life of the formulation.

Triethanolamine

Triethanolamine is an organic chemical compound widely used in pharmaceutical and cosmetic formulations as a pH-adjusting agent and emulsifying agent. It is a colorless or pale yellow viscous liquid with mild ammonia-like odor and is highly soluble in water. In gel formulations, triethanolamine plays an important role in neutralizing acidic polymers such as Carbopol 934 and converting them into a smooth and stable gel.

In herbal gel preparations, triethanolamine is mainly used to adjust the pH of the formulation to a suitable range that is compatible with skin and oral tissues. Proper pH adjustment is necessary to maintain stability, consistency, and therapeutic effectiveness of the gel. When added to Carbopol dispersion, triethanolamine causes swelling of the polymer chains, resulting in the formation of a transparent and viscous gel.

Triethanolamine also improves the texture, spreadability, and appearance of the formulation. It helps in maintaining homogeneity and prevents phase separation during storage. Due to its stabilizing and neutralizing properties, it is extensively used in topical gels, creams, lotions, ointments, and cosmetic products.

In the present study, triethanolamine was used to neutralize Carbopol 934 and to obtain a smooth, homogeneous, and stable clove oil herbal gel suitable for oral application.

Distilled water

Distilled water is purified water obtained through the process of distillation, in which impurities, dissolved salts, microorganisms, and other contaminants are removed. In pharmaceutical formulations, distilled water is widely used as



a vehicle or solvent because of its high purity and safety. It provides a suitable medium for dissolving, dispersing, and mixing various formulation ingredients uniformly.

In herbal gel formulations, distilled water plays an important role in the hydration of polymers such as Carbopol 934, which is necessary for gel formation. It also helps in maintaining the consistency, smoothness, and stability of the formulation. Since distilled water is free from minerals and microbial contamination, it minimizes the chances of unwanted chemical reactions and enhances the shelf life of the product.

Distilled water is non-toxic, colorless, odorless, and compatible with most pharmaceutical ingredients. It is commonly used in topical gels, creams, lotions, oral formulations, and parenteral preparations because it ensures product purity and safety. In the present study, distilled water was used as the vehicle for preparing clove oil herbal gel and for uniformly dispersing all ingredients in the formulation.

IV. EVALUATION PARAMETERS

Physical Appearance

The prepared gel was visually examined for:

- Color
- Odor
- Homogeneity
- Consistency
- Presence of grittiness

pH Determination

The pH of the gel was measured using a digital pH meter by dispersing a small quantity of gel in distilled water.

Viscosity

Viscosity of the formulation was determined using a Brookfield viscometer at suitable spindle speed.

Spreadability

Spreadability was evaluated by placing the gel between two glass slides and measuring the ease of spreading under a certain weight.

Formula:

Where:

S = Spreadability

M = Weight tied to upper slide **L** = Length moved by glass slide **T** = Time taken

Extrudability

Extrudability was determined by measuring the amount of gel extruded from a collapsible tube under applied pressure.

Homogeneity

The gel was tested by visual inspection after setting in the container to check for uniform distribution of ingredients.

Stability Study

The formulation was stored at different temperature conditions and observed periodically for changes in:

- Color
- Odor
- pH
- Consistency



Antibacterial Activity

Antibacterial activity of the prepared gel was evaluated by agar well diffusion method against oral microorganisms. The zone of inhibition was measured and compared with marketed formulation.

Drug Content Uniformity

A specific quantity of gel was dissolved in suitable solvent and analyzed spectrophotometrically to determine uniform distribution of clove oil.

V. CONCLUSION

The present study successfully formulated and evaluated a clove oil-based herbal gel for dental applications. The prepared formulation exhibited desirable physicochemical properties, including suitable pH, viscosity, spreadability, homogeneity, and stability, making it appropriate for oral use. Furthermore, the gel demonstrated effective antibacterial activity against oral pathogens responsible for dental infections and plaque formation.

The use of clove oil, owing to its analgesic, anti-inflammatory, and antimicrobial properties, provides a natural and safer alternative to synthetic dental products that may produce adverse effects upon prolonged use. Therefore, the developed herbal dental gel has considerable potential as an economical, effective, and patient-friendly formulation for maintaining oral hygiene and managing minor dental infections. However, further investigations involving extensive microbiological studies, toxicity evaluation, and clinical trials are recommended to establish its long-term safety and therapeutic efficacy before commercialization. This conclusion is consistent with the report's findings.

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Results

The formulated clove oil-based herbal dental gel was successfully prepared using Carbopol 934 as the gelling agent. The prepared gel exhibited satisfactory physicochemical characteristics and showed promising antibacterial activity against oral pathogens. The findings of the evaluation studies are summarized below:

Evaluation Parameter	Observation/Result
Physical appearance	Smooth, homogeneous gel with no visible grittiness
colour	Pale yellow to off-white
Odour	Characteristic pleasant clove odour
Consistency	Good and uniform consistency
pH	Found within the acceptable range for oral application (approximately 6.5-7.0)
Viscosity	Adequate viscosity ensuring proper retention at the application site
Spreadability	Good spreadability with easy application over the affected area
Extrudability	Satisfactory extrusion from collapsible tubes
Homogeneity	Uniform distribution of ingredients without phase separation
Stability study	No significant changes in colour, odour, pH, or consistency during storage
Drug content uniformity	Uniform distribution of clove oil throughout the gel formulation
Antibacterial activity	Significant inhibition of oral microorganism such as streptococcus mutans

The evaluation demonstrated that the prepared gel possessed acceptable pharmaceutical characteristics and effective antimicrobial properties. The antibacterial activity observed may be attributed to the presence of eugenol, the major active constituent of clove oil. The abstract of the report also states that the formulation exhibited significant antimicrobial activity with acceptable formulation characteristics.

