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(RESEARCH ARTICLE)

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The role of *Mangifera indica* and *Psidium guajava* in the treatment of peptic ulcer

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Abstract

Background: Modern day life style brings a lot of habitual changes in human beings that directly or indirectly affects individual health. For example, bad food eating habits leads to many disorders of gastrointestinal tract, such as peptic ulcer, Gastroesophageal Reflux Disease (GERD), Irritable Bowel Syndrome (IBS), constipation, diarrhea, gastritis, hemorrhoids and in some cases, an increased risk of colorectal cancer. Peptic ulcers occur due to factors like Spicy, acidic, fatty food items, alcohol consumption, smoking, persistent inflammation and unchecked oxidative damage etc. While standard treatments provide relief, their frequent side effects have sparked a growing interest in nature derived options. Based on traditional rationale, this investigation explores the protective promise of leaves from *Mangifera indica* (mango) and *Psidium guajava* (guava), containing/ consisting of bioactive compounds like mangiferin, limonene, quercetin and gallic acid etc. that possess anti-inflammatory, antimicrobial, antibacterial, antidiabetic, antioxidant and tissue healing properties through different pathways, including NF-κB blockade and free radical neutralization etc.

Objective: To investigate the gastroprotective efficacy of *Mangifera indica* and *Psidium guajava* leaf extracts in formulating a topical mucoadhesive gel for managing mouth ulcers.

Methods: Leaves sourced and verified from Himachal Pradesh, India, underwent hydroalcoholic extraction (95% ethanol) via the Soxhlet method. Standard qualitative assays verified key phytoconstituents alkaloids, flavonoids, phenols, tannins, saponins, terpenoids, glycosides, proteins and carbohydrates in the yields. These extracts (5% w/w each) were blended into a Carbopol 940 mucoadhesive gel matrix, enhanced with menthol for soothing, analgesia and rigorously tested for various physicochemical parameters including pH, viscosity, spread ability, homogeneity, drug content and irritancy.

Results: The mucoadhesive mouth gel emerged as a cohesive, semi-solid preparation boasting a consistent light-green appearance, agreeable aroma, neutral pH (6.0–7.5), broad viscosity range (5,000–100,000 cP), superior spread ability, even distribution (±5% deviation) and reliable drug uniformity (95–99%), all while showing zero irritancy hallmarks of a formulation ready for real-world application.

Conclusion: The formulation proved stable, exhibiting no phase separation or microbial contamination over the evaluation period. As such, this herbal mouth gel offers a natural, affordable and user-friendly alternative to standard treatments for oral ulcers. Scaling up production and conducting accelerated stability tests would further bolster its prospects for commercial rollout as a plant-based oral care solution.

Keywords: *Mangifera indica*; *Psidium guajava*; Mangiferin; Limonene; Peptic Ulcer; Mouth Sores; Herbal Mouth Gel.

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1. Introduction

1.1. *Mangifera indica*

Mango (*Mangifera indica*) is one of the oldest and most popular fruits having delightful flavour and taste. Mango the "King of Fruits" is an economically significant fruit in different areas of the globe. In addition to its great tropical taste, mangoes encapsulate nutrients and make eating healthy and pleasant sensory experience. Mango fruit is a member of the Anacardiaceae family and, in the Sapindales order. India is the largest producer, followed by China, Thailand and Mexico, with Mexico leading in international trade, accounting for 20% of the global market. Mango is a most cultivated fruit that originated in India around 4,000 years ago [1]. Andhra Pradesh, Uttar Pradesh, Karnataka, Bihar, Gujarat and Tamil Nadu are the main mango-producing states. Uttar Pradesh is the largest producer of mangoes, accounting for 23.47% of total production and producing the most fruit (APEDA, 2021) [2]. India ranks as a major exporter of fresh mangoes to international markets. Mangoes consist of carbohydrates minerals fiber and vitamins that play a vital role in human health. These encompass minerals such as nitrogen potassium phosphorus iron sodium calcium and magnesium together with vitamins A B E and C. Protein stands as the primary macromolecule in mango leaves. Every part of the mango plant - fruit pulp seed peel flowers leaves and bark - provides potential benefits that underpin its widespread appeal for nutraceutical and medicinal purposes [3].

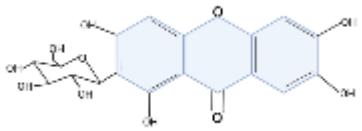
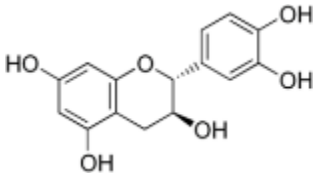
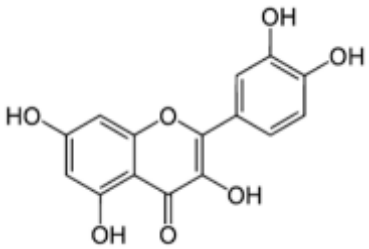
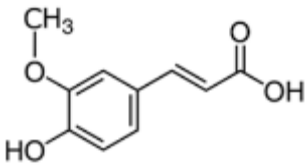
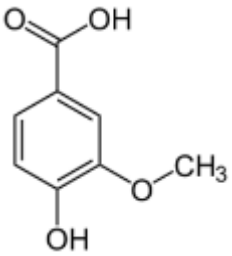
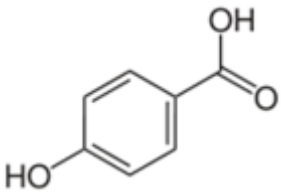
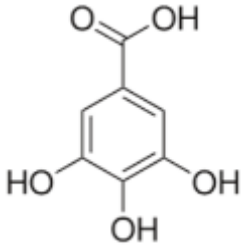
Mangifera indica serves as a vital source of macronutrients including carbohydrates lipids and fatty acids proteins and amino acids plus organic acids. Mango also supplies micronutrients such as vitamins and minerals alongside non-nutrient compounds like phenolic compounds flavonoids and other polyphenols chlorophyll carotenoids and volatile compounds. Mangiferin stands as the most bioactive constituent in mango. It drives the bulk of its biological effects. Mango leaf oil contains monoterpenes sesquiterpenes minor amounts of related compounds and traces of non-terpenoid and oxygenated hydrocarbons [3, 4]. Mango leaf essential oil shows bacteriostatic effects and harbours antimicrobial agents such as α-gurjunene, trans-caryophyllene, α-humulene, α-selinene and camphor. Benzophenone compounds in mango leaves exhibit potent α-glucosidase inhibitory and immunosuppressive effects [5]. Mango leaves support broad applications through their diverse phytochemical biological and pharmacological activities such as antimicrobial antioxidant anti-diabetic anti-tumour and immunomodulatory properties [6].

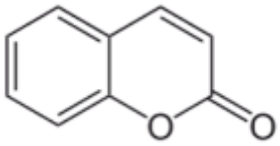
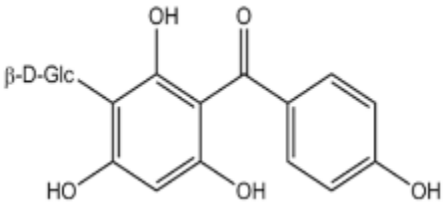
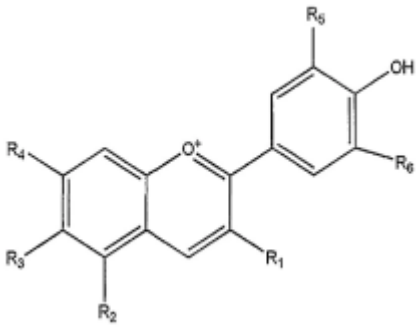
Figure 1 Mango Tree

Figure 2 Mango Leaves

1.1.1. Chemical constituents

Table 1 Phytochemistry of *Mangifera indica* [6, 7]

Sr. No.	Phytochemicals	Chemical Structure	Pharmacological Activity
1.	Mangiferin		Antidiabetic, Hypolipidemic, anti-inflammatory and antioxidant
2.	Catechin		Antidiabetic, Anti- inflammatory, antibacterial and antioxidant
3.	Quercetin		Anti-inflammatory and antioxidant
4.	Ferulic acid		Antioxidant anti-inflammatory and photoprotective
5.	Vanillic acid		Antioxidant
6.	4-hydroxy benzoic acid		Antioxidant and anti-inflammatory
7.	Gallic acid		Antioxidant, anti-inflammatory, antimicrobial and anti-proliferative

8.	Coumarin		Bronchodilator, fungicide, anticoagulant, vasodilator, spasmolytic and anti-thrombotic
9.	Iriflophenone 3-C-glucoside		Antioxidant and anti-proliferative
10.	Antocyanin		Antioxidant, anti- inflammatory, anti-diabetic and anti-proliferative

1.2. Pharmacological Activities

1.2.1. Anti-Bacterial

Various morphological components of the mango plant such as leaves exhibit antibacterial properties against pathogens including Staphylococcus sp. Bacillus subtilis Escherichia coli Candida albicans Proteus vulgaris Pseudomonas fluorescens Shigella flexneri Klebsiella pneumoniae and Salmonella typhi. *Mangifera indica* leaf extract represents the most researched element for antibacterial effects [8]. It demonstrates notable efficacy against Staphylococcus aureus, Streptococcus pyogenes, Streptococcus pneumoniae, Pseudomonas aeruginosa, Candida albicans and Enterococcus faecalis. The antibacterial potential of extract also targets Salmonella enterica, Listeria monocytogenes and Escherichia coli [9].

1.2.2. Anti-Fungal

Mangiferin exhibits activity against seven bacterial species - Bacillus pumilus B. cereus Staphylococcus aureus, S. citreus, Escherichia coli, Salmonella agona and Klebsiella pneumoniae - one yeast (Saccharomyces cerevisiae) and four fungi (Thermoascus aurantiacus Trichoderma reesei Aspergillus flavus and A. fumigatus) [10].

1.2.3. Anti-Inflammatory

Mangiferin and other phenolic compounds suppress the nuclear factor kappa light chain enhancer (NF-κB) pathway. This action lowers transcription of pro-inflammatory genes. It thereby reduces production of inflammatory mediators such as TNF-α and IL-1β. Cytokine Reduction: Research indicates marked decreases in tumour necrosis factor-alpha (TNF-α) and interleukin-1beta (IL-1β) levels after mango leaf extract treatment. These cytokines contribute key roles in pain perception and tissue inflammation [7].

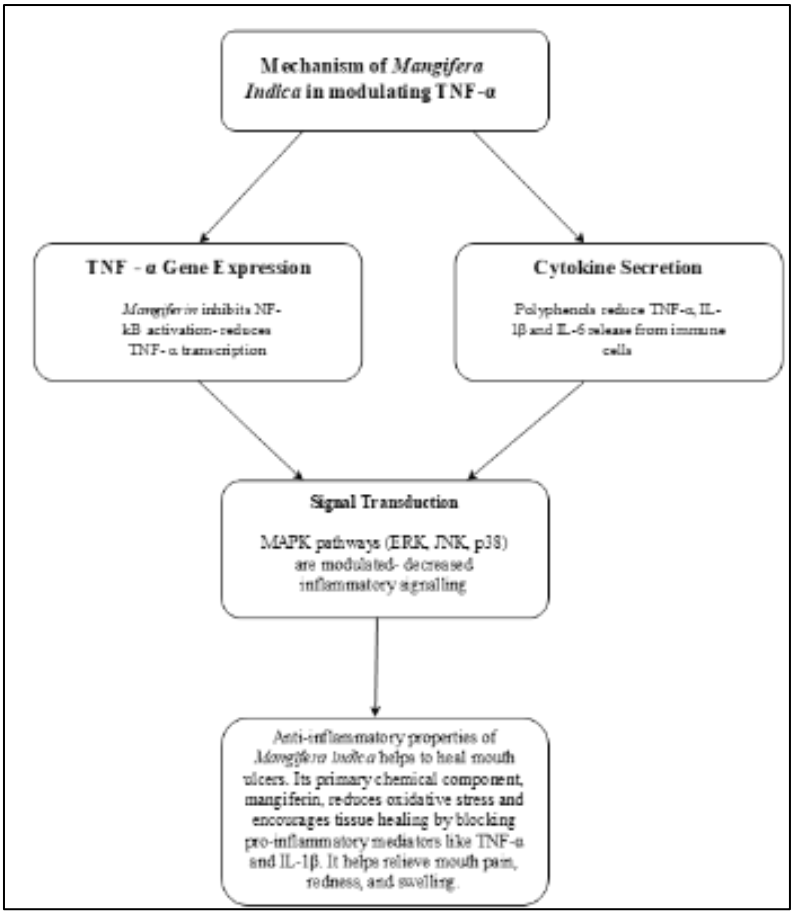


Figure 3 Role of Mangiferin in TNF- α transcription

1.2.4. Anti-cancer

Polyphenols in *Mangifera indica* leaves such as phenolic acids gallotannins mangiferin and quercetin exhibit chemo-preventive effects against multiple cancers. These stem from their strong antioxidant and anti-inflammatory actions. Mangiferin reduces various tumours by blocking their migration invasion and proliferation. Additional mechanisms of mangiferin encompass inhibition of telomerase and the gene [11]. Mangiferin also alleviates oxidative stress and prevents methylmercury-induced DNA damage in the human neuroblastoma cell line IMR-32 [12].

1.2.5. Anti-diabetic

Mangifera indica leaves have strong anti-diabetic potential owing to their hypoglycaemic compounds like flavonoids and benzophenones. Mangiferin exhibited lower α-glucosidase inhibition which can be enhanced by replacing the glucose group with hydrogen which may decrease the steric hindrance during the mangiferin enzyme interaction [13].

1.2.6. Antioxidant

Mango fruit displays antioxidant properties from phenolic acids such as gallic and ellagic acids. Gallic acid neutralizes ROS including OH, O_2.- and ROO and suppresses lipid peroxidation [14].

1.2.7. Antiviral

Flavonoids in mango encompass quercetin catechin and epicatechin. These compounds demonstrate antioxidant capacity and scavenging effects against reactive oxygen species and free radicals. Their pharmacological effects strengthen through penetration of microbial cell membranes. Flavonoids display antiviral activity against Herpes simplex virus respiratory syncytial virus Parainfluenza virus and Adenovirus. Flavonoids exert antiviral effects by blocking various stages in the viral replication cycle [15, 16]

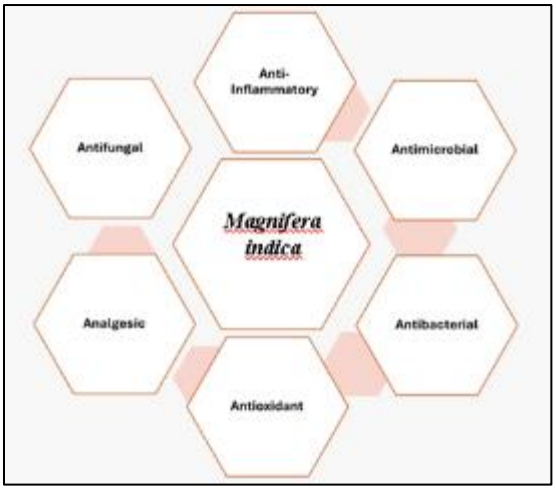


Figure 4 Pharmacological Activities of *Magnifera indica*

1.3. *Psidium guajava*

The fruit *Psidium guajava* (guava) a member of the Myrtaceae family, is widely consumed in tropical regions such as South America, Bangladesh, Pakistan, Indonesia and India. Numerous phytochemicals, including quercetin, avicularin, apigenin, guaijaverin, kaempferol, hyperin, myricetin, gallic acid, epicatechin, catechin, chlorogenic acid, epigallocatechin gallate and caffeic acid, have been linked to the health benefits of guava plant leaves. The biological properties of guava leaf extracts, such as their hepatoprotective, lipid-lowering, anticancer, antidiabetic, antioxidant and antidiarrheal properties, have been investigated. Minerals like calcium, potassium, sulfur, sodium, iron, boron, magnesium, manganese and vitamins C and B are abundant in guava leaves. Because guava leaves include higher amounts of Mg, Na, S, Mn and B. They are an excellent option for both human nutrition and animal feed in preventing micronutrient deficiencies [17].

Figure 5 Guava Tree

Leaves of the *Psidium guajava* serve commonly in traditional medicine for treating thrush and diarrhea. These leaves harbor a specific chemical [18].

Guava trees thrive across India owing to their diverse commercial applications. Key cultivation states include Andhra Pradesh Assam Bihar Maharashtra Uttar Pradesh and West Bengal though the plant grows in nearly all states [19].

In India guava ranks as the fourth leading fruit crop. Annual production reaches 1.80 million tonnes from 0.15 million hectares under cultivation. Bihar tops output ahead of Andhra Pradesh and Uttar Pradesh. Prominent cultivars in India encompass Khaja (Bengal Safeda) Chittidar Harija Lalit Pant Prabhat Dhareedar and Arka Mridula. Hybrid varieties such as Arka Amulya Safed Jam and Kohir Safeda have also been developed [20].

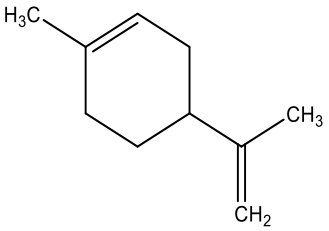
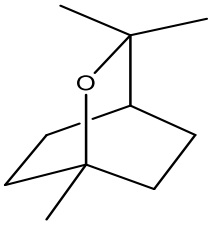
Figure 6 Guava leaves

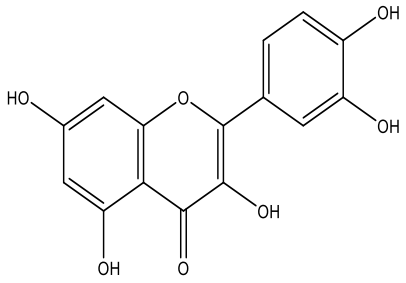
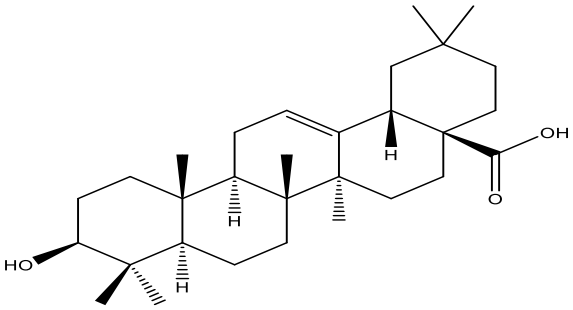
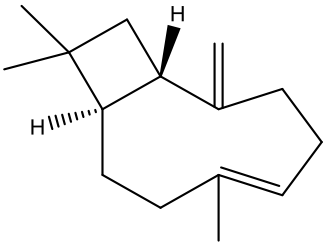
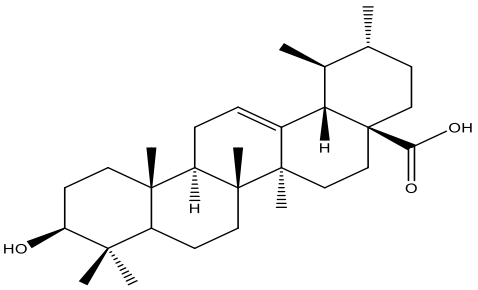
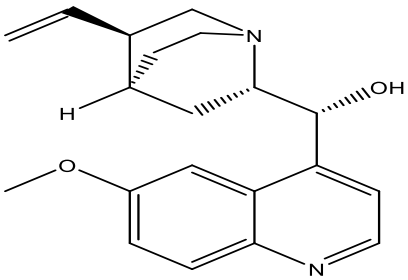
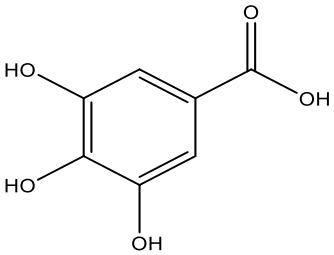
Figure 7 Guava fruit

1.3.1. Chemical Constituents

Psidium guajava leaves consist phenolic compounds, iso-flavonoids, gallic acid, catechin, quercetin, epicatechin, rutin, naringenin, kaempferol, caryophyllene oxide, p-selinene and other chemical elements [21, 22]. Guava fruit provides vitamins A and C plus iron phosphorus and calcium. It exceeds oranges in vitamin C content. The fruit also features saponins, oleanolic acid, lyxopyranoside arabopyranoside, guaijavarin, quercetin and flavonoids [29-31]. Guava leaves hold elevated levels of limonene (42.1%) and caryophyllene (21.3%) [32].

Table 2 Chemical constituents of Psidium guajava [23-28]

Sr. No.	Phytochemicals	Structure	Actions
1.	Limonene		Anti-inflammatory, Analgesic, Antimicrobial, Hepatorenal Protective Activity, Hypoglycemic, Anti-cancer activity.
2.	1,8- Cineole		Antibacterial, Antifungal, Antiviral Activity.

3.	Quercetin		Anti-oxidant, Anti-microbial activity, Anti-inflammatory activity, Immuno- suppressive effects, Anti-cancer, Antiviral.
4.	Oleanolic acid		Anti-inflammatory, Anti-tumor, Anti-microbial, Anti-oxidant, Hepatoprotective ability, Anti-hypertensive activity
5.	Caryophyllene		Anti-inflammatory, Antioxidant, Analgesic properties
6.	Ursolic Acid		Antioxidant, Anti-inflammatory, Antimicrobial, Hepatoprotection, Immuno-modulatory
7.	Quninine		Antifungal, Antibacterial, Anti- viral, Antimalarial activity Immuno-modulatory activity
8.	Gallic Acid		Anti-inflammatory, Anticancer activity, Gastrointestinal diseases

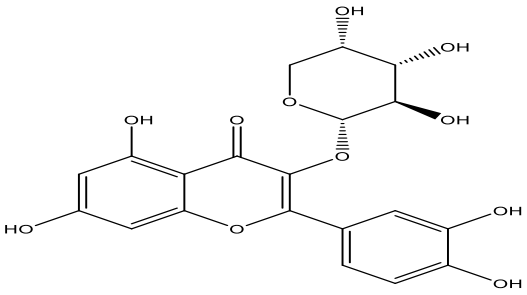
9.	Guaijaverin		Antimicrobial activity

Table 3 Essential Oil of Guava Leaves [33]

Compounds	**Content / Composition**
Limonene	54.7%
1,8- Cineole (Eucalyptol)	32.14%
β–Caryophyllene	2.91%
α- Terpineol	1.79%
α- Pinene	1.53 %
Benzaldehyde	0.83%
α- Humulene	0.77%
p- cymene	0.52%
γ- Terpinene	0.38%
β- cis- Ocimene	0.28%
Total identified constituents	95.85%

1.3.2. Pharmacological Activity

Psidium guajava harbours diverse pharmacologically active components with biological effects such as anti-diabetes anti-diarrhea anti-microbial anti-oxidant cardioactive hepatoprotective antipyretic spasmolytic immunomodulatory and contractile [34].

Anti-diabetic activity

Psidium guajava has been shown to reduce blood glucose levels. Guava fruit extract can help diabetics lose weight and control blood sugar levels. Guava extract protects pancreatic tissues, particularly islet beta cells, from lipid peroxidation, reducing insulin-positive beta cell loss and output [35].

Anti- diarrheal activity

Diarrhea represents a major global concern. Guava fruit functions as a natural laxative to relieve constipation. Studies show that guava fruit peel strengthens its antidiarrheal effects [36]. Excessive consumption of unripe guava fruit can trigger indigestion and vomiting [37]. Guava leaf decoction treats gastroenteritis and chronic diarrhea [38]. Young leaves and shoots address dysentery and diarrhea [39]. Guava leaf extract includes quercetin which curbs intestinal motility and lowers capillary permeability [40]. It also blocks excessive watery output in acute diarrhea [41].

Anti- microbial activity

Psidium guajava leaf extract consists four antibacterial flavonoids: morin-3-O-lyxoside morin-3-O-arabinoside quercetin and quercetin-3-O-arabinoside. These flavonoids target pathogenic bacteria such as Bacillus stearothermophilus Brochothrix thermosphacta Escherichia coli O157:H7 Listeria monocytogenes Pseudomonas fluorescens Salmonella enterica and Staphylococcus aureus [42, 43]. Guava leaf extract demonstrates antibacterial

action against gram-positive and gram-negative pathogens including Sarcina lutea, Staphylococcus aureus and Mycobacterium phlei due to its tannin content [44, 45].

Antioxidant activity

Oxidative stress occurs when free radical generation surpasses its antioxidant capacity, causing damage to essential substances like lipids, carbohydrates, proteins and DNA [46, 47]. *Psidium guajava* inhibits NF-kB activation and restores enzymatic antioxidants, making it an effective antioxidant [48]. Guava leaf extracts and fruits contain natural antioxidants [49].

Anti-tussive activity

Research suggests that infusing water with *Psidium guajava* leaf extract can reduce coughing caused by capsaicin aerosol [50, 51]. Study indicate that the unripe fruit of *Psidium guajava* has a strong hepatoprotective substance [52].

Anticancer Effect

Investigation has found that *Psidium guajava* have anti-proliferative effects on human oral epidermal carcinoma and murine leukemia cells [53]. The blossoming leaves of *Psidium guajava* contain significant levels of soluble polyphenolics (SP), including gallic acid (348 mg/g), catechin (102 mg/g), epicatechin (60 mg/g), rutin (100 mg/g), quercetin (102 mg/g) and rutin (100 mg/g), which have been shown to have powerful anticancer activity [54].

Figure 8 Pharmacological activities of *Psidium guajava*

Anti- inflammatory activity

The leaf decoction can treat rheumatism and other inflammatory disorders. Polyphenolic compounds and triterpenoids found in the leaf extracts contribute to its anti-inflammatory and analgesic properties [55].

Cardiovascular effect

The aqueous leaf extract of *Psidium guajava* demonstrated cardioprotective properties against myocardial ischemia-reperfusion injury in isolated rat hearts [56]. Aqueous fractions from the acetic extract have a negative inotropic effect, lowering atrial contractility and opening potassium channels in heart tissue [34].

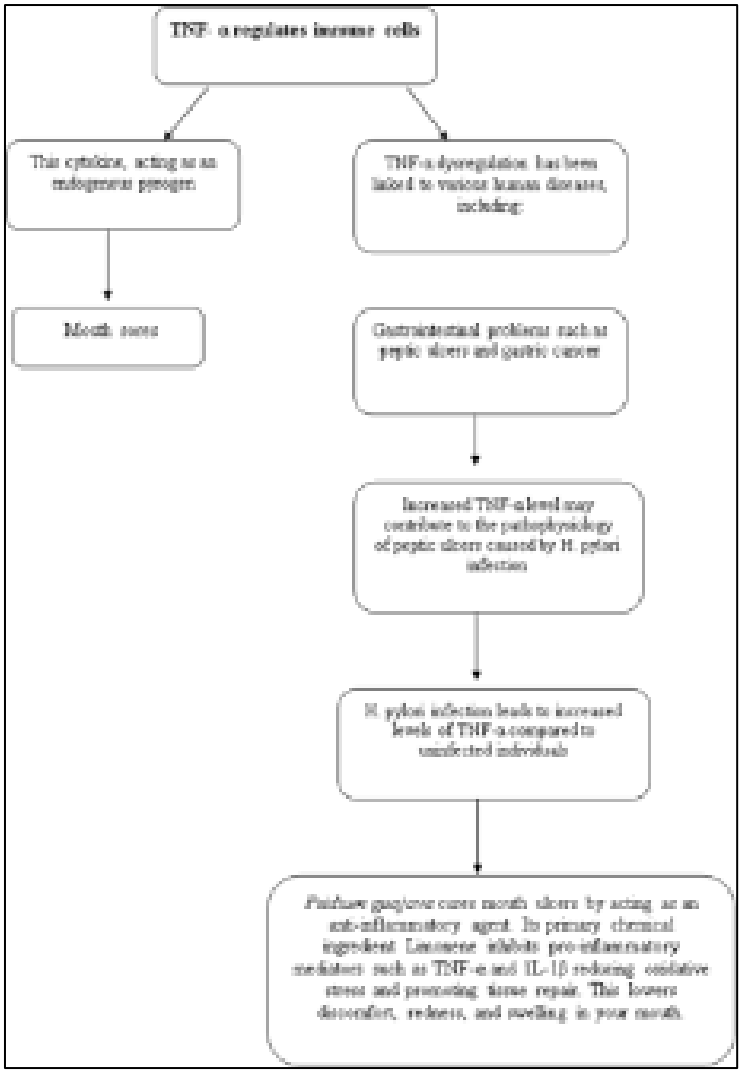


Figure 9 Role of *Psidium guajava/* Limonene in ulcer

1.4. Ulcer

An ulcer represents a painful sore that heals slowly and may recur. Ulcerations occur frequently. Ulcers develop on various body sites including the stomach lining and skin surface. They often demand medical intervention to prevent severe complications. An ulcer constitutes a lesion on the skin or mucous membrane that triggers tissue breakdown. It can result in complete loss of the epidermis plus portions of the dermis and subcutaneous fat. Ulcers appear most often on lower limb skin and in the gastrointestinal tract [57]. A skin ulcer typically presents as inflamed tissue with a reddish area. Such ulcers arise from exposure to heat or cold inflammation or circulatory problems. Immobility also provokes them through sustained tissue pressure. This circulatory strain induces skin ulcers known as bedsores or decubitus ulcers. Ulcers commonly become infected and produce pus [58].

1.4.1. Sign and Symptoms

Symptoms:

- Painful mouth sores
- Burning/tingling sensations
- Difficulty eating/drinking/speaking
- Swelling in Affected area
- Fever/enlarged lymph nodes (severe cases)

- Discomfort, occasional bleeding

- Dry mouth [59, 69]

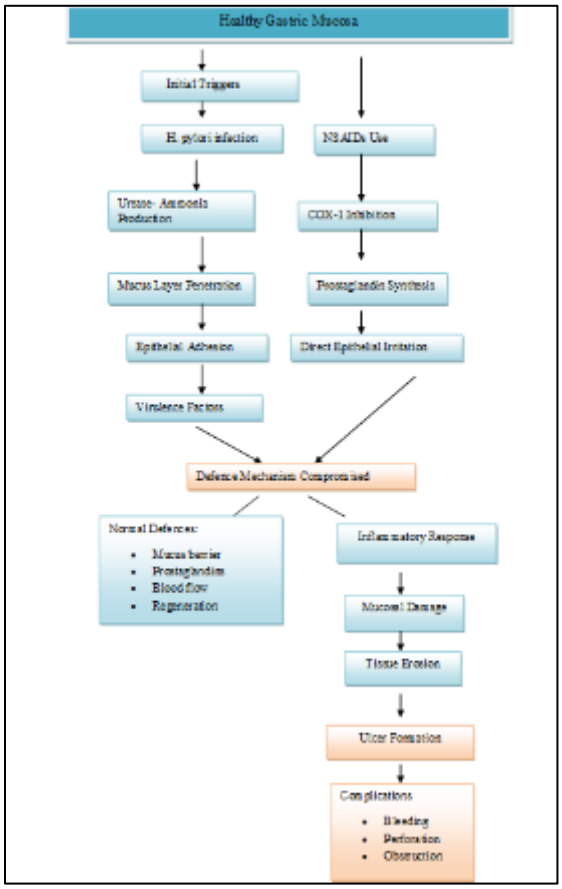


Figure 10 Etiology of Peptic Ulcer

Mouth Ulcer:

Mouth ulcers manifest as yellowish or white depressions with red margins in the oral mucous lining. They provoke inflammation and discomfort [63]. Aphthous stomatitis - commonly termed mouth ulcer - constitutes an inflammatory condition impacting the oral mucosa. It triggers recurrent ulcers in the throat and oral cavity [64]. Mouth ulcers stem from diverse factors such as cheek inner lining bites food sensitivities and rough surfaces. Additional contributors include improper tooth brushing hormonal changes vitamin deficiencies bacterial infections and diseases [65].

Mouth ulcers prove common arising from various illnesses and triggers though often without serious underlying causes. Rarely a persistent non-healing mouth ulcer signals oral cancer. These ulcers may appear alone or in multiples [66]. An ulcer denotes a tissue defect penetrating the epithelial-connective tissue barrier with roots in the submucosa muscle or periosteum [67]. An ulcer exceeds erosions or excoriations in epithelial depth causing harm to both the epithelium and lamina propria [68, 69].

Causes of Mouth Ulcer:

- Injury or Trauma
- Stress
- Nutritional deficiencies
- Hormonal Changes
- Medical conditions
- Allergic reactions [70, 71]

Types of mouth ulcers

- **Recurrent Aphthous Stomatitis (Canker Sores)**

Canker sores represent the most prevalent form of mouth ulcers. These lesions often arise from minor injuries such as cheek biting or consumption of acidic foods. Psychological stress also contributes.

Canker sores typically appear white or yellow with red borders. They classify into three primary types:

- Minor aphthous ulcers (under 5 mm in diameter that generally resolve in 7-14 days).
- Major aphthous ulcers require weeks or months for healing and may leave scars [72].

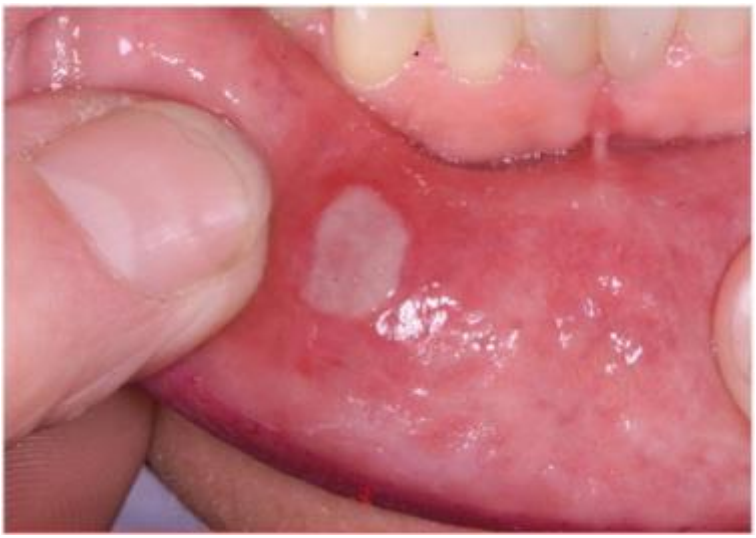


Figure 11 Recurrent Aphthous Stomatitis (Canker Sores) [73]

- **Leucoplakia**

Leukoplakia manifests as white spots within the oral cavity. These regions typically prove asymptomatic and resist removal through friction. The disorder often arises from sustained inflammation of the oral mucosa. Patients with leukoplakia require evaluation and treatment from a specialist per dental recommendation due to oral cancer potential. Leukoplakia advancement yields white patches on sites such as gums inner cheeks mouth floor and tongue. These lesions generally remain noncancerous yet some display precancerous changes. Cancers frequently emerge adjacent to leukoplakic sites especially on the mouth floor [72].

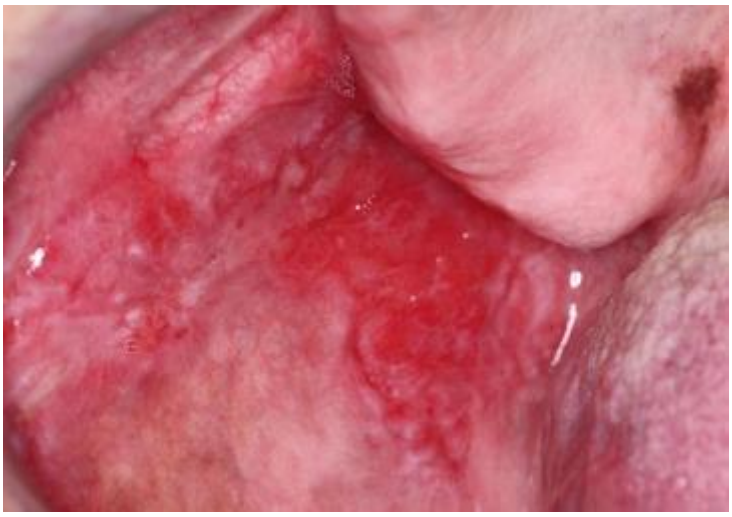


Figure 12 Leucoplakia [74]

- **Herpetiform ulceration**

Herpetiform ulcers describe clustered lesions. This ulcer type features dozens of pinhead-sized lesions. It holds no connection to herpesvirus infection. These clusters - numbering 10 to 100 small lesions at once - merge into larger plaques. Ulcers heal with scarring in 7-30 days based on size and depth [72].

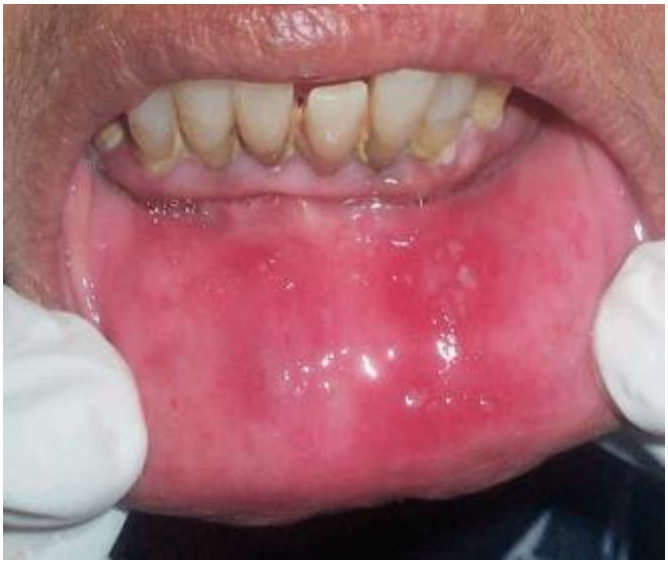


Figure 13 Herpetiform ulceration [75]

- **Traumatic ulcers**

Traumatic ulcers are the most common type of ulcer, with an immediate start. These ulcers are often caused by physical, thermal, or chemical damage to the oral mucosa. Dental trauma can result from normal activities like brushing and flossing, as well as sharp dental equipment or teeth. Patients who get local anaesthesia after dental procedures may unwittingly do themselves harm. Thermal injuries can be caused by consuming hot meals or beverages like pizza, coffee, or tea, or using heated dental equipment during operations [72].

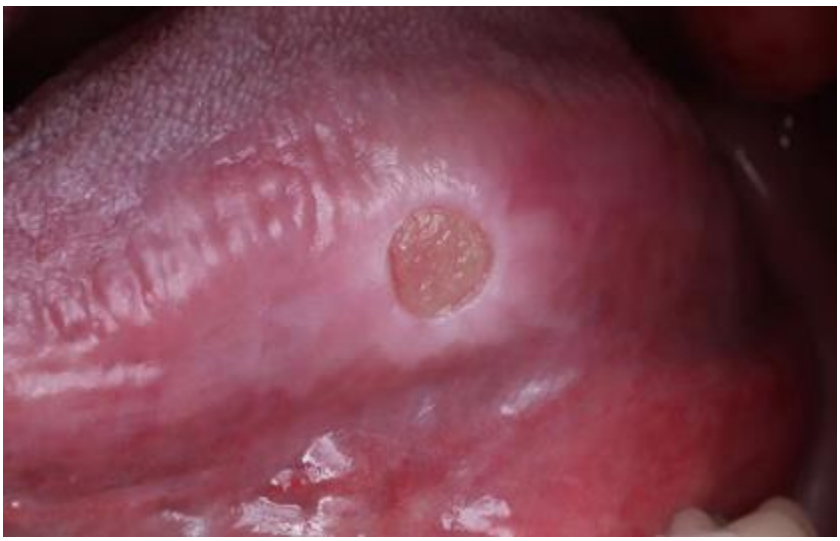


Figure 14 Traumatic ulcers [76]

1.5. Mouth Gel

Mouth gels constitute specialized topical preparations for oral hygiene. Often employed to soothe or manage oral issues like ulcers sores or cavity irritation. Users apply them straight to the site where they create a barrier layer foster recovery and ease pain. Mouth gels also address gingivitis dry mouth or gum swelling. Their chief benefit compared to

conventional mouthwashes or creams lies in extended efficacy. The barrier keeps active components localized for prolonged therapeutic impact [77]. Certain gels incorporate antiseptics or analgesics for symptom relief while others feature hydrating agents against dryness [78]. Manufacturers promote them as superior owing to straightforward application quick onset and precise targeting which deliver prompt alleviation for otherwise distressing or lingering oral problems [79].

1.5.1. Types of Mouth Gel

Mouth gels function as semi-solid topical formulations for direct use on the oral mucosa. They offer localized therapeutic benefits such as pain relief antimicrobial action wound healing and moisturizing. Differences stem from variations in base composition purpose and active ingredients.

Analgesic and Anti-inflammatory Gels

These formulations incorporate agents such as benzocaine lidocaine or herbal extracts with anti-inflammatory effects. They serve mainly to ease pain from conditions like mouth ulcers stomatitis or denture irritation [80].

Antimicrobial and Antiseptic Gels

Antimicrobial gels incorporate chlorhexidine triclosan povidone-iodine or herbal extracts such as guava clove and turmeric. These agents help lower bacterial and fungal loads in oral infections periodontal diseases and aphthous ulcers [81].

Antifungal Gels

Antifungal gels incorporate agents such as miconazole clotrimazole or ketoconazole. They address oral candidiasis (oral thrush) prevalent in immunocompromised patients [82].

Corticosteroid-containing Gels

Employed in inflammatory oral mucosal conditions such as lichen planus and recurrent aphthous stomatitis. Examples include triamcinolone acetonide and hydrocortisone gels [83].

Mucoadhesive Herbal Gels

Formulated with natural gelling agents such as carbopol sodium alginate or xanthan gum plus herbal extracts like guava aloe vera and licorice. These options earn preference for minimal side effects and broad pharmacological benefits such as antimicrobial wound-healing and anti-inflammatory effects [84].

Moisturizing and Protective Gels

Formulated for xerostomia (dry mouth) patients. These gels incorporate humectants such as glycerin carboxymethylcellulose and hyaluronic acid. They deliver lubrication and safeguard the mucosa from irritation [85].

1.5.2. Benefits of uses of mouth gels in mouth ulcers

- **Pain relief:** Local anesthetics such as lidocaine and benzocaine ease pain burning and discomfort [86].
- **Protective barrier:** Bio adhesive gels cover the ulcer surface. They shield it from friction spicy or acidic foods and drinks [87].
- **Anti-inflammatory action:** Corticosteroids or herbal extracts like aloe vera guava, liquorice and turmeric lessen swelling and erythema [88].
- **Antimicrobial effect:** Gels with chlorhexidine triclosan or plant-based actives block secondary bacterial or fungal infections [89].
- **Moisturizing and soothing:** Gels sustain hydration relieve dryness and calm burning sensations.
- **Faster healing:** They boost tissue regeneration via a moist protected environment [90].

- **Improved drug delivery:** Bio adhesive gels extend contact time at the ulcer site. This ensures sustained drug release [91].
- **Reduced recurrence:** Extended use of medicated gels cuts ulcer episode frequency and severity [92].
- **Enhanced patient compliance:** Straightforward topical use pleasant taste and focused action heighten acceptance versus systemic therapy.
- **Reduced systemic side effects:** Localized effects minimize risks of systemic adverse reactions linked to oral corticosteroids or antibiotics [93].

2. Material and Methodology

2.1. Methodology for *Psidium guajava* gel formulation for mouth ulcers:

2.1.1. Collection of Plant Material

The herbal plant materials (Mango leaves and Guava leaves) were collected from different parts of Hamirpur and Kangra District. The chemicals and reagents are from Gautam College of Pharmacy Hamirpur, Himachal Pradesh, India -177001. Mature, healthy leaves that were free of illness or physical injury were chosen. Data documentation included details such as the date of collection, habitat and environmental conditions.

2.1.2. Authentication

The Department of Forest Products, College of Horticulture and Forestry, NERI- Hamirour-177001 affiliated with Dr. YS Parmar UHF- Nauni, Solan (H.P.) validated the obtained plant materials and confirmed with Authentication number i.e. UHF/COHF/FP/Acad/- 1937 and UHF/COHF/FP/Acad/- 1985 the scientific legitimacy of the plant materials utilised in this project.

2.1.3. Processing of Plant Material

To eliminate any remaining dust or contaminants, the gathered leaves were carefully rinsed with tap water. The leaves were then shade-dried at room temperature for 10-14 days until they reached a consistent weight, after which they were ground into a coarse powder using a mechanical grinder. The powdery substance was kept in sealed containers.

2.1.4. Preparation of Magnifera indica leaves extract

A weighed quantity of dry, coarsely powdered ***Magnifera indica*** leaves was fed into the Soxhlet assembly. 95% ethanol and 5ml of water were pumped through the top of the condenser. The solvent gently poured onto the powdered leaves in the Soxhlet assembly. Ethanol gradually permeated the drug bed, dissolving phytoconstituents. The extract-laden solvent was collected in the round-bottom flask illustrated below. This setup allowed the Soxhlet apparatus to function as a percolator, with solvent flowing downhill by gravity. The extraction technique was repeated until the entire extract was collected in the round-bottom flask.

2.1.5. Preparation of Psidium guajava leaves extract

Figure 15 Soxhlet Apparatus for *Mangifera indica*

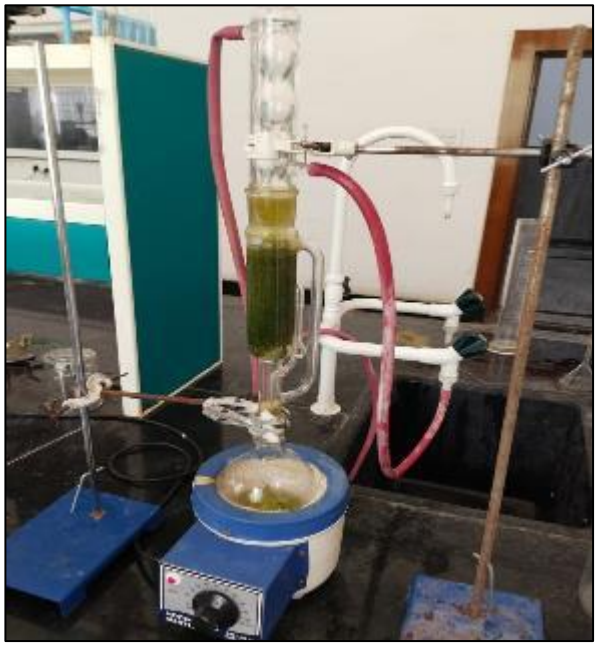


Figure 16 Soxhlet Apparatus for *Psidium guajava*

A weighed quantity of dry, coarsely powdered ***Psidium guajava*** leaves was fed into the Soxhlet assembly. 95% ethanol and 5ml of water were pumped through the top of the condenser. The solvent gently poured onto the powdered leaves in the Soxhlet assembly. Ethanol gradually permeated the drug bed, dissolving phytoconstituents. The extract-laden solvent was collected in the round-bottom flask illustrated below. This setup allowed the Soxhlet apparatus to function as a percolator, with solvent flowing downhill by gravity. The extraction technique was repeated until the entire extract was collected in the round-bottom flask.

3. Phytochemical Screening of *Mangifera indica* and *Psidium guajava*

Standard phytochemical screening methods were employed to analyse the extracts for the presence of active components such as alkaloids, tannins, saponins, flavonoids, phenolic compounds and cardiac glycosides [94,95].

- **Test for alkaloids:** In a test tube, 1.5ml of 1% hydrochloric acid (HCl) was mixed with 2.0ml of each extract. Six drops of Wagner's reagent were applied after heating the test tube contents over a water bath. An orange precipitate was formed, indicating the presence of alkaloids.
- **Test for flavonoids:** To each 2.0 ml extract, add a few drops of ferric chloride hexahydrate ($FeCl_3 \cdot 6H_2O$) solution. The appearance of intense green colour suggested the presence of flavonoids.
- **Test for phenols:** To each 2.0 ml extract, add a few drops of a 5% ferric chloride hexahydrate ($FeCl_3 \cdot 6H_2O$)) solution. The presence of phenols was indicated by a deep blue-black colour.
- **Test for tannins:** Mix 1.0ml of each extract with 2.0ml of distilled water. Adding 2.0 ml of 5% ferric chloride hexahydrate ($FeCl_3 \cdot 6H_2O$)) solution to the mixture resulted in a brownish-green or dark-green solution, indicating tannin presence.
- **Test for cardiac glycosides:** To prepare the test tube, 3.0 ml of glacial acetic acid (CH_3COOH) was added to 2.0 ml of each extract, followed by 1 drop of 5% ferric chloride hexahydrate ($FeCl_3 \cdot 6H_2O$) and 0.5 ml of concentrated sulphuric acid (H_2SO_4) carefully added on the side. The blue colour formed in CH_3COOH indicates the presence of cardiac glycosides.
- **Test for steroids:** To each extract, add 5.0ml of chloroform ($CHCl_3$) and 2.0ml of acetic anhydride ($(CH_3CO)_2O$ before adding concentrated (H_2SO_4). The reddish-brown colour at the interface indicated the presence of steroids.
- **Test for saponins: -** The extracts were diluted with distilled water and agitated in a test tube for 15 minutes. A layer of foam formed, indicating the presence of saponins [94, 95].

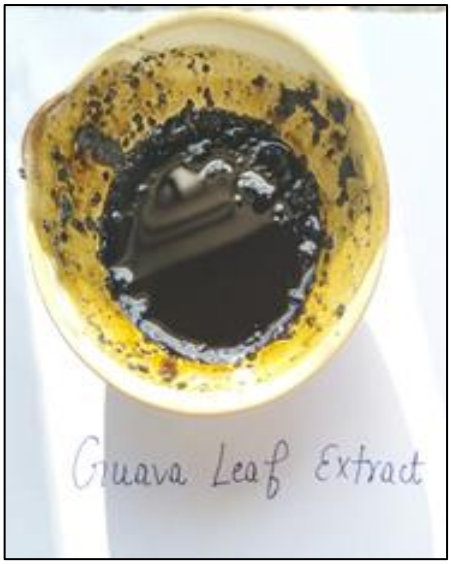


Figure 17 *Psidium guajava* Leaf Extract

Figure 18 *Mangifera indica* Leaf Extract

4. Results

4.1. Phytochemical Screening Results

Phytochemical Screening of *Mangifera indica* and *Psidium guajava* was done at Gautam college of Pharmacy Hamirpur. The results are mentioned below,

Table 4 Phytochemical Screening Results of the Formulation

Phytochemical	Test Used	Observation	Result in *Mangifera indica* and *Psidium guajava*
Alkaloids	Mayer's / Wagner's	Cream / reddish ppt	Present
Flavonoids	Alkaline reagent	Yellow colorless (HCl)	Present
Phenols & Tannins	Ferric chloride	Blue-black / green colour	Present
Saponins	Foam test	Persistent froth	Present
Terpenoids	Salkowski test	Reddish-brown interface	Present
Glycosides	Keller-Killiani	Brown ring at interface	Present
Proteins	Biuret test	Violet coloration	Present
Carbohydrates	Benedict test	Brick-red precipitate	Present

4.2. Formulation (for 100 g batch)

Table 5 Constituents and amount of the Formulation for 100 g batch

Ingredient	Function	% w/w	Amount (g)
Mango leaves extract (hydroalcoholic)	Active	5.0	5.0
Guava leaves extract (hydroalcoholic)	Active	5.0	5.0

Menthol	Chilling agent	0–0.5	0–0.5
Carbopol 940	Gelling mucoadhesive base	1.0	1.0
Glycerin	Humectant, solvent	5.0	5.0
Polysorbate 20	Solubilizer/wetting agent	0.5	0.5
Methyl Paraben	Preservative	0.5	0.5
Triethanolamine (TEA) 10% or 10% NaOH)	Neutralizer (to gel Carbopol)	qs	~0.2–0.6
Purified water	Vehicle	81.0–82.0	~81.0–82.0

Figure 19 Final Product

4.3. Evaluation Parameters for Mouth Gel

Different parameter for evaluation of mouth gel of extracts of *Mangifera indica* and *Psidium guajava* was done at Gautam college of Pharmacy, Hamirpur (H.P.)

Table 6 Evaluation Parameters for Mouth Gel

Sr. No.	Name	Result
1.	Appearance	Smooth, Uniform, Bubble-free and homogenous
2.	State	Semi Solid
3.	Color	Uniform Light Green
4.	Odor	Pleasant, Characteristic, no sour smell
5.	Texture	Smooth, Non- Gritty, Moderately adhesive
6.	Viscosity	5000- 100000cP

7.	Spreadability	Smooth, Quick spread
8.	Irritancy test	No Irritation
9.	Temperature	25 ± 1
10.	pH Determination	6.0-7.5
11.	Homogeneity	Uniform, Smooth, ± 5% drug variation
12.	Drug Content Uniformity	95 – 99%

5. Conclusion

The formulated mouth gel containing *Mangifera indica* (mango) and *Psidium guajava* (guava) extracts with menthol showed promising potential for the management of mouth ulcers associated with peptic ulcer conditions. The formulated herbal mouth gel containing *Mangifera indica* and *Psidium guajava*, was designed to provide a better and adaptable therapeutic approach for the treatment of mouth ulcers. The herbal constituents provided effective anti-inflammatory, antimicrobial and wound-healing properties, supporting their role in promoting rapid healing of mouth ulcers. The menthol provided local analgesic and cooling sensation enhancing patient comfort.

The formulation showcased desirable organoleptic characteristics, homogeneity and spread ability, ensuring ease of application and better retention in the oral cavity. The herbal mouth gel represents a safe, natural and effective alternative for the treatment and relief of various types of mouth ulcers.

The overall formulation was stable and showed no signs of phase separation or microbial contamination during the evaluation period. Thus, the formulated mouth gel presents a natural, economical and patient-friendly alternative to conventional mouth ulcer treatments.

Large-scale production and stability testing under accelerated conditions would support its potential for commercial development as an herbal oral care product.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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