# FORMULATION AND EVALUATION OF CARDAMOM LODED LOZENGES FOR ANTI-MICROBIAL ACTIVITY.

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## 1. ABSTRACT:

Cardamom lozenges are formulated as medicated or herbal dosage forms intended to provide therapeutic effects within the oral cavity while improving patient acceptability. Cardamom (Elettaria cardamomum) possesses antimicrobial, antioxidant, anti-inflammatory, and flavouring properties due to the presence of bioactive constituents such as cineole and terpenes. The formulation of cardamom lozenges aims to deliver local action in the throat and mouth, offering soothing effects and potential relief from oral infections, irritation, and bad breath. The prepared lozenges are evaluated using various physicochemical and quality control parameters to ensure efficacy, stability, and patient compliance. Evaluation parameters include appearance, weight variation, thickness, hardness, friability, moisture content, disintegration time, dissolution studies, drug content uniformity, pH, stability studies, and organoleptic properties such as taste, odour, and mouthfeel. These parameters help determine the quality, safety, and performance of the formulated cardamom lozenges.

**KEY WORDS: Antimicrobial Activity, Cardamom, Herbal Lozenges, Oral Infections, Therapeutic Effects.**

## 2. INTRODUCTION:

### 2.1. PLANT PROFILE:

1. **Common name:** Cardamom / Elaichi.
2. **Scientific name:** Elettaria cardamomum.
3. **Family:** Zingiberaceae (Ginger family).
4. **Type:** Perennial herb.
5. **Native:** India (Western Ghats), Sri Lanka, Guatemala, Tanzania.
6. **Climate:** Tropical and humid, Requires shade and well-drained soil.
7. **Height:** 2 to 4 meters.
8. **Stem:** Underground rhizome (like ginger).
9. **Leaves:** Long, lance-shaped, Dark green and aromatic.
10. **Flowers:** Small, pale green or white, Grow near the base of the plant.
11. **Fruits (Capsules):**Small green pods, Contain black aromatic seeds (used as spice).
12. **Chemical constituent:** Essential oils (main active components): 1,8-Cineole,Terpinyl acetate, Limonene [5].

## 2.2 CARDAMOM PROPERTIES:

1. Cardamom is really good for digestion boost, Cardamom helps people who have a lot of bloating, gas and stomach discomfort. It makes the digestive enzymes work better which is why people in India like to eat it after meals.[21]
2. Breath and oral health are important when you chew cardamom it can make your breath smell good and kill the bad bacteria in your mouth. Cardamom is like a natural mouth freshener. It is even better than some gums.[6]
3. Cardamom has anti-inflammatory and antioxidant properties cardamom has some compounds that help fight inflammation and oxidative stress which can make you look old and get diseases.[7]
4. Cardamom may help people; with blood pressure Some people did some studies and they think that cardamom can act like a mild diuretic and make the blood vessels relax which can help with blood pressure control.[8]

## 2.3. WHAT ARE HERBAL LOZENGES?

Herbal lozenges are solid, flavoured dosage forms meant to dissolve slowly in the mouth, releasing active herbal ingredients for local (throat) or systemic effects. They're commonly used for:

1. Sore throat.
2. Cough relief.
3. Mouth infections.

## 2.4. PROCUREMENT OF MATERIAL:

## 2.4.1. CARDAMOM:

The most important active substance used in making cardamom lozenges is cardamom, known for its flavours, aroma, and medicinal benefits.

**FIG. NO.10 ,CAPSULE OF CARDAMOM**

### 2.4.1.1. Functions of Cardamom

1. Antimicrobial action: Possesses essential oils, such as cineole and terpinyl acetate, that act against bacteria and fungi, thereby ensuring dental and throat health.
2. Fresh breath: Helps eliminate bad breath naturally due to its wonderful aromatic nature.

3. Improves digestion: It aids in digestion and relieves bloating problems.
4. Anti-inflammatory property: Heals sore throats and cough.
5. Antioxidant actions: Has phenolics that fight oxidative stress on cells.[9]

#### 2.4.1.2. Uses in Cardamom Lozenges:

1. It is incorporated as either powder or an extracted oil in these lozenges. Cardamom in lozenges performs the following functions:
2. Furnishes the unique taste and scent to the product
3. Aids as a remedy to various diseases like coughs, cold, and throat infections 4. Improves the efficacy of honey and others.[10]

## 2.4.2. ISOMALT:

Isomalt is a sugar alcohol commonly utilized in the production of lozenges as a substitute for sugar and an essential component.

#### 2.4.2.3. Functions of Isomalt:

1. Calorie-free sugar: Has a slight sweetness (approx. 45-65%) of sugar and contains lower amounts of calories, thus making the lozenges low in sugar content.
2. Does not cause tooth decay: Non-cariogenic and, therefore, will not cause any problems with one's dental health like regular sugar.
3. Has good stability: Highly resistant to moisture, so there won't be a situation when the lozenges become sticky.
4. Heat-stable: Will endure high temperatures when being made into candies or lozenges.
5. Bulk-forming agent: Provides necessary structural properties to the lozenges such as hardness and consistency.

**Uses of Isomalt in Cardamom Lozenges:**

Here, isomalt is used as the main ingredient that enables inclusion of cardamom extracts or oils. [11]

## 2.4.3. BEESWAX:

It is a kind of natural wax formed by honeybees, and it is used in lozenges as an ingredient for coating and thickening purposes.


**FIG. NO.2: IMAGE OF BEESWAX**

### 2.4.3.1. Functions of Beeswax

1. Coating agent: Provides protection by creating a thin layer over the lozenges that gives a shiny appearance to the outer layer of lozenges.
2. Moisture barrier: Prevents the absorption of moisture from the environment and enhances the shelf life.
3. Texture modifier: Improves the texture of the lozenges, which gives a slightly firm feeling to the lozenges, preventing it from getting soft and sticky.
4. Controlled release: Increases the dissolution time and allows controlled release of the cardamom flavours from the lozenges.
5. Natural and food grade: It is considered as food-grade material with E901 code and used extensively in confectioneries.[12]

### 2.4.3.1. In Cardamom Lozenges

1. Beeswax is generally added as a coating material or in low quantity. The addition of beeswax in cardamom lozenges ensures better maintenance of the aroma and antimicrobial property of cardamom.
2. It is incorporated as either powder or an extracted oil in these lozenges. Cardamom in lozenges performs the following functions:
3. Furnishes the unique taste and sent to the product
4. Aids as a remedy to various diseases like coughs, cold, and throat infections 5. Improves the efficacy of honey and others.[13]

## 2.4.4. HONEY:

lozenges made using cardamom, honey is utilized for its natural sweetness, as well as its binding capabilities and healing properties.

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**FIG. NO. 3: IMAGE OF HONEY**

### 2.4.4.1. Functions of Honey in Lozenges:

1. Antimicrobial properties: Honey consists of bioactive molecules, such as phenolics, flavonoids, hydrogen peroxide, and organic acids that prevent the growth of microbes.
2. Anti-inflammatory properties: Works to reduce inflammation caused by sore throat.
3. Demulcent properties: Coats the throat to provide relief from cough and soreness.
4. Sweetening properties: Makes it easier to consume medicines with strong flavours such as cardamom.[14]

## 2.5. ANTI-MICROBIAL ACTIVITY:

Plants contain a variety of bioactive compounds that have strong antimicrobial properties against foodborne and spoilage microorganisms. Key compounds include:

1. Phenolics, which disrupt microbial cell membranes and metabolic processes.
2. Essential oils, which are strong membrane disruptors with broad-spectrum activity.
3. Alkaloids, which interfere with microbial nucleic acid synthesis.
4. Antimicrobial peptides, which target bacterial cell walls and membranes.

Recent progress in molecular docking and dynamics simulations has sped up the identification and improvement of plant antimicrobials. This is especially true for inhibiting quorum sensing and biofilm formation.[1]

**TABLE NO.1: MECHANISM OF ACTION OF ANTI-MICROBIAL ACTIVITY**

Cardamom acts against microorganisms by

↓

Disrupting cell membranes, which leads to leakage of cellular content

↓

Inhibiting enzyme activity

↓

Interfering with metabolic processe

↓

Resulting growth of microbes slowed down or completely stopped.

### 2.5.1. Cardamom contains:

Essential oils mainly 1,8- cineole, α-terpinyl acetate, Phenolic compounds such as caffeic acid, syringic acid and Flavonoids such as quercetin, kaempferol, luteolin these compounds are responsible for its antimicrobial effects.

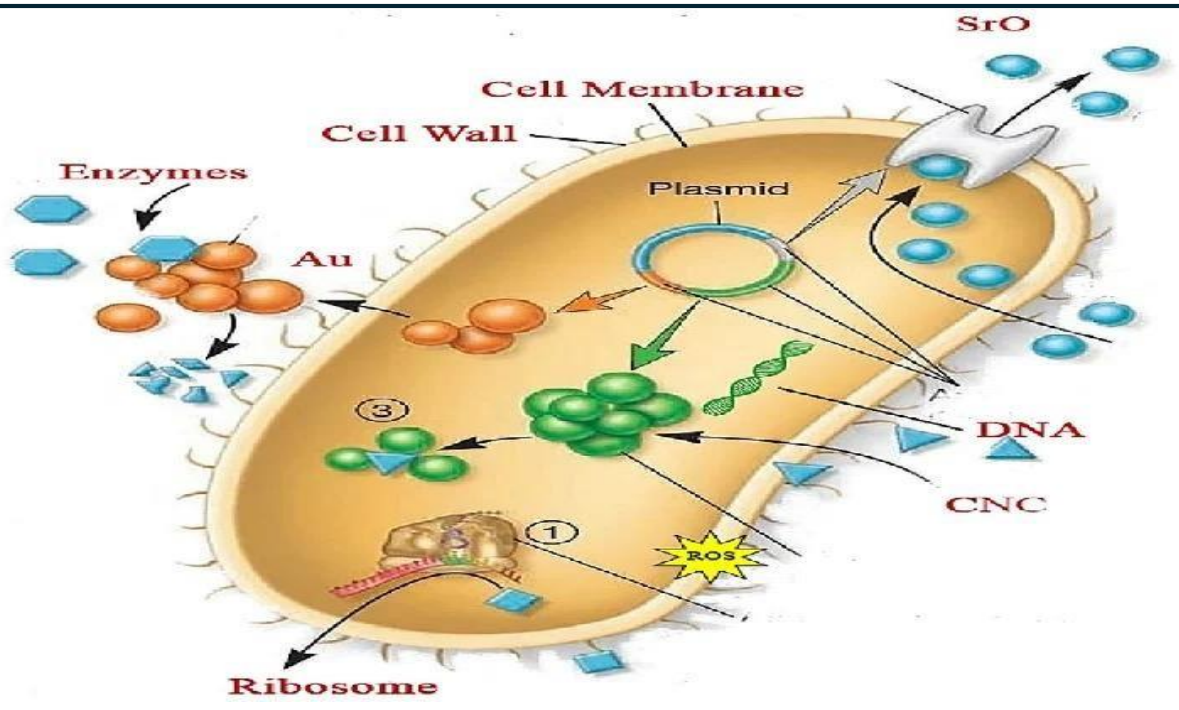


**FIG.NO. 4: SCHEMATIC REPESENTATION OF ANTIMICROBIA MECHANISM**

Target Micro-organisms:

Cardamom has shown activity against

1. Bacteria: E. coli, Staphylococcus aureus, Salmonella.
2. Fungi: Candida albicans, molds.
3. Effective against both Gram-positive and Gram-negative bacteria.

**2.5.2. Applications:**

1. Food preservation, as it prevents spoilage.
2. Natural food additive.
3. Pharmaceutical uses in antimicrobial formulations. Medical Applications Used as: Antibiotics (e.g., for bacterial infections), Antifungals (for fungal infections), Antivirals (e.g., for flu, HIV).
4. It Prevent infections during Surgeries (prophylaxis), Immunocompromised conditions.[3]
5. It used in Disinfection & Sterilization of Surgical instruments**.** [2]

## 2.6. BENEFITS OF CARDAMOM LOZENGES:

**1. Freshens breath instantly**: Cardamom is a natural mouth freshener. It helps fight the bacteria that cause bad breath. That's why it's used in chewing gums and lozenges.[23]

**2. Improves oral health:** Cardamom has antibacterial properties, which may reduce cavity-causing bacteria. It supports healthier gums and teeth.[22]

**3. Soothes throat and cough**: Lozenges slowly dissolve and coat the throat. Cardamom helps with mild cough, throat irritation, and mucus relief.

**4. Helps digestion**: It stimulates digestive enzymes and reduces bloating, gas, and nausea. That's why people chew elaichi after meals**.**[21]

**5. Supports overall health**: Possible effects include helping control blood pressure and supporting metabolism and heart health.[4]

## 3. PREPRATION OF EXTRACT:

### 3.1. Collection of cardamom seed:

Collection of cardamom capsule from the market.

### 3.1.2. EXTRACTION PROCEES:

**INFUSION:**

**TABLE NO. 2: EXTRACTION OF CARDAMOM**

100g of cardamom seed

Soaked in 250 ml of diethyl ether

remove diethyle ether using evaporator

Store in air tight container and cool place

**TABLE NO. 4: FORMULATION TABLE OF CARDAMOM LOZENGES**

| SR.NOS | INGREDIENTS | QUANTITY | USE |
|---|---|---|---|
| 1. 1. | Cardamom Extract | 0.05 ml | API |
| 2. 2. | Beeswax | 0.08 mg. | C controlled releasing Agent |
| 3. 3. | Isomalt | 4.5 mg. | Base |
| 4. 4. | Honey | 0.3 ml | Sweetening Agent |

**TABLE NO.3: METHOD OF PREPRATION OF LOZENGES**

Weigh all ingredient accurately in beaker

Add beeswax and melt completely

Add cardamom extract

Add honey after solution cooled down little

↓

Pour solution into pre-lubricated mould

↓

Allow to harden at low temperature

↓

Remove from mould and packed in air tight container

## 4. EVALUATION TEST:

### 4.1. Hardness test

A lozenge is sandwiched between two jaws, subjected to a pressure that will cause it to break or crack. The pressure exerted can be measured in kg/cm² or Newtons (N). Obtain a sample of lozenges randomly. Insert a lozenge into the hardness tester. Increase pressure slowly. Note the pressure point of breaking.[16]

### 4.2. Disintegration test

The tank of the disintegration apparatus was filled with distilled water 650 ml of distilled water. The temperature of water in beakers to 37°C was maintained. One lozenge was introduced into each tube and added a disk to each. The assembly was suspended in the beaker containing water and the apparatus was operated. The time duration at which lozenges disintegrate was noted.[17]


Fig. No. 6: Disintegration Test

### 4.3. Friability Test:

It checks how much a tablet or lozenge breaks or crumbles when it is handled, shipped, or rubbed. Will your lozenges survive rough handling or turn into dust. Take a sample of tablets or lozenges, usually 10 to 20. Weigh them to get the initial weight ($W_1$). Place them in a machine called a friabilator, which rotates and drops them repeatedly. Run the machine for about 4 minutes, which is roughly 100 rotations. Take them out, remove any dust, and weigh them again to get the final weight ($W_2$).[18]

Formula: $F = \frac{W1 - W2}{W2} \cdot 100$

Where:

W1 = Initial weight of tablets (before test)

W2 = Final weight of tablets (after test)

F = Friability (%)


**Fig. No. 7: friability test**

## 4.4. pH DETERMINATION:

Crush 1 to 2 lozenges into a fine powder. Weigh the right amount. Dissolve it in a specific volume of distilled water, usually 50 to 100 mL. Mix well Stir until completely dissolved; some excipients might not dissolve fully, so filter if necessary. Measure pH Use a calibrated pH meter for better accuracy. Alternatively, you can use pH paper for a quick estimate. The temperature should be around room temperature, about 25°C.Calibrate the pH meter with standard buffers at pH 4, 7, and 9. If the formulation has flavours or sugars, they might slightly change the readings.[19]


Fig. no.8. pH determination

### 4.5. PHARMACOLOGICAL EVALUATION OF CARDAMOM:

Agar plate preparation, Agar (used commonly in antibiotic assays), Evenly spread test bacteria over the plate Create holes in the medium using a sterile cork borer dip each well in various concentrations of test sample place the plates at 37°C for 18-24 hours. Note clear zones around the wells.

**1. Observations**

Clear zone size determines strength of antimicrobial effect

Zone absence means there is no antimicrobial effect

Measure diameters using a scale in mm

**2. Applications**

Plant extract screening (cardamom, neem, etc.)

Antibiotic comparison

Discovery of novel antimicrobials

### 4.6. UV- SPECTROSCOPY:

UV spectroscopy measures the number of active compounds from cardamom extract in lozenges by assessing how much UV light they absorb. Compounds in cardamom, such as essential oil components, absorb UV light at specific wavelengths. This follows the BeerLambert Law.

**1. Sample preparation**

Crush lozenges.

Weigh an amount that matches a known drug amount.

Dissolve in a suitable solvent, often ethanol or methanol.

Filter to remove excipients.

**2. Standard preparation**

Prepare known concentrations of cardamom extract.

Scan the wavelength.

Find λ max, usually around 250 to 280 nm depending on the extract.

**3. Measurement**

Measure absorbance using a UV spectrophotometer.

**4. Calculation**

Use a calibration curve (Absorbance vs. Concentration).

Determine the unknown concentration.[20]


**FIG.NO. 9: PREPRATION OF SOLUTION**

**HEMICAL PARAMETER**

## 4.8. EVALUATION PARAMETER:

**TABLE NO.5 MORPHOLOGICAL EVALUATION**

| SR.NO | PARAMETER | OBSERVATION |
|---|---|---|
| 1. | Colour | Green / pale yellowish-green |
| 2. | Odour | Strong, aromatic, pleasant fragrance |
| 3. | Taste | Warm, sweet, slightly pungent |
| 4. | Texture | Smooth, hard, slightly rough pod surface |
| 5. | Shape | Oval to spindle- shaped pods with ridges |

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**FIG.NO.11: CARDAMOM CAPSULE**

## 4.10 MICROSCOPIC EVALUATION:

### 4.10.1. CARDAMOM T.S.:

The transverse section (T.S.) of cardamom fruit shows characteristic tissues that help in its identification and pharmacognostic evaluation.

1. Epicarp: The outermost layer of the fruit wall. Made up of a single layer of epidermal cells. Cells are compact, rectangular, and covered by a thick cuticle.

2. Mesocarp: Broad region composed mainly of thin-walled parenchymatous cells. Contains numerous Oil cells / oleoresin cells filled with volatile oil.

3. Endocarp: Innermost layer of the pericarp. Consists of compact cells surrounding the seeds. Helps in enclosing and protecting the seeds.

4. Seed Coat: Thick and hard protective covering around the seed. Contains Sclerenchymatous fibres Stone cells (sclereids) with lignified walls gives mechanical strength.

5. Endosperm: Major portion of the seed. Composed of polygonal parenchymatous cells. Rich in Fixed oil, Aleurone grains, Starch grains.

6. Embryo: Small and embedded inside the endosperm.

Difficult to observe clearly without proper staining.

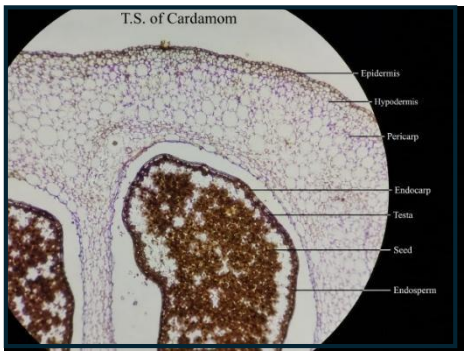



**FIG. NO.12: T.S. OF CARDAMOM**

**Table no.6. preliminary phytochemical test**

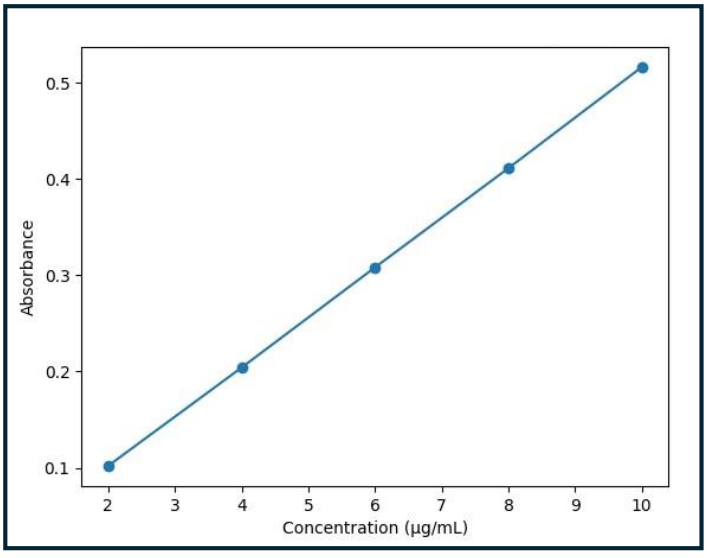
| TEST NAME | PROCEDURE | OBSERVATION | INFERENCE |
|---|---|---|---|
| Resorcinol test | A Add resorcinol + con.H warm gently. | P ink / reddish colou | Confirm cineole |
| Phosphoric acid te | Add con. Phosphoric ac | Turbidity P recipitation | I Indicate cineole |
| odour | Smell the sample | Aromatic odour | Preliminary identification |
| Solubility test | Test in and water | Slightly soluble water | Support identification |

**TABLE NO.7: ORGANOLEPTIC EVALUATION OF CARDAMOM LOZENGES**

| SR.NO | PARAMETER | EVALUATION CRITERIA | OBSERVATION |
|---|---|---|---|
| 1. 1. | Appearance | Shape, Surface, Uniformity. | Smooth, Uniform Round. |
| 2. 2. | Colour | Visual Consistency. | Light Brown, Even Colour. |
| 3. 3. | Odour | Smell Quality. | Pleasant, Strong Cardamom aroma. |
| 4. 4. | Texture | Mouth feel, Hardness. | Hard, Smooth, Slowly Dissolvi |
| 5. 5. | Taste | Residual Taste. | P Pleasant, no bitterness |

**TABLE NO. 8: ANALYTICAL EVALUATION**

| SR. NO. | CONCENTRATION (ug/ml) | ABSORBANCE |
|---|---|---|
| 1. 1. | 2 | 0.102 |
| 2. 2. | 4 | 0.204 |
| 3. 3. | 6 | 0.308 |
| 4. 4. | 8 | 0.411 |
| 5. 5. | 10 | 0.516 |




**GRAPH NO. 2: CALLIBARATION CURVE**

## 5. RESULT AND DISCUSSION:

The medicated lozenges of cardamom extract (F1–F5) were successfully prepared using the molding method. All formulations exhibited acceptable physical characteristics such as smooth surface, uniform shape, and pleasant appearance with characteristic aroma of cardamom. The hardness and weight of lozenges were found to increase with increasing control release concentration, indicating improved structural integrity and uniform formulation.

friability were within acceptable limits for all batches, suggesting good stability and handling properties. As the controlled releaser concentration increased from F1 to F5, a gradual increase in disintegration time was observed, indicating a controlled release behavior. Formulation F1 showed faster disintegration, while F5 exhibited comparatively slower disintegration due to higher matrix density.

Uniformity of drug content confirmed the even distribution of cardamom extract throughout all formulations, ensuring dose consistency. This indicates successful mixing and processing during preparation.

In vitro dissolution studies demonstrated that F1 released the active constituents more rapidly, whereas F5 showed a sustained release profile. Among all formulations, F3 exhibited an optimal balance between mechanical strength, palatability, and release characteristics.

Therefore, F3 was identified as the optimized formulation for cardamom lozenges, providing a suitable combination of taste masking, stability, and controlled release of the active extract.

## 6. CONCLUSION:

The present study successfully developed herbal lozenges containing cardamom extract using a infusion-based formulation approach. The prepared lozenges exhibited good physical appearance, uniform weight variation, adequate hardness, and acceptable organoleptic properties including pleasant aroma and taste masking of the active extract. The evaluation parameters confirmed that all formulations met the required standard quality specifications for solid oral dosage forms.

The disintegration time and release of active constituents were found to be influenced by the type and concentration of excipients used in the formulation. An increase in binding agent concentration improved mechanical strength and hardness of the lozenges but resulted in a slight delay in disintegration and drug release.

Among all formulations, the optimized batch demonstrated the best balance between palatability, mechanical strength, and rapid release characteristics. Content uniformity studies indicated proper mixing and uniform distribution of cardamom extract within the dosage form. The in-vitro release study confirmed a satisfactory and controlled release of active components over time.

Overall, the developed cardamom lozenges represent a promising herbal dosage form for oral delivery. They offer improved patient acceptability, soothing effect on the throat, ease of administration, and potential therapeutic benefits. The optimized formulation can be further explored for large-scale production and clinical evaluation.

## 7. FUTURE PROSPECTIVE:

1. cardamom lozenges are expected to grow due to:

2. Rising demand for herbal/chemical-free products as people prefer natural remedies over synthetic medicines.

3. Increasing throat and respiratory issues caused by pollution, especially in urban areas.

4. Growth of Ayurvedic and wellness-based healthcare, where herbal lozenges are widely accepted.

5. Expansion of OTC (over-the-counter) herbal products in pharmacies and online markets.

6. Product innovation, like sugar-free, honey-infused, and immunity-boosting variants.

7. Export potential, since herbal throat products are gaining popularity globally.

## 8.REFEREANCE:

1. Burt, S. (2004). Essential oils: their antibacterial properties and potential application in foods. International Journal of Food Microbiology, 94(3), 223–253.

2. Aggarwal, K. K., & others (2002), Antimicrobial activity of essential oils from spices Journal of Agricultural and Food Chemistry, 50(22), 6470–6476.

3. Khan, M.S.A. et al. (2010) "Antimicrobial activity of essential oil of Elettaria cardamomum Maton." African Journal of Biotechnology, 9(49), 8439–8442. 4. Bhat, R. et al. (2011) "Evaluation of antimicrobial activity of spices against dental caries bacteria." Journal of Medicinal Plants Research, 5(4), 551–555.

5. Mimica-Dukic, N. et al. (2003) "Essential oils as natural anti-inflammatory and carminative agents." Phytotherapy Research, 17(3), 251–258. Peter K.V. (Ed.). Handbook of Herbs and Spices, Vol.1, Woodhead Publishing, 2001. Nair K.P.P. Spices: Agronomy and Economy, Springer, 2013. CSIR. The Wealth of India: Raw Materials, Vol. III. New Delhi.

6. Verma SK, Jain V, Verma D, Khamesra R. Cardamom (Elettaria cardamomum): A comprehensive review on phytochemistry and pharmacological activities. Journal of Drug Delivery and Therapeutics. 2018;8(4):161–166.

7. Herbal Medicine: Biomolecular and Clinical Aspects — Chapter: Cardamom (Elettaria cardamomum). CRC Press; 2011.

8. Effect of Cardamom on Blood Pressure, Fibrinolysis and Antioxidant Status NHP Azadbakht et al. Indian Journal of Biochemistry & Biophysics. 2009; 46:503–506.

9. Review of therapeutic properties of cardamom Ashokkumar, K., et al. (2020). "Cardamom (Elettaria cardamomum) and its bioactive components: A review." Journal of Ethnic Foods, 7(1), 1–13.

10. Medicinal properties of cardamom Verma, S.K. et al. (2012). "Therapeutic potential of cardamom." International Journal of Pharmaceutical Sciences and Research.

11. Sugar alcohol overview Grembecka, M. (2015). "Sugar alcohols—the role in the modern world of sweeteners." European Food Research and Technology.

12. Beeswax properties and applications Fratini, F., et al. (2016). "Beeswax: A minireview of its antimicrobial activity and applications." Asian Pacific Journal of Tropical Medicine.

13. Beeswax properties and applications Fratini, F., et al. (2016). "Beeswax: A minireview of its antimicrobial activity and applications." Asian Pacific Journal of Tropical Medicine.

14. Honey in medicine review Mandal, M.D., & Mandal, S. (2011). "Honey: Its medicinal property and antibacterial activity." Asian Pacific Journal of Tropical Biomedicine, 1(2), 154–160.

15. Trease GE, Evans WC. Trease and Evans Pharmacognosy. 16th ed. London:
Saunders Elsevier; 2009.

16. The Theory and Practice of Industrial Pharmacy
Lachman L, Lieberman HA, Kanig JL. The Theory and Practice of Industrial Pharmacy. 3rd ed. Philadelphia: Lea & Febiger; 1986.

17. Indian Pharmacopoeia Commission. Indian Pharmacopoeia, Ghaziabad, India; General Chapter: Disintegration Test for Tablets and Capsules.

18. European Pharmacopoeia, Chapter 2.9.7: Friability of Uncoated Tablets. European Directorate for the Quality of Medicines (EDQM).

19. United States Pharmacopeia and National Formulary (USP–NF). General Chapter ⟨791⟩ pH. Rockville, MD: United States Pharmacopeial Convention.

20. United States Pharmacopeia and National Formulary (USP–NF). General Chapter ⟨857⟩ Ultraviolet-Visible Spectroscopy. Rockville, MD: United States Pharmacopeial Convention USP–NF UV-Visible Spectroscopy.

21. Ashokkumar K, Murugan M, Dhanya MK, Warkentin TD. Botany, traditional uses, phytochemistry and biological activities of cardamom [Elettaria cardamomum (L.) Maton]: A critical review. Journal of Ethnopharmacology. 2020; 246:112244.

22. Antibacterial and anti-inflammatory activities of cardamom (Elettaria cardamomum) extracts: Potential therapeutic benefits for periodontal infections. Anaerobe. 2020; 61:102089.

23. Holder IA, Boyce ST. Agar Well Diffusion Assay Testing of Bacterial Susceptibility to Various Antimicrobials in Concentrations Non-Toxic for Human Cells in Culture.
Burns. 1994; 20:426–429.

24. World Health Organization, Antimicrobial Resistance Illustration, https://www.who.int/, Accessed 26 May 2026.

25. Pixabay, Cardamom Pods and Spices Image, https://pixabay.com/, Accessed 26 May 2026.

26. Unsplash, Natural Beeswax Blocks Image, https://unsplash.com/, Accessed 26 May 2026.

27. National Honey Board, Honey Jar and Honeycomb Image, https://www.honey.com/, Accessed 26 May 2026.