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FORMULATION AND EVALUATION OF HERBAL TOOTH CLEANING CHEWING GUM

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ABSTRACT

Maintaining oral hygiene is an essential and vital part of our life. We are very much familiar with toothpaste and toothbrush. These products are used to clean our teeth, reduce the chances of cavities, and remove bad odor from the mouth. White and cleaned teeth are one of the parameters of personal hygiene. We can make this oral hygiene process easier and more enjoyable by using chewable herbal tooth-cleaning gum. Chewable herbal tooth cleaning is small-sized chewable gums that can be chewed for cleaning and whitening of the teeth, and at the same time, we can enjoy the best of flavors in our mouth. The main approach of this formulation is to make the oral cleaning process enjoyable and minimize water usage. Chewable herbal tooth-cleaning gums are formulated using plant extracts like neem leaves, lemon peel, clove extraction, turmeric, baking soda, and xanthan gum base. These extract ingredients possess antibacterial, anticavity, and whitening characteristics, while the addition of peppermint extract and xylitol sugar gives a flavourful experience. The outcome of this formulation shows equal patronizing and engrossing passion over the marketed preparation. It has been a good scope for future research to make the oral cleaning process easier and promote public health.

KEYWORDS: Oral hygiene, Cavities, Patronizing, Engrossing, Xanthan Gum, Xylitol Sugar.

INTRODUCTION

Herbal Mouth Cleaning Chewing Gum is a groundbreaking oral care product meticulously formulated to harness the power of natural herbs for maintaining oral hygiene. This

innovative gum offers a unique combination of traditional herbal remedies and modern convenience, making it an ideal choice for individuals seeking an effective, natural solution for oral care. It is an innovative oral care product crafted to seamlessly blend the benefits of natural herbs with the convenience of modern-day chewing gum. This product offers a unique solution for individuals seeking to enhance their oral hygiene effortlessly while enjoying the refreshing flavor and therapeutic properties of carefully selected herbs. It is designed to provide fresh breath, clean the mouth, and support oral health, all in a convenient chewing gum format.

Oral care products have existed since the beginning of time and are an essential part of oral health care. Ancient times (around 3000 BCE) used chewing sticks and natural abrasives; the Middle Ages (5th-15th centuries) saw a decline in Europe but advanced care in Islamic cultures using siwak (tooth-stick); the Renaissance (14th-17th centuries) brought resurgence with tooth powders in Europe; the 18th-19th centuries introduced animal hair toothbrushes and early toothpaste; the 20th century developed nylon toothbrushes (1938), fluoride toothpaste (1950s), and regular dental check-ups; the 21st century features electric toothbrushes, water flossers, and natural products.[1]

Herbal chewing gum for tooth cleaning has a rich historical background spanning various cultures. Ancient civilizations utilized natural substances such as resins, tree sap, and aromatic herbs to maintain dental hygiene practices. This tradition persisted through the ages, with ingredients like mint, eucalyptus, and cloves being integrated into modern herbal chewing gums for their oral health benefits.

PRODUCT PROFILE

Chewable tooth-cleaning gums are tiny little circular discs that resemble breath mints and are made entirely of natural components that are designed to keep your teeth clean by eradicating plaque. Once in your mouth, you chew the gum with your teeth, usually your larger and stronger back molars. The natural beneficial dental components in gum interact with the teeth surface during chewing and show their action.

"Tooth cleaning herbal chewing gum" typically features natural ingredients like xantham gum, xylitol sugar, neem, black paper, mint, and clove, known for their antibacterial, anti-plaque properties, teeth whitening, and breath-freshening effects. It aims to combat plaque and bacteria, promoting gum health without artificial flavors or synthetic chemicals. Some

varieties use sugar-free or natural sweeteners such as xylitol or stevia, reducing cavity-causing bacteria. Packaged in eco-friendly materials, these gums often draw on ancient practices and cultural traditions of using natural substances for oral hygiene, appealing to those seeking effective, natural dental care solutions.

ADVANTAGES

Herbal tooth-cleaning chewing gums offer several potential advantages over traditional chewing gums and oral hygiene products:

Natural Ingredients

- Gentler on teeth and gums.
- Free from artificial chemicals.

Improved Oral Hygiene

- Helps reduce plaque.
- Increases saliva production for cleaning.

Antibacterial Properties

- Neem and clove reduce harmful bacteria.
- Promotes overall oral health.

Gum Health: Baking soda and salt soothe and heal gums.
Freshens Breath: Peppermint and fennel provide a refreshing effect.
Convenience: Easy to use anywhere, anytime.
Reduced Cavities: Saliva stimulation helps prevent cavities.
Holistic Approach: Natural and preventive care.
Sugar-Free Options: Xylitol reduces cavity risk.
Eco-Friendly Choices: Some brands use sustainable practices and packaging.

Oral problems

1. HALITOSIS

Bad breath and halitosis are the terms used to describe unpleasant breath. Halitosis is a sign of a variety of disorders. In general, poor dental hygiene, periodontitis, or tongue coating are thought to be the leading cause of halitosis. The word halitosis comes from the Latin

word halitus, which means "breath," and the Greek suffix -osis, which means "diseased" or "a state of."[2]

To use **baking soda** as one of the natural remedies for bad breath (halitosis), Include a few drops of peppermint essential oil.[3]

2. FLUOROS

Mild dental fluorosis is frequently linked to fluoridated water. Dental fluorosis is most commonly seen in children, particularly those under the age of 8, as this is when permanent teeth are still forming under the gums. Exposure to high levels of fluoride during this critical period can lead to fluorosis. This causes yellow stains in the teeth. It also can occur in adults in some rare cases.[4]

Baking soda can help reduce surface stains, Neem is used to improve overall oral health and potentially reduce discoloration.[5]

3. DENTAL-PLAQUE

Dental plaque is a soft, sticky film that builds up on teeth, due to a variety of bacterial species (Streptococcus mutans and Lactobacillus), especially sugars and starches, which bacteria metabolize to produce acids. It is a primary cause of various oral health issues, including cavities (dental caries) and gum diseases like gingivitis and periodontitis.[6]

Neem, baking soda, and clove are used to reduce the growth of bacteria in the mouth, help neutralize acids, and reduce the formation of plaque.[7]

4 GINGIVITIS

Gingivitis is a common and mild form of gum disease (periodontal disease) that causes irritation, redness, and swelling (inflammation) of the gingiva(the part of your gum around the base of your teeth). T Gingivitis is primarily caused by poor oral hygiene that allows plaque to form on teeth, leading to inflammation of the surrounding gum tissue. Gingivitis can lead to much more serious gum disease called periodontitis and tooth loss.[8]

Salt has anti-inflammatory properties that can reduce swelling and soothe gum irritation. Other ingredients like baking soda, neem powder, and peppermint oil are used to reduce bacteria in the mouth and freshen your breath.[9]

MORPHOLOGY

1. HIMALAYAN PINK SALT

SOURCE: This mine is located in the foothills of the Salt Range Himalayan mountains and is one of the oldest and largest salt mines in the world.

TASTE: Salty in the test.

PHYTOCHEMICAL CONSTITUENTS: Himalayan pink salt is composed mainly of sodium chloride (95-98%), with trace minerals like potassium, magnesium, calcium, and iron, which give it its pink color. It also contains over 80 trace elements, such as zinc, copper, and manganese, contributing to its unique properties. Its pH is slightly alkaline (6.5-7.5), and it is low in moisture.[10]

USE

- **Saltwater Rinse**: A rinse made with Himalayan pink salt can help reduce bacteria, soothe gum inflammation, and promote the healing of oral sores.
- **Toothpaste Ingredient**: Mixed with other natural ingredients, it is used in DIY or commercial toothpaste to help remove plaque, whiten teeth, and maintain oral hygiene due to its mild abrasiveness and antibacterial properties.
- **Mouthwash and Gargle**: It is used in homemade mouthwashes for its mineral content, freshening breath, and maintaining pH balance in the mouth, potentially reducing the risk of tooth decay and gum disease.[11]

2. AZADIRACHTA INDICA

BOTANICAL NAME	Azadichta Indica
KINDOM	Plantae
FAMILY	Meliaceae
DIVISION	Magnoliophyta
CLASS	Mangoliopsida
ORDER	Sapinadales
GENUS	Azadirachta
TASTE	Bitter
ODOUR	Distinct and strong

PHYTOCHEMICAL CONSTITUENTS: Neem leaves contain several important phytochemicals including azadirachtin, nimbin, nimbolide, nimbidin, quercetin, beta-sitosterol, vitamin C, carotenoids, and volatile oils.[12]

USES

- Neem leaves are important in dental care due to their antibacterial properties
- Help combat oral bacteria, reduce plaque formation, and prevent gum disease like gingivitis.
- They are also used for their anti-inflammatory effects, soothing gums, and promoting oral hygiene.[13]

3. PIPER NIGRUM

BOTANICAL NAME	Piper Nigrum
KINDOM	Plantae
FAMILY	Magnoliophyta
DIVISION	Magnoliopsida
CLASS	Piperaceae
ORDER	Piper
GENUS	P.Nigrum
TASTE	Spicy
ODOUR	Pungent, Aromatic

PHYTOCHEMICAL CONSTITUENTS: Black pepper (Piper nigrum) contains primarily piperine, an alkaloid responsible for its pungent taste and potential health benefits. It also contains other phytochemicals such as terpenes (β-caryophyllene, limonene), flavonoids (quercetin, kaempferol), and vitamins/minerals (A, C, K, calcium, manganese).[14]

USES

- Helps to inhibit the bacterial growth.
- Shows potent action of anti-microbial on dental products.[15]

4. XANTHAN GUM

BOTANICAL NAME	Xanthomonas Campestris
KINDOM	Bacteria
DIVISION	Proteobacteria
CLASS	Gammaproteobacteria
FAMILY	Xanthomonadaceae
GENUS	Xanthomonas
SPECIES	Xanthomonas Compestris
TASTE	Tasteless
ODOUR	Slightly earthy or musty

PHYTOCHEMICAL CONSTITUENTS: Xanthan gum has a polysaccharide structure containing glucose, mannose, and glucuronic acid.[16]

USES

- It mainly provides texture, consistency, and stability.
- It has moisture-retaining properties.
- It helps to provide flexibility and elasticity.[17]

5. XYLITOL SUGAR

BOTANICAL NAME	Betula Pendula
KINDOM	Plantae
DIVISION	Magnoliophyta
CLASS	Magnoliopsida
FAMILY	Betulaceae
GENUS	Betula
SPECIES	Betula pendula
TASTE	Sweet
ODOUR	Aromatic

PHYTOCHEMICAL CONSTITUENTS: Xylitol sugar contains flavonoids or terpenoids, mainly sugar alcohol derivatives from plants.[18]

USES

- Helps to reduce tooth decay and promote remineralization.

- Helps to maintain pH by stimulating saliva production.
- Hepls to decrease the plaque formation.[19]

6. LEMON PEEL

BOTANICAL NAME	Citrus Limon
KINDOM	Plantae
DIVISION	Magnoliophyta
CLASS	Magnoliopsida
FAMILY	Rutaceae
GENUS	Citrus
SPECIES	Citus Limon
TASTE	Citrusy, slightly bitter
ODOUR	Distinctly lemony

PHYTOCHEMICAL CONSTITUENTS: Lemon peel contains flavonoids, essential oil (Limonene, citral, linalool), vitamin C, carotenoids, pectin, coumarins, polyphenols, etc.

USES

- Helps in the whiting of teeth and freshens breath.
- It contains antibacterial properties.
- Vitamin C helps to support gum health.
- Helps to maintain the pH of the formulation.[20]

7. PEPPERMINT OIL

BOTANICAL NAME	**Mentha Piperita L.**
KINDOM	Plantae
DIVISION	Magnoliophyta
CLASS	Magnoliopsida
FAMILY	Lamiaceae
GENUS	Mentha
TASTE	Refreshing
ODOUR	Minty

PHYTOCHEMICAL CONSTITUENTS: Peppermint contains menthol, menthone, menthyl acetate, limonene, rosemarinic acid, flavonoids, tannins, etc.

USES

- It is a flavoring agent.

- It helps to provide breath freshening.
- It has anti-inflammatory, analgesic, and antimicrobial properties.[22]

8. CORN SYRUP

BOTANICAL NAME	Zea mays
KINDOM	Plantae
DIVISION	Magnoliophyta
CLASS	Liliposida
FAMILY	Poales
ORDER	Poaceae
GENUS	Zea
TASTE	Mild sweet
ODOUR	Sweet aroma

PHYTOCHEMICAL CONSTITUENTS: Corn syrup is a sugar derivative obtained from corn starch and contains glucose, maltose, oligosaccharides, etc.

USES

- It works as a binding agent.
- It also provides sweetness and texture in the chewing gum preparation.
- It helps to maintain moisture and increase the product's shelf life.[23]

9. BAKING SODA

Common Name: Baking soda is also known as sodium bicarbonate.

Taste: Alkaline and slightly salty

Odor: Odorless.

Uses

- Baking soda has abrasive properties.
- It neutralizes the acid in the mouth.
- It helps to neutralize odors.[24]

10. GLYCERINE

Source: Glycerin is mainly obtained from animal fats and plant oils.

Taste: Slightly sweet.

Odor: Odourless.

Uses

- Glcernrine is mainly used as a softening agent in the preparation of chewing gum.
- It also works as a binder and sweetening agent.
- It helps to give chewing gum its desired texture and chewingness.
- It is a preservative agent.[25]

METHODOLOGY

1. DRY AND GRINDING METHOD

- **Azadiachita Indica (Neem leaves)Powder:** The leaves are collected from the college campus as per the required quantity and washed properly and gently with distilled water. Then they are shade-dried and powered by using a blender or motor pastle. Then powered leaves should go through the sieve to get a uniform particle size and be stored in an air-tight container for further use.[29]



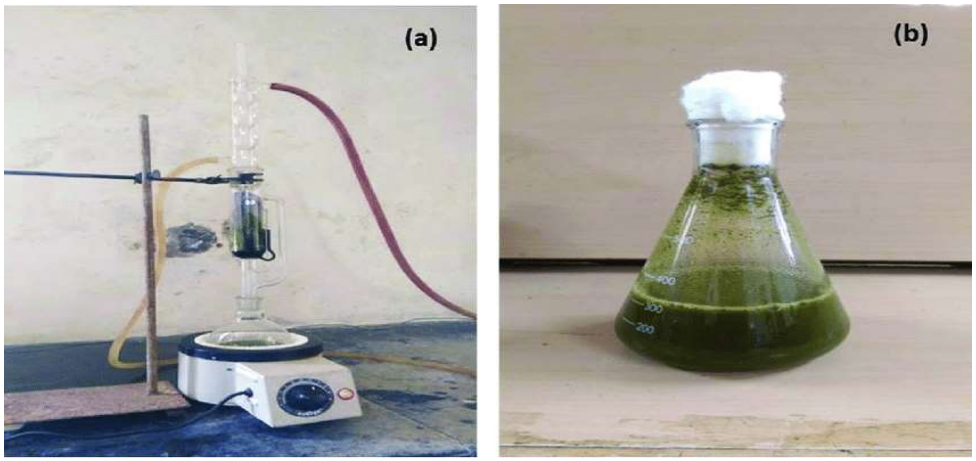
- **Citrus Lemon (Lemon Peel) Powder:** Lemons are collected from the market and the peel of the lemon is removed. Then clean it properly to remove impurities and dried in the sun for 5-6 days or a week until it dries properly. Then grind it with the help of a blender to get fine powder and sieve.[30]

2. GRIND METHOD

- **Piper Nigrum(Black pepper) Powder:** Take pepper in a dring pan and roast it for 4-5 minutes. Then keep it for cooling. Put it in a blender or mortar pestle for grinding till coarse powder forms.

3. STEAM DISTILLATION METHOD

- **Mentha Peperita oil extraction:** Peppermint oil can be extracted using the Soxhlet apparatus. In the first step, dry the peppermint leaves to remove moisture and crush or grind the leaves. Then set up the Soxhlet apparatus and the steam distillation process starts. The oil separates at 250–300 °C after some hours. Then the vaporized condensed collector is collected and the oil phase is to be separated from the water phase. Peppermint oil is ready for use.[28]



FORMULATION

The total amount of product=100gm.

INGREDIENTS	F1	F2	F3
Xantham gum	42gm	42gm	42gm
Xylitol sugar	20gm	25gm	25gm
Glycerine	5.68gm	5.68gm	5.68gm
Corn syrup	14.16gm	14.16gm	14.16gm
Baking soda	9.5gm	4.2gm	2.5gm
Lemon peel powder	4.26gm	4.26mg	4.26gm
Black pepper powder	0.1gm	0.4gm	0.2gm
Pink salt	3gm	4.2gm	3gm
Azardirachta indicia powder	1.5gm	0.5gm	1gm
Peppermint flavor	0.8ml	0.3ml	0.5ml

PROCEDURE

1. MIX AND HEAT THE INGREDIENTS

First place the gum base, corn syrups, glycerin, lemon juice, and flavoring agent in the required and measured quantities. Then turn on the stove or gas after arranging the double boiler setup. Stir the mixture occasionally with the help of a spoon or stirrer, until all the ingredients are mixed after heating.

2. PREPARE A SUGAR BED: In the second step, take some powdered sugar and pour it into a clean surface or cut board. Mix the all other ingredients with sugar powder properly. Then make a smooth and square surface.

3. POUR AND MIX THE GUM BASE INTO THE SUGAR BED: Then directly pour the melted mixture into the prepared sugar bed. At the time of mixing, we should be careful that any moisture or water should not come in contact with this mixture.

4. PREPARE A PROPER GUM DOUGH: Dast the finger with powdered sugar and knead all ingredients properly with the help of your hands. Add the powdered sugar into the melted mixture until it becomes soft and no longer sticky. Knead at least for 15 minutes.

NOTE

- If the kneading is not proper, then the gum tends to separate.
- The dough should be stiff and smooth.

5. ROLL OUT AND CUT INTO PIECES: Place the dough on a clear surface on the cut board. Place your hands palm down on top of it. Roll the dough using your hands so that it

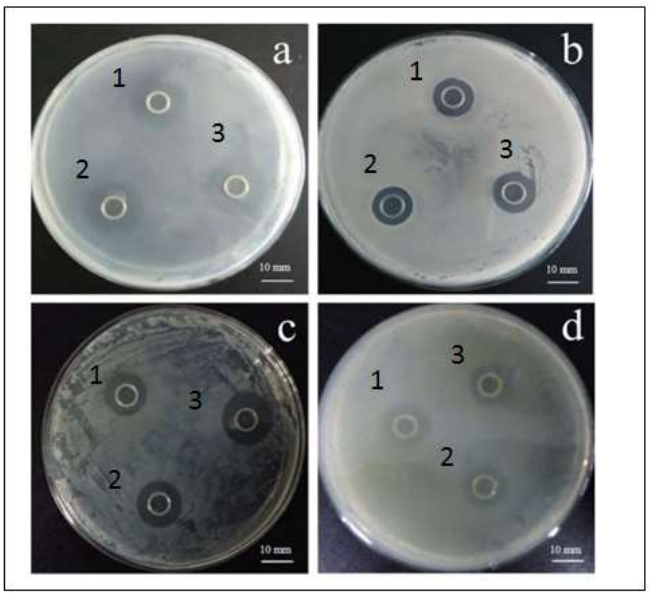
becomes long, like a thin rope. Try to make the same width and thickness throughout the length of the rope. Cut into small equal bite-size pieces using a knife.

6. FINISH AND WRAPPING THE GUM: Sprinkle powdered xylitol sugar on the gum pieces to keep them free from sticking to each other. Take the pieces of gum and wrap them in a small square-shaped parchment paper. Our product is ready.[26]

EVALUATION TESTS

1. **Microbiological Testing**

- **Antimicrobial Activity**
  - **Purpose:** To determine if the herbal chewing gum can inhibit the growth of oral pathogens (like Streptococcus mutans and Lactobacillus), which are known to cause dental caries and plaque.
  - **Methodology**: Agar Diffusion Test: Agar plates are inoculated with target bacteria. Wells are then created in the agar, and the herbal gum extract is placed in these wells. After incubation, the zone of inhibition (clear areas around the wells) is measured.
  - **Result:** Formulation number 3 shows better antimicrobial activity incompare with other two formulation.[31]



2. Physicochemical Tests

- **Moisture Content**
  - **Purpose**: To ensure the gum maintains its texture and chewability, and prevents microbial growth.

- **Method**: Use a moisture analyzer or the Karl Fischer titration method to measure the water content in the gum.
- **Result**: Formulation number 2 shows more moisture content, 10% due to more sugar and salt. While formulations 1 and 3 show 3% and 5% water content.[32]

- **pH Testing**
- **Purpose**: To determine if the gum is safe for teeth and does not cause enamel erosion.
- **Method**: Dissolve the gum in distilled water and use a pH meter to measure the acidity or alkalinity.
- **Result**: Formulation 1 is showing pH 6.2, while Formulation 2 is having pH of 7.2. But the best accepted pH is shown by Formulation 3, pH 6.5.[33]

- **Texture Analysis**
- **Purpose**: To assess the chewiness, hardness, and cohesiveness of the gum.
- **Method**: Use a texture analyzer with specific probes to measure force and deformation during chewing simulations.
- **Result**: All the formulations have nearly the same texture.

- **Color and Odor Stability**
- **Purpose**: To ensure that the gum does not undergo undesirable changes in appearance or smell over time.
- **Method**: Use a colorimeter for color analysis and gas chromatography-olfactometry (GC-O) for odor stability tests.
- **Result**: All the formulations are having near about the same color and odor stability.[34]

3. Safety Testing

- **Allergenicity Tests**
- **Purpose**: To check for potential allergic reactions that could be caused by the herbal ingredients.
- **Method**: Conduct skin patch tests on human volunteers or use in vitro methods like basophil activation tests to evaluate the immune response to the herbal extracts.
- **Result**: All the formulations are having near about the same non-allergic properties.[35]

4. Organoleptic Evaluation

- **Taste, Smell, and Mouthfeel Testing**
  - **Purpose**: To evaluate the sensory properties of the gum, including its flavor, aroma, texture, and aftertaste.
  - **Method**: Human sensory panels (trained or untrained) chew the gum and rate its attributes on a structured scale (e.g., 1 to 10) for factors like taste intensity, sweetness, bitterness, cooling effect, and overall acceptance.
  - **Result**: Formulation number 3 is having the balanced taste and mouthfeel, but formulation 2 has strong taste and flavour, while formulation 1 has mild taste.

- **Aftertaste Analysis**
  - **Purpose**: To check if the gum leaves a pleasant or unpleasant aftertaste.
  - **Method**: Panelists provide feedback on the aftertaste immediately and a few minutes after chewing.
  - **Result**: Formulation number 3 is having the best after test in compare with the other formulations.

5. Shelf Life Testing

- **Stability Testing**
  - **Purpose**: To predict the gum's shelf life by storing it in normal room conditions.
  - **Method**: The gum is stored at room conditions in normal temperature and relative humidity for several months. Samples are tested periodically for changes in moisture content, color, flavor, texture, and active ingredient potency.
  - **Result**: Formulation number 2 has the less stability compared with the other formulations due to the presence of less amount of sugar and more amount of salt, which causes less binding capacity of the gum.[36]

6. Consumer Acceptability Studies

- **Purpose**: To determine how consumers perceive and accept the product.
- **Methodology**
  - Conduct surveys, focus groups, or in-home testing with target demographics. Collect feedback on various attributes such as taste, texture, mouthfeel, packaging, and perceived benefits.

- **Result:** After doing survey on 20 people, it's confirmed that most of the consumers like the balanced teste of formulation 3, while some like formulation 2 and least of the people like the teste, flavour of formulation 1.

DISCUSSION

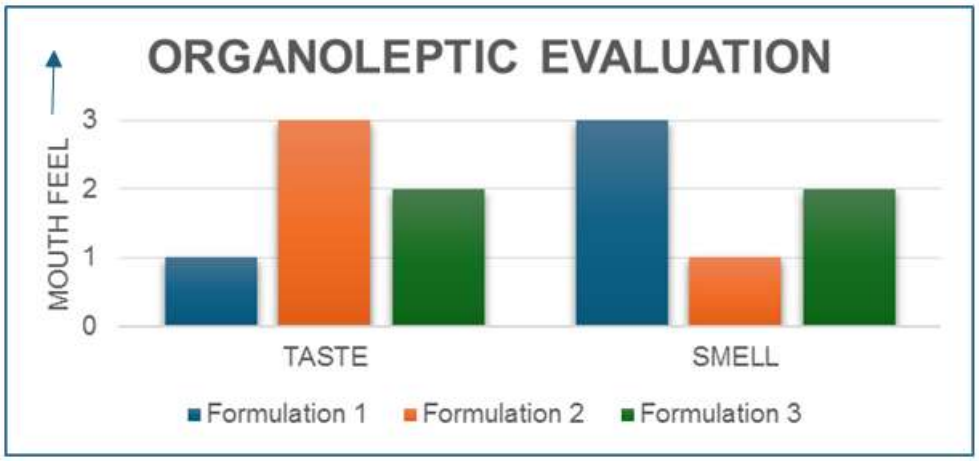
- When evaluating herbal tooth-cleaning chewing gum products of three different concentrations, the comparison focuses on understanding how each concentration affects oral hygiene efficacy, safety, stability, sensory attributes, and consumer acceptability. Here's a discussion of the comparison:

1. Oral Hygiene Efficacy

- All three different formulations of "Herbal tooth-cleaning chewing gum" are effective in reducing plaque, preventing gingivitis, and maintaining oral hygiene through antimicrobial and anti-inflammatory properties. Balanced concentrations of herbs typically balance efficacy and safety, reducing harmful bacteria without disturbing the oral microbiome. Enhanced salivary stimulation and pH buffering also contribute to oral health. Consistent use and a pleasant taste are essential for long-term compliance and benefits.

2. Organoleptic Evaluation

	F1	F2	F3
TASTE	Mild	Strong	Balanced
SMELL	Strong	Mild	Balanced



2. Anti-microbial Activity

The anti-microbial properties of gum are crucial for its ability to reduce harmful oral bacteria. **Formulation number 2** is typically inadequate for exerting strong antimicrobial effects,

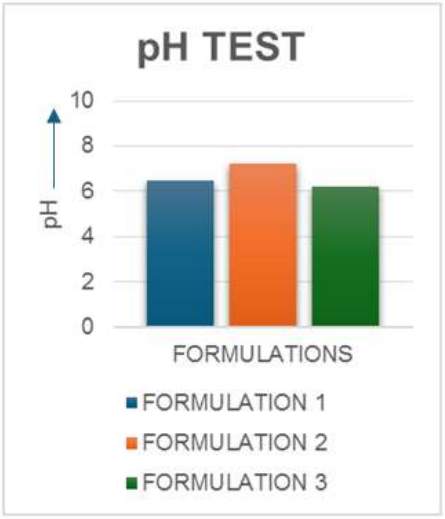
which might result in minimal reduction of pathogens. **Formulation 3** is obtained optimal showing significant antibacterial activity without disrupting the natural oral microbiome. However, **formulation 1** may lead to overly aggressive antimicrobial activity, potentially impacting beneficial oral bacteria and causing issues like dry mouth or oral mucosal imbalance.

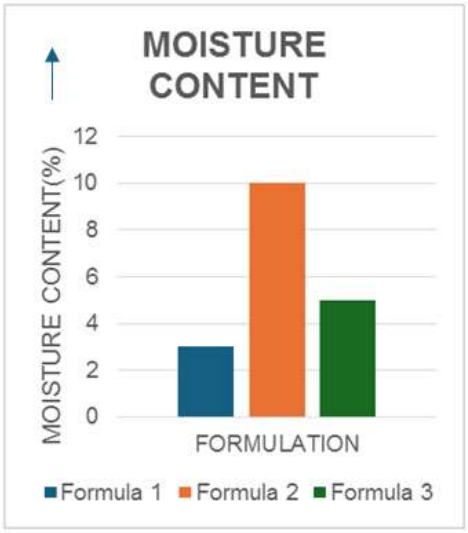
3. Safety

Safety is a parameter, especially when considering the continuous use of an oral care product. All our formulations are safe and without any side effects for short and long-term usage.

4. Physicochemical Properties and Stability

TESTS	F1	F2	F3
pH	6.5	7.2	6.2
Moisture Content	3%	10%	5%

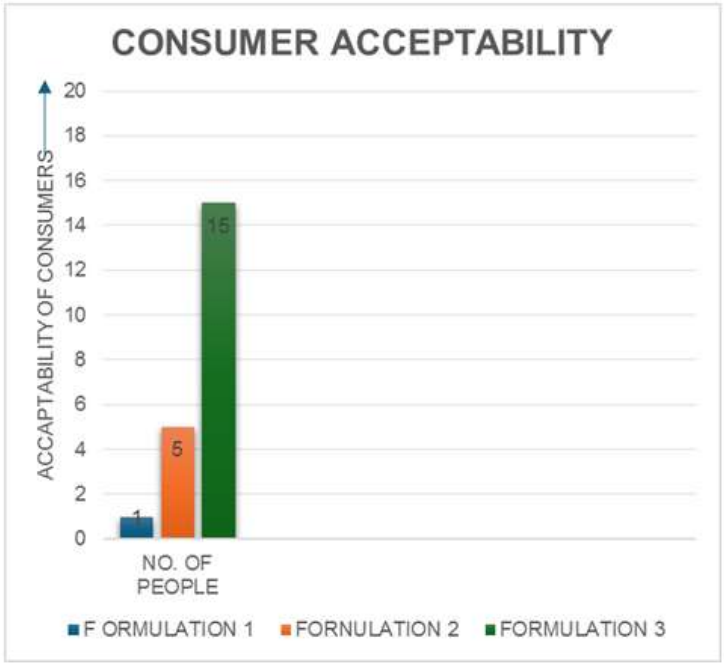




The stability and sensory attributes of the gum are influenced by the concentration of herbal ingredients. **Formulation number 1** may lack robust flavor or aroma due to the presence of less salt and less sugar, leading to reduced consumer satisfaction and shorter shelf life due to insufficient natural preservative effects. **Formulation number 2** could result in overly strong flavors, bitterness, or undesirable textural changes, negatively impacting both stability and user experience. Conversely, **Formulation number 3** tends to maintain a pleasant balance of taste, texture, and stability, making them more appealing to consumers.

5. Consumer Acceptability

NO. OF PEOPLE	F 1	F 2	F 3
1	✗	✗	✓
2	✗	✗	✓
3	✗	✓	✗
4	✗	✗	✓
5	✗	✓	✗
6	✗	✗	✓
7	✗	✗	✓
8	✗	✗	✓
9	✗	✗	✓
10	✗	✗	✓
11	✗	✓	✗
12	✗	✓	✗
13	✗	✗	✓
14	✗	✗	✓
15	✗	✓	✗
16	✗	✗	✓
17	✗	✗	✓
18	✓	✗	✗
19	✗	✗	✓
20	✗	✗	✓



Consumer preferences often guide the success of an oral care product. **Formulation number 1** may fail to meet consumer expectations due to perceived ineffectiveness and lackluster flavor. **Formulation number 2**, while potentially more effective, may face consumer resistance due to intense flavors, possible irritation, or other sensory discomforts. **Formulation number 3** generally receives favorable feedback, as they balance efficacy, taste, and overall experience, making them the most likely to succeed in the market.

CONCLUSION

The study on the "Formulation and Evaluation of Herbal Tooth Cleaning Chewing Gum" with three different concentrations of herbal ingredients shows:

1. **Effectiveness**: The highest concentration formulation (Formulation 2) demonstrated the most effective antibacterial activity and plaque removal, while the lowest concentration (Formulation 1) was the least effective. The moderate concentration (Formulation 3) provided a good balance between efficacy and other attributes.
2. **Safety and Stability**: All formulations were stable and safe, with no adverse effects observed, confirming their suitability for oral use.

3. **Organoleptic Properties**: Formulation 3 was the most preferred due to its balanced taste and texture. Formulation 1 had a stronger herbal taste, less favored by some, while Formulation 2 had the mildest taste and was well-received.
4. **Recommendation**: Formulation 3 is the most promising for broad consumer acceptance, balancing effectiveness and sensory appeal. Formulation 2 could be ideal for those seeking stronger antibacterial effects, while Formulation 1 may appeal to those preferring a milder taste.

Further optimization could focus on enhancing flavor profiles and assessing long-term benefits.

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