ejpmr, 2025, 12(6), 699-710

SJIF Impact Factor 7.065

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 2394-3211

EJPMR

TO PREPARE AND EVALUATE PROPER EDIBLE TOOTHPASTE FOR CHILDREN

Sagar A. Chandankhede[1]*, Saumy S. Adhao[2], Manisha R. Chavhan[3], G.J. Rathod[4] and Dr. Manisha D. Kitukale[5]

[1,2]Student, P. Wadhwani College of Pharmacy, Yavatmal.
[3,4]Assistant Professor P. Wadhwani College of Pharmacy, Yavatmal.
[5]Principal, P. Wadhwani College of Pharmacy.

***Corresponding Author: Sagar A. Chandankhede**

Student, P. Wadhwani College of Pharmacy, Yavatmal.

Article Received on 29/04/2025 **Article Revised on 19/05/2025** **Article Accepted on 09/06/2025**

ABSTRACT

Maintaining oral hygiene in patients is essential for overall health, yet concerns regarding the ingestion of conventional toothpaste have led to the development of edible alternatives. Edible toothpaste offers a safe and effective means of cleaning children teeth while eliminating risks associated with fluoride or other harmful ingredients. This review explores the composition, benefits, and effectiveness of edible toothpaste specifically designed for use. It highlights key ingredients such as Xylitol (8.5 gm), Xanthan Gum (3 gm), Glycerine (21.5 gm), Calcium Carbonate (15.5 gm), Sodium Bicarbonate (14 gm), Vitamin E Oil (4 gm), Sodium Lauryl Sulphate (1.20 gm), Saccharine (1 gm), Flavour (4.50 gm), Natural Colour (4.50 gm) in a 100- gram batch that promote oral health without adverse effects. Furthermore, the article discusses safety considerations, acceptance among children, and recommendations for selecting the most suitable edible toothpaste. By analysing current formulations and scientific evidence, this review aims to provide insights into the ideal characteristics of edible toothpaste for dentistry, ensuring both safety and efficacy in maintaining children oral hygiene.

KEYWORD:- Toothpaste, Edible, Children, Fluoride, Safe, Effective, Oral Hygiene.

1. INTRODUCTION

Ensuring Safe and Effective children toothpaste

The early years of a child's life are crucial for establishing lifelong oral health habits. As children begin to explore the world around them, they often engage in behaviours that involve putting objects, including toothbrushes and toothpaste, into their mouths. This natural curiosity underscores the importance of selecting toothpaste formulations that are not only effective in promoting oral hygiene but also safe for ingestion. The concept of "edible" or "safe-to- swallow" toothpaste has gained prominence in children dental care, aiming to mitigate risks associated with accidental ingestion during the brushing process.[1]

The need for edible toothpaste in children dentistry

Children, especially those under the age of six, often lack the coordination to spit out toothpaste effectively. This can lead to the ingestion of toothpaste, making it imperative to choose products that are non-toxic and free from harmful chemicals. Traditional adult toothpaste formulations, which may contain higher concentrations of fluoride and abrasive agents, are not suitable for young children due to the potential risks of dental fluorosis and enamel damage. Therefore, children toothpaste must be specifically designed to cater to the unique needs and safety concerns of children.[2]

I. Types

A) By Purpose/Function

- **Whitening toothpaste**

Contains mild abrasives like baking soda or silica to help remove surface stains and polish teeth.

- **Sensitivity toothpaste**

Designed for people with sensitive teeth, often containing ingredients like potassium nitrate or strontium chloride to desensitize teeth.

- **Tartar control toothpaste**

Formulated to prevent tartar buildup, often containing ingredients like zinc citrate or triclosan.

- **Fluoride toothpaste**

Contains fluoride, which helps strengthen enamel and protect against cavities.

- **Natural toothpaste**

Made with natural ingredients like plant-based extracts and minerals, rather than synthetic or chemical compounds.

B) By target audience

- **Children toothpaste**

Typically contains less fluoride and fewer abrasives to be gentle on children teeth and reduce the risk of accidental ingestion.

- **Adult toothpaste**

Formulated for the needs of adults, often with higher fluoride levels and more abrasive cleansers.

C) Other types

- **Gel toothpaste**

Comes in a gel-like consistency, often with a smooth texture and various flavours.

- **Charcoal toothpaste**

Contains activated charcoal, which is marketed as having stain-binding properties.

- **Toothpaste with hydroxyapatite**

Hydroxyapatite is a mineral that is a key component of tooth enamel, and some toothpastes contain it to help remineralize teeth.

II. METHODS

1. Vacuum mixing

Vacuum mixing is a critical step in toothpaste manufacturing to remove entrapped air, which can affect the stability and texture of the final product. By applying vacuum conditions during the mixing process, air bubbles are eliminated, resulting in a dense and uniform paste. This technique is commonly used in conjunction with other methods to enhance the quality of the toothpaste.[3]

2. Dry gum method

The Dry Gum Method is a traditional approach in toothpaste manufacturing. In this method, all solid components, including abrasive agents and binding agents, are mixed together in a dry state. The liquid components, such as humectants and water, are then gradually added to the dry mixture. This process continues until a smooth paste is formed. Subsequently, surfactants and flavouring agents are introduced under vacuum conditions to ensure uniform dispersion and to remove any entrapped air. This method is known for producing a stable and homogeneous paste suitable for various toothpaste formulations.[4]

3. Wet gum method

The Wet Gum Method involves initially mixing all liquid components to form a uniform liquid phase. A binding agent is then incorporated into this liquid phase to form a mucilage. Gradually, solid ingredients, excluding surfactants, are added to the mucilage with continuous stirring to form a homogeneous paste. Finally, surfactants, flavouring agents, and colouring agents are added under vacuum conditions to achieve the desired consistency and stability. This method is particularly effective for formulations requiring clear gels or specific rheological properties.[4]

4. Hot liquid phase technique

The Hot Liquid Phase Technique involves mixing abrasive agents, binding agents, and preservatives in a dry mixer. Separately, a liquid phase consisting of humectants, sweeteners, and water is heated. This hot solution is then gradually added to the dry mixture under constant stirring. The resulting mass is mixed under vacuum conditions to achieve a smooth paste. Finally, flavouring agents and surfactants are added, and mixing continues under vacuum to ensure uniform distribution. This method is advantageous for producing clear and homogeneous toothpaste formulations.[4]

5. Multiple liquid phase technique

The Multiple Liquid Phase Technique is suitable for formulations that utilize specific combinations of ingredients like carboxymethyl cellulose (CMC) and magnesium aluminium silicate. In this method, hot water is used to disperse magnesium aluminium silicate, forming a gel. Other liquid components, including humectants, flavouring agents, binding agents, and preservatives, are mixed separately. These are then added to the gel, and the final volume is adjusted using humectants. Vacuum mixing is employed to remove air, followed by the addition of abrasive agents and surfactants to achieve a homogeneous paste. This method is particularly effective for creating clear gel formulations.[4]

6. Cold compression technique

The Cold Compression Technique is a method where humectants like sorbitol or glycerine are combined with binding agents in a mixer. A liquid phase containing water, sweeteners, preservatives, and any therapeutic additives is prepared separately. This liquid phase is then added to the humectant-binder mixture, and mixing continues under vacuum conditions to remove air. Abrasive agents are introduced, followed by surfactants and flavouring agents, with continued mixing under vacuum to achieve a smooth, air-free paste. This technique is advantageous for producing toothpaste with a consistent texture and minimal air content.[4]

7. High-Shear Mixing

High-shear mixing is employed to handle viscous pastes and ensure uniform dispersion of ingredients, especially in formulations with high solid concentrations and abrasive particles. Ultrasonic high-shear mixers provide intense shear forces that facilitate thorough wetting of powders, homogenization of colloidal slurries, and even particle size distribution. This method is particularly useful in the manufacturing of natural and clean-label toothpastes, as it preserves the integrity of sensitive ingredients.[5]

8. Ultrasonic mixing for clean-label toothpastes

Ultrasonic mixing is a non-thermal, purely mechanical method that utilizes high-frequency sound waves to

create intense shear forces. This process ensures homogeneous blending of ingredients without altering the properties of sensitive natural components. Ultrasonic mixers are particularly suitable for small to mid-scale manufacturing of clean-label toothpastes, which often contain organic and natural ingredients. The method is efficient, rapid, and capable of handling high solid concentrations.[5]

III. Applications

- **Cleaning and Plaque removal**

Toothpaste, especially with abrasive agents like silica, helps remove food debris and plaque from teeth, preventing tooth decay and gum disease.[6]

- **Breath freshening**

Toothpaste often contains flavours and ingredients that help freshen breath and combat bad breath.[6]

- **Gum health**

Some toothpastes contain ingredients that help reduce gum inflammation and bleeding.[7]

- **Sensitivity relief**

Toothpastes designed for sensitive teeth contain ingredients that help reduce sensitivity to hot, cold, and other stimuli.

- **Cleaning**

Toothpaste can be used to clean various surfaces, including silverware, jewellery, and even car headlights.[9]

- **Removing stains**

Toothpaste can be used to remove stains from carpets, wood, and other surfaces.[10]

- **Beauty applications**

Some people use toothpaste to treat pimples or relieve irritation from insect bites.[11]

- **Treating burns**

While not recommended by medical professionals, some people use toothpaste to soothe minor burns.[11]

- **Safe for swallowing**

Edible toothpastes are formulated without detergents, fluoride, or other potentially harmful components, making them safe for children who may swallow toothpaste while brushing.[12]

- **Promotes good habits**

They help parents establish good oral hygiene habits in young children by providing a safe and palatable option for brushing.

- **Reduced fluoride exposure**

Since children tend to swallow toothpaste, edible toothpastes minimize the risk of excessive fluoride intake, which can lead to dental fluorosis.[13]

- **Bedridden patients**

Edible toothpastes are beneficial for individuals who are bedridden or have limited mobility, as they can be used without the need for expectoration.[14]

- **Paraplegics and Patients with Oral-Facial Paralysis**

These toothpastes are also suitable for patients with conditions that impair their ability to spit or swallow, such as paraplegics or those with oral-facial paralysis.

- **Mentally handicapped**

Edible toothpastes can be used for individuals with mental handicaps who may have difficulty with traditional oral hygiene practices.[14]

2. MATERIAL AND EQUIPMENT

Table 1: Material in investigation.

Sr. No.	Name of ingredients	Category	Manufacturing
1.	Xylitol	Active Ingredient	Purchased
2.	Xanthan Gum	Thickening Agent, Stabilizer	P.W.C.O.P. Moha Phata
3.	Glycerine	Humectant, Bacteriostatic	P.W.C.O.P. Moha Phata
4.	Calcium Carbonate	Abrasive, PH Balancer	P.W.C.O.P. Girija Nagar
5.	Sodium Bicarbonate	Antibacterial	P.W.C.O.P. Girija Nagar
6.	Vitamin E Oil	Anti-Inflammatory Agent	P.W.C.O.P. Girija Nagar
7.	Sodium Lauryl Sulphate	Foaming Agent,	P.W.C.O.P. Girija Nagar
8.	Saccharine	Sweetening Agent	P.W.C.O.P. Girija Nagar
9.	Flavour	Flavouring Agent	Bake King
10.	Colour	Colouring Agent	P.W.C.O.P. Girija Nagar

Table 2: Equipment in investigation.

Sr. No.	Name of instrument	Manufacturing
1.	Mortal	P.W.C.O.P. Girija Nagar
2.	Pestle	P.W.C.O.P. Girija Nagar
3.	Measuring Cylinder	P.W.C.O.P. Girija Nagar
4.	Weighing Balance	P.W.C.O.P. Girija Nagar

5.	PH Analyzer	P.W.C.O.P. Girija Nagar
6.	Glass Plate	P.W.C.O.P. Girija Nagar
7.	Syringe	Purchased
8.	Water Bath	P.W.C.O.P. Girija Nagar
9.	Glass Stirrer	P.W.C.O.P. Girija Nagar
10.	Filter Paper	P.W.C.O.P. Girija Nagar
11.	Agar Plates	P.W.C.O.P. Girija Nagar
12.	Sterile Forceps	P.W.C.O.P. Girija Nagar

3. EXPERIMENTAL WORK

I. Materials

- Xylitol, Xanthan Gum, Glycerine, Calcium Carbonate, Sodium Bicarbonate, Vitamin E Oil, Sodium Lauryl Sulphate, Saccharine, Flavour, Colour.
- Equipment used included: Mortal, Pestle, Measuring Cylinder, Weighing Balance, PH Analyzer, Syringe.

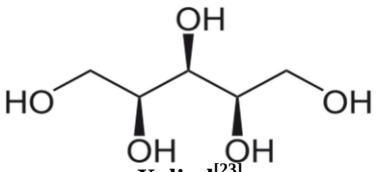
Table 3: Toothpaste formulation.

Sr. No.	Ingredients (gm)	F1	F2	F3	F4	F5
1.	Xylitol	8.5	8.5	8.5	8.5	8.5
2.	Xanthan Gum	2.25	2.25	3	3	3
3.	Glycerine	20.5	20.5	21	21.5	21.5
4.	Calcium Carbonate	15	15	15.5	15.5	15.5
5.	Sodium Bicarbonate	13	13	13.5	13.5	14
6.	Vitamin E Oil	3	3	3.5	4	4
7.	Sodium Lauryl Sulphate	0.80	0.80	1	1.10	1.20
8.	Saccharine	0.10	0.30	0.70	1	1
9.	Flavour	4.50	4.50	4.50	4.50	4.50
10.	Colour	4.50	4.50	4.50	4.50	4.50

- The batch F5 was passed in the preparation of edible toothpaste for children due to the evaluation test done for toothpaste includes colour, odour, taste, determination of PH, foamability, spreadability, solubility and abrasiveness were successful.

1) Xylitol

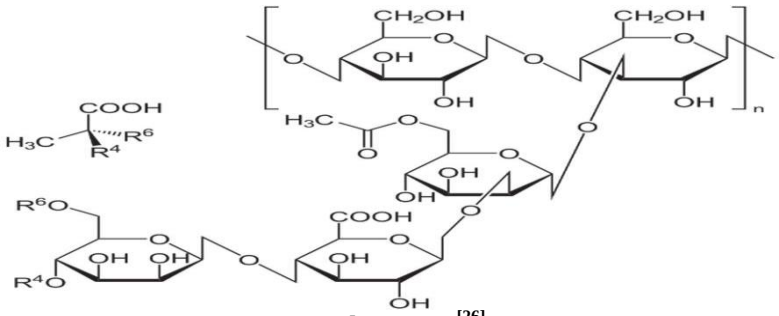
Xylitol is a chemical compound with the formula $C_5H_{12}O_5$, it is a colourless or white crystalline solid.[24] Xylitol reduces cavities by preventing the growth of cavity-causing bacteria. It adds a sweet taste and helps maintain healthy teeth.[25]



Xylitol[23]

2) Xanthan gum

Xanthan gum is a polysaccharide with many industrial uses, including as a common food additive. It is an effective thickening agent and stabilizer that prevents ingredients from separating.[27] Xanthan gum is commonly used in toothpaste as a thickening agent and stabilizer. It helps create a smooth, uniform paste that is easy to extrude from the tube. It also prevents the toothpaste from drying out and helps maintain its consistency.[28]

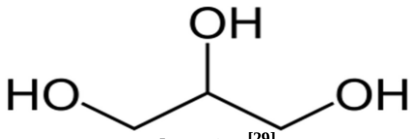


Xanthan Gum[26]

3) Glycerine

Glycerol is a simple triol compound. It is a colourless, odourless, sweet-tasting, viscous liquid.[30] Glycerine is a humectant which attracts and holds moisture, which helps to keep the toothpaste moist and prevent it from drying out.

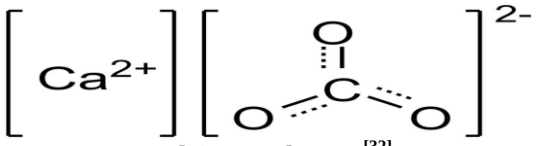
Glycerine also helps to create a smooth, creamy texture, making it easier to spread and apply.[31]



Glycerine[29]

4) Calcium carbonate

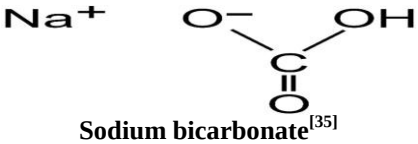
Calcium carbonate is a chemical compound with the chemical formula CaCO3.[33] It is a common abrasive agent used in toothpaste to help clean and remove plaque and stains from teeth. It's also used as a thickening and white colouring agent.[34]



Calcium carbonate[32]

5) Sodium Bicarbonate

Sodium bicarbonate commonly known as baking soda or bicarbonate of soda is a chemical compound with the formula NaHCO3. It is often used for its plaque-removal and whitening properties. It's believed to physically dislodge plaque and neutralize acids in the mouth.[36]

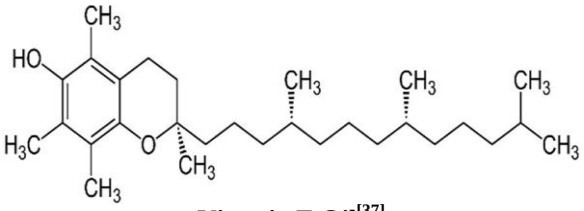


Sodium bicarbonate[35]

6) Vitamin E Oil

Vitamin E oil in toothpaste can offer benefits like supporting gum health, promoting wound healing, and protecting oral tissues by leveraging its antioxidant and anti-inflammatory properties.

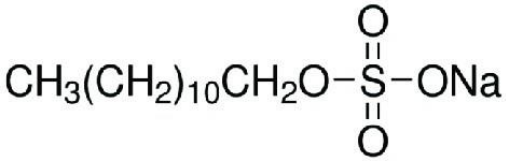
It can help reduce inflammation, protect against free radicals, and even accelerate wound healing.[38]



Vitamin E Oil[37]

7) Sodium lauryl sulphate

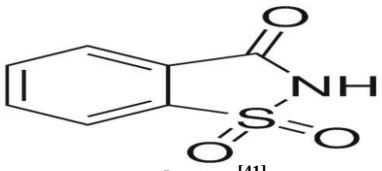
Sodium lauryl sulfate (SLS) is a common surfactant used in toothpaste, acting as a foaming agent and helping to remove debris and stains.[40]



Sodium lauryl sulphate[39]

8) Saccharine

Saccharin is used as a sweetener in toothpaste to make it taste better, not for any oral health benefits. It's a synthetic sweetener, not sugar, so it won't cause tooth decay.[42] It helps to loosen and remove food debris and plaque from teeth. SLS is relatively inexpensive to produce, making it a popular choice for manufacturers.[43]



Saccharine[41]

II. METHOD

- **Preparation of Edible Toothpaste (Dry Gum Method)**

1) The edible toothpaste of 75 gm was prepared by weighing all the ingredients in the form of gram.
2) Dry ingredients (Xylitol, Xanthan Gum, Calcium Carbonate, Sodium Bicarbonate, Saccharine) are all mixed in the mortar thoroughly for (Approx. 15 min) until it became a fine powder.
3) Liquid phase (Glycerine and Vitamin E Oil) is then gradually added to the to the mixture of dry ingredients.
4) Then the glycerine is slowly added in the mixture of dry ingredients and mixed well to form a base paste.
5) Trituration: The dry mixture is quickly and thoroughly triturated with the liquid (in a mortar and pestle) to form a smooth, uniform paste.
6) Flavour (Bubble Gum) and Natural Colour is added gradually once the base paste is formed.
7) Adjust the consistency with remaining liquid phase (Glycerine and Vitamin E Oil).
8) Then finally Sodium Lauryl Sulphate is added to the mixture as foaming agent.
9) Final mixing: Continue mixing until a homogeneous, smooth paste is Formed.
10) Packaging: Toothpaste is then filled into tubes or containers and stored in cool and dry place

Fig. 1: (Formulation 1).

Fig. 2: (Formulation 1).

Fig. 3: (Formulation 2).

Fig. 4: (Formulation 2).

Fig. 5: (Formulation 3).

Fig. 6: (Formulation 3).

Fig. 7: (Formulation 4).

Fig. 8: (Formulation 5).

Fig. 9 and Fig. 10 (Filling of Toothpaste)

III. Evaluation of toothpaste

- **General appearance**

The general appearance of the toothpaste from every formulation batch becomes observed. The general appearance parameters like colour, texture and presence or absence of odour and flavour was been evaluated.

- **Physical characterization**

1) Determination of PH

Weigh 1 gram of toothpaste is mixed with 10 ml of distilled water. Stirred thoroughly and dip the red and blue litmus paper into the mixture for 2-3 sec. Both the red and blue litmus paper doesn't change colour that indicate the PH is neutral and safe for use.

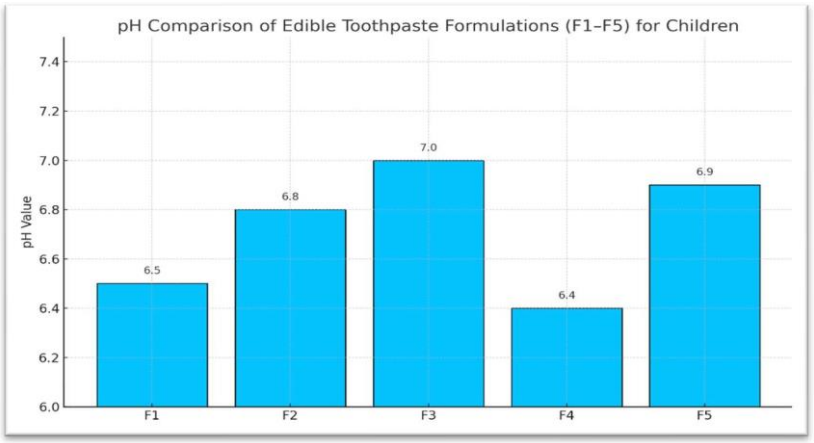


Fig. 11: (Determination of PH).

2) Foamability

Measure 5 gm of the edible toothpaste into a 100 ml graduated cylinder. Add 50 ml of distilled water. Close and shake the cylinder vigorously for 30 seconds with stopwatch. Immediately place the cylinder on a flat surface and allow it to stand for 1 minute. The total volume was 65 ml in which the liquid volume was 50 ml and foam volume was 15 ml.

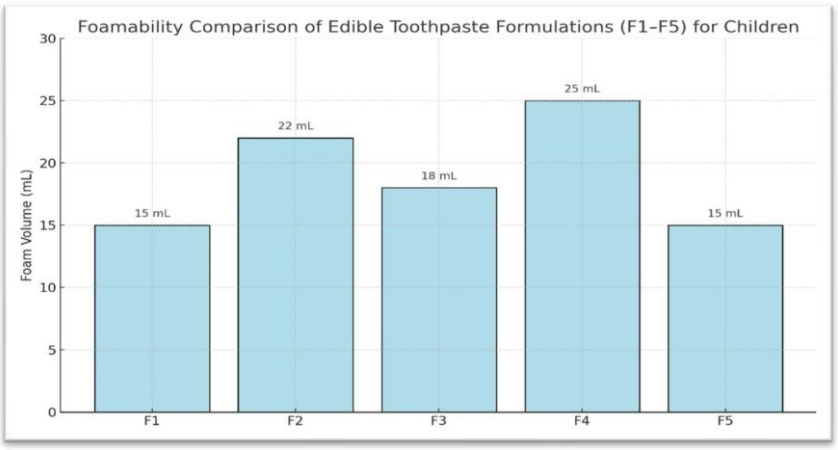


Fig. 12: Foamability.

3) Spreadability

Place 1 gm of the edible toothpaste at the centre of one glass slide. Place the second slide on top of the sample without applying pressure. Place a weight (500 gm) on top of upper slide. Allow setup to stand for 1 minute. Remove weight and carefully lift top slide. Measure diameter of the spreaded paste using a ruler. Repeat the test 3 times for accuracy.

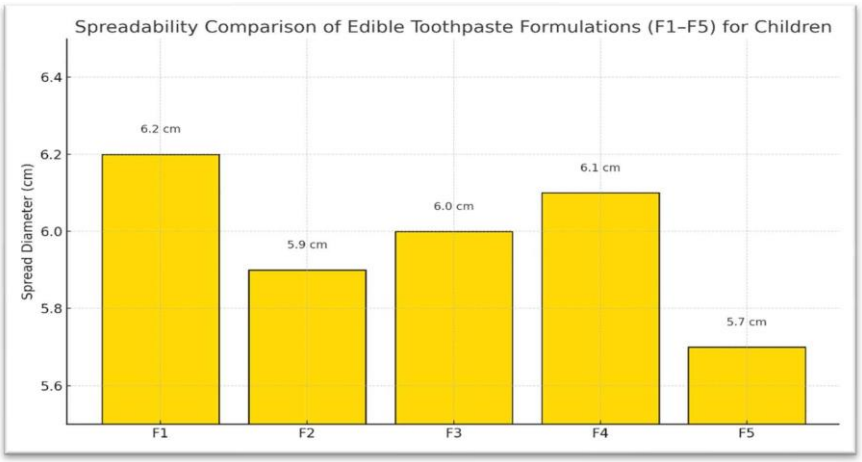


Fig. 13: Spreadability.

4) Solubility

Measure 50 ml of distilled water into a beaker and add 1 gm of toothpaste sample into the beaker and stir thoroughly using glass rod for 5 min. The toothpaste was partially dissolved into the water and left some residue.

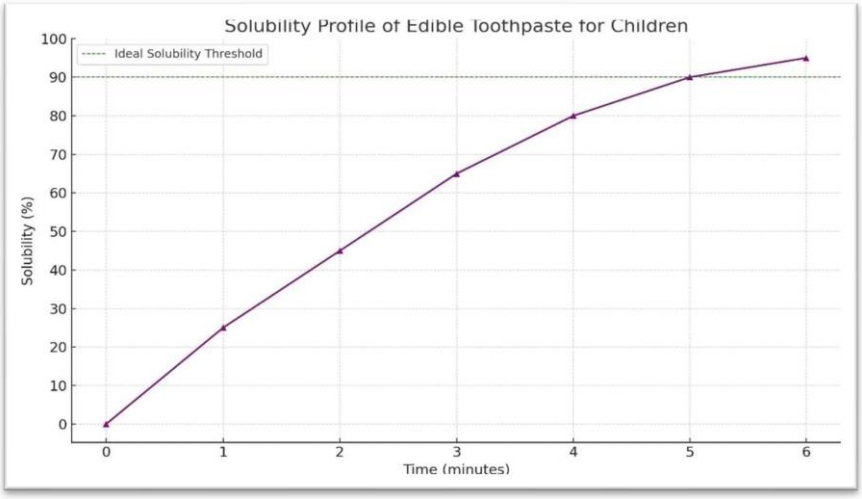


Fig. 14: Solubility.

5) Abrasiveness

Apply 10 gm of toothpaste onto a moistened toothbrush. Brush the surface of a clean glass slide for 2 min. using a moderate pressure. Compared with another slide brushed without toothpaste and slide brushed with toothpaste was concluded safe and effective for regular use and have low to moderate abrasiveness to protect enamel while ensuring cleaning.

$$\text{RDA} = \left[\frac{\text{Dentin loss from sample}}{\text{Dentin loss from reference}} \right] \times 100$$

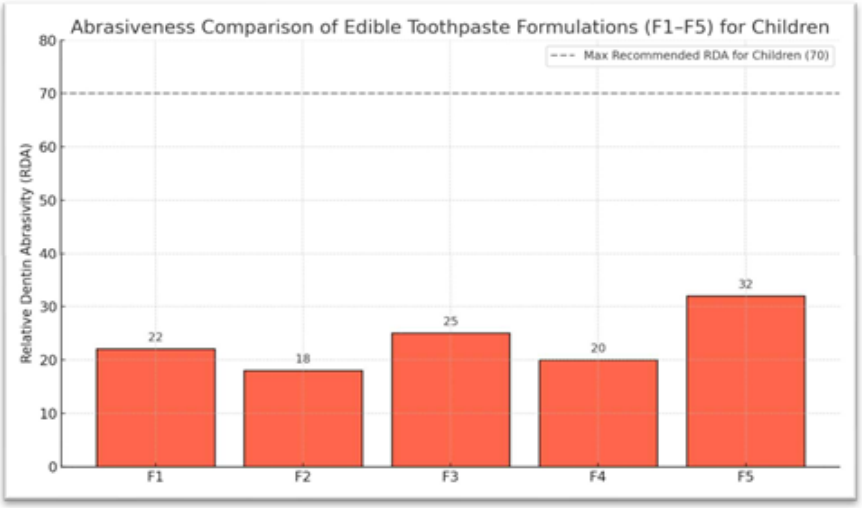


Fig. 15: Abrasiveness.

6) Microbiological studies

The standard cup plate technique was used to determine the antimicrobial activity by using Sabouraud's dextrose agar (Hi-media) and Mancockys agar and nutrient agar. The melted media were seeded with the suspension of microorganisms and allowed to solidify. The formulations were aseptically transferred to petri dish with the help of sterile forceps. The dental pastes were kept for diffusion in an incubator at 30°C for 5-7 days. The assessment of antimicrobial activity was based on the measurement of diameter of zone of inhibition in mm.

4. RESULT AND DISSCUSSION

The batch F5 was passed in the preparation of edible toothpaste for children due to the evaluation test done for toothpaste includes colour, odour, taste, determination of PH, foamability, spreadability, solubility and abrasiveness were successful.

Table 4: Evaluation parameters of edible toothpaste.

Sr No.	Test	Observation
1.	Colour	Baby Pink
2.	Odour	Pleasant
3.	Taste	Sweet
4.	Texture	Smooth

Table 5: Determination of PH.

Sr No.	Formulations	PH
1.	Formulation 1	6.5
2.	Formulation 2	6.8
3.	Formulation 3	7.0
4.	Formulation 4	6.4
5.	Formulation 5	6.9

Table 6: Foamability parameter.

Sr No.	Formulations	Foam (ml)
1.	Formulation 1	15 ml
2.	Formulation 2	22 ml
3.	Formulation 3	18 ml
4.	Formulation 4	25 ml
5.	Formulation 5	15 ml

Table 7: Speadability parameter.

Sr No.	Formulations	Spread Diameter (cm)
1.	Formulation 1	6.2
2.	Formulation 2	5.9
3.	Formulation 3	6.0
4.	Formulation 4	6.1
5.	Formulation 5	5.7

Table 8: Solubility parameter.

Sr No.	Formulations	Solubility Time (min)
1.	Formulation 1	6:14 min
2.	Formulation 2	5:22 min
3.	Formulation 3	5:49 min
4.	Formulation 4	6:35 min
5.	Formulation 5	5:03 min

Table 9: Abrassiveness parameter.

Sr No.	Formulations	Abrassiveness (RDA)
1.	Formulation 1	22
2.	Formulation 2	18
3.	Formulation 3	25
4.	Formulation 4	20
5.	Formulation 5	32

Table 10: Microbiological studies

Sr No.	Organism	25ug/ml	50ug/ml	100ug/ml	100ug/gm
1.	E. Coli	+	+	+	++
2.	S. Aureus	++	++	++	+++
3.	C. Albicans	++	++	++	+++

Highly Active [+++] Moderately Active [++] Slightly Active [+]

An edible toothpaste was successfully prepared using natural and food-safe ingredients such as Xylitol (8.5 gm), Xanthan Gum (3 gm), Glycerine (21.5 gm), Calcium Carbonate (15.5 gm), Sodium Bicarbonate (14 gm), Vitamin E Oil (4 gm), Sodium Lauryl Sulphate (1.20 gm), Saccharine (1 gm), Flavour (4.50 gm), Natural Colour (4.50 gm) in a 100-gram batch that promote oral health without adverse effects. The final

product was smooth in texture, had a pleasant taste and aroma, and was safe for ingestion. The toothpaste may show good consistency, may not separate during storage, and was maintained a neutral PH. It may effectively cleaned teeth and provided a refreshing feel, making it suitable for children and adults alike.

The choice of ingredients allowed for the formulation of a product that is not only safe to ingest but also effective in basic oral hygiene. Bubble gum flavour improved the experience and freshness, encouraging regular use. The formulation remained stable over the observation period, showing no signs of separation or spoilage, which indicates a good shelf-life under normal conditions.

Overall, the successful preparation demonstrates the potential of edible toothpaste as a safe and effective alternative for specific consumer groups, with further scope for commercial development and flavour diversification.

5. SUMMARY AND CONCLUSION

The project develops a safe and effective edible toothpaste. The formulation included sodium bicarbonate for gentle cleaning, Glycerine for bacteriostatic effect xylitol as a natural sweetener, and bubble gum extract for flavour. The final product was smooth, palatable, and stable, with a neutral PH suitable for oral use. It may be a safe alternative to conventional toothpaste, especially for children and individuals who may accidentally swallow it.

The results confirmed that edible toothpaste may effectively clean teeth while being safe to swallow. This formulation provides a healthy, eco-friendly option free from harmful chemicals, with potential for further development and flavour variations. It can be considered a practical and innovative solution for promoting oral hygiene in sensitive groups.

6. REFERENCE

1. Denise Duijster et al, 2015. https://pmc.ncbi.nlm.nih.gov/articles/PMC4676163/
2. Bojan Petrović et al, 2023. https://pmc.ncbi.nlm.nih.gov/articles/PMC10622757/
3. https://newji.ai/japan-industry/manufacturing-process-of-toothpaste-and-ingredient- blending-technology/
4. https://www.pharmacy180.com/article/preparation-of-toothpaste-835
5. https://www.hielscher.com/tooth-paste-manufacturing.htm
6. Sonja Steinert et al, 2020. https://www.mdpi.com/2313-7673/5/2/17#:~:text=Toothpastes%20have%20been%20developed%20and,7%2C8%2C9 %5D.
7. Frank Lippert et al, 2013. https://www.researchgate.net/publication/244480193_An_Introduction_to_Toothpaste_-_Its_Purpose_History_and_Ingredients
8. https://en.wikipedia.org/wiki/Toothpaste
9. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiEhaSNs8WMAxUFa_UHHZbqCcYQ-tANegQIKBAl&url=https%3A%2F%2Fwww.bhg.com%2Fclean-with-toothpaste-7643623%23%3A~%3Atext%3DIf%2520the%2520headlights%2520on%2520your%2520car%2520shine%2Ccircular%2520motion%2520to%2520remove%2520dirt%252C%2520tar%252C%2520insects&usg=AOvVaw2XPyegxfIj3V9LNLhDldT0&opi=89978449
10. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiEhaSNs8WMAxUFa_UHHZbqCcYQ-tANegQIKBAl&url=https%3A%2F%2Fwww.bhg.com%2Fclean-with-toothpaste-7643623%23%3A~%3Atext%3DIf%2520the%2520headlights%2520on%2520your%2520car%2520shine%2Ccircular%2520motion%2520to%2520remove%2520dirt%252C%2520tar%252C%2520insects&usg=AOvVaw2XPyegxfIj3V9LNLhDldT0&opi=89978449
11. Angela Palmer et al, 2025. https://www.verywellhealth.com/does-using-toothpaste-on-pimples-really-work-15530
12. Susana Rubido et al, 2013. https://pmc.ncbi.nlm.nih.gov/articles/PMC3909439/
13. A K Mascarenhas et al, 1998. https://pubmed.ncbi.nlm.nih.gov/9758424/
14. Jihyun Lee et al, 2021. https://pmc.ncbi.nlm.nih.gov/articles/PMC8524865/
15. https://en.wikipedia.org/wiki/File:Xylitol-2D-structure.svg
16. https://en.wikipedia.org/wiki/Xylitol
17. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiIq86n_oGNAxVKz6ACHUY0CZUQ-tANegQIJhAW&url=https%3A%2F%2Fwww.gordonekruegerdds.com%2Fblog%2F1976 22-does-xylitol-prevent-cavities-the-facts-you-need-to-know&usg=AOvVaw2QOf88MwqvlWJcpcwAT6jW&opi=89978449
18. https://en.wikipedia.org/wiki/File:Xanthan.svg
19. https://en.wikipedia.org/wiki/Xanthan_gum
20. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiokKjmioKNAxW2kq8BHXgwG94Q-tANegQIGBAM&url=https%3A%2F%2Fwww.sciencedirect.com%2Ftopics%2Fneuroscience%2Fxanthan&usg=AOvVaw2s5qURxbrxwOwUCQYvlWgJ&opi=89978449https://en.wikipedia.org/wiki/File:Glycerin_Skelett.svg
21. https://en.wikipedia.org/wiki/Glycerol
22. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=

8&ved=2ahUKEwj93dXcjIKNAxXsafUHHTwgBSUQ-tANegQIGBAM&url=https%3A%2F%2Fwww.colgate.com%2Fen-us%2Foral-health%2Fkids-oral-care%2Fglycerin-for-baby-s-mouth-do-dentists-recommend-it%23%3A~%3Atext%3DAs%2520far%2520as%2520glycerin%2520uses%2Cbody%2520and%2520moisture%2520as%2520well.&usg=AOvVaw01USsFG1YRycJy_AQ6BJgs &opi=89978449

23. https://en.wikipedia.org/wiki/File:Calcium_carbonate.png
24. https://en.wikipedia.org/wiki/calcium_carbonate?variant=zh-cn
25. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjZ4MHKj4KNAxVZh68BHfWNGYkQ-tANegQIFRAQ&url=https%3A%2F%2Fsunrise-dentistry.com%2Fblog%2Ftoothpaste-ingredients-the-good-and-the-bad%2F&usg=AOvVaw3FLyeVOdsvJ3XJX-GKV_Ya&opi=89978449
26. https://en.wikipedia.org/wiki/Sodium_bicarbonate
27. https://www.haleonhealthpartner.com/en-in/oral-health/brands/parodontax/science/sodium-bicarbonate/
28. https://en.wikipedia.org/wiki/File:Alpha-Tocopherol_Structural_Formulae_V.1.svg
29. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiw5sXxk4KNAxVicmwGHe64PBEQ-tANegQICRAK&url=https%3A%2F%2Fwww.mycedarparkdentist.com%2F2024%2F07%2F29%2Fthe-impact-of-vitamin-e-on-oral-health%2F%23%3A~%3Atext%3DSupporting%2520Gum%2520Health%2CSupporting%2520Immune%2520Function&usg=AOvVaw0h0Q0y3TzfwoFGq81T4- uB&opi=89978449
30. https://www.researchgate.net/figure/Chemical-structure-of-sodium-lauryl- sulfate_fig3_346445475
31. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwikiLDMloKNAxXDR2cHHQddJkUQ-tANegQIGxAM&url=https%3A%2F%2Fmyacare.com%2Fblog%2Fhow-safe-is-the- sodium-lauryl-sulfate-in-toothpaste%23%3A~%3Atext%3DSodium%2520lauryl%2520sulfate%2520(SLS)%2520is%2Cbacteria%2520and%2520the%2520tooth%2520surface.&usg=AOvVaw0ZYzL6luCMOKp8lCYDWKAN&opi=89978449
32. https://en.wikipedia.org/wiki/Saccharin
33. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiO9YKwl4KNAxXW4DgGHTLyMCkQ-tANegQICRAK&url=https%3A%2F%2Fwww.colgate.com%2Fen-us%2Foral- health%2Fselecting-dental-products%2Fwhat-is-in-toothpaste-five-ingredients-and-what- they-do%23%3A~%3Atext%3DToothpaste%2520flavors%2520typically%2520come%2520from%2520sweetening%2520agents%252C%2Cnot%2520recommend%2520a%2520toothpaste%2520that%2520contains%2520sugar.&usg=AOvVaw1TIh_UGBK1U3mKqK---obb&opi=89978449
34. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwikiLDMloKNAxXDR2cHHQddJkUQ-tANegQIGxBC&url=https%3A%2F%2Fwww.onlymyhealth.com%2Fsls-toothpaste-side- effects-1646977328%23%3A~%3Atext%3DSLS%2520in%2520Toothpastes%2Cfoaming%2520and%2520thickening%2520the%2520toothpaste.&usg=AOvVaw27WOIv9tXdWrtB7Cy60ZH1&opi=89978449