



INTERNATIONAL JOURNAL OF PHARMA PROFESSIONAL'S RESEARCH



Tooth Tablets: A Review of Formulation Consideration

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Keywords:

Tooth tablet, Toothpaste tablet, Chewable tooth tablet, Eco-friendly.

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ABSTRACT: Toothpaste tablets are small-sized chewable tablet that can be chewed to paste before brushing once it comes in contact with saliva. Toothpaste tablets are claimed to be a sustainable alternative to other oral care products, especially toothpaste, and mouthwash. The main concept behind toothpaste tablets is to lower plastic waste generated after the empty disposal of toothpaste tubes. Toothpaste tablets come in a reusable and refillable jar so a plastic-free approach can be introduced. Though we are unable to promote the zero-waste management concept we can move towards minimization of waste. Also, the concept of minimal use of preservative is another considerable benefit as toothpaste tablet is a solid dosage form free from water. Water is a main component in toothpaste that gives it a semi-solid consistency which makes it a semisolid dosage form. Currently, In India, there is a growing awareness of proper waste management and the production of eco-friendly products. Nowadays people are using medicated and herbal toothpaste for the prevention of tooth-related problems. This review article gives insight into the exploration of tooth tablets as an oral care product to give eco-friendly, cost-effective, and improved dental health.

Introduction: Oral and dental diseases are most widely prevalent in India. This disease is not life-threatening but is often painful, expensive treatment, and can affect a person's lifestyle.¹ Also, it has been reported that oral and general health are closely interlinked. However, they are preventable if certain precautions and care are taken.² The major oral and dental disorders are 1. Dental caries, 2. Periodontal Diseases, 3.

Fluorosis, 4. Dentofacial anomalies, 5. Tooth loss, 6. Dental injuries, and 7. Oral cancer¹⁻³

Dental caries is an infectious microbial disease affecting teeth resulting in the decalcification of teeth and destruction of calcified tissue. As per the study dental caries is the second most common cause of teeth loss.¹ The WHO Global Oral Health Status Report concluded that oral diseases affect around 3.5 billion people worldwide. Worldwide

prevalence of dental caries is estimated at 2 billion people suffer from dental caries of permanent teeth and around 514 million children suffer from dental caries of milky teeth.² The overall prevalence of dental caries in India was 54.16%.³ The global increase in the prevalence of oral disease is due to urbanization and changes in living conditions.² Research suggests that dental caries prevalence is a pressing health concern affecting at least half of the Indian population.³

As per the report published by Allied Market Research, the global toothpaste tablet market size was valued at \$45.6 million in the year 2020 and is projected to reach \$90.3 million by 2030, registering a CAGR of 7.3% from 2021 to 2030. Global toothpaste tablet sales are expected to grow at a healthy Compound annual growth rate (CAGR) of over 6.1% during the study forecast period 2021-2031. Hence toothpaste tablet sales are expected to grow significantly in the forthcoming years. There is a future need in our developing country. This review article is focused to explore dental problems with a new application of tablet dosage form i.e., chewable toothpaste tablets in the form of tooth tablets.⁴

1.1 Tooth tablets:

Toothpaste tablets are small, bite-sized chewable tablets that can be chewed into a paste before brushing and are used to clean teeth.^{5,6} They are intended to show a similar effect as traditional oral toothpaste. Before placing the tooth tablet oral cavity and brush are rinsed with water. Further Tooth tablets are simply placed in the mouth, chewed, break it up, and then brushing is done as usual. Tooth Tablet crumbles and foams as we brush and tooth cleaning action is obtained.⁵

1.2 Benefits of Tooth Tablet:

1.2.1 Eco-friendly: Toothpaste tablets are an environment-friendly alternative to toothpaste. Traditionally available toothpaste tubes, are marketed in double packaging and are harmful to the environment. The tubes are manufactured

from materials of construction like aluminum and plastic. This is utilizing a lot of time and labor. Toothpaste plastic tubes break down into microplastics over time after they are dumped, posing a risk to the environment as well as human and animal health.^{5,7} We often use lots of dental products and after complete utilization, the containers and closures are dumped in waste bins without thinking that they are recyclable or not. This is the major problem in our country India, as compared to other countries. There is a lack of awareness in the field of proper waste management, the production of eco-friendly products, and renewable products.⁴

The marketed tubes of toothpaste which are normally packed within a secondary packing material of a paper box make it more expensive. This paper box is for the purpose of beautification or protection of Toothpaste for the makers but it's completely incompetent for the consumers. After purchasing a product, it is a tendency of consumers to just dump the paper box packets and become a participant in creating valuable paper waste. Though millions of people globally use paper-boxed toothpaste still some places like Iceland, and Sweden toothpaste are marketed without boxes.⁸

The worldwide toothpaste market is growing at a tremendous speed and the projected rate of growth during the period of 2109-2024 is 6.1%. 55% of the Indian population which means approx. 682 million users use toothpaste on a daily basis. 10 tubes of 80 g toothpaste are used by every individual every year. This creates a useless packet of 6820 million each weight 3 g. So, on average Indian people are wasting 20460 tonnes of paper by using toothpaste. According to the Centre for Environment and Development, paper boxes may be the second biggest organic waste which contributes 13% of the total domestic solid waste.^{4,8} As a result, toothpaste tablets are now emerging as a practical solution and ecologically sustainable alternative. The tabs can be marketed in reusable jars or packed in

recyclable materials. Manufacturing companies can also provide refills of Tabs.⁹

1.2.2 Travel friendly: Tooth tablets are a good alternative for maintaining oral hygiene health while traveling. They are beneficial in terms of portability and resistance to temperature fluctuations. Thus, consumers don't have to carry bulky toothpaste tubes.⁵ Tooth tablets are much easy to store, and while traveling one can be free from messy sticky pastes making untidy travel bags. They are in pre-portioned sizes as are unit dose formulations so no wastage as the exact amount is being used.⁹ The containers can be easily stored in small bags, and also users can use them even without a toothbrush for a fast cleansing.⁵

1.2.3 Solid dosage form: One of the main components of toothpaste is water. The main function of water in toothpaste is that it gives the toothpaste a semi-solid dosage form. The water content of toothpaste ranges from 20-42% which helps in keeping it from drying out and gives semisolid consistency of paste. Thus, if one thinks to eliminate water content from the toothpaste, the size or volume of the gel will be reduced which will help in the transportation process and as well as increase the efficiency of the supply chain.⁴

Toothpaste tablets are formulated using ingredients from toothpaste formulations like xylitol, calcium carbonate, sodium bicarbonate, and tartaric acid derivatives, without adding water. Thus, can have all benefits of the solid dosage form of long shelf life and are free from preservatives and they can be packed in a similar manner to medicinal pills.⁷

1.2.4 Safe and free from preservatives: Tooth tablets are in solid dosage form and thus there is no need to incorporate preservatives. It is free of preservatives such as parabens and can have a long shelf-life and inadequate storage conditions. The cleaning benefits are the same as toothpaste also it's sustainable too. Toothpaste contains Paraben and sodium benzoates as preservatives to

protect it from bacterial growth and enhance its shelf life which is not required for tooth tablets. Tooth tablets are dry there is minimal or no incorporation of preservatives and hence it's safe and eco-friendly.⁹

1.2.5 Hygienic use and storage: Toothpaste tubes could be non-hygienic as different users touch the tube opening to their brush without knowing their oral and dental issues. Hence there are more chances of spreading germs to one another. Especially now after the covid pandemic, tooth tabs are a safer and better option as no passing of germs when the tube is swiped from brush to brush.⁹ Tooth tablets are hence chemically stable and sanitary as compared to toothpaste.⁶

1.3 Drawbacks of Tooth Tablets:

- Tooth tablets have fewer mechanical strengths like chewable tablets than conventional tablets and thus must be handled carefully.⁴
- Tooth tablets require special storage conditions as the ingredients used in the formulation are hygroscopic.⁴
- Tooth tablets are not recommended for children and older people as they have a little more ablativity as compared to toothpaste.^{4,9}
- Incorporation of herbal ingredients may have an unpleasant flavor and that becomes difficult to conceal for a chewable tablet.^{4,8}
- It may have ingredients like sorbitol which have been reported of causing diarrhea and flatulence if ingested accidentally in higher quantities.^{4,10}
- Flavouring agents used in Tooth tablets may cause ulcers of the oral cavity.^{4,10}

2. Excipients Used in Tooth Tablets Formulation:

2.1 Abrasives: Abrasives are substances used for abrading, polishing, and grinding that can remove substances adhered to the surface of the teeth

without scratching the tooth surface and maintain their natural luster. The major properties of abrasives are their particle size and shape. Particle size should be 20 µm or less, if found more than this then it can damage the tooth surface and gums. Abrasive used are crystal, small and smooth particles. Needle and rod-shaped particles should be avoided. The pH of abrasives must be Weakly acidic to weakly alkaline. They should be white powders, water-insoluble, flavorless and odorless.¹¹ Calcium carbonate, Calcium Phosphate, Calcium phosphates, di-calcium orthophosphate dehydrates, calcium pyrophosphate, tricalcium phosphate, calcium polymetaphosphate, hydrated alumina, Silica, and Silica hydrate are examples of abrasives.^{4,11}

2.2 Binders: They are thickening agents incorporated in tooth tablets. When Tooth tablets are placed in the mouth and chewed little, these agents provide paste-like consistency by swelling in contact with saliva.⁴ These agents also have an influence on the dispersion, foaming, and rising property of tooth tablets.¹¹ Pregelatinized starch, gums such as agar, locust bean gums, and guar gums. carrageenan, alginate, xanthan, dextran, and cellulose derivatives such as sodium carboxymethyl cellulose, methylcellulose, and sodium carboxymethyl hydroxyethyl cellulose, hydroxy propyl cellulose are examples of thickening agents. Gum karaya, gum Arabic, and gum Tragacanth are all-natural gums that can be employed. To enhance texture, synthetic silicates such as colloidal magnesium aluminum silicate or finely split silica can be added to the thickening agent. The thickening agent should be present in the overall composition in the range of 0.2 percent to 5.5 percent by weight.⁴

2.3 Foaming agents: Foaming agents help in the proper dispersion of tooth tablets throughout the oral cavity and enhance the cleaning effect by acting as a surfactant that cleans away dirt easily. Surfactants have excellent foaming, dispersion cleaning, and hard water resistance properties. Surfactants lower the surface tension of the liquid

environment in the oral cavity; hence the content of tooth tablets can easily come in contact with the tooth surface, enhancing the cleaning effect. sodium lauryl sulfate, sodium lauryl sarcosine, sodium alkylsulfo succinate, sodium coco monoglyceride sulfonates, and sucrose fatty acid ester.¹¹

2.4 Super disintegrants: manufacturing of orally disintegrating tooth tablets may involve the use of super disintegrants in smaller quantities. They facilitate easy dispersion of tablet when comes in contact with the saliva of the oral cavity. Croscarmellose sodium, Sodium starch glycolate, and Cross povidone can be used as a super disintegrant when a dispersible tooth tablet is to be manufactured.¹⁰

2.5 Pharmaceutical agents: single or multiple pharmaceutical agents are added to tooth tablets for anticaries, antiplaque, anti-calculus, and halitosis activity. Currently, there is the development of different tooth tablets with additional purposes such as stain and calculus removal, also for the prevention of gingivitis, sensitive teeth, and gum problems. The following category of pharmaceutical agents can be incorporated:¹¹

- Anticaries agents: Fluoride, Xylitol, calcium phosphate supplement, sodium carbonate.
- Anti-plaque agents: sodium lauryl sulfate, Triclosan, stannous, and zinc metal ions.
- Anti-calculus agents: pyrophosphates, zinc ions.
- Anti-dentine hypersensitivity agents: Potassium salts.
- Whitening agent: Whitening agents are abrasives that provide a whitening effect by removal of discolored pellicles examples include dimethicones, papain, sodium bicarbonate.
- Anti-halitosis agents: Zinc ions

2.6 Lubricants and glidants: Lubricants when added in tablet formulation prevents adherence of

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tablet material to the surface of dies and punches. Glidants are added to improve the flow property of granules and decrease interparticle resistance during flow from dies to punches. Magnesium stearate and Talc are the most widely used lubricants.^{10,12}

2.7 Flavours, sweeteners, and colouring agent:

Flavours and sweeteners are added to tooth tablets to improve palatability and hence enhance the taste. Sweeteners like sucrose, Saccharin, and Aspartame can be used. Flavors like peppermint vanilla, orange cinnamon, mint, and menthol can be incorporated. Titanium dioxide is often added to tooth tablets to give them a white color. Coloring agents like sunset yellow, and ferric oxide remains optional for obtaining a better appearance of tooth tablet.^{10,12}

3. Method of preparation of Tooth Tablet:

Tooth tablets can be formulated in the same manner as chewable conventional tablets. Conventional methods for the preparation of chewable tablet is wet granulation and dry granulation. The wet granulation method is the most widely used method in tablet preparation as it provides the most satisfactory results. The direct compression method can also be applied for producing tooth tablets, as long as it produces non-gritty smooth tablets and does not cause tablet defects like capping.⁴ The chewable tablet can be broken in the mouth so tablet weight can be as high as 1000mg.¹²

4. Evaluation of Tooth Tablet: Precompression evaluation parameters for tooth tablets remain to be similar to a conventional tablet. Precompression evaluation parameters are the angle of repose, bulk density, tapped density, Carr's index, and Hausner's ratio.^{13,14} Many Formulation requirements of tooth tablets are the same as chewable conventional tablets:

4.1 Tablet physical appearance shape, color and odor: The shape and size may vary depending on the tableting tooling used in manufacturing. Uniformity of color of tooth tablet is very much important to avoid mottling. The odor of the tablet indicates the stability of the tablet as chewable tablet comprises of flavoring agent.¹⁵

4.2 Tablet thickness: The dimensions of the tablets were measured using the Vernier caliper scale. The thickness of 10 tooth tablets should be measured and the average is to be calculated. Tablet thickness should be controlled within a $\pm 5\%$ variation of the mean value.¹⁶⁻¹⁷

4.3 Weight variation: The weight of the tablet is determined to ensure that the manufactured tooth tablet has uniform weight. 20 tablets are taken at random for the test and are weighed, Individually and the average weight is calculated. Not more than 2 of the individual weights deviate from the average weight by more than the percentage given in the pharmacopeial specification and none deviates by more than twice that percentage. The % deviation of each tablet from the average weight is calculated and the test was performed according to Indian Pharmacopoeia (IP).^{18,15}

4.4 Specifications for weight variation test:¹⁸

Sr. No	Avg. wt. of tablet	% of deviation allowed
1	80 mg or less	± 10
2	80 mg to 250 mg	± 7.5
3	250 mg or more	± 5

4.5 Hardness: A hardness test was conducted for three tablets from each batch using a Monsanto hardness tester and average values were calculated. In this, a tablet is placed between the plungers and was tightened from one end, and the pressure required to break the tablet diametrically was measured. Tooth tablet hardness must lie

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within 8- 12 kg/cm² Hardness should be controlled within $\pm 5\%$ variation of mean value.¹⁵⁻¹⁷

4.6 Friability: In this test Tooth tablets are weighed and placed in a friability test apparatus, and then the tablets are subjected to rolling and repeated shocks, resulting from free falls within the apparatus from a height of 6 inches. After 100 revolutions the tablets will be removed, de-dusted, and weighed again. The friability was determined as the percentage loss in weight of the tablets. For tablets with a unit weight equal to or less than 650 mg take a sample of tablet weight equal to 6.5 g. For a tooth tablet with a unit weight of more than 650 mg take a sample of 10 tablets.¹⁵⁻¹⁶

$$\% \text{ Friability} = 1 - (\text{wt. of tablets after test} / \text{wt. of tablets before the test}) \times 100$$

4.7 pH: pH of the tooth tablet is measured by dissolving 3 tablets in a beaker filled with 200 ml of distilled water. This formed dispersion is then used to measure pH by using a digital pH meter.⁵

4.8 Foamability: The foaming ability of a tooth tablet is estimated by adding a tooth tablet to a 100 ml graduated measuring cylinder filled with 10 ml of distilled water. The initial volume of distilled water is recorded. Further measuring cylinder is shaken 10 times and the final volume is recorded after the production of foam.⁵

4.9 Wettability: The wettability of the Tooth tablet is evaluated by placing a Whatman filter paper in a glass Petri dish. 10 ml of a solution of distilled water with water-soluble dye amaranth is added to the filter paper in the Petri dish. The tooth tablet is carefully placed on Whatman filter paper and the time to complete wetting of the tooth tablet is recorded.⁵

4.10 Stability study: To assess the drug and formulation stability, stability studies were done according to ICH and WHO guidelines.

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Optimized formulation Tooth Tablets are kept in the humidity chamber maintained at 40°C and 75% RH.^{19,20}

4.11 Method of use of tooth tablet: To Clean the teeth using a tooth tablet, first of all, rinse the mouth with water and then place the tooth tablet into the mouth, bite and crush the tooth tablet between teeth and then brush as normal and rinse.

5. Marketed Formulations of Tooth Tablets:

Sr. No	Brand Name	Manufacture d by
1	Colgate Tooth Tabs	Anywhere Colgate-Palmolive, USA
2	Apollo Noni toothpaste tablet	HCP Wellness Pvt. Ltd., India
3	Dent tabs	Dent tabs Innovative, Germany
4	Teeth-a-bit	Trillion Bits India Pvt Ltd, India
5	Archtek Toothpaste tabl et	Archtek, USA

6. Conclusion: Toothpaste tablet is a versatile dosage form that comprises advantages and properties of solid unit dosage form Tablet while providing better organoleptic properties. Tooth tablets can emerge as the most stable, preservative-free, eco-friendly alternative to Toothpaste for maintenance of oral cavity hygiene.

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