



Natural Excipients As Teeth Whitening Agents: A Review

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ABSTRACT

Patients are increasingly expecting more from dental aesthetics and spend a lot of money on oral hygiene products such as toothbrushes, toothpaste, mouth rinses and so on. People who have their teeth whitened feel more socially accepted and satisfied with their appearance. Natural teeth whitening excipients improve oral health and reduce enamel erosion while bleaching. Popular bleaching products were ineffective at whitening teeth. Furthermore, brushing with dental formulations containing agents such as hydrogen peroxide increased the surface roughness of the enamel and decreased the microhardness of the enamel over time. As a result, people are attempting to replace these products with natural, cost-effective and safe alternatives that produce significant results. This article was focusing on efficacy of natural excipients as teeth whitening agents.

Keywords: Dental aesthetics, Teeth whitening, Natural excipients, Enamel erosion, Dental formulation.

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INTRODUCTION

Patients are increasingly expecting more from dental aesthetics and spend a lot of money on oral hygiene products such as toothbrushes, toothpaste, mouth rinses, and so on. People who have their teeth whitened feel more socially accepted and satisfied with their appearance.¹ The main cause of tooth discoloration is the consumption of certain foods or beverages such as coffee, tea, wines, and alcohols, as well as the continuous consumption of some fruits such as apples, pineapple, pomegranate, and vegetables such as potatoes and beetroot. Other factors like continuous smoking and tobacco chewing cause nicotine deposition in the enamel, use of antibiotics such as Tetracycline or Doxycycline. Environmental factors also play a significant role in tooth discoloration, with some areas' ground water containing higher concentrations of fluoride result in tooth discoloration. Poor oral hygiene, such as improper brushing and tooth paste, is another cause of yellow teeth. Tooth discoloration is also linked to age.² These factors, alone or in combination, are linked to changes in tooth colour and surface texture. Bleaching is the term used to describe the process of removing stains from teeth and the substances that are used for this process are referred to as bleaching agents. Different bleaching agents, both natural and artificial, are easily accessible on the market.³

Tooth whitening or bleaching is divided into two categories: professional and natural methods. The professional techniques are further divided into three categories: professionally prescribed, professionally performed (in-office), and over-the-counter bleaching. In professional teeth whitening procedure, the bleaching agent is applied directly to the teeth by the dentist, who performs the procedure. This involves use of peroxides based agents like hydrogen peroxide and carbamide peroxide. However, as chemical whitening agents have a detrimental effect on tooth enamel, individuals are now promoting and using natural teeth whitening products since natural herbal teeth whitening products perform as well to chemical bleach, they have more advantages in terms of improving oral health, reduction of enamel erosion while bleaching, cost and safety.

The purpose of this article was to discuss the effectiveness of natural excipients as teeth whitening agents.

Enamel Structure and Teeth Whitening Metabolism

Enamel structure: On top of the dentin, enamel covers the tooth's crown and a portion of the neck. Physically, tooth enamel is extremely tough because it is mostly made of inorganic minerals; 95% comprises calcium and phosphate ions that compose a strong substance - hydroxyapatite crystals.⁴

Teeth whitening metabolism: It's crucial to comprehend the physiology and metabolism of teeth in order to comprehend the causes of teeth discoloration. The structure that makes up the majority of a tooth's crown and root is called dentin. Dental pulp that is fed by blood vessels nourishes the interior of the crown and tooth. The cementum covers the root dentin, which aids in the root's attachment to the bone. The thickness of the enamel, which shields the crown dentin, varies with age and dietary



patterns. The tooth's exterior exposed part is covered in enamel, which helps guard against external damage. Using chemical bleaching treatments for months or years has caused legitimate worries concerning long-term negative consequences on the soft and hard tissues. In order to treat patients with stained teeth, vital tooth whitening with natural substances would be a secure and efficient aesthetic therapy.⁴

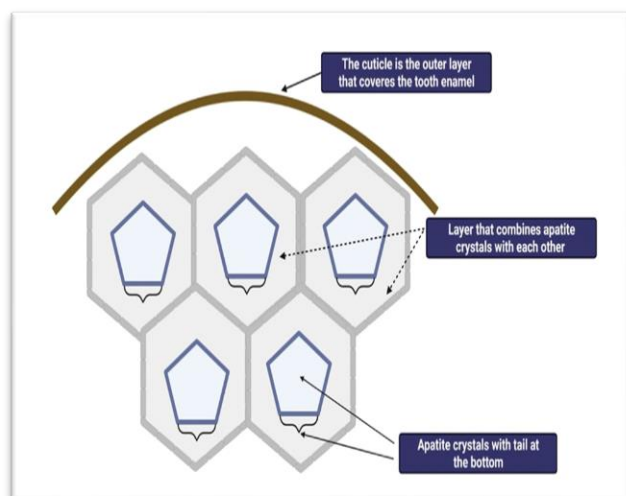


Figure 1: A scheme of the structure of tooth enamel.

Staining of tooth surface

Chromophores, or coloured substances, are both biological and inorganic in origin and are found in the tooth. In the visible spectrum, chromophores absorb light and mostly reflect the complementary hue that is seen by the eyes, which is often yellow or brownish in the case of teeth. Small organic compounds called organic chromophores, such as those found in fruits, coffee, tea, red wine, and tannins, are examples. These compounds' double bonds are a characteristic (e.g., carbonyl groups or aromatic groups). Transition metal ions with a specific hue, such as $\text{Fe}^{2+}/\text{Fe}^{3+}$, Cu^{2+} , or Mn^{2+} , are known as inorganic chromophores. In the form of metal complexes, organic and inorganic chromophores may also coexist. For instance, haemoglobin has an iron ion and a colourful porphyrin ligand (inorganic).⁵

Both intrinsic and extrinsic sources can produce stains. Localized inside the tooth, intrinsic stains can occur in the dentin or the enamel. They can be brought on by tetracycline incorporation, high fluoride intake (fluorosis), certain metabolic illnesses, and systemic causes during tooth growth. For instance, the Dean's index can be used to categorise the degree of fluorosis, with scores ranging from dubious through very light, mild, moderate, and severe.

Extrinsic staining is evident on the tooth surface, i.e., on enamel and exposed dentin, particularly on difficult-to-clean dental surfaces and surfaces with a thick pellicle layer. These stains are made up of both organic and inorganic chromophores, and they can either be directly adsorbed to the tooth (especially if its surface is rough), or

(more likely) they can be incorporated into calculus, biofilm, and/or pellicle. These settings are perfectly adapted chemically to host both organic and inorganic chromophores. Since most organic dyes have a strong affinity for proteins, it is very likely that plaque and pellicle will contain them.⁶

Additionally, the substances in oral care products themselves may cause tooth surfaces to get stained. Because these components frequently have a different hue than the resultant stain, this process is known as "indirect staining". Examples of this type include stannous fluoride.⁶

Extrinsic stains can be cleaned using chemical treatments as well as abrasive methods (such as toothpaste, toothbrushes, and professional dental cleaning) (e.g., by peroxides).

Natural Teeth Whitening Agents

Because of the desire to have whiter teeth, tooth whitening has become the most popular therapy. Tooth whitening is a technique that alters the structure of tooth enamel. This can be accomplished by modifying the inherent colour or eliminating or managing extrinsic stains.⁴

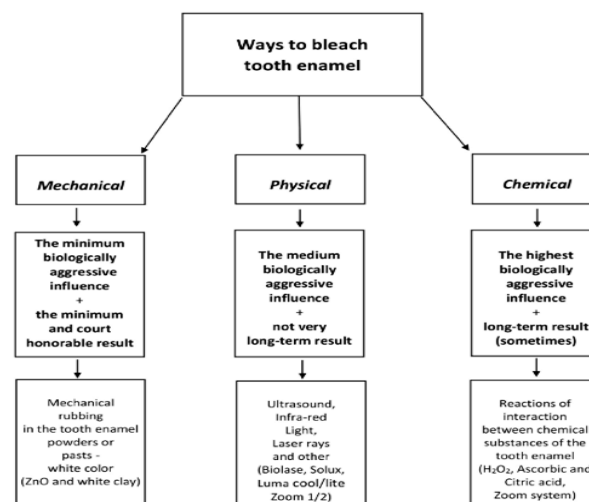


Figure 2: Different techniques for bleaching of tooth enamel.

Extracts of numerous natural ingredients such as vegetables and fruits such as apple, banana, carrot, lemon, orange, papaya, and strawberry, as well as other substances such as baking soda and activated charcoal are formulated as toothpaste, mouthwash, gel and powder and tested for their efficacy as natural teeth whitening agents.

Advantages of natural teeth whitening agents

- 1) Easily available.
- 2) Cost effective.
- 3) Biologically safe.
- 4) Reduced enamel erosion.

Sources of Teeth Whitening Agents

Table 1: List of natural teeth whitening agents

Activated Charcoal	Dairy Products
Apple	Dark Chocolate
Aloe Vera	Guava
Baking Soda	Lemon
Banana Peel	Orange Peel
Basil	Olive Oil
Carrot	Papaya
Celery	Pineapple
Coconut Oil	Strawberry

1) Apple

Apples contain hydrogen peroxide and ellagic acid (C₁₄H₆O₈); has potential OH clusters. These clusters act as powerful oxidizer. The H₂O₂ help in process of metabolism. These processes together help in whitening of teeth. The higher the concentration of bleaching chemicals, the greater the degree of whitening obtained, because the quantity of free radicals combines with the teeth colouring agent and produces a greater amount of smaller and lighter organic molecules.^{3,7}

2) Banana Peel

Mineral and phytochemical components are among the many ingredients found in banana peel. Alkaloids, flavonoids, phenols, tannins, and saponins make up the phytochemical component, while potassium, calcium, sodium, manganese, and iron make up the mineral component. It also acts as an excellent biosorbent. These contents and it's ability to act as a biosorbent makes banana peel a good source of natural teeth whitening agent.⁸

3) Celery and Carrot

Celery and carrot have a high fibre content, operate as a mild abrasives, and efficiently brush away surface stains. Celery is an alkalizer that, through controlling acid, also encourages a healthy grin. Carrots carry lots of water, beta-carotene, vitamin A and B6 that can help naturally break down dental calculus due to their propensity to produce more saliva.^{9,10}

4) Dairy Products

Dairy products like cheese, milk, yoghurt contain lactic acid which acts as a natural enamel whitener and stimulates the secretion of saliva. Casein, a protein found in milk, has been shown to stop the demineralization of enamel by stabilising the high concentrations of amorphous calcium phosphate present on tooth surfaces.¹¹

5) Dark Chocolate

Dark chocolate contains polyphenols, which are natural compounds that can inhibit oral microorganisms.

Theobromine, a bitter substance in dark chocolate, helps to harden the surface of teeth's enamel. They are also capable of preventing some bacteria from converting sugar and starches into acid and neutralise germs that cause bad breath.¹²

6) Guava

Guava leaves can be used to treat a range of dental conditions, including plaque, infections, and gum swelling. Its flavonoids and phenols eliminate the oxidative stress that various microorganisms generate on the teeth, which is one of the causes of teeth discoloration. Additionally, it has antioxidant, antibacterial, and anti-inflammatory properties.^{13,14}

7) Lemon

Lemons contains malic acid, 5% citric acid, ascorbic acid (vitamin C), gluaric acid, and polyphenols, which can be used to whiten teeth. Malic acid belongs to a class of carboxylic acids that can whiten teeth by oxidising the surface of the tooth enamel. This chemical can enter the dentin and break the double bonds of organic and inorganic molecules in the dentinal tubules, releasing free oxygen.²³

8) Orange peel

Citrus is one of the horticultural plants contains 40 mg of calcium which beneficial to bones and teeth. Orange peel (*Citrus reticulata*) contains like Tangeraxanthin, Tangeritin, Terpinen-4-ol, Terpinolene, Tetradecanal, Threonine, Thymol, Thyme-methyl-ether, Tryptophan, Tyrosine, Cis-3-hexenol, Cis-carveol, Citric-acid, Citronellal, Citronellic-acid, Citronellyl-acetate, Cystine, Decanal, Decanoic-acid, Decanol, Nobiletin. Citrus fruit contains a molecule called citric acid, which is known for its capacity to whiten teeth that are discoloured. This is due to the presence of an OH group in its chemical makeup. It also possesses anti-bacterial, anti-fungi, emulsion stabiliser and anti-inflammation on gum activity.^{10,13,15}

9) Papaya

Papaya contains enzymes bromelain and papain. Since both papain and bromelain are proteases, they have the ability to break down large molecules that cause stains and increase the amount of light that reflects off the surface of the tooth, producing a whitening effect.¹⁶

10) Strawberry

Strawberries have a significant amount of malic acid, which aids in plaque removal, plaque prevention, and natural teeth whitening. The acid works as a strong oxidizing agent on the enamel surface of the tooth. However, it's acidic nature may result in enamel erosion hence, this property of strawberry should be minimised to accepted value for safer use.^{11,17}



Various Natural Ingredients Used as Teeth Whitening Agents in Dental Formulation

A lot of study and research has been done to explore sources of teeth whitening agents. There are few studies where researchers claim that the particular source shows the respective activity, is safe, cost effective and can be used on daily basis. Some of these studied explained are as follows.

1. A patented composition by Gerald McLaughlin on Activated Charcoal:

Study:- With time and exposure to substances like tea and coffee, teeth often become darker in colour. It has long been an aim of dentistry to offer a way to safely and efficiently stop this darkening process. Two methods have been used to solve the issue historically. The first step entails getting rid of pigmentation that has grown on the teeth's surface. Abrasives are frequently used to do this, occasionally with the use of solvents. These methods, while quickly successful, have the drawback of being unable to remove any interior pigmentation and only being able to remove external stains. As a result, the whitening impact is very minimal.

Claim:- An effective amount of a bleaching compound and a catalytic activator are used in one embodiment of the invention to offer a composition for whitened teeth, wherein the catalytic activator catalyses the reaction of a large portion of the bleaching compound within ten minutes.¹⁸

2. A patented formulation containing actinidin by Chantal Bergeron.

Study:- Numerous approaches have been tried to whiten teeth, the two most common of which are the use of abrasives, such as diatomaceous earth, silica and baking soda, or chemical whiteners, such as peroxides. To remove stains and discolorations from the surface of the teeth, abrasives are used in conjunction with a polishing action. However, abrasives are only partially effective at whitening teeth, and many of the harsh, non-natural abrasives used in prior art formulations have been shown to damage tooth enamel. Some people dislike putting harsh chemicals in their mouths, and peroxides can irritate delicate tissues (such the gums and other oral tissues).

Additionally, neither of these currently accessible methods for tooth whitening works to lighten artificial teeth. The fact that it includes potentially harmful peroxides as well as other harsh chemicals means that it still shares the same issue as the other chemical-based prior art formulations. Therefore, it is necessary to develop compositions and procedures for the whitening of both natural and artificial teeth without the use of harsh abrasives or chemicals based on peroxide.

Claim:- The current invention relates to materials and procedures for bleaching both man-made and natural teeth without the use of abrasives or peroxides. The "actinidin" (crude, partially refined, or purified) used in the

current invention is made from kiwi fruit. A product without peroxide for bleaching natural or synthetic teeth includes one of the following: (a) a polymeric strip for contact with, and bleaching of, natural or synthetic teeth; (b) a dentifrice including (peroxide-free actinidin preparation); or (c) a whitening tray having (peroxide-free actinidin preparation) coated thereon.¹⁹

3. Carla Roberta de Oliveira Maciel et al. (2022)

Study:- The effect of brushing with popular natural agents; activated charcoal, curcumin, banana peels used by the population to obtain tooth whitening but not indicated for that purpose, on the color, whitening, and superficial properties of dental enamel. The null hypothesis was that there would be no difference in the dental enamel brushed with natural substances compared to the conventional toothpaste regarding the color change, surface gloss, surface roughness, and microhardness.

Claim:- It was concluded that, regardless of the period of usage, the popular natural agents used to get tooth bleaching but not indicated with that goal did not offer whitening efficacy. Changes in the substrate's surface roughness are related to variations in the enamel's surface gloss. The enamel surface roughness can be changed by the suggested bleaching chemicals. Different from turmeric and banana peel, ordinary toothpaste, charcoal, and carbamide peroxide gel altered the enamel surface.¹

4. Mahitab H. El Bishbishy et al. (2021)

Study:- a study, aiming to characterize and formulate some of the home remedies and to compare their teeth whitening effect to conventional teeth whitening toothpaste after tooth brushing at one and six months' intervals. *Cocos nucifera* L. (Coconut) oil, along with the alcoholic extracts of *Salvia officinalis* L. (Sage) herb, *Curcuma longa* L. (Turmeric) rhizomes, *Psidiumguajava* L. (Guava) leaves, *Citrus limon* L. (Lemon) fruits peels and *Fragaria ananassa Duchesne* (Strawberry). The toothpaste formulations were of variety of colours, smooth in texture, with a pH of 8.2 and a foamability of roughly 10. Since, *S. officinalis* (SO), *C. longa* (CL), and *C. nucifera* (CN) had the best formulations, their respective toothpastes were further examined.

Claim:- It was concluded that SO toothpaste produced outcomes that were on par with conventional toothpaste in terms of modifying the colour of dental enamel.²⁰

5. Malini Murali et al. (2018)

Study:- Evaluated the efficacy of lemon, apple, carrot, baking soda in the whitening of the extracted natural teeth that are stained with tea decoction.

Permanent anterior teeth were collected for the study. 108 selected teeth were washed with 2% hydrogen peroxide followed by 2 days of soaking in normal saline and then it was stained with tea decoction. This staining was brought about by immersing the teeth in this beverage for



10 days. The tea extract was freshly prepared and changed every day.

Claim:- The results revealed that lemon, apple, carrot and baking soda showed statistically significant results of bleaching when applied directly. Lemon and baking soda showed statistically significant results while soaking, whereas, apple and carrot showed insignificant results while soaking. Overall, lemon showed the highest significance followed by baking soda, apple and carrot.³

6. Kalliath et al.(2018)

Study:- Evaluated and compared the effect of commercially available chemical teeth whitening

toothpaste and teeth whitening toothpaste containing ingredients of herbal origin on human enamel. Twenty samples were collected and divided into two groups, A and B, of ten each, for an in vitro investigation that lasted 14 days. Group A was treated with conventional chemical toothpaste and group B was treated with toothpaste containing ingredients of herbal origin.

Claim:- It was concluded that chemical whitening toothpaste exhibited superior whitening of teeth than toothpaste having herbal ingredients, but surface imperfections on the surface of the enamel were enhanced with chemical whitening toothpaste as compared to toothpaste containing herbal ingredients.⁹

MARKETED DENTAL FORMULATIONS CONTAINING NATURAL INGREDIENTS AS WHITENING AGENTS

Table 2: Marketed Products

Formulation	Natural Excipient Used	Marketed Product
Bio Neem Tulsi Toothpaste Gel	Neem, Holy Basil, Liquorice, Lemon	
Dabur Activated Charcoal Toothpaste	Activated Charcoal	
Himalaya Sparkling White Toothpaste	Papaya and Pineapple	
Himalaya Whitening Antiplaque Toothpaste	Turmeric and Coconut Oil	
Natural Whitening Toothpaste	Tea Tree Oil	

CONCLUSION

Given that they are non-toxic, inexpensive, and readily available, natural products have been in demand for use in delivering bioactive compounds.

Natural substances are becoming more popular or being used more frequently. Many natural products or substances are discarded because they are deemed to be waste. There are various natural ingredients that are used as teeth

whitening agents, however many of these items have not been investigated for the purpose. Therefore, more study is required to comprehend the diverse activities of natural compounds.

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