Original Article

Unlocking the Whitening Potential: Investigating the Benefits of Solanum lycopersicum. L Ethanol Extract on Teeth Discoloration

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Abstract:

Background and Aim: Self-appearance, including clean and white teeth, impacts confidence. Natural products like tomatoes, rich in vitamin C and lycopene, are promising teeth-whitening agents. This study aims to explore the efFects of tomato extract on teeth whitening by comparing different toothpaste formulations.

Methods: Experimental laboratory methods were employed, utilizing a sample of 20 human premolar teeth. We processed the tomatoes by washing, drying, grinding, macerating with 96% ethanol, and evaporating them to obtain a concentrated form. We incorporated different concentrations of tomato extract (5%, 7.5%, and 10%) into toothpaste formulations. Then, we compared it with negative control and a commercial toothpaste brand (Zact).The toothpaste was applied twice daily for 14 days, followed by rinsing and placement in an artificial saliva solution. Teeth color change was measured using the shade guide. Statistical analyses, including the Kruskal-Wallis and Dunn-Bonferroni tests, were conducted to determine the significance of color changes.

Results: Based on the results, the study found that tooth brightness increased with the concentration of tomato extract in each formula, with higher concentrations leading to more significant improvements.

Conclusion: This research provides valuable insights into the potential of tomato extract as a natural teeth-whitening agent. Furthermore, the practical applications and potential for commercialization are promising, suggesting that tomato extract could be developed into a widely used product in the dental care industry.

Keywords: teeth whitening, tomato extract, Solanum lycopersicum L., toothpaste formulation, laboratory experiment.

Introduction:

Self-appearance plays a crucial role in the way individuals present themselves to others, encompassing various aspects such as clothing[1,2] , hairstyle[3], makeup[4], and even posture[3]. Numerous studies have explored the relationship between self-appearance and the perception of attractiveness, self-esteem, and social acceptance[6-9].

It is undeniable that self-appearance can affect a person's self-confidence. When a person feels attractive, he will feel more confident interacting with others. Self-appearance will make it easier for someone to perform daily tasks and improve performance in various activities. When a person appears neat, clean, and attractive, he will be more respected and appreciated by others. A pleasing appearance can open up opportunities in social and professional life[10].

One of the critical factors in a person's appearance is teeth. Clean, white teeth are considered attractive and can positively impact self-confidence[11]. Discoloration, cavities, and other dental issues can negatively impact self-esteem, leading people to hide their smiles and avoid social situations[12]. A person with these tooth problems usually seeks dental treatments[13].

Several teeth whitening treatments are available to address discoloration and other dental issues. These treatments include in-office bleachings, at-home bleaching using custom-made trays, and natural remedies such as activated charcoal and baking soda[14-19]. In-office bleaching is an effective and quick treatment that can significantly improve tooth color in one visit. However it is expensive and may cause tooth sensitivity and gum irritation. At-home and modified bleaching can also effectively whiten teeth, but it requires several sessions over several weeks[15].

Recently, natural remedies have gained popularity as an alternative to traditional teeth whitening treatments. Activated charcoal and baking soda have had some whitening effects. However, their long-term outcomes and safety are still under investigation, and they may cause enamel erosion and gum irritation[16,17,19].

Among these natural whitening products, tomatoes have been recognized as a potential teeth-whitening agent due to their rich source of nutrients. Tomatoes contain vitamin C, an antioxidant that can reduce teeth discoloration. An ethanol extract from tomatoes also contains natural whitening agents, such as citric acid, which can help whiten teeth[19-21]. Furthermore, tomatoes are abundant in bioactive compounds, such as lycopene, carotenoids, and phenolic acids, which have antioxidant and anti-inflammatory properties[22]. These compounds have been shown to positively impact oral health by reducing inflammation, preventing bacterial growth, and improving periodontal health[23,24]. Studies have demonstrated that lycopene, in particular, can help protect against diseases by reducing oxidative stress and inflammation[25].

Despite the extensive research on natural whitening agents, the effectiveness of tomato extract has not been extensively explored. Our study contributes new insights into this area by demonstrating the potential of tomato extract as a safe and effective teeth-whitening agent. The novel aspect of our research lies in the

focus on tomatoes, which are rich in antioxidants like lycopene and vitamin C. These compounds not only offer teeth-whitening benefits but also promote overall oral health by combating bacteria and reducing inflammation.

Until now, few studies have been conducted on the teeth-whitening properties of tomato extract. In addition, it is not yet clear how the efficacy of toothpaste with different concentrations of tomato extract varies. Therefore, this study aims to investigate the effect of tomato extract on teeth whitening by comparing different toothpaste formulas. This research is essential because it will provide valuable information on the potential use of tomato extract as a teeth-whitening agent that is safe, effective, and affordable.

Materials and Methods:

This research used laboratory experiment methods to investigate the effectiveness of toothpaste containing ethanol extract from tomato (Solanum lycopersicum L.) formulation as a teeth whitener. The study sample consisted of 20 human premolar teeth. We used the following instruments in the study: mortar and pestle, hot plate, spatula, scoop, horn spoon, glass slide, sieve, filter paper, funnel, analytical balance, ointment pot, glass beaker, measuring glass, porcelain bowl, pH meter, stirring rod, oven, spatula, viscometer, toothbrush, premolar teeth, tissue, and vitaPan classical tooth color measuring tool. The materials used in the study were: aquadest, 70% alcohol, 96% ethanol, coffee, tomato, calcium carbonate, glycerin, sodium carboxymethyl cellulose, saccharin, sodium benzoate, sodium lauryl sulfate, and menthol.

Before extraction, the tomatoes were washed, drained, quartered, and deseeded. The pieces were air-dried and oven-dried for three days, then ground into powder using a blender. The tomato powder was placed in a maceration container and covered with 96% ethanol. The container was sealed and stored away from direct sunlight for three days, with occasional stirring. After three days, the solution was filtered and remacerated for another 24 hours. Finally, the extract was evaporated at 50 to obtain a thick tomato extract. Furthermore, we prepare the toothpaste. Five formulas were used, including negative control (F1/K-), 5% concentrate of tomato extract (F2), 7.5% concentrate of tomato extract (F3), 10% concentrate of tomato extract (F4), and positive control, commercial toothpaste brand Zact (F5/K+). The composition of the toothpaste can be seen in Table 1.

Table 1. Composition of toot ipaste.

Composition	Formula (%)					Function
	Fl(K->	F2	F3	F4	F5(K~>	
Tomato extract	0	5	7.5	10	Zact	Active substances
Calcium carbonate	40	40	40	40		Fillers
Glycerine	15	15	15	15		Moisturizer
Sodium carboxymethyl cellulose	1	1	1	1		Thickener
Saccharin	0.1	0.1	0.1	0.1		Sweetener
Sodium Benzoate	0.1	0.1	0.1	0.1		Preservatives
Sodium lauryl sulfate	1	1	1	1		Foam maker
Menthol	0.4	0.4	0.4	0.4		Fragrances
Aquadest	Ad 100 ml	Ad 100 ml	Ad 100 ml	Ad 100 ml		Solvent

This study used 20 human premolar teeth, divided into five groups (Fl (K-), F2, F3, F4, and F5 (K+)), with four teeth each. The teeth were sterilized in 70% alcohol for 15 hours and dried. A coffee solution was prepared by mixing 30 grams of coffee with 300 ml of water. The teeth were immersed in this solution in a chemical beaker for seven days to induce a brownish color change. Afterward, their color was measured using the VitaPan Classical.

The experiment assessed toothpaste effectiveness by applying 1 gram of toothpaste to the teeth twice daily for 3 minutes over 14 days. After each treatment, the teeth were washed, dried, and placed in an artificial saliva solution in an incubator at 37°C for 23 hours. The teeth color was measured using the VitaPan Classical, which has 16 shades numbered by appearance: A1-A4 (red-brown), B1-B4 (red-yellow), C1-C4 (grey), and D1-D4 (red-grey).

VitaPan Classical shade guide was used to measure the tooth color before and after the toothpaste treatment. The changes in tooth color were recorded and analyzed using the Kruskal-Wallis non-parametric test with a significance level set at $p<0.05$. Additionally, a posthoc test was conducted using the Dunn-Bonferroni test.

Results

Figure 1 illustrates the changes in tooth color scale before and after the application of five different formulas: Fl, F2, F3, F4, and F5. Measurements were taken to evaluate the effectiveness of each formula in teeth whitening. The results indicate that Formula Fl did not cause any change in tooth color, with the color scale value remaining at 11 before and after treatment. Formula F2 showed a slight change with the color scale value decreasing from 11 to 10 (p-value=0,317), indicating minimal and not significant whitening effect. Formula F3 demonstrated a reduction in the color scale value from 11 to 4.25, although this change was not statistically significant (p-value= 0.066). Formula F4 exhibited even better results, with the color scale value decreasing from 11 to 3 (p-value=0,045), suggesting a more effective whitening outcome compared to F3. Formula F5 (The Zact formula)

showed a reduction in the color scale value from 11 to 2 (p-value = 0.063), indicating that this formula had the strongest whitening effect among all the formulas tested.

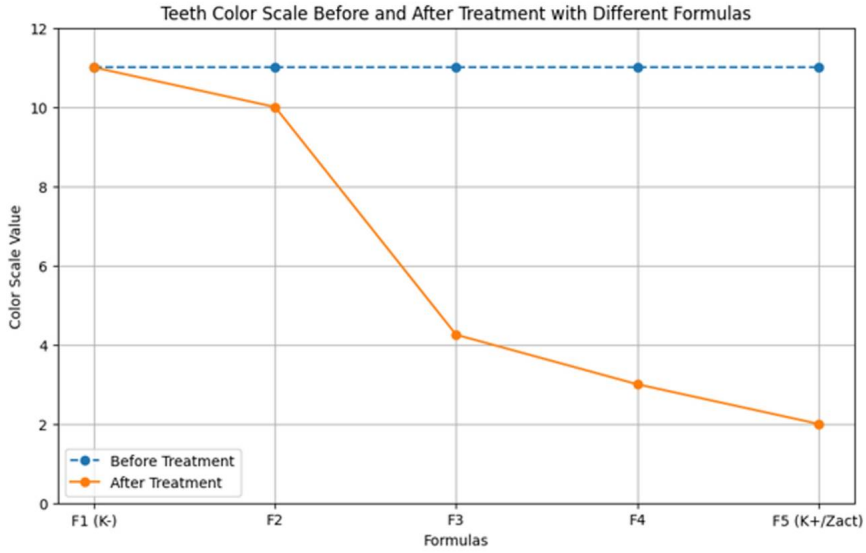

Figure 1: Tomato (Solanum lycopersicum L.) extract teeth whitening activity test results

Based on the results of this study, it was found that the mean color change after treatment showing an increase in tooth brightness corresponding to the concentration of the tomato extract in each formula. Higher concentrations of tomato extract led to more significant improvements in tooth brightness. Figure 2 illustrates the pairwise comparisons of five toothpaste formulas (F1,F2, F3, F4, F5) based on their color scale values. Each node represents a formula, with higher values indicating greater tooth whitening effectiveness. Formula F5 (17.25) exhibited the strongest whitening effect, followed by F4 (15.00) and F3 (11.25). Formulas F2 (5.00) and Fl (4.00) showed lesser effects. The connecting lines highlight the relative differences in effectiveness, demonstrating that F5 and F4 significantly outperform the others in tooth whitening.

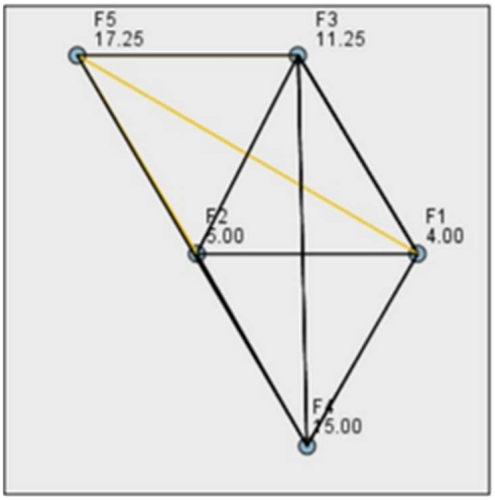

Figure 2: Painvise Comparison of Formulas

The Kruskal-Wallis test indicated a significant difference between the groups (p=0.02). Post hoc analysis revealed that the mean color change of the Fl group was significantly different from that of the F5 group (p=0.09). At the same time, the mean color change of the F2 group was also significantly different from that of the F5 group (p=0.022).

Discussion

The results of this study are consistent with findings from previous research on the teeth-whitening properties of various fruit extracts. Previous studies have utilized different fruits such as strawberries, papaya, lemon, and orange, which are known for their high vitamin C content[26]. Vitamin C, or ascorbic acid, is a potent antioxidant that plays a vital role in promoting healthy gums, improving the gingival index, and supporting collagen production. Collagen is a protein essential for the connective tissue in gums and teeth, thereby preventing tooth decay and loss. The presence of ascorbic acid in natural fruits and vegetables offers a safer and more natural alternative to traditional teeth-whitening agents like hydrogen peroxide or carbamide peroxide. With its ability to brighten teeth without causing harmful side effects, ascorbic acid is a promising ingredient for developing new, effective, and affordable teeth-whitening products[26].

While vitamin C significantly contributes to the teeth-whitening properties of fruits like strawberries and lemons, the role of natural acids in these fruits is also important. The acids help remove surface stains on the teeth, providing a mild bleaching effect. However, excessive exposure to these acids can lead to enamel erosion, which necessitates careful balancing in the application of fruit extracts for tooth whitening to avoid potential harm[26]. Additionally, a clinical study by Yoon et al. developed toothpaste containing natural extracts such as citrus peel (Citrus unshiu), mulberry root bark (Morus alba L.), strawberry, and lemon to test its effectiveness in whitening teeth. The study demonstrated that using this toothpaste for 10 weeks resulted in significant whitening of the upper and lower anterior teeth, particularly on the right canine, right central incisor, and left central incisor. The results indicated that higher concentrations of extracts and longer usage duration enhanced the degree of tooth brightness[27].

Moreover, the study by Yoon et al. examined the long-term effects of using toothpaste based on natural extracts. The results revealed that although the whitening effect was not as immediate as that of hydrogen peroxide-based whitening agents, toothpaste with natural extracts provided a more sustainable effect with fewer side effects[27]. For instance, hydrogen peroxide-based whitening toothpaste is often associated with increased dentin sensitivity and damage to gum tissue, whereas the natural extracts used in this study did not exhibit such side effects. This highlights the potential of natural ingredients as a safer and more effective alternative for daily tooth whitening. This finding aligns with our study, which showed that higher concentrations of tomato extract similarly increased tooth brightness.

In contrast to commercial teeth-whitening

agents, which often rely on hydrogen peroxide or carbamide peroxide, natural fruit extracts offer a gentler approach. Studies have shown that peroxide-based whiteners, although effective, can lead to tooth sensitivity and gum irritation[28]. The use of natural extracts can potentially mitigate these side effects, making them a preferable choice for individuals with sensitive teeth.

Specifically regarding tomatoes, a study by Febriani demonstrated the efficacy of tomato juice in reducing teeth discoloration through varied soaking durations[29]. Additionally, research by Ibrahim has demonstrated the influence of tomato juice on the cleaning of extrinsic stains on composite resin[30]. This study provides further evidence of the effectiveness of tomato-based products in oral care, particularly in maintaining the aesthetic and hygienic qualities of dental materials. This adds to the growing body of evidence supporting the multifunctional benefits of tomatoes in dental health. This is consistent with our findings, where the whitening effect increased with higher concentrations of tomato extract, as shown in Figures 1 and 2.

The increased effectiveness with higher concentrations of tomato extract can be attributed to the greater availability of active compounds, such as vitamin C which play a crucial role in the whitening process. Additionally, the presence of more natural acids at higher concentrations aids in breaking down and removing extrinsic stains more effectively. Therefore, a higher concentration of tomato extract provides a more potent and comprehensive whitening effect.

Lycopene, a powerful antioxidant found in tomatoes has recently garnered attention for its potential benefits in dental health, particularly in the treatment of periodontal diseases. The use of antioxidants as adjuncts to periodontal treatment has been proposed as an alternative to traditional antimicrobials. Lycopene has shown potential therapeutic effects when applied locally or systemically for the treatment of periodontitis. Studies have indicated that lycopene can enhance periodontal therapy outcomes by reducing plaque, probing depth and clinical attachment loss31.This suggests that lycopene could also contribute to oral health beyond its whitening properties, further validating its inclusion in dental care products.

Moreover, this study emphasizes the importance of using environmentally friendly and health-conscious products, especially in an era increasingly aware of the impact of chemical use on human health and the environment. Therefore, further development and commercialization of toothpaste based on natural extracts, particularly tomato extract, could represent a significant advancement in the dental care industry, offering consumers healthier and more sustainable choices.

Furthermore, the findings suggest that tomato extract-based toothpaste not only provides a gentle whitening effect but also contributes to overall oral health. The antimicrobial properties of tomato extract can combat bacteria responsible for bad breath and gum disease, thereby promoting overall oral hygiene. These benefits, combined with the whitening effects, position tomato

extract-based toothpastes as comprehensive oral care solutions.

Conclusion

This study indicates that tomato extract has a significant beneficial effect on teeth whitening, with its efficacy increasing with higher concentrations of the extract in the toothpaste formula. The findings provide valuable insights into the potential uses of tomato extract as a safe, effective, and natural teeth-whitening agent. Furthermore, the practical applications and potential for commercialization are promising, suggesting that tomato extract could be developed into a widely used product in the dental care industry.

There are several limitations to this study. Firstly, the sample size was relatively small, which may limit the generalizability of the findings. Secondly, the study was conducted in vitro, and the results may not reflect the true efficacy of tomato extract toothpaste in vivo. Thirdly, the study only examined the short-term effects of tomato extract toothpaste, and further research is needed to determine the long-term effects of its use.

To address the limitations of this study, future research should consider increasing the sample size and conducting a randomized controlled trial (RCT) on human participants to compare the efficacy of tomato extract toothpaste with other tooth whitening products. Additionally, future research could explore the long-term effects of using tomato extract toothpaste and its safety profile. Finally, investigating the mechanism by which tomato extract whitens teeth could help optimize its use as a natural tooth-whitening agent.

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Conflict of Interest

The authors have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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