

Review Article

The Role of Antioxidants in Dental Health Care: A Comprehensive Review

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ABSTRACT:

Antioxidants play a crucial role in maintaining oral health by mitigating oxidative stress and preventing cellular damage. This review explores the significance of various antioxidants, such as vitamins C and E, flavonoids, and polyphenols, in dental applications. It examines their effectiveness in reducing dental caries, periodontal disease, and oral cancers. The review also discusses the mechanisms through which antioxidants neutralize reactive oxygen species (ROS), enhance the immune response, and promote tissue repair. Furthermore, it highlights the potential of incorporating antioxidants into dental materials and therapeutic agents to improve patient outcomes. Overall, understanding the role of antioxidants in dentistry may lead to innovative preventive and therapeutic strategies.

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INTRODUCTION

Since the 20th century, significant progress has been achieved in the prevention and treatment of oral diseases, leading to a marked reduction in the incidence of dental caries and oral inflammation. Numerous oral health issues are associated with an imbalance between antioxidants and reactive oxygen species (ROS) within the body. Recent studies have established a link between free radicals and the initiation and progression of dental diseases, highlighting the critical role of integrating antioxidants into dental therapies.^{1,2}

Free radicals and ROS are generated as a consequence of oxidative stress and possess highly oxidative characteristics. Notable sources of free radicals in the oral cavity include specific dietary components (particularly those that are high in fat and calories), alcohol consumption, tobacco products, various dental procedures (such as surgical interventions, laser

treatments, and ultraviolet therapies), dental materials (including adhesives and composite resins), and periodontal diseases. The capacity for antioxidant defense in the oral environment can vary considerably among individuals. Oxidative stress is characterized by an imbalance favoring oxidative processes, which significantly contributes to oral and dental pathologies. Antioxidants mitigate potential harm by interacting with free radicals; they do so by donating an electron, thereby converting free radicals into stable molecules.^{3,4}

Antioxidants protect healthy cells by preventing free radicals from extracting electrons from them, a process that helps to safeguard normal cellular integrity. Furthermore, they can neutralize free radicals before they inflict damage on cellular structures, thereby providing a supportive mechanism in the management of oral health issues such as periodontitis. Importantly, it has also been

demonstrated that the intake of antioxidants can effectively inhibit the proliferation of oral cancer cells.^{4,5}

Antioxidants can be categorized into two primary types: endogenous and exogenous.

Endogenous antioxidants are produced by the human body and include substances like superoxide dismutase (SOD), catalase (CAT), and reduced glutathione (GSH). Exogenous antioxidants, on the other hand, cannot be synthesized by the body and include commonly recognized compounds such as ascorbic acid (vitamin C), tocopherol (vitamin E), quercetin, tannic acid, and N-acetyl cysteine (NAC).¹ To improve the delivery of these antioxidants, various methods have been developed, such as encapsulation and sol-gel technology. However, during these processes, antioxidants may decompose due to their inherent instability, which can lead to a reduction in their effectiveness. While a certain level of reactive oxygen species (ROS) possesses bactericidal properties, the decomposition of antioxidants can negatively impact the treatment of various diseases. Therefore, it is essential to consider the biocompatibility of current antioxidant formulations in therapeutic applications.

Objectives of Using Antioxidant in Dentistry: The use of antioxidants in dentistry serves several important objectives, aimed at enhancing oral health and improving treatment outcomes. The main objectives include:^{6,7}

- 1. Reduction of Oxidative Stress:** Antioxidants help neutralize reactive oxygen species (ROS) that can contribute to oxidative stress, thus protecting oral tissues from damage.
- 2. Prevention of Oral Diseases:** By combating oxidative stress, antioxidants can help prevent the onset and progression of various oral diseases, including dental caries and periodontal disease.
- 3. Promotion of Healing:** Antioxidants may facilitate tissue repair and regeneration following dental procedures or injuries by reducing inflammation and accelerating the healing process.
- 4. Enhancement of Treatment Efficacy:** Incorporating antioxidants into dental treatments can improve the effectiveness of therapies for conditions such as periodontal disease and oral cancer by targeting oxidative damage.
- 5. Support of Immune Function:** Antioxidants support the immune system, which is crucial for combating infections and inflammation in the oral cavity.
- 6. Reduction of Side Effects:** By mitigating the oxidative side effects of certain dental treatments, antioxidants can enhance patient comfort and reduce complications.
- 7. Enhancement of Antimicrobial Properties:** Antioxidants may potentiate the antimicrobial effects of certain dental products, leading to

improved oral hygiene and reduced microbial load.

- 8. Promotion of Oral Cancer Prevention:** Antioxidants have been studied for their potential role in inhibiting the development of oral cancers by counteracting oxidative damage to DNA.

- 9. Improvement of Patient Compliance:** Formulations containing antioxidants can be more palatable and acceptable for patients, encouraging adherence to oral health regimens.

These objectives underscore the potential of antioxidants as valuable adjuncts in dental practice, contributing to better oral health outcomes and enhanced patient care.

Types of Antioxidants: Antioxidants are compounds that help protect the body from damage caused by free radicals. Here are some types of antioxidants:^{6,8}

- 1. Vitamin C:** A water-soluble vitamin found in fruits like oranges, strawberries, and kiwi. It helps in reducing oxidative stress.
- 2. Vitamin E:** A fat-soluble vitamin found in nuts, seeds, and green leafy vegetables. It protects cell membranes from oxidative damage.
- 3. Beta-Carotene:** A carotenoid and precursor to vitamin A, found in carrots, sweet potatoes, and spinach. It has protective properties against free radicals.
- 4. Selenium:** A mineral with antioxidant properties, found in seafood, meat, grains, and nuts. It plays a key role in enzyme function.
- 5. Flavonoids:** A group of antioxidants found in fruits, vegetables, tea, and red wine, known for their anti-inflammatory and heart-protective properties.
- 6. Resveratrol:** Found in red wine, grapes, and berries, this antioxidant is linked to heart health and may have anti-aging effects.
- 7. Lycopene:** A carotenoid found in tomatoes, watermelon, and pink grapefruit, known for reducing the risk of certain chronic diseases.
- 8. Coenzyme Q10 (CoQ10):** A compound produced in the body and found in some foods that helps produce energy in cells and has antioxidant effects.
- 9. Glutathione:** A powerful antioxidant produced by the body, crucial for detoxification and maintaining cellular health.
- 10. Curcumin:** The active compound in turmeric, known for its anti-inflammatory and antioxidant effects.

VARIOUS APPLICATION IN DENTISTRY

Prevention of Dental Caries: Dental caries, commonly known as tooth decay, is one of the most prevalent oral health issues globally. It impacts individuals across all demographics—regardless of sex, socioeconomic status, race, and age. This condition underscores the importance of preventive strategies in dentistry aimed at reducing its incidence.

The development of dental caries is influenced by several factors, including oral hygiene practices and salivary characteristics. Recent research has highlighted the critical role of oxidative stress in this process, specifically focusing on an imbalance among free radicals, reactive oxygen species (ROS), and antioxidants present in saliva. These imbalances can significantly contribute to the onset and progression of dental caries.

Understanding the concentrations and activities of various components in saliva can help identify individuals who are at an increased risk for developing dental caries. This evaluation could pave the way for personalized recommendations tailored to each individual's specific needs, enhancing preventive measures.

One of the most crucial components in saliva with respect to caries prevention is the salivary peroxidase system. This enzymatic system serves as one of the principal antioxidant defenses within saliva. Salivary peroxidase plays an important role in controlling oral bacteria that can lead to carious lesions.

The mechanism by which salivary peroxidase functions involves the catalysis of the peroxidation process of thiocyanate ions (SCN⁻). When salivary peroxidase acts on thiocyanate, it generates more stable oxidation products, notably hypothiocyanite (OSCN⁻). These oxidation products exhibit antimicrobial properties that inhibit the growth and metabolic activities of various microorganisms found in the oral cavity. By curtailing the proliferation of harmful bacteria, the salivary peroxidase system effectively slows down or even prevents the progression of dental caries.

In conclusion, as dental caries remains a significant public health concern, understanding the biochemical factors at play—particularly the role of salivary components like peroxidase—can lead to the development of targeted preventive strategies. Emphasizing the importance of maintaining a healthy balance of antioxidants and managing oxidative stress in saliva could play a pivotal role in reducing the prevalence of this common dental issue.

Prevention of Oral Cancer: Antioxidants have emerged as promising agents in both the prevention and treatment of various stages of oral carcinogenesis. Recent studies indicate that the consumption of dietary antioxidants can inhibit the phenotypic expression of oral cancer. Among these antioxidants are proanthocyanidins, which are compounds belonging to the flavonoid family. These substances have demonstrated significant abilities to suppress both growth and proliferation in oral carcinoma cells.⁶ The protective role of dietary antioxidants becomes particularly critical as they act to safeguard lipids and other vital membrane components from oxidative damage. This protection is primarily achieved by intercepting free radicals and other oxidants before they can inflict harm on tissues. Consequently,

antioxidants not only function as critical defenders against oxidative stress but also play a vital role in mitigating conditions that may lead to cancer development.

An essential strategy in cancer prevention is the reversal or suppression of premalignant lesions, which are precursors to cancerous growth. Various studies, including those involving animal models, epidemiological surveys, and interventional trials, have provided substantial evidence for the chemopreventive potential of several antioxidant nutrients. Notably, beta-carotene and vitamin E have been identified as particularly effective in guarding against oral cancer.^{7,8}

Several vitamins are recognized as crucial micronutrients with the strongest associations with cancer prevention and control. These include vitamin A, beta-carotene, vitamin C, vitamin E, vitamin B12, and folate. Deficiencies in any of these vitamins—whether at the dietary, systemic, or mucosal level—can have significant implications, particularly in individuals who use tobacco products, as this combination markedly increases the risk of developing oral precancerous lesions.^{7,8}

The therapeutic potential of vitamin A in treating conditions such as oral leukoplakia began to gain attention in the early 1960s. Silverman et al. reported that administering between 300,000 to 900,000 international units (IU) of vitamin A per day resulted in notable partial or complete resolution of leukoplakia in patients.⁹

Furthermore, a population-based case-control study conducted in Japan provided compelling evidence regarding the relationship between antioxidant levels and oral precancerous conditions. This study revealed that males diagnosed with leukoplakia exhibited significantly lower serum levels of both lycopene and beta-carotene compared to healthy controls. These findings underscore the potential link between antioxidant nutrient deficiency and the development of oral lesions that could be precursors to cancer.¹⁰

In summary, the role of antioxidants in oral carcinogenesis is a promising field of research that suggests dietary antioxidants may serve as effective tools in preventing and treating oral cancers. By addressing antioxidant deficiencies, particularly in conjunction with prolonged tobacco use, there is potential for reducing the risk and incidence of oral precancerous lesions and subsequent cancers.¹⁰

Periodontology Therapy: In periodontal therapy, antioxidants are acknowledged for their anti-inflammatory properties and ability to enhance healing. They can help manage gum diseases such as gingivitis and periodontitis by reducing oxidative stress in the periodontal tissues. For instance, antioxidants can improve the outcomes of scaling and root planing procedures and local delivery systems that target infected areas. The incorporation of antioxidants like vitamin C in oral care products may

also contribute to the promotion of tissue regeneration and reduced inflammatory responses.¹¹

Wound Healing: Antioxidants play an essential role in the wound healing process by promoting tissue repair and regeneration. They help to minimize oxidative damage at wound sites, support collagen synthesis, and enhance the healing of oral mucosa after surgical procedures, such as extractions or periodontal surgeries. Vitamins A, C, and E, along with herbal extracts rich in antioxidants, are often utilized in oral wound care to accelerate healing and reduce the risk of infection. Furthermore, the application of antioxidants can improve blood flow to the affected area, which is critical for optimal healing.¹²

Dental Implantology: In dental implantology, antioxidants may facilitate better integration of implants into the jawbone and support soft tissue healing around the implant site. The presence of oxidative stress can compromise osseointegration, making antioxidants beneficial in preventing peri-implantitis and promoting successful outcomes. Supplements of antioxidants or their incorporation into implant materials can potentially enhance bone healing and stability, ultimately leading to improved longevity of dental implants.⁶

Xerostomia: Xerostomia, or dry mouth, is a condition that can have detrimental effects on oral health, including an increased risk of caries and periodontal disease. Antioxidants can help mitigate some of the complications associated with xerostomia by protecting oral tissues from oxidative damage due to reduced saliva production. Products containing antioxidants may provide symptomatic relief and promote saliva flow, enhancing the overall oral environment.¹³

Aphthous Ulcer: Aphthous ulcers, or canker sores, are painful lesions in the oral cavity often associated with inflammation and immune response. Antioxidants can assist in reducing the severity and duration of these ulcers. They help control inflammation and may accelerate healing processes. Topical formulations containing antioxidants, such as vitamins C and E, are sometimes recommended to alleviate pain and promote faster recovery by minimizing oxidative stress in the affected tissues.⁶

Doses and Safety Concerns: Here are some common antioxidants used in dental practices, their potential doses, and safety concerns:

Vitamin C (Ascorbic Acid)

- **Dosing:** Generally, 500 mg to 1,000 mg daily is considered safe for most adults.
- **Safety Concerns:** High doses (>2,000 mg/day) can lead to gastrointestinal disturbances and may

increase the risk of kidney stones in susceptible individuals.

Coenzyme Q10 (Ubiquinone)

- **Dosing:** Typical doses range from 30 mg to 300 mg per day.
- **Safety Concerns:** Generally well-tolerated, but may cause gastrointestinal upset or allergic skin reactions in some individuals.

Curcumin

- **Dosing:** Common dosages for supplements range from 400 mg to 600 mg per day.
- **Safety Concerns:** High doses can cause stomach upset and may interact with blood thinners and medications affecting liver enzymes.

Resveratrol

- **Dosing:** Daily doses of 150 mg to 500 mg are commonly used in supplements.
- **Safety Concerns:** Can interact with anticoagulant medications and may cause gastrointestinal issues.

Green Tea Extract

- **Dosing:** Typically, 250 mg to 500 mg per day of the extract is used.
- **Safety Concerns:** Excessive intake can lead to liver toxicity; caution is advised in individuals with liver disease.

GENERAL SAFETY CONSIDERATIONS

Allergies: Individuals may have allergies to certain antioxidants, necessitating a thorough medical history prior to use.

Drug Interactions: Antioxidants can interact with medications, including anticoagulants, antidiabetic drugs, and certain cancer treatments. It's crucial for patients to disclose all medications to their dental provider.

Underlying Conditions: Patients with certain conditions, such as diabetes or liver disease, should consult with healthcare professionals before taking antioxidant supplements.

Natural vs. Synthetic: Natural sources of antioxidants (e.g., fruits and vegetables) are typically safer compared to concentrated supplements, which can pose risks when consumed inappropriately.

CONCLUSION

Antioxidants play a significant role in dentistry by helping to combat oxidative stress and inflammation associated with various oral conditions. The incorporation of antioxidants such as Vitamin C, Coenzyme Q10, curcumin, resveratrol, and green tea extract into dental treatments presents potential benefits for enhancing oral health and promoting healing. However, it is crucial to consider the appropriate dosing and to remain cognizant of possible safety concerns and interactions with other medications.

A cautious approach, including patient education and thorough discussions with healthcare providers, will ensure that the benefits of antioxidants can be maximized while minimizing risks. As research continues to evolve, the role of antioxidants in dentistry may expand, offering new therapeutic avenues for improving patient outcomes and overall oral health.

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