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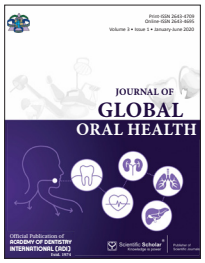

Review Article

Antioxidants: Oral health and diseases

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ABSTRACT

An antioxidant molecule can inhibit oxidations and free radicals' harmful activities. Numerous varieties of antioxidant items are available in the market, and they can originate from various sources such as minerals, vitamins, or dietary and botanical supplements. In advanced nations, the utilization of antioxidants has become prevalent. Just like in all branches of medicine, the utilization of antioxidants is rising. Antioxidants can serve as a valuable addition to the treatment of oral conditions such as periodontitis or gingivitis by assisting in halting their progression. Extensive research has been conducted to investigate the characteristics of antioxidants, aiming to comprehend their underlying mechanisms and shed light on their functions. The growing body of evidence instills optimism about antioxidants' potential benefits for human well-being.

Keywords: Antioxidants, Aging, Free radicals, Oxidative stress

INTRODUCTION

The article aims to highlight the role of antioxidants in oral health by helping protect the oral tissues from oxidative stress and damage caused by free radicals. Antioxidants are a molecule that can inhibit the oxidation of other molecules. Oxidation of molecules produces free radicals. These free radicals can cause harmful chain reactions responsible for cell damage or cell death, which can be responsible for carcinogenesis or low-density lipoprotein oxidations in cardiovascular diseases.

Oxidative stress is a characteristic feature of many diseases. Most of the harmful free radicals affecting biological processes are oxygen-free radicals, referred to as "reactive oxygen species" (ROS). ROS can be formed during ultraviolet light irradiation, by X-rays, and gamma rays produced during metal-catalyzed reactions are present in the atmosphere as pollutants are produced by neutrophils and macrophages during inflammation and are by-products of mitochondrial-catalyzed electron transport systems and various other mechanisms.[1] An imbalance between the generation of ROS and the quantity of available antioxidants to neutralize them leads to elevated oxidative stress. ROS are oxygen-derived small molecules produced as intermediates in redox reactions, such as ozone, superoxides, singlet oxygen, and hydrogen peroxide. Hence, ROS plays an important role in cellular signaling processes and triggers diseases.[2] Antioxidants can neutralize free radicals before the radicals harm human cells. Humans have developed intricate antioxidant systems, both enzymatic and non-enzymatic, that function together and complement each other to shield cells and organs from free radicals. These antioxidants can be produced within the body (endogenous) or obtained from external sources, such as diet or dietary supplements (exogenous).[3] An antioxidant assumed to be effective must

contain some properties: (a) Enzymatic antioxidants that work by catalyzing the oxidation of different molecules and (b) the chain-breaking action, the substances including thiol groups that act largely sequestering transition metallic ions and damage Fenton reactions.[4,5]

The application of antioxidants can eliminate or halt destructive chain reactions. Antioxidants can act by being oxidized themselves and they can be divided into subcategories such as ascorbic acids and polyphenols according to their type. Antioxidants can be categorized into two main groups, based on their solubility in either water or lipids. These antioxidants can be either naturally produced within the body or acquired through dietary sources.[6] Antioxidants are produced from several sources including minerals, vitamins or food, and herbal supplements. These supplements can be obtained in capsule, liquid, or tablet forms. In the dental field, there are toothpaste, mouth rinses, and oral sprays that include antioxidant supplements. These products are designed to enhance oral health by delivering antioxidants directly to the mouth, helping to reduce inflammation, combat harmful bacteria, and protect the gums and teeth from oxidative stress. Most supplements commonly feature ingredients such as green tea, propolis, grape seed, or pine bark extracts.[4,7] There is a correlation between the intake of dietary antioxidants and the functioning of the human immune system.[8] Researchers should be more focused on antioxidants' effects and there should be more research, randomized controlled trials, and final conclusions about their effects-efficiencies or safety.

PERIODONTOLOGY

Oxidative stress remains a central factor in the development of periodontal damage resulting from interactions between the host and pathogens. This stress is a result of excess ROS activity, antioxidant deficiency, or activation of redox-sensitive transcription factors and the creation of an inflammatory stage. It is known that there are significant relations between oxidant status and periodontal status and oxidative stress can play an important role in the pathology of periodontitis.[9] Antioxidants can alter the course of oral conditions such as periodontitis and gingivitis by diminishing the antioxidant capacity of crevicular fluid and plasma. One contributing factor to gingivitis is the deficiency of ascorbic acid. Hence, antioxidant support is preferred against struggling periodontal diseases.[10,11] Plant oils and green, leafy vegetables can break free radical chain reactions and thus may contribute to reducing periodontal inflammation. Flavonoids acquired from antioxidants can possess anti-inflammatory properties that reduce inflammatory molecule expressions in immune system warriors such as monocytes within the gingival connective tissues.[4] In addition, the cranberry fraction could prevent biofilm formation by *Phorphyromonas gingivalis* which is a major pathogen of chronic periodontitis.[12] Carvalho *et al.,*[13] stated that Vitamin E has the potential to reduce oxidative damage in experimental periodontitis but does not prevent alveolar bone loss and could cause anxiety.

RESTORATIVE DENTISTRY

It was reported that green tea's epigallocatechin-3-gallate molecule had a scavenging effect on dental caries prevention. Cranberries, especially their Type A oligomers, were capable of having antibacterial activity against *Streptococcus Mutans* and stopping dental caries.[14] In the restorative treatment of caries, to increase the bond strength of composites, grape seed or pine bark extract solutions can be performed, especially to raise decreased bond strength values for restorative treatments after bleaching.[15-17]

ORTHODONTICS

In the field of orthodontics, comparable substances can be employed to enhance the adhesive strength of brackets.[16-18] For bracket bonding, complex preparations of ascorbic acid solutions were utilized to augment the bond strength values. In a recent study, it was reported that the usage of pine bark extract solution could be used instead of an ascorbic acid solution.[18] For maxillary expansion, numerous investigations have explored the impact of antioxidant substances on bone development and maturation. Uysal *et al.,* examined the influence of Vitamin C and resveratrol on the expanded premaxillary suture, and their findings indicated a statistically significant impact of antioxidants on bone formation.[19,20] Laila Baidas *et al.,*[21] studied the effects of antioxidants on the shear bond strength (SBS) of orthodontic brackets bonded to bleached human teeth. Given the rising number of adults seeking orthodontic treatment alongside teeth whitening, this research suggests that antioxidants could potentially be employed to counteract the decrease in the SBS of orthodontic brackets following teeth whitening. This approach would enable orthodontists to avoid the need for postponing the bonding process after teeth whitening, all while preserving the mechanical and physical strength of the bond formation. They discovered that using antioxidants enables clinicians to whiten teeth before starting orthodontic treatment without postponing the bonding process. The elevation in the nickel content within saliva, released from orthodontic devices, appears to be the cause of alterations in the oxidative condition of the saliva.

ORAL-MAXILLOFACIAL SURGERY

According to Ohnishi *et al*.,[22] reactive oxygen, such as hydrogen peroxide, is responsible for the alveolar bone

loss that is accompanied by decreased endothelial nitric oxide synthase expression in mice and they stated that the occurrence of oxidative stress is a fundamental systemic condition that exacerbates the loss of alveolar bone. Research has indicated a noteworthy enhancement in bone healing in rat models for bone formation through the utilization of caffeic acid phenethyl ester, a compound present in propolis.

ORAL CANCER

Antioxidants demonstrate the capacity to prevent and treat various phases of oral cancer development. Recent research has indicated that consuming antioxidants can inhibit the development of oral cancer phenotypes. Antioxidants present in the diet can safeguard lipids and other membrane molecules from oxidative harm by intercepting oxidants before they attempt to damage the tissues.

QUESTION MARKS ABOUT ANTIOXIDANTS

There are several questions and debates regarding antioxidants and their effects on health:

Effectiveness in disease prevention

While antioxidants are known to neutralize free radicals, the extent to which they prevent diseases such as cancer or heart disease is still under investigation. Some studies have shown benefits, whereas others have not found significant protective effects.

Supplementation versus diet

There is ongoing debate about whether antioxidant supplements provide the same benefits as those obtained from a diet rich in fruits and vegetables. Some studies suggest that high doses of supplements can be harmful or have no benefit compared to getting antioxidants from natural food sources.

Optimal levels

The ideal amount and type of antioxidants needed for optimal health are not well defined. Different people may have varying requirements based on their health status, lifestyle, and genetic factors.

Interactions with medications

Antioxidants can interact with certain medications, potentially affecting their efficacy or causing side effects. For example, high doses of Vitamin E supplements may increase the risk of bleeding in people taking blood thinners.

Balance of oxidants and antioxidants

While antioxidants help combat oxidative stress, some level of free radicals is necessary for normal cellular functions, such as signaling and defense against infections. The balance between oxidants and antioxidants is complex, and excessive antioxidant intake might disrupt this balance.

Impact on exercise

Some research suggests that high doses of antioxidants might interfere with the beneficial effects of exercise on muscle adaptation and insulin sensitivity, as oxidative stress plays a role in these processes. To decide on antioxidant treatments or their endorsement, clinicians need to address several key questions. Are there enough convincing studies in the literature for your case? Do we clearly know the adverse effects of the antioxidants we choose? Is oxidative damage considered a factor in the disease's pathophysiology? At the tissue level, do we know the place where the oxidative damage takes place? Will our antioxidants get to that area?

CONCLUSION

The properties of most of the antioxidants have been studied to understand their mechanisms and to clarify their activities. Future research should continue with the aim of investigating the antioxidant biocompatible and understanding their pathways to human health. Certain antioxidants exhibit greater anti-inflammatory effects, whereas others possess more prominent anti-tumor properties. Consequently, some researchers have proposed the utilization of combined antioxidant supplements to enhance overall protection against free radicals. Although there are some debates about research methods, protocols, or proper doses, the increasing shreds of evidence are raising hopes about antioxidants for human health.

Ethical approval

Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent is not required as there are no patients in this study.

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Conflicts of interest

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Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

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