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THE POTENCY OF KATUK LEAVES AS AN ANTIOXIDANT IN ORTHODONTICS

(POTENSI DAUN KATUK SEBAGAI ANTIOKSIDAN DALAM PERAWATAN ORTODONTI)

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ABSTRACT

Katuk leaves (*Sauropus androgynus L. Merr*) are known for their antioxidant, anti-inflammatory, and antimicrobial properties. Orthodontic treatments often involve prolonged use of metal appliances, which can lead to oxidative stress and inflammation in the oral environment. Antioxidants are crucial in mitigating these effects, potentially improving the outcomes and comfort of orthodontic treatments. Katuk leaves, rich in antioxidants such as flavonoids, saponin, tannin, quinone, polyphenols, and vitamins, can slow down the formation of free radicals during the tooth movement process. This literature review explores the potential application of katuk leaves as a natural antioxidant in orthodontics, focusing on enhancing patient care by reducing oxidative stress and inflammation associated with orthodontic appliances. This study was conducted using a comprehensive literature review approach. Relevant keywords from articles were sourced from databases, including Google Scholar, PubMed, ResearchGate, Europe PMC, and Elsevier. Selection criteria

included the year of publication, relevance to the topic, availability of abstract, full text, and alignment with the study's objectives. The review revealed evidence supporting the antioxidant effects of katuk leaves in reducing oxidative stress during tooth movement. However, there are still limitations regarding the utilization and processing of katuk leaves in clinical settings. Further research is necessary to develop standardized methods for applying katuk leaves in orthodontic treatment. Utilization of katuk leaves in orthodontic care shows the potential to enhance antioxidant levels, thereby reducing oxidative stress and improving treatment outcomes.
Keywords: *antioxidant; katuk leaves*

ABSTRAK

Daun katuk (Sauropus androgynus L. Merr) dikenal memiliki sifat antioksidan, antiinflamasi, dan antimikroba. Perawatan ortodontik sering kali melibatkan penggunaan perangkat logam dalam jangka waktu yang lama, yang dapat menyebabkan stres oksidatif dan peradangan di lingkungan mulut. Antioksidan sangat penting dalam mengurangi efek ini, yang berpotensi meningkatkan hasil dan kenyamanan perawatan ortodontik. Daun katuk, yang kaya akan antioksidan seperti flavonoid, polifenol, dan vitamin, dapat memperlambat pembentukan radikal bebas selama proses pergerakan gigi. Tinjauan literatur ini bertujuan untuk mengeksplorasi potensi aplikasi daun katuk sebagai antioksidan alami dalam ortodontik, dengan fokus pada peningkatan perawatan pasien melalui pengurangan stres oksidatif dan peradangan yang terkait dengan penggunaan alat ortodontik. Penelitian ini dilakukan dengan pendekatan tinjauan literatur yang komprehensif. Artikel-artikel diperoleh dari database termasuk Google Scholar, PubMed, ResearchGate, Europe PMC, dan Elsevier, dengan menggunakan kata kunci yang relevan. Kriteria seleksi meliputi tahun publikasi, relevansi dengan topik, ketersediaan abstrak, teks lengkap, dan kesesuaian dengan tujuan penelitian. Tinjauan ini

menemukan bukti yang mendukung efek antioksidan daun katuk dalam mengurangi stres oksidatif selama pergerakan gigi. Namun, masih terdapat keterbatasan terkait pemanfaatan dan pengolahan daun katuk dalam praktik klinis. Penelitian lebih lanjut diperlukan untuk mengembangkan metode standar untuk aplikasi daun katuk dalam perawatan ortodontik. Pemanfaatan daun katuk dalam perawatan ortodontik menunjukkan potensi untuk meningkatkan kadar antioksidan, sehingga mengurangi stres oksidatif dan memperbaiki hasil perawatan..

***Kata kunci**: antioksidan; daun katuk*

INTRODUCTION

The use of *Katuk* leaves as an herbal plant in Indonesia is readily available and often consumed by the community because it contains vitamin K, vitamin A, vitamin B, and vitamin C, calcium, iron, potassium, phosphorus, magnesium, protein, fat, tannins, saponins, flavonoids, and alkaloids that can be used as antioxidants, anti-inflammatory agents, and antimicrobial agents.[1,2] The content of flavonoids and vitamin C in *Katuk* leaves can capture reactive oxygen compounds inside and outside cells and prevent oxidized compounds by reducing superoxide radicals, hydroxyl, hypochlorous acid, and products produced by activated neutrophils and monocytes.[3] The mechanism of action of antioxidants is that they can neutralize free radicals, reduce peroxide concentration and improve oxidation, encourage reduced ROS production, and neutralize ROS with lipid metabolism, short-chain free fatty acids, and cholesterol esters.[4] According to other recent studies, orthodontic wires and brackets can produce increased concentrations of free radicals without causing acute toxicity, making stainless steel materials more biocompatible.[5,6] In the research of Herawati et al. in 2021, the use of an ethanol extract from *Katuk* leaves can increase the number of osteoblasts, thus proving that antioxidants in *Katuk* leaves can inhibit ROS by maintaining osteoblasts and osteocytes, which have a role in bone remodeling.[7]

METHOD

The design of this research is a *literature review*. This design is a research methodology that gathers information from various literature sources about the

formulation of research papers' problems. These sources can address the number of samples of scientific research journals utilized in the study and include prior research articles, scientific research journals, relevant textbooks, and more.

The chosen papers, which focused on applying the ethanol extract *Katuk* leaf with natural antioxidant properties, were conducted between 2013 and 2023. Articles that display the abstract are not selected; only full-text articles are. A literature search was carried out using the keywords "*benefits of Katuk leaf on orthodontic movement*" and *" Katuk leaf for oral health. "An electronic search was done using the Google Scholar*, Pubmed, *Research Gate, EuropePMC, and Elsevier* databases.

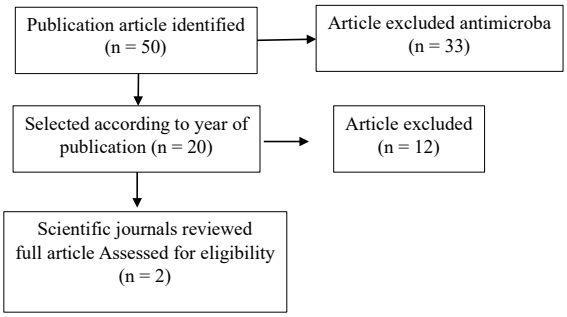

Figure 1. PRISMA result of the study selection.

RESULT

Orthodontic treatment

Fixed orthodontic appliances have become increasingly popular in recent years, especially among the younger generation. A healthy smile with well-aligned teeth influences an attractive smile. Orthodontic treatment is a dental treatment aimed at correcting dental growth abnormalities. Additionally, the goals of orthodontic treatment are to achieve functional occlusion, enhance aesthetics, and improve the health of the supporting tissues of the teeth. As part of this treatment, brackets, wires, and orthodontic rubber bands work together to create the pressure that allows tooth movement.[8]

Oxidative stress causes an imbalance between osteoclast and osteoblast activity, leading to metabolic bone diseases and contributing to the pathogenesis of skeletal disorders, including osteoporosis, characterized by low bone mineral density and decreased bone mass, making bones weak and more susceptible to fractures. ROS induces apoptosis of osteoblasts and osteocytes, cells localized within the bone matrix and derived from mature osteoblasts, thus supporting osteoclastogenesis. ROS elicit a spectrum of responses ranging from proliferation, growth, and arrest of differentiation to cell death by activating various signaling pathways. High levels of ROS inhibit and reduce osteoblast activity and differentiation, thereby impairing mineralization and osteogenesis. This event

increases bone remodeling turnover, resulting in changes and decreases in bone mass. Antioxidants have the opposite effect, contributing to osteoblast differentiation and bone formation, maintaining vital osteocytes that contribute to osteoblast activity and osteogenesis while reducing osteoclast differentiation and activity.[9]

The orthodontic appliance and the biomechanics of tooth movement can contribute to oxidative stress during treatment. Orthodontic alloys release metal ions, with nickel-titanium archwires releasing more ions than stainless steel, temporarily affecting the oral oxidative–antioxidant balance.[10,11] The constant irritation and inflammation caused by orthodontic appliances can create a pro-inflammatory environment that promotes ROS generation.[12] Atuğ Özcan et al. study showed that most oxidative stress occurs during the first phases of orthodontic treatment due to the inflammatory reaction triggered as dental movement begins. Mechanical pressure from orthodontic treatment can initiate a series of biological responses involving inflammation and changes in bone tissue. This process starts with the release of inflammatory mediators, such as TNF-α and IL-1β.[10,13,14] The presence of orthodontic appliances can make it harder to keep teeth clean, leading to plaque buildup and gum inflammation. This inflammation can contribute to oxidative stress in the mouth.[10,15]

Katuk Leaves

Katuk leaves (*Sauropus androgynous L.*) is a herbal plant that grows to a height of 50 cm to 3.5 m and is commonly found in tropical countries such as India, Sri Lanka, Vietnam, Indonesia, Malaysia, Papua New Guinea, and the Philippines.[16]

Katuk leaves (*Sauropus androgynus (L.) Merr.*), a member of the *Euphorbiaceae* family, is a plant with dark green leaves often used as an alternative medicine due to its rich content of vitamins and nutrients. Katuk leaves contain bioactive compounds such as saponins, tannins, flavonoids, steroids, and alkaloids. These offer various benefits, including antidiabetic, anti-obesity, and antioxidant properties and the ability to stimulate milk production in lactating mothers.[17]

In Indonesia, this plant is also used in traditional medicine to treat urinary tract infections and fever. Fresh young leaves and shoots are often consumed in salads. Katuk leaves are generally non-toxic to humans when consumed in moderation. Based on these findings, *Katuk* leaves can be categorized as a functional food and medicine with promising potential in treating various diseases.[17,18]

The taxonomic classification of *Katuk* leaves is Division: *Spermatophyta*, Subdivision: *Angiospermae*, Class: *Dicotyledoneae*, Order: *Graniales*, Family: *Euphorbiaceae*, Subfamily: *Phyllanthoidea*, Genus*: Sauropus*, and Species: *Sauropus androgynus (L.) Merr*.

Katuk leaves (*Sauropus androgynus (L.) Merr.*), commonly known as *Katuk*, is a small shrub growing up to 3 meters tall. The stem is brownish-green, longitudinally furrowed, and has a smooth bark. Leaves are alternately arranged on a single stem, with approximately 11-21 leaves per branch. The leaf blade can vary in shape from oblong to round. Flowers are solitary or in clusters of three, borne among the leaves. Perfect flowers have round petals, dark red or red with yellow spots. Male flowers are pendulous, with petals and corolla similar to the perfect flowers, and are brownish-red in colour. Each male flower has three closely packed, thick, fleshy reddish-green petals. The pollen is yellowish-white, and there are six stamens. Female flowers also have similar petals and corolla, which are brownish-red. Each female flower also has three thin, persistent petals that remain attached to the fruit.[19] A picture of the *Katuk* plant can be seen in Figure 2.

Figure 2. Katuk leaves (*Sauropus androgynus L.*).
Source: personal documentation.

Katuk **Leaves as a Natural Antioxidant Source**

Antioxidants are compounds that neutralize or scavenge free radicals, thereby preventing degenerative diseases such as cardiovascular and carcinogenic conditions. These compounds are essential for the body to counteract free radicals and prevent them from damaging normal cells, lipids, and proteins. Based on their source, antioxidants can be categorized into two types: enzymatic antioxidants, which are produced by the body, and non-enzymatic antioxidants, which can be synthetic or natural. The human body possesses an organized antioxidant system consisting of enzymatic and non-enzymatic antioxidants that work synergistically. The primary function of antioxidants is to protect cells from oxidative damage and to prevent the production of oxidative products.[20,21]

The benefits of antioxidants include the ability to directly scavenge free

radicals, reduce peroxides, repair oxidized membranes, and decrease the production of reactive oxygen species (ROS) through lipid metabolism. The presence of antioxidants in the body is crucial for preventing and neutralizing oxidative reactions involving free radicals. Antioxidants react directly with newly formed free radicals, particularly during the initiation and propagation phases of lipid peroxidation, thereby inhibiting and neutralizing their negative effects or decomposing peroxides.[20,21]

Katuk leaves (*Sauropus androgynus*) are known for their high antioxidant content, including flavonoids, polyphenols, and vitamins. Flavonoids have the ability to scavenge and reduce the risk of diseases caused by reactive oxygen species (ROS). They can also inhibit enzymes that produce superoxide anions and prevent lipid peroxidation. Flavonoids can form complexes with metal ions, acting as antioxidants, and bind to proteins such as enzymes and structural proteins, thereby enhancing their antioxidant effects under specific conditions15,16

Free Radicals

Free radicals are unstable molecules with at least one unpaired electron in their outer orbital. These unpaired electrons make the molecules highly reactive. Consequently, they seek electrons from other molecules to form pairs, often leading to damage to the molecules from which the electrons are taken. Free radicals destroy molecules by destroying lipid proteins and potentially compromising the integrity of biomolecules and DNA. It can lead to increased oxidative stress and contribute to the development of neurodegenerative diseases, diabetes, cardiovascular diseases, premature ageing, and even cancer. When free radicals enter the body in abnormal amounts, they attack vulnerable compounds such as lipids and proteins, causing various diseases. An imbalance between ROS and antioxidants can result in oxidative stress.[23]

Free radicals are generated within the body due to respiration, cellular metabolism, excessive or maximal exercise, inflammation, and byproducts of cellular oxidation and combustion during exposure to external pollutants. The most abundant free radical formed in the body is superoxide. Superoxide is converted into hydrogen peroxide (H_2O_2). Hydrogen peroxide is converted into hydroxyl radical ($OH•$) during the propagation phase. The hydroxyl radical causes lipid peroxidation of cell membranes, leading to cell damage. If this continues, it can cause an imbalance between free radicals and endogenous antioxidants, known as oxidative stress.

Therefore, these compounds are called free radicals or reactive oxygen species (ROS). Free radicals include OH-, O_2-, ROO-, H_2O_2, NO-, and HOCl. These free radicals can damage and break DNA strands, interfering with cell division.[23,24]

The highly reactive nature of free radicals allows them to convert other molecules into new free radicals. Antioxidants can counteract these radicals. Antioxidants can slow down, delay, and prevent oxidative reactions caused by free radicals in lipid oxidation. Antioxidants can prevent oxidative damage to lipids in cells. An imbalance between oxidants and antioxidants, where the production of Reactive Oxygen Species (ROS) exceeds the antioxidant capacity, can lead to damage, a condition known as oxidative stress. Consuming foods rich in antioxidants can help neutralize free radicals. Katuk leaves are one natural source of antioxidants. Phenolic flavonoids have a significant impact on free radical scavenging activity. The antioxidant capacity is directly related to the presence of hydroxyl groups. Flavonoids can also help maintain normal cell membranes by reducing lipid peroxidation and scavenging free radicals.

The two selected articles have research methods with quasi-experimental pre and post-design methods with a control group. The first article of research from Syarifah S et al . examined the effectiveness of ethanol extract of *Katuk* leaves on the population of osteoblasts and osteoclasts in orthodontic treatment in an in vivo study. Syarifah S et al., by examining the number of Osteoblast and Osteoclast before and after using ethanol extract of *Katuk* leaves, it was found that the distribution of the number of Osteoblast in the control group was 13,56 and osteoclast was 2,56. Post-test on *doses of ethanol extract 39.15 mg/BW*, the average number of Osteoblast is 10,30, and the osteoclast is 1,73. Post-test on group *doses of ethanol extract 78.3 mg/BW*, the average number of Osteoblast is 15,3, and the osteoclast is 2,27. Post-test on group *doses of ethanol extract 156.5 mg/BW*, the average number of Osteoblast is 10,80, and the osteoclast is 2,10. Statistically, the number of osteoblasts between the treatment and control groups showed a significant difference. *Katuk* leaf extract had effectiveness in increasing the number of osteoblasts in orthodontic treatment.[25]

The second article, using in vitro study post-design methods, this article of research from Arista M., examined the antioxidant activity of 80% and 96% ethanol extracts of *Katuk* leaves. Based on the study's results, it can be concluded that

the antioxidant activity of 80% ethanol extracts of *Katuk* leaves shows that EC50 values are significantly higher and better than the 96% ethanol extract.[26]

DISCUSSION

Katuk, with the Latin name *Sauropus androgynus L. Merr*, is an herbal plant that grows in Indonesia and several Southeast Asian countries, India, China, and Australia, and is commonly used as a traditional herbal medicine. This plant grows in areas with high humidity. Katuk leaves have a high antioxidant content.[27–29] *Katuk* leaves have several anti-inflammatory, antioxidant, and antibacterial benefits. The contents contained in *Katuk* leaves include saponins, flavonoids, amino acids, alkaloids, and tannins.

Antioxidants can slow down and neutralize free radicals by inhibiting cell lipid oxidation. Antioxidant compounds can help prevent degenerative diseases caused by free radical processes such as cardiovascular, carcinogenic, ageing, and other diseases. Antioxidants are substances the body needs to avoid damage caused by free radicals to normal cells.[30–32] The body can produce its antioxidants, called enzymatic antioxidants, but antioxidants can also be obtained from natural and synthetic materials.

Antioxidants are divided based on their source, namely enzymatic and non-enzymatic antioxidants. Natural antioxidants are easily obtained from the surrounding environment, which can be obtained from fruits, leaves, herbs, vegetables, and seeds. Natural antioxidant compounds are usually ascorbic acid (vitamin C), retinol (vitamin A), tocopherol (vitamin E), flavonoids, phenolic compounds, and polyphenolic flavonoids, including flavones, flavonols, isoflavones, catechins, flavonols, and chalcones.[33]

Phytochemical tests and vitamin C content of *Katuk* leaf infuse as a natural ingredient for the remodeling process in orthodontic treatment showed that *Katuk* leaves contain flavonoids, alkaloids, tannins, polyphenols, quinones, and saponins. Flavonoids are a large group of phytochemicals that are protective and are found in all parts of the plant, including fruit, pollen, and roots. Flavonoids are often known as bioflavonoids, which act as antioxidants. Flavonoids are divided into nine groups: anthocyanins, proathocyanins, flavonols, flavones, glycoflavones, biflavonyls, chalcones, aurones, flavanones, and isoflavones.[34,35]

The saponins in *Katuk* leaves exhibit anti-inflammatory properties by inhibiting exudate formation and reducing vascular permeability. Tannins have antioxidant activity that acts as an anti-

inflammatory by inhibiting the production of oxidants (O2) by neutrophils, monocytes, and macrophages, which will reduce the formation of H2O2.[36] The anti-inflammatory effect of polyphenols, on the other hand, occurs through the mechanism of suppressing tumour necrosis factor-alpha (TNF-α) and Nuclear Factor kappa β (NF-κB), which are vital in strengthening wound healing in the oral mucosa. In addition, quinone compounds also have anti-inflammatory properties by promoting cell regeneration and increasing blood vessel formation.[24]

The benefits of antioxidants are that they can directly neutralize free radicals, reduce peroxide concentration, repair oxidized membranes, and reduce ROS production through lipid metabolism.[37] The role of antioxidants is significant for the health of the human body because their function can inhibit and neutralize oxidation reactions involving free radicals. Good antioxidants react directly to newly formed free radicals, usually working during lipid peroxidation reactions at the initiation and propagation stages in the body by absorbing and neutralizing free radicals or decomposing peroxides.[33,37] Studies have shown that plant-based antioxidants can help treat ROS-related diseases and enhance the body's natural defense against free radicals.[38,39] Numerous studies have documented the abundance of antioxidants and bioactive phytochemicals, such as steroids, terpenoids, tannins, alkaloids, phenols, flavonoids, volatile oils, and fatty acids, in the *S. androgynous* plant.[40]

CONCLUSION

Based on the results of the study, it can be concluded that there are benefits to using ethanol extract from *Katuk* leaves as an antioxidant in tooth movement.

CONFLICT OF INTEREST

The authors reported no potential conflict of interest.

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