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Reviews Article

Antioxidant Potential of Sugarcane Leaves, Stems, and Derivatives: A Literature Review

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Abstract

The bioactive component content and enzymatic activity of sugarcane (Saccharum officinarum L.) demonstrate significant antioxidant effects. Numerous studies have shown the presence of phenolic compounds, flavonoids, triterpenoids, and other metabolites which contribute to the antioxidant activity of sugarcane. Various study have reported on the potential benefits of sugarcane for health. This review presents the antioxidant properties of leaves, stems, and sugarcane derivatives, along with the potential benefits for health and industrial applications. The study aims to provide some understanding about the role of sugarcane in reducing oxidative stress, considered the underlying cause of various kinds of medical conditions, for future studies and development.

Keywords: *sugarcane, sugarcane leaves, sugarcane stems, sugarcane products, antioxidants.*

Introduction

Sugarcane (Saccharum officinarum L.) is a plant in the Poaceae family that produces the world's most sugar. Sugarcane has been grown in many different kinds of tropical and subtropical regions around the world, including America, Brazil, China, and Indonesia. Sugarcane leaves, stems, and product contain numerous kinds of bioactive chemicals and enzymatic properties, including amino acids, organic acids, alkaloids, phenolics, flavonoids, and triterpenes. Sugarcane's components contain significant antioxidant abilities[1–3]. Furthermore, sugarcane stem and leaf extracts have been shown to be potential sources of antioxidant chemicals, indicating their potential as an antioxidant agent. The chemical composition of anthocyanins contribute to sugarcane's antioxidant properties[4,5]. The antioxidant activity of sugarcane is also associated with its ability to induce defense responses through phenolic compounds mediated by rhizobacteria[6] and its ability to combat oxidative stress when exposed to stress factors such as high concentrations of cobalt[7]. The antioxidant mechanism of sugarcane involves the presence of bioactive compounds in the leaves, stems, and their derivatives. This review explored the antioxidant potential of sugarcane leaves, stems, and related products.

Sugarcane Leaves as Antioxidants

Sugarcane leaves' antioxidant activity has the potential for application as pharmaceuticals. Sugarcane leaf extract contains a variety of bioactive chemicals, including polyphenols, which have high antioxidant properties. Phenolic compounds such as gallic acid, chlorogenic acid, and caffeic acid have contributed to its antioxidant ability[4]. Sugarcane leaves have been demonstrated to contain various kinds of compounds with potential health benefits, particularly antioxidants. Several studies have identified flavonoids, phenolic acids, and other chemicals in sugarcane leaves, which contribute to the antioxidant properties[8–12].

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Sugarcane young leaves on the tip, considered a waste product, have high antioxidant polyphenol features[13]. Furthermore, antioxidant activity in sugarcane leaves varies with genotype, demonstrating variations in total antioxidant activity and ROS scavenging capacity[14]. More importantly, sugarcane leaves contain antibacterial and protective capabilities against chronic illnesses, which have been related to antioxidant activity[10,15]. According to study results, sugarcane leaves have a high total phenolic content (TPC), approximately 1,804.15 mg/kg dry basis, indicating reliable antioxidant activity with a DPPH radical scavenging rate of 92.34%[5]. Sugarcane leaves have antioxidant and anti-inflammatory effects that are beneficial for managing diseases such as diabetes, possibly due to the synergistic interactions of flavonoids, tannins, and saponins[16]. Another investigation further discovered that liposome formulations for sugarcane leaves can improve stability and long-term releases as a pharmaceutical innovation[17].

Sugarcane leaves contain significant quantities of bioactive compounds such luteolin-8-C-(rhamnosylglucoside), quercitrin, caffeic acid, ferulic acid, and p-coumaric acid, which are known antioxidants. Several in vitro experiments have demonstrated sugarcane leaf extracts' antioxidant properties. The DPPH radical scavenging assay showed IC_{50} values ranging from 20.82 to 27.47 µg/mL for several cultivars, demonstrating significant antioxidant ability comparable to other well-known plant antioxidants. Furthermore, sugarcane leaf extracts demonstrated a considerable ability to block hydroxyl radical-induced DNA strand breaks, indicating a function in genomic integrity and protection from oxidative stress[18]. In vivo models were additionally applied to investigate the sugarcane leaves extract’s preventive role towards oxidative damage. The study conducted chemical profiling of sugarcane leaf extracts and fractions using a combination of GC–MS, HPLC–UV–VIS, LC-TOF–MS/MS, and 1D and 2D NMR techniques, identifying metabolites such as phenolics, flavonoids, terpenes, β-sitosterol, and polyunsaturated fatty acids (PUFAs). Compounds including n-hexadecanoic acid, octadec-9-enoic acid, 4-hydroxycinnamic acid, flavonoid glycosides (tricin-7-O-neohesperidoside), gallic acid, and the unique dilaurylthiodipropionate were detected in specific fractions and are thought to contribute to the observed antimalarial activities through various mechanisms such as antioxidant effects, immune system stimulation, inhibition of fatty acid and protein synthesis in the parasite, and free radical scavenging. These compounds are suggested to be responsible, at least in part, for the schizonticidal activity of the sugarcane leaf extract[19].

Antioxidant Potential of Sugarcane Stems

The sugarcane stem (Saccharum officinarum L.), which provides the primary site for sucrose accumulation, is not only a major source of sugar production but also a store of rich bioactive chemicals. Traditionally, sugarcane stems were primarily used for their sucrose content. However, further study demonstrates the potential as sources of natural antioxidants, mainly due to the presence of phenolic acids, flavonoids, and other polyphenolic compounds. Sugarcane stem extracts have been demonstrated in studies containing antioxidant-rich phenolic chemicals[20]. These compounds have been shown to be capable to eliminate free radicals and have a high antioxidant potential[21]. Sugarcane extract's antioxidant capability inhibits the synthesis of toxic substances including Nε-(carboxymethyl)lysine and Nε-(carboxyethyl)lysine, suggesting its role in preventing oxidative damage[22]. Furthermore, metabolites identified in sugarcane have been shown to contribute to its antioxidant capability, emphasizing the variety of chemicals that

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contribute to its beneficial characteristics[23]. The antioxidant capacity of sugarcane extracts has been investigated in a variety of forms, including molasses and bagasse, understanding the versatility of sugarcane byproducts in the context of antioxidant components[24]. Moreover, the stability and encapsulation of these bioactive compounds were studied, demonstrating that they potentially used as antioxidants and antimicrobials[25]. Sugarcane stems are rich in phenolic acids such gallic acid and caffeic acid, with a total phenolic concentration of about 0.179 mg equivalent per gram of extract[4]. Sugarcane extract's antioxidant activity has been showed by a variety of tests, including DPPH and ABTS, which demonstrated high radical scavenging potential[5,26].

Sugarcane juice extracted from the stem contains various kinds of phenolic chemicals, including caffeic acid, sinapic acid, ferulic acid, and chlorogenic acid. It also contains flavonoids tricin, luteolin, and apigenin, as well as glycosylated derivatives such as tricin-7-O-glucoside and luteolin-8-C-(rhamnosylglucoside). These compounds significantly enhance the antioxidant activity of sugarcane stem extracts. The total phenolic concentration in sugarcane juice has been identified to be around 160 mg/L, with tricin derivatives contributing to more than 10% of the total flavonoid content[27].

Sugarcane Products as Antioxidant

Sugarcane products and byproducts are widely recognized for their high levels of natural antioxidants, according to their polyphenolic component. Molasses, a thick syrup formed during sugar crystallization, contains high levels of phenolic compounds such ferulic acid, caffeic acid, gallic acid, and flavonoids like tricin and apigenin. These chemicals contribute to potent antioxidant capacity, as confirmed by DPPH, ABTS, FRAP, and β-carotene bleaching tests. Molasses' flavonoid content can reach up to 297 mg quercetin equivalents (QE)/100 g extract, which is significantly higher than that in other sugarcane products like juice (259 mg QE/100 g) or even common antioxidant-rich foods such as apples and onions[27]. Moreover, Non-centrifugal sugar (NCS), also known as jaggery or panela, is another sugarcane product that maintains most of its phenolic compounds and minerals due to minimal refining, including gallic acid and flavonoids, which demonstrate high antioxidant capacities across DPPH, ABTS, and β-carotene-linoleate assays[26]. Bagasse, the fibrous residue left after juice extraction, is another sugarcane product gaining interest due to its high concentration of lignin-bound polyphenols. While bagasse is predominantly utilized as a boiler fuel, it is now being valued for its antioxidant properties. Bagasse phenolic extracts contain high quantities of catechin, epicatechin, gallic acid, caffeic acid, and ferulic acid, all of which have significant antioxidant properties. Recent extraction investigations have demonstrated that bagasse-derived polyphenol-rich fractions can achieve significant DPPH radical scavenging capacity and even protect cellular systems from damage caused by oxidative stress[1].

Sugarcane straw has been shown in studies to have various types of hydroxybenzoic acids, hydroxycinnamic acids, and flavonoids with significant antioxidant activity based on the findings using ABTS and DPPH[28]. These compounds not only contribute to radical scavenging capabilities, but they also have antibacterial, anti-inflammatory, and anti-diabetic properties, which makes sugarcane straw extract, which used to be considered waste, a potential alternative for medicine products. In addition, lignin derived from sugarcane bagasse and straw demonstrated strong antioxidant activity. Lignin, a complex aromatic biopolymer, contributes to antioxidant action via its phenolic hydroxyl groups and ability to chelate metals, lowering oxidative

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stress[29]. Lignin extraction and purification procedures have demonstrated its promise as a natural antioxidant ingredient in bioproducts, cosmetics, and materials. These lignin-based solutions can help to replace synthetic antioxidants while also improving environmental sustainability. These useful polyphenols play a role to neutralize reactive oxygen species, preserve biological components from oxidative damage, and contribute to the health advantages. The polyphenol profiles and antioxidant efficacy of these sugars vary amongst sugarcane varieties, highlighting the possibility of selective breeding and processing approaches to maximize their functional benefits.

Conclusion

Sugarcane leaves, stems, and derived products have remarkable antioxidant potential due to their high concentration of polyphenols, flavonoids, and other bioactive chemicals. These natural antioxidants have beneficial free-radical scavenging capacities, as well as antibacterial, anti-inflammatory, and antidiabetic properties. The varied antioxidant actions of sugarcane components emphasize their potential applications in the pharmaceutical, dietary supplement, food preservation, and cosmetic industries.

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Conflict of Interest

There is a no conflict of interest.

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