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Sweet potato bioactives: A comprehensive exploration of physiological functions and multidisciplinary applications

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Abstract

This article provides a review of sweet potato plants. Sweet potatoes, as an important global food and economic crop, possess both nutritional and functional characteristics. Its tubers, leaves and epidermis are rich in a variety of bioactive substances and have significant physiological functions. This review summarizes their functions of anti-oxidation, anti-bacterial, anti-inflammatory, anti-diabetes, anti-cancer, anti-hepatotoxicity, anti-aging, promoting intestinal health, anti-hypertension, lowering blood lipid and anti-atherosclerosis. This article summarizes the nutritional components of sweet potatoes, their applications in the food industry, their potential efficacy in the pharmaceutical field, their nutritional value as feed, and their development prospects in the energy sector. This review explores the comprehensive utilization value of sweet potatoes, providing theoretical basis and practical reference for their further development and utilization.

Keywords: Sweet potato, physiological function, application

1. Introduction

Sweet potato (*Ipomoea batatas*) is recognized as one of the most extensively studied members of the Convolvulaceae family ^[1]. Originating from Central America, it is now the seventh most important food crop globally ^[2]. Sweet potatoes are a cornerstone crop in warm climates due to their minimal resource demands and rapid maturation cycles ^[3].

Cultivars vary by skin and flesh color, with orange-fleshed varieties rich in carotenoids and purple-fleshed varieties rich in anthocyanins ^[4, 5]. The roots, leaves, and stems contain phytochemicals like phenolics, flavonoids, and anthocyanins, as well as essential nutrients. Starch accounts for 80% of dry matter ^[6]. Purple-fleshed cultivars are rich in acylated anthocyanins with antioxidative properties ^[7]. Leaves contain polyphenols at levels 7-9 times higher than grape seeds (Table 1) ^[8]. Due to their nutritional value, sweet potato consumption is increasing globally ^[9]. Reported biological activities include antioxidant, anti-cancer, and anti-diabetic effects ^[10]. Orange-fleshed sweet potatoes address vitamin A deficiency ^[2], while purple varieties show neuroprotective effects ^[11, 12]. This article reviews the physiological functions and applications of sweet potatoes.

2. Physiological functions

Sweet potato extracts demonstrate antioxidant capacity correlated with phenolic content, with flavonoids and anthocyanins contributing to oxidative stress mitigation through pathways including AMPK/SIRT1/PGC1 α ^[13-16]. The extracts display antibacterial activity against pathogens like *Staphylococcus aureus* and *Escherichia coli* through disruption of cell division and membrane integrity ^[17, 18]. Anti-inflammatory effects involve suppression of pro-inflammatory mediators including IL-1 β , IL-6, and nitric oxide ^[19-21].

For metabolic disorders, Caiapo tablets (white sweet potato extract) reduce HbA1c and improve insulin sensitivity ^[22]. Purple sweet potato anthocyanins regulate glycemic control, while leaf extracts reduce hyperglycemia in diabetic models through inhibition of α -glucosidase and α -amylase ^[23-26].

Anticancer activity is demonstrated through daucosterol compounds inhibiting breast cancer cell proliferation and anthocyanins inducing apoptosis in various cancer cell lines ^[27-29].

Antihypertensive effects include protection against chemical-induced hepatotoxicity through reduction of oxidative damage and inhibition of hepatic stellate cell proliferation [30-32].

Anti-aging properties are evidenced by improved cognitive function in aging mouse models through reduced oxidative stress [33, 34]. Sweet potato dietary fiber promotes probiotic

growth while suppressing pathogens, showing prebiotic effects comparable to fructooligosaccharides [35-37].

Cardiovascular benefits include reduced systolic blood pressure through ACE inhibition, elevated HDL-C levels, reduced atherogenic lipid ratios, and decreased aortic plaque coverage [38-42].

Table 1: Nutritional composition of sweet potato leaves and tubers.

Nutrient Category	Sweet Potato Leaves	Sweet Potato Roots (Tubers)
Macronutrients	Protein, crude fiber, crude fat, carbohydrates	Protein, dietary fiber, carbohydrates (amylose, amylopectin), fat
Vitamins	Vitamin C, β -carotene	Vitamin C, β -carotene (orange-fleshed varieties)
Minerals	Calcium (Ca), magnesium (Mg), sodium (Na), manganese (Mn), copper (Cu), iron (Fe), zinc (Zn), potassium (K), phosphorus (P)	Potassium (K), magnesium (Mg), zinc (Zn), iron (Fe), manganese (Mn), sodium (Na)
Bioactive Compounds	Polyphenols (7-9 $\times$ higher than grape seeds), flavonoids, tannins, steroids	Anthocyanins (purple-fleshed varieties), carotenoids (β -carotene in orange-fleshed varieties), phenolic acids, flavonoids
Dietary Fiber	Soluble and insoluble dietary fiber	Resistant starch, soluble and insoluble dietary fiber
Other Components	Antioxidants (e.g., hydroxycinnamic acids)	Starch (80% of dry matter), non-nutritional factors (e.g., amylase inhibitors)

3. Applications

Sweet potatoes are utilized across multiple sectors. In the food industry, they can be directly consumed or processed into starch products including vermicelli, as well as syrup, jam, vinegar, and soy sauce. Anthocyanin-rich extracts are used in health products, while β -carotene-rich varieties are used in infant foods [43, 44].

In pharmaceutical applications, anthocyanins are used in cardiovascular health products. Dietary fiber promotes intestinal probiotic proliferation and activates AMPK/SIRT1 to reduce lead-induced kidney damage. β -carotene from orange-fleshed sweet potato addresses vitamin A deficiency, particularly in Africa [45-48].

In agriculture, tubers, leaves, and residues serve as livestock feed and silage. Sweet potato rotation with corn or soybean improves soil structure and fertility. For environmental protection, sweet potato starch can be fermented to produce bioethanol and used to manufacture biodegradable packaging materials [49, 50].

4. Discussion

Anthocyanin and carotenoid content correlates with antioxidant capacity, with extracts regulating AMPK/SIRT1 and Nrf2 pathways. Human studies remain limited, requiring further clinical validation [7, 11, 38]. Sweet potato extracts show hypoglycemic effects comparable to pharmaceuticals with fewer adverse effects, though long-term safety studies are lacking. Phytosterols and anthocyanins demonstrate anticancer potential, though bioavailability concerns remain [22, 26, 27, 28].

Prebiotic properties promote probiotic growth, while antihypertensive and lipid-modulating effects are documented, though sustained dietary intake is necessary [35, 38, 39]. Sweet potato byproducts can produce bioethanol and biodegradable polymers, though scaling requires technological innovation [49, 50].

Most research is preclinical with limited human trials. Standardization is challenged by cultivar variability. Future research should focus on clinical trials, bioavailability optimization, sustainable practices, and cultivar development.

5. Conclusion

Sweet potato bioactives can address nutritional and medicinal needs while supporting sustainability. Addressing standardization and translational research challenges will maximize their global impact.

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