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Updated Review on the Phytochemicals and Pharmacological Properties of Ipomoea batatas L.

Chen Hao[1], Liu Yang[1], Wang Mei[1*]

[1]School of Pharmacy, Sichuan University, Chengdu, China.

***E-mail** ✉ wang.mei@yahoo.com

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ABSTRACT

This review presents a comprehensive overview of Ipomoea batatas L., belonging to the Ipomoea genus, highlighting its traditional uses, nutritional profile, phytochemical composition, pharmacological activities, and toxicity evaluations. Information was gathered from scientific databases and online search engines. Sweet potatoes are traditionally utilized in many countries as sources of dietary fiber, remedies for allergies, and energy boosters, particularly in the management of diabetes mellitus. Key phytochemicals in Ipomoea batatas include phenolic compounds, flavonoids, anthocyanins, and carotenoids, while its nutritional components comprise vitamin C, protein, fiber, carbohydrates, β-carotene, and essential minerals. The plant demonstrates diverse pharmacological effects, including antioxidant, aphrodisiac, anticancer, and anti-inflammatory activities. Phytochemical content varies among different plant parts, and the pharmacological effects and mechanisms are influenced by the specific phytochemicals, plant part, variety, and extraction method. Nevertheless, additional research is needed to assess the chronic toxicity of Ipomoea batatas.

Keywords: Updated review, Ipomoea batatas, Pharmacological, Traditional use, Phytochemical

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Introduction

Ipomoea batatas (L.) Lam. is a member of the Ipomoea genus, the largest within the Convolvulaceae family [1]. Several varieties of I. batatas exist, distinguished by the color of their tuber peel and flesh, including purple-purple, purple-orange, yellow-yellow purple, and yellow-yellow orange (YYO) [2]. This tuberous-rooted perennial plant is typically cultivated as an annual. Its stems grow as trailing vines up to 4 m in length, usually slender and prostrate, containing milky sap and short, unbranched shoots. The leaves are ovate-cordate, borne on long petioles, and vary by variety in being palmately veined, angular, or lobed, with green or purplish coloration. Flowers are infrequent, presenting a funnel-shaped corolla in white or pale purple, arranged in cymes. The round pods contain 1–4 flattened, hard-coated seeds. Native regions include tropical America, India, China, the Philippines, and the South Sea Islands [3]. Sweet potato is a crop of significant economic importance globally, ranking as the eighth most critical food crop in the tropics and sixth worldwide in terms of annual production, following sugarcane, maize, rice, wheat, and raw milk. Although it originated in Central and western South America, major cultivation now occurs in China, Malawi, Tanzania, Nigeria, and Indonesia [4].

Sweet potatoes are rich in phytochemical compounds, including phenolics, flavonoids, anthocyanins, carotenoids, and tannins, distributed across roots, tubers, leaves, and stems [5, 6]. They also provide essential nutrients such as vitamin C, protein, fiber, carbohydrates, β-carotene, amylose, amylopectin, fat, and minerals [7–9].

Traditionally, sweet potatoes have been utilized in countries such as Malaysia, Pakistan, the Philippines, Indonesia, and Tanzania, serving as a dietary fiber source, a remedy for allergies and anemia, and an energy booster for individuals with diabetes mellitus [10–16]. Numerous studies have demonstrated that bioactive compounds in sweet potatoes exhibit diverse pharmacological activities, including antioxidant, aphrodisiac,

genoprotective, anticancer, antibacterial, anti-inflammatory, antihypertensive, hypolipidemic, antidiabetic, xanthine oxidation inhibition, hypouricemic, antidepressant, wound healing, prebiotic, anti-obesity, anti-sickling, immunostimulant, anti-fatigue, diuretic, and hepatoprotective effects.

Previous research highlights the long-standing medicinal value of sweet potatoes, which contain a variety of phytochemicals responsible for distinct pharmacological actions [17]. Building on this foundation, the current review provides an updated and comprehensive overview of the plant's traditional uses, nutritional composition, phytochemical content, pharmacological activities, and toxicity, focusing on studies conducted from 2013 to 2022. The review also compares the phytochemical profiles and pharmacological effects among different plant parts and cultivars.

Materials and Methods

Information for this review was collected by searching scientific databases and search engines, including PubMed, Elsevier, Springer, Frontiers, Google Scholar, Scopus, ScienceDirect, and MDPI. Search terms targeted Ipomoea batatas, emphasizing traditional uses, ethnomedicine, ethnobotany, nutritional composition, phytochemicals, pharmacological activities, toxicity, and related properties such as antioxidant, aphrodisiac, and genoprotective activities. Articles published within the past ten years were considered, with at least 30 studies from the last two years. Digital Object Identifiers (DOIs) were included for easy reference and citation.

Traditional uses

In Malaysia, sweet potatoes are commonly consumed in desserts and snacks and can serve as a supplementary staple to rice. Nutritionally, they are comparable to rice in protein content but superior in dietary fiber, minerals, and vitamins. Dietary fiber supports the management of diabetes, constipation, and possibly colorectal cancer. Potassium contributes to hypertension prevention and cardiovascular health, calcium supports bone strength, and iron is particularly important for women of childbearing age. Vitamins A, C, and E provide strong antioxidant effects against fetal malformations, certain cancers, and aging, while vitamin E reduces cardiovascular disease and stroke risk [13].

In Pakistan, I. batatas, locally called "Shakarqandi," is traditionally used to address infertility, allergies, arthritis, cardiovascular disease, cancer, HIV, and aging [11, 14, 15]. On Batan Island, Philippines, it is used for anemia and diarrhea [10]. In Bulumario Village, North Sumatra, Indonesia, sweet potatoes serve as an energy source for individuals with diabetes mellitus [16]. In northern Benin, sweet potato flour is a nutritional supplement combating malnutrition in children, particularly vitamin A deficiency [18], while farmers use the leaves for headache relief and raw tubers to improve sexual function. In southern and central Benin, sweet potato roots and leaves are employed to prevent or treat diseases, showing potential aphrodisiac, anti-anemic, abortifacient, wound-healing, antimicrobial, purgative, analgesic, blood pressure–regulating, and antimalarial effects [19]. In Mkuranga, Tanzania, I. batatas is used to treat anemia due to its iron and ascorbic acid content, as ascorbic acid enhances absorption of non-heme iron, supporting its ethnomedicinal anti-anemic role [12].

Nutritional values

Sweet potato is widely consumed for its nutritional advantages. Its tubers, roots, and leaves serve as important dietary sources, providing proteins, carbohydrates, vitamins, and minerals. The nutrient composition varies among these plant parts, while the stems have been less studied in terms of their nutritional content. **Table 1** summarizes the nutritional components found in different parts of Ipomoea batatas.

Table 1. Parts of sweet potato with nutritional constituents.

Plant part	Nutritional constituents	References
Tubers and roots	Vitamin C, Protein, fiber, carbohydrates, β-carotene, amylose, amylopectin, fat, mineral (potassium, magnesium, zinc, iron, manganese, sodium)	[7–9]
Leaves	Protein, crude fiber, crude fat, carbohydrates, mineral (calcium, calcium, magnesium, sodium, manganese, cuprum, iron, zinc, potassium, phosphorus), vitamin C, β-carotene	[20, 21]

Phytochemical compounds

Sweet potato (Ipomoea batatas) contains a variety of bioactive phytochemicals distributed across its roots, tubers, leaves, and other plant parts, which contribute to its health-promoting properties. Major phytochemicals identified in the plant include phenolic compounds, flavonoids, anthocyanins, carotenoids, and tannins [22]. These substances are largely responsible for the plant's strong antioxidant activity, as they can donate hydrogen atoms, neutralize singlet oxygen, and act as effective reducing agents [23]. An overview of the different types of secondary metabolites and phytochemicals in each part of Ipomoea batatas is displayed in **Table 2**.

Table 2. Parts of sweet potato with class and phytochemical compounds.

Plant part	Classes of secondary metabolites	Phytochemical compounds	References
Tubers and roots	Flavonoids	Rutin, apigenin, myricetin, and quercetin	[5, 24–29]
	Phenolic	Gallic acid, catechin, caffeic acid	
	Anthocyanins	Cyanidin-3-O-(6"-p-hydroxybenzoylsophoroside)-5-O-glucoside and cy-3-O-(6",6"-dicaffeoylsoph)-5-O-glc	
	Sesquiterpen	Trifostigmanoside I	
	Carotenoids	β-carotene isomer, β-cryptoxanthin, β-carotene mono-epoxides and di-epoxides, lutein epoxide, lutein, violaxanthin isomers, β-zeaxanthin isomers	
	Chlorogenic acid	5-caffeoylquinic acid, 6-O-caffeoyl-b-D-fructofuranosyl-(2-1)-a-D-glucopyranoside, trans-4,5-dicaffeoylquinic acid, 3,5-dicaffeoylquinic acid, and 4,5-dicaffeoylquinic acid	
Leaves	Carotenoids	Lutein, zeaxanthin, β-xanthine, 13 cis β-carotene, All-trans β-carotene, and β-9 cis β-carotene)	[5, 6, 30, 31]
	Anthocyanins	cyanidin-3-O-(6"-p-hydroxybenzoylsophoroside)-5-O-glucoside [cy-3-O-(6"-p-hydroxybenzoylsoph)-5-O-glc], peo-3-O-(6"-p-hydroxybenzoylsoph)-5-O-glc, cy-3-O-(6",6"-dicaffeoylsoph)-5-O-glc, cy-3-O-(6"-caffeoyl-6"-p-hydroxybenzoylsoph)-5-O-glc, cy-3-O-(6"-caffeoyl-6"-feruolylsoph)-5-O-glc, peo-3-O-(6",6"-dicaffeoylsoph)-5-O-glc, peo-3-O-(6"-caffeoylsoph)-5-O-glc, peo-3-O-(6"-caffeoyl-6"-p-hydroxybenzoylsoph)-5-O-glc, and peo-3-(6"-caffeoyl-6"-feruolylsoph)-5-glc)	
	Diterpene	Phytol	
	Fatty acid	(Z)-9-Octadecenamide	
Stem	Phenolic	1,4-benzenediol (hydroquinone) and benzenesulfonic acid	[32, 33]

Pharmacological activities

Antioxidant activity

The tubers and roots of Ipomoea batatas have demonstrated considerable antioxidant effects in multiple in vitro assays, although the strength of this activity varies depending on the type of extract and solvent used. Among the solvents tested, ethyl acetate extracts consistently showed superior antioxidant potential compared to ethanolic extracts, largely due to their rich polyphenol content [26]. Studies have also shown a strong positive relationship between phenolic concentration and DPPH radical scavenging, indicating that antioxidant efficacy increases with higher phenolic levels [34].

In silico analyses revealed that aqueous extracts of sweet potato tubers can restore normal levels of key antioxidant enzymes, reduce lipid peroxidation, and counteract ROS accumulation and mitochondrial TCA cycle disruptions caused by bisphenol A (BPA), while also preventing histopathological damage [35]. Flavonoids, particularly anthocyanins, are considered major contributors to these antioxidant effects [36]. Purple anthocyanin-rich sweet potatoes (APSP) may also mitigate lead-induced reproductive toxicity through JNK signaling modulation and antioxidant action [37]. Similarly, high-soluble dietary fiber (HSDF) from sweet potatoes has been shown to reduce oxidative stress and protect against lead-related kidney injury [38].

Ethyl acetate extracts of purple-orange tubers (PO2) exhibited the strongest antioxidant activity, with the lowest IC50 for DPPH (10.54 μg/mL) and the lowest EC50 for FRAP (11.14 μg/mL), confirming previous observations that ethyl acetate efficiently extracts antioxidant compounds [39, 40]. PO2 extracts also contained the highest total phenolic (11.91 g GAE/100 g) and flavonoid (17.83 g QE/100 g) levels [2]. Red sweet potato varieties also display

significant antioxidant activity in both peel and pulp, with ethanolic peel extracts (PERS) and methanolic pulp extracts (PUWS) achieving DPPH scavenging rates of 90.26% and 88.59%, respectively [41]. Flavonoids act as antioxidants by scavenging free radicals, inhibiting ROS-producing enzymes, and supporting the body's antioxidant defenses, while phenolics mainly function through hydrogen atom donation [42, 43].
In sweet potato leaves, antioxidant activity depends not only on the plant part but also on the extraction solvent. Maximum DPPH scavenging was observed in 50% acetone extracts (36.6 mg VcE/g DM), followed by 70% acetone (35.1 mg VcE/g DM) and 50% ethanol (33.4 mg VcE/g DM) extracts [44].

Aphrodisiac and gonadoprotective activity
Research in animal models has shown that extracts from sweet potato tubers and vines enhance sexual function and protect reproductive organs. These extracts improve libido, sexual performance, and penile erection, with ethyl acetate extracts generally showing the strongest effects. Compounds such as polyphenols, vitamins, proteins, and iron support blood flow to reproductive tissues, while polyphenols, tannins, anthocyanins, terpenoids, and zinc contribute to spermatogenesis and reproductive health. Gonadoprotective effects were also demonstrated in BPA-exposed rats, reflected by reduced mounting and intromission frequencies and increased hesitation times [26]. Secondary metabolites, including rutin, quercetin, and gallic acid, play a critical role in supporting male reproductive function. In particular, gallic acid mitigates reproductive toxicity by reducing lipid peroxidation, enhancing antioxidant defenses, and regulating hormone levels [45, 46].

Genoprotective activity
Studies have shown that extracts from sweet potato tubers and stems can protect DNA from oxidative damage. Compounds such as polyphenols, tannins, and terpenoids help neutralize free radicals and bind iron ions, preventing the Fenton reaction that leads to DNA strand breaks. These extracts have been effective against hydrogen peroxide-induced damage in pBR322 DNA by lowering reactive oxygen species (ROS), reducing DNA fragmentation, and improving cell survival, highlighting their role as natural genoprotective agents [26].

Provitamin a activity
Sweet potatoes are an excellent dietary source of provitamin A carotenoids, which the body converts into vitamin A, helping prevent deficiency. β-Carotene content in tuber flours varies widely among cultivars, ranging from very low in white varieties to high levels in orange-fleshed types (0.19–22.71 μg/g DM). Orange-fleshed sweet potatoes are particularly effective in combating vitamin A deficiency among children in rural communities of Côte d'Ivoire [47]. Consuming as little as 6 g of dry orange sweet potato or 25 g of other varieties daily can meet recommended vitamin A intake [48]. Incorporating 80% orange-fleshed sweet potato into white maize meal has also been shown to significantly increase provitamin A intake in children aged 6–59 months, offering a practical strategy to reduce deficiency in rural populations [49].

Anticancer activity
Phytosterols present in I. batatas, including daucosterol linolenate (DLA), daucosterol linoleate (DL), and daucosterol palmitate (DP), demonstrate inhibitory effects on breast cancer cells. In vitro, DL showed the strongest suppression of MCF-7 cell proliferation, while in vivo studies in nude mice xenograft models confirmed that these compounds can slow tumor growth. The mechanism involves cell cycle arrest, induction of apoptosis, mitochondrial membrane depolarization, and modulation of the Bax/Bcl-2 protein ratio [50, 51].
Anthocyanins from sweet potato leaves and tubers also induce apoptosis in cancer cells. Leaf anthocyanins, in particular, have shown slightly stronger effects on HCT-116 and HeLa cell lines compared to tuber anthocyanins [5]. Diets enriched with 10% purple sweet potato flesh, skin, or 0.12% anthocyanin extracts over 18 weeks decreased adenoma formation in APCMIN mice, largely by inhibiting tumor cell proliferation [52]. Anthocyanins, as flavonoids, can regulate miR-27a, reducing cancer development and offering a potential preventive and therapeutic role [53, 54].

Antibacterial activity
Methanol extracts of sweet potato tubers have exhibited antibacterial properties against multiple pathogens, including Staphylococcus aureus, Escherichia coli, Streptococcus pyogenes, and Serratia marcescens. Cold

extracts tend to be more effective than hot extracts, with flavonoids playing a major role by disrupting bacterial cell division [33, 55–57].

Antibacterial activity varies by plant part and extract type. Red tubers inhibit S. aureus and Bacillus subtilis, while white tubers are more effective against Pasteurella multocida [41]. Ethanol extracts of leaves, containing flavonoids, tannins, steroids, and other polyphenols, also show activity against Shigella dysenteriae, with dose-dependent inhibition at MIC values of 10–20% w/v [58]. Certain flavonoid glycosides, such as chrysoeriol derivatives, exert antibacterial effects by damaging the bacterial membrane, increasing permeability, causing leakage of intracellular contents, and ultimately leading to bacterial cell death [59].

Anti-inflammatory activity

Both tubers and roots of Ipomoea batatas have demonstrated the ability to reduce inflammation and oxidative stress in both acute and chronic conditions. Various experimental models, including heat-induced albumin denaturation, carrageenan-induced paw edema, and croton oil-induced ear and anal edema, have confirmed the anti-inflammatory effects of sweet potato extracts compared with controls. Among these, the IPR-EA extract showed the most pronounced edema reduction, inhibiting carrageenan-induced paw swelling by 79.11 ± 5.47% and croton oil-induced ear and anal edema by 72.01 ± 7.80% and 70.80 ± 4.94%, respectively [60]. Additionally, ethanol extracts of purple sweet potato tubers, which are rich in anthocyanins, were found to lower liver levels of pro-inflammatory cytokines such as TNF-α and IL-6, indicating their potential in modulating inflammatory responses [61].

Phenolic compounds from sweet potato leaves (SPLPA), including caffeic acid, at concentrations of 0.2 mg/mL, significantly decreased nitric oxide (NO) production and downregulated inflammation-associated factors such as iNOS, TNF-α, IL-6, and NF-κB. These extracts also preserved the integrity of Caco-2 cell monolayers, highlighting their promise as anti-inflammatory agents [62].

Antihypertensive activity

Purple sweet potato tuber aqueous extracts have been shown to reduce systolic blood pressure (SBP) significantly ($p < 0.05$) across treatment groups. Administration of 100 mg of the extract effectively prevented SBP elevation for up to ten days. Peptic hydrolysates derived from sweet potato proteins also exhibit antihypertensive activity by inhibiting angiotensin-converting enzyme (ACE), a key regulator of blood pressure. Hydrolysates with molecular weights between 1 and 5 kDa demonstrated the strongest ACE-inhibitory effect, with an IC50 of approximately 0.396 mg/mL [63].

Clinical studies support these findings; in Caucasian participants, consumption of a purple-fleshed sweet potato beverage for four weeks led to significant reductions in SBP ($p = 0.0125$). Acylated anthocyanins present in these tubers are believed to contribute to blood pressure reduction by enhancing vascular relaxation [64].

Hypolipidemic and anti-atherosclerotic activity

Sweet potato root-derived proteoglycans (SPG) demonstrate lipid-lowering effects by increasing serum HDL-C through activation of lecithin-cholesterol-acyltransferase (LCAT), raising ApoA-I levels, and decreasing serum lipid concentrations via modulation of lipoprotein lipase (LPL) activity [65].

Leaf extracts of I. batatas have also shown potential in improving lipid profiles and atherosclerotic outcomes. Four weeks of treatment with these extracts significantly reduced LDL-C/HDL-C and TC/HDL-C ratios ($p < 0.01$) at all tested doses. Extract administration, as well as atorvastatin, decreased aortic thickness and surface area, although only doses of 500 and 600 mg/kg produced statistically significant reductions ($p < 0.05$). Hypercholesterolemic animals treated with the extracts exhibited fewer and less prominent atherosclerotic plaques compared with untreated controls [66].

Flavonoids such as luteolin and luteoloside further contribute to lipid regulation and improvement of hepatic steatosis. Their beneficial effects are likely mediated through antioxidant mechanisms and modulation of liver enzymes involved in fatty acid, cholesterol, and triglyceride metabolism [67].

Antidiabetic and hypoglycemic effects

Extracts from the leaves of Ipomoea batatas Simon No. 1 cultivar have demonstrated protective effects on pancreatic beta cells and a reduction of insulitis in STZ-induced diabetic rats, highlighting their antidiabetic potential [68]. Within the phenolic acids identified in sweet potato leaves, ethyl caffeate emerged as the strongest

α-glucosidase inhibitor, exhibiting an IC50 of 70 ± 1 μg/mL, which is approximately 6.77 times more effective than acarbose. Additionally, both phenolic acids and flavonoids suppressed α-amylase activity, with ethyl caffeate showing an IC50 of 8.0 ± 0.3 μg/mL, making it 13.1 times more potent than acarbose [69].

Cyanidin 3-caffeoyl-p-hydroxybenzoylsophoroside-5-glucoside, the main anthocyanin in purple-fleshed sweet potato, was reported to decrease hepatic glucose production and lower blood glucose effectively. Oral administration in vivo significantly reduced fasting blood glucose levels, which initially ranged between 186–205 mg/dL [70]. Studies with white-skinned sweet potato (WSSP) roots and peel revealed significant decreases ($p<0.05$) in blood glucose, protein glycation, total cholesterol, triglycerides, and LDL-cholesterol, while HDL-cholesterol levels increased significantly ($p<0.05$), suggesting potential for managing diabetes and improving lipid metabolism [71].

Ethanolic leaf extract of I. batatas (EIBL) also exhibited blood sugar-lowering effects in STZ-induced rats. This activity was linked to flavonoids functioning as antioxidants, with a clear dose-dependent correlation between flavonoid concentration and antihyperglycemic effect. Furthermore, a positive relationship was observed between the effects of flavonoid antioxidants and glibenclamide. Anthocyanins in the extract contributed to maintaining blood glucose by limiting sugar absorption and protecting pancreatic beta cells [72].

Xanthine oxidase inhibition and hypouricemic activity

Anthocyanin-rich extract from purple sweet potato (APSPE), prepared from dried powder, displayed uric acid-lowering effects in hyperuricemic mice through inhibition of xanthine oxidase (XO) in both laboratory and live models. In vitro studies demonstrated a dose-dependent XO suppression, while in vivo, APSPE reduced XO activity in the liver and decreased serum uric acid levels [73]. The extract inhibited XO with an IC50 of 7.194 ± 0.858 × 10^{-5} mol C3G equivalent L. Computational analysis identified fraction 3 as containing the most effective XO inhibitors, including cyanidin 3-sophoroside-5-glucoside, cyanidin 3-(6’’-caffeoyl-6’’-feruloyl sophoroside)-5-glucoside, and peonidin 3-(6’’-caffeoyl-6’’-feruloyl sophoroside)-5-glucoside [74]. Moreover, 25 mg/kg of double acylated anthocyanins from purple sweet potato (HAA-PSP) were more effective than APSPE in lowering uric acid and inhibiting key enzymes in its production [75].

Antidepressant potential

Computational studies suggest that cyanidin-3-O-glucoside and peonidin-3-O-glucoside, predominant anthocyanins in purple sweet potato tubers, may have antidepressant effects by interacting with D2 dopamine receptors [76].

Wound healing properties

A 1% gel containing ethanolic extract of I. batatas root peels produced the most notable wound closure in mice compared to other treatments. Anti-inflammatory secondary metabolites—including gallic acid, kaempferol, rutin, catechin, and quercetin—limited neutrophil infiltration and decreased TNF-α, IL-1β, and NO levels. Anthocyanins enhanced this effect by suppressing pro-inflammatory cytokines and NF-κB signaling [60, 77–79].

Ointments derived from white sweet potato tubers (2.5%) significantly promoted wound healing, as demonstrated by increased metaphase cell counts and accelerated tissue re-epithelialization, showing a 4.5-fold improvement ($p<0.01$). Re-epithelialization was 43% and 75% more pronounced after 4 and 10 days of treatment, respectively, compared with Beeler’s base, likely due to carotenoids and polyphenols mitigating oxidative stress during inflammation [80].

In vitro experiments with the anthocyanin-rich ‘Sinjami’ cultivar showed that tip and tuber extracts achieved 75% wound closure at 100 μg/mL and 90% at 32 μg/mL, indicating that anthocyanins can act as natural wound-healing agents by modulating inflammatory responses [81].

Prebiotic activity

Flours from roots of four sweet potato varieties—two with white skin (Rainha branca and Campina branca) and two with purple skin (Vitória and Lagoinha)—contain varying amounts of fiber, resistant starch, fructooligosaccharides (FOS), phenolics, and sugars. These flours demonstrated prebiotic potential by selectively promoting the growth of beneficial microbes such as Lactobacillus acidophilus, Lactobacillus casei, and Bifidobacterium animalis, while inhibiting the growth of competing enteric bacteria [82].

Further microbial studies revealed that peonidin derivatives (P1–P5) and anthocyanins from purple sweet potato (PSPAs) stimulated the proliferation of Bifidobacterium bifidum, Bifidobacterium adolescentis, Bifidobacterium infantis, and Lactobacillus acidophilus [83]. Extracted sweet potato fiber (SPFE) from the Bestak cultivar showed prebiotic activity comparable to FOS and higher than inulin. Specifically, Lactobacillus plantarum Mut7 grew significantly on SPFE (3.21 log CFU/mL), while Bifidobacterium longum performed better on FOS (2.19 log CFU/mL). The highest prebiotic activity score was 1.62 for L. plantarum Mut7 on SPFE, likely due to the abundance of prebiotic compounds such as FOS, inulin, and raffinose [84].

Anti-obesity effects

Administration of high doses of purple sweet potato color (PSPC) to rats on a high-fat diet (HFD) markedly reduced obesity ($p<0.01$), with effects comparable to control rats. PSPC's anti-obesity action may result from anthocyanins and other flavonoids that reduce oxidative stress and modulate leptin/AMPK signaling in the hypothalamus [85].

Consumption of sweet potato leaves alongside a HFD also demonstrated anti-obesity effects. Mice fed a 5% freeze-dried sweet potato leaf powder (SPLP) exhibited significantly lower body weight gain and adipose tissue accumulation without reducing food intake, likely due to polyphenols and dietary fiber influencing lipid metabolism [86]. Fermented purple sweet potato (PSP) similarly prevented abnormal white adipose tissue expansion and body weight gain in obese mice, potentially through promoting adipose browning and providing antioxidant protection against HFD-induced stress [87].

Antisickling activity

Anthocyanin extracts from sweet potato leaves were able to restore sickle-shaped erythrocytes to their normal biconcave shape, particularly under hypoxic conditions. The antisickling effect is attributed to anthocyanins' interaction with hemoglobin, which inhibits the polymerization of hemoglobin S and prevents erythrocyte sickling [88].

Immunostimulatory effects

Fiber extracts from sweet potato tubers (SFE) enhanced IgM production by HB4C5 cells following heat and dialysis treatment, indicating immunostimulatory potential in vitro [89]. The 18.3 kDa polysaccharide component PSPP-1 from purple sweet potato tubers boosted RAW264.7 macrophage functions, including phagocytosis, nitric oxide and reactive oxygen species production, and cytokine secretion. PSPP-1 activated both TLR2- and TLR4-mediated pathways, enhancing protein expression in MyD88-dependent, MAPK, NF-κB, AP-1, and TRIF-dependent signaling pathways [90]. Sweet potato glycoprotein (SPG-1) also increased immune activity in a dose-dependent manner, reflected by elevated serum lysozyme and T-cell responses [91].

Anti-fatigue effects

Total flavonoids from sweet potato leaves (TFSL) significantly improved endurance in mice, as evidenced by extended swimming time. TFSL reduced blood lactic acid (BLA), lowered serum urea nitrogen (SUN), and increased glycogen stores in liver and muscle, demonstrating its capacity to mitigate fatigue [92].

Diuretic effects

An aqueous extract of I. batatas root (AEIB) at 400 mg/kg (p.o.) significantly increased urine output ($p<0.01$). The diuretic effect may be linked to the presence of carbohydrates, flavonoids, and tannins [93]. While the exact mechanism remains unclear, flavonoids like quercetin are thought to contribute by interacting with adenosine A1 receptors, which are associated with diuretic activity [94].

Hepatoprotective activity

Administration of sweet potato leaf extract (SPLE) significantly lowered cholesterol and triglyceride levels ($p<0.05$) compared to the negative control group. Among the doses tested, 200 mg/kg body weight of SPLE showed the greatest efficacy in reducing serum glutamic pyruvic transaminase (SGPT) and serum glutamic oxaloacetic transaminase (SGOT) levels. The quercetin present in SPLE functions as an antioxidant, neutralizing free radicals and protecting the liver from oxidative damage, which results in decreased SGOT and SGPT activity and demonstrates its hepatoprotective properties [95].

Water-soluble polysaccharides (PSWP) extracted from purple sweet potato tubers also displayed protective effects against acute liver injury induced by CCl4. Among the polysaccharides tested, PSWP exhibited the strongest hepatoprotective action. These polysaccharides exert their effects by scavenging free radicals through antioxidant enzymes, mitigating lipid peroxidation, and enhancing levels of GSH and total antioxidant capacity (T-AOC) [96].

Anthocyanins from purple sweet potato (APSPE) have likewise demonstrated hepatoprotective effects against CCl4-induced liver damage. APSPE effectively prevented liver weight gain, decreased aspartate transaminase (AST) and alanine transaminase (ALT) release, increased superoxide dismutase (SOD) activity and glutathione (GSH) content, and lowered malondialdehyde (MDA) levels in mice livers, indicating therapeutic potential against liver injury. The observed anti-cytolytic effects are likely attributed to anthocyanins [97, 98].

Toxicity

In vivo studies indicated that sweet potato extracts caused no significant behavioral changes, toxicity, or mortality during acute toxicity assessment. Doses ranging from 100 to 2000 mg/kg in rats were considered safe, as no deaths or overt signs of toxicity were observed [26]. Additional studies using 300–4000 mg/kg doses of various I. batatas extracts, including IPT-EA, IPT-M, IPR-EA, and IPR-M, confirmed safety even at the highest dose of 4000 mg/kg [60]. The LD50 for purple sweet potato extract exceeds 5,000 mg/kg body weight [99]. Aqueous extracts of leaves and stems showed no mortality at doses up to 10 g/kg, with an acute oral LD50 of 12.0 ± 1.2 g/kg [100], which contrasts with earlier studies suggesting potential liver toxicity [17].

In vitro cytotoxicity testing using Hoechst 33342 Live Cell Staining demonstrated that anthocyanins from purple sweet potato roots and leaves were non-toxic to cells at concentrations of 100–400 μg/mL [5]. I. batatas extracts showed no IC50 values, reflecting high cell viability (59.67 ± 0.83–63.34 ± 0.85%), suggesting its safe potential for therapeutic use [31].

Conclusion

The phytochemical composition varies across different parts of the plant. Consequently, the pharmacological effects and mechanisms of action depend on the plant part, variety, phytochemical profile, and extraction method.

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