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Review Article

A Review on Phytoconstituents and Pharmacological Study of *Ipomoea batatas*

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ABSTRACT

Sweet potatoes (Ipomoea batata L. Lam) are now thought to be a particularly fascinating nutritive diet due to their high content of health-promoting secondary metabolites and their richness in complex carbohydrates. Vitamins, minerals, antioxidants, dietary fiber, and vital fatty acids can all be found in sweet potatoes. A popular food crop around the world, sweet potatoes (Ipomoea batatas) are becoming acknowledged as functional foods because of a number of their nutraceutical qualities. Sweet potatoes' anti-inflammatory, immunomodulatory, antioxidant, anti-tumor, antibacterial and anti-ulcer properties can all be advantageous in the prevention or treatment of chronic illnesses. This research reviews the literature on the hematinic action of potato leaves and their capacity to improve certain hematological parameters. Moreover, the review offers a summary of the importance and impact of cultivar on the makeup and pharmacological properties of sweet potatoes. Numerous health-promoting compounds, some unique to specific kinds, can be found in sweet potatoes. To properly investigate the therapeutic potential of sweet potatoes, it is consequently necessary to continuously evaluate and choose cultivars with the right phytoconstituents composition and bioactivities.

INTRODUCTION

Ipomoea batatas is the scientific name for sweet potatoes. A vine belonging to the Convolvulaceae family produces this starchy root, which is a significant tropical crop.[1] Thirteen of the genus Ipomoea's more than 600 species are found in the section Batatas. All 13of these species are indigenous to the Americas; the only two that are farmed and hexaploid (6x=90) are the sweet potatoes. The complicated compatibility and sterility systems, as well as the differences in ploidy (chromosome level) between their wild relatives and sweet potatoes, prevent them from naturally cross-pollinating. In an effort to enhance several elements of sweet potatoes, researchers are experimenting with the usage of wild relatives

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while still utilizing biotechnology. The word "sweet potato variety" in this handbook refers to a group of sweet potato plants that are genetically unique and, as a result, have different qualities from other groups of sweet potato plants within the Species. A variety that has been chosen and grown is referred to as a cultivator. There are numerous varieties of sweet potato. Most of the roots have elongated slightly pointed shape to them, and come in a range of sizes, forms and colors. Depending on the variety the outside skin may be white, yellow, red, purple or brown, and the flesh white, yellow, orange or purple. There are a wide range of tastes and textures amongst the different sweet potato varieties[1].

Fig 1: **Sweet potato**

The classification of sweet potatoes as tuber crops or roots is sometimes unclear. It's a crop with roots. In tuber crops, the tuber is actually a modified stem (stolon or runner) that becomes bloated and specialized for use as a storage organ as it thickens. As a result, the tuber will feature nodes and internodes in addition to other typical stem components. A round or Irish potato is a tuber crop; each node, or eye, on the tuber is actually a leaf scar. The tuber's insides are composed of the pith, vascular zones, and cortex that characterize stem cell formations. The larger sweet potato roots, on the other hand, which are also utilized as storage organs, have the interior and external cell architectures of normal roots, devoid of buds, internodes, and nodes. With respect to other major food crops, potatoes rank seventh in the globe, behind wheat, rice, corn, barley, and cassava. Around 8 million hectares of agricultural land were devoted to the production of sweet potatoes in 2011, with developing nations producing the majority of the crop. a summary of the production of sweet potatoes by region.to emphasize the relatively enormous scope of sweet potato production in China, the data has been divided. In Africa, the sweet potato is especially important in the nations that surround the Great Lakes in East and Central Africa; in Southern Africa, Malawi, Angola, Mozambique, and Madagascar; and in West Africa, Nigeria[1]

Bioactive Compound

Several bioactive substances can be found in sweet potatoes, but the ones that are most abundant are (poly)phenols, terpenoids, tannins, saponins, glycosides, alkaloids, and phytosterols. This root vegetable's variation in skin and flesh color is caused by varying concentrations of (poly)phenols and carotenoids.[7][8][9] Therefore, phenolic acids and anthocyanins predominate in purple sweet potatoes, while phenolic acids, flavonoids, and carotenoids are more prevalent in yellow and orange-fleshed sweet potatoes. Apart from genetics, the concentration and bioavailability of bioactive compounds in sweet potatoes and their derivatives are impacted by exogenous factors like cultivar, storage conditions, and processing; additionally, the extraction and analytical techniques can have an impact on the data that is currently available.[11][12]

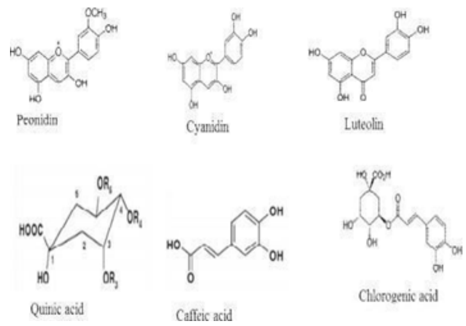

Fig. 2: **Some Phytochemicals in Sweet Potato**

Polyphenols

Sweet potatoes exhibit a notable quantity of phenolic acids and flavonoids. Purple-fleshed potatoes contain the highest concentrations of flavonoids in the form of quercetin glycosides and anthocyanins. A combination of phenolic acids,[9] primarily derivatives of caffeic acid, chlorogenic acid, and caffeoylquinic acid, are present in the yellow- and orange-fleshed tubers.

Flavonoids

Phenols Sweet potatoes include flavonoids such as quercetin, myricetin, luteolin, kaempferol, and apigenin, particularly the orange and purple flesh types. As previously stated, the amount of flavonoids varies depending on the variety; purple-fleshed sweet potatoes have a higher flavonoid content (579.5 µg/g dry weight) than orange- and white-fleshed sweet potatoes (121.1 µg/g dry weight) (45.4 µg/g dry weight).[13] Quercetin is the main flavonoid found in purple and orange potatoes, with myricetin, kaempferol, and luteolin following closely behind.[6]

Anthocyanins

A The flavonoid family called anthocyanins is what gives sweet potato flesh and skin their purple hue. With reported values ranging from 14 to 182 mg/100 g fresh weight,[7] the purple variety have higher total anthocyanin contents than the orange-fleshed species. Sweet potatoes have been found to have over 20 different types of anthocyanins.[14][15] The predominant ones found in purple cultivars are aglycones of peonidin, cyanidin, and pelargonidin 3-sophoroside-5- glucoside derivatives; nearly all of these are mono- or di-acylated with p-hydroxybenzoic acid, ferulic acid, or caffeic acid.[16] These acylated forms account for almost 98% of the anthocyanin concentration in purple sweet potatoes, The anthocyanin content varies greatly throughout types, though. Therefore, according to Im et al., "Sinjami," "Danjami," and "Yeonjami" have 72–77% more di-acylated anthocyanins More than 90–95% in the Korean cultivars "Jami" and "Borami." On the other hand, "Sinjami," "Danjami," and "Yeonjami" have higher levels of mono-acylated anthocyanins (21–24%) than "Jami" and "Borami." The process of acylation with phenolic acids, specifically p-coumaric, ferulic, or caffeic acids, improves the stability of anthocyanins under heat, pH, and UV radiation conditions. This makes it easier to use them as natural colorants in the food sector. In contrast to non- and di-acylated anthocyanins, mono-acylated forms—particularly those sourced from cyanidin 3-hydroxybenzoylsophoroside-5- glucoside have a greater heat tolerance. Consequently, in comparison to sweet potatoes of various colors, purple sweet potatoes may have more antioxidant activity due in part to these acylated forms.[6][17]

Carotenoids

Carotenoids which give sweet potato tubers their yellow and orange hue, are abundant in them. The color and variety of potatoes have a considerable impact on the overall carotenoid content More than 99% of the total carotenoid content is found in orange-fleshed animals, while trans-β- carotene is more prevalent in white and purple-fleshed animals. β-carotene levels in orange cultivars to be

5.9–12.9 mg/100 g,[8] and by 0.38–7.38 mg/100 g. The minor carotenoids lutein and zeaxanthin, with reported ranges of 0.1–0.4 and 0.1–0.2 mg/100 g dry weight, respectively, have been discovered in sweet potatoes. Park et al. (2016) found that potatoes have greater levels of lutein and zeaxanthin whitish flesh contrasted with purple.[13]

Phytoconstituents [2]

Table 1: **Phytoconstituents of *Ipomoea batata***

Sr.no	Phytoconstituents	Plant Part
1	**Phenolic acids-** Caffeic acid, Caffeoylquinic acid derivatives (chlorogenic acid, isochlorogenic acid, dicaffeoylquinic acid, tricaffeoylquinic acid, hydroxyl cinnamic acid and neochlorogenic acid).	Leaf, Root, Peel
2	**Coumarins**-Scopolatin, Esculetin, Umbelliferone, Peonidin, cyanidins.	Leaf, Root
3	**Triterpenes/Steroid**-Beta-amirin acetate, Boehmerylacetate, Friedelin	Root, Leaf
4	**Sesquiterpenoids**-6-myoporol, 4-hydroxy-dehydro-myoporone and ipomeamarone(most abundant)	Root
5	**Alkaloid-**CalystegineB1, Calystegine B2, Calystegine C1, Calystegine B3, Ipomine	Tuber root, Leaf
6	**Carbohydrates**-Starch, Sugars, Dietary fiber	Root
7	**Vitamins**-Vitamin A, Vitamin C, Vitamin B1(Thiamine), Vitamin B2(Riboflavin), Vitamin B3(Niacin), Vitamin B5(Pantothenic acid), Vitamin B6, Vitamin B9(Folate), Vitamin E, and Vitamin k.	Root, Leaf
8	**Minerals**-Magnesium(Mg), Copper(Cu), Phosphorous(P), Calcium(Ca), Iron(Fe), Manganese(Mn), Potassium(K), Sodium(Na), Zinc(Zn)	Root, Leaf
9	**Storage protein-** Sporamin/ipomoein,	Root
10	**Anthocyanins-**Carotenoids(beta-carotene, Leutein)	Root, Leaf
11	**Tannins**-Phlobatannin	Root, Leaf
12	**Flavonoids-** Tiliroside, Astragalin, Rhamnocitrin, Rhamnetin and Kaempferol	Leaf
13	**Saponins**	Leaf
14	**Enzyme-** Chitinases	Leaf
15	**Glycosides-** Batatins (including batatin I and batatin II),	Leaf, Root

	batatosides (including batatoside III, batatoside IV, and batatoside V)	

Cultivation And Collection

Tropical, subtropical, and temperate regions between 40° N and 32° S are where the crop is most commonly farmed. Frost does not harm the plant. Warm evenings, lots of sunshine, and an average temperature of 24 °C (75 °F) are ideal for its growth. The ideal amount of rainfall is between 750 and 1,000 mm (30 and 39 in) each year, with at least 500 mm (20 in) throughout the growing season. Vegetative development is promoted by high temperatures, high rainfall, and excessive cloud cover. For sweet potatoes, close spacing is usually advised in order to maximize root yield. Even while sweet potatoes quickly cover the soil, weeding is still important, especially in the initial phases of the crop's growth.[2]

Soil

Although sweet potatoes can be grown in a range of soil types, they thrive best in light- to medium-textured, well-drained soils with a pH range of 4.5 to 7.0. It is advised to apply potassium and phosphorus during field preparation.[2] A well-drained, light, sandy loam or silt loam soil is required for the growth of more and higher- quality roots. Sweet potatoes yield large amounts of low-quality roots on rich, heavy soils, but little amounts of high-quality roots on very poor, light sandy soils. Both internal and surface drainage are critical because inadequate internal drainage lowers yields and may result in damp areas that lower yields. Batata roots are big, distorted, fractured, and have rough skin because these soils have little aeration and high moisture content. Avoid areas that have recently been disturbed by pasture or sod, as well as areas with an abundance of organic materials. Sweet potatoes can grow in soil with a pH of 5.5 to 6.8, with 5.8 to 6.0 being the ideal rang[3][18].

Climate

The region used for sweet potato cultivation spans latitudes roughly 40° N to 40° S and elevations in tropical highland zones from sea level to around 2000 m. It needs to be frost- free for at least 120 to 150 days. thrives at minimum temperatures over 24 °C and struggles to grow below 10 °C. It detests shade and enjoys warm nights and lots of sunlight. Long days encourage top growth, while short days encourage the development of fleshy roots and flowers. During its growing season, it requires 500 mm of rain, although year-round rainfall of 750–1000 mm is required. Because the storage roots are growing, it is not a good idea to have a dry period for 50 days following planting. Sweet potatoes can tolerate drought after their roots are established, but they thrive on irrigation or 2-2.5 cm of rain per week. It is best to have little or no rain when the crop is about ready to be harvested. Water tension at the beginning of the tuber Compared to the stress during the tuber growth phase, and tuber maturity stages negatively impact tuber development and yield[3][18].

Fig 3: **Growing and maintenan**

Fig 4: Growing sweetpotato in cool climate

One of the most effective ways to irrigate sweet potatoes is by drip irrigation.

Storage

- Store sweet potatoes at 55°F and 80 to 90% relative humidity.
- Keep in a well-ventilated, cool, and dark area. Utilize in two weeks. Keep out of the refrigerator.[2]

Medicinal Potentials Of Sweet potato

Numerous research have documented various medical benefits associated with sweet potatoes. These characteristics have been linked to the actions of one or more of the phytochemicals found in the plant. Sweet potatoes have been used in traditional medicine to treat a wide range of illnesses, including diabetes and inflammatory and oral infections. The pharmacological potential of sweet potatoes has been studied recently, with several in vitro studies, animal models, and human trials demonstrating its promise.[19]

Anti-oxidant activities

Sweet potatoes typically include phytochemicals called flavonoids and related phenolic compounds, which have been shown to have a variety of biological benefits, including antioxidant activity. It has been stated that the purple-fleshed type contains anthocyanins, which have antioxidant properties. Free radicals and reactive oxygen species are scavengers that antioxidants remove from cells. Numerous pieces of evidence point to the beginning of degenerative diseases like cancer, diabetes, asthma, senile dementia, and eye disease being harmful free radical reactions.[20] Using the 1, 1-diphenyl-2-picrylhydrazyl (DPPH) assay, the free radical scavenging ability of extracts from the leaves of eight different cultivars of sweet potatoes was verified.[21] There was a correlation found between the total polyphenol content and the antioxidant activity of the leaf extract study revealed that extracts of sweet potato leaves from several cultivars had the ability to scavenge free radicals in n-hexane, ethyl acetate, and ethanol. Antioxidant activity has also been shown in various cultivars[22][23] of sweet potato root tubers. When compared to the flesh samples,[24] the peels of the white and purple kinds exhibited a greater antioxidant activity, indicating that the skin of sweet potato root tubers is also a rich source of anti-oxidative phytochemicals.[4]

Anti-diabetic effect

According to certain research, sweet potatoes may be able to reduce blood glucose levels. Various types of sweet potatoes have been shown to help minimize insulin resistance and regulate blood sugar levels in a few trials including both humans and animals. Long marketed and used as a diabetic treatment in Japan, "caiapo" is a nutritional supplement and a crude extract of white-skinned sweet potatoes.[25] The native sweet potato cultivars "White Star" from Pakistan and "Beauregard" from the United States both help diabetic patients'[26] blood glucose levels to drop. In Alloxan-induced diabetic mice, sweet potato leaf extract dramatically lowers blood glucose levels and hepatic enzyme activity.[27] which showed that adding the sweet potato's aqueous extract dramatically improved the blood glucose profile of diabetic rats.[28]

Anti-cancer potential

It has also been shown that extracts from various sweet potato sections have anticancer and antitumor effects. Prostate cancer cells treated with sweet potato extract undergo both in vitro and in vivo apoptosis and proliferation inhibition;[32] the extract's high polyphenol content has been linked to this anticancer effect. Similarly, a fairly recent study discovered that purple fleshed sweet potato extract inhibited the proliferation of cancer cell lines, specifically MCF-7 for breast cancer and SNU-1 for stomach cancer.[33] The high anthocyanin content of purple fleshed sweet potatoes has been primarily linked to their medicinal potential. A variety of cancer cells have shown that anthocyanins or extracts high in anthocyanins have an inhibitory effect on cancer cell development.[34] Additionally, researchers found that human colorectal cancer SW480 cell proliferation, migration, and invasion are inhibited in a dose- and time-dependent manner by isolated protein derived from the storage root of sweet potatoes.[4][35]

Anti-ulcer potential

The loss of inflammatory tissue from the skin or mucous membrane is a characteristic of ulcers.[36] In Wistar rats, methanol extract from sweet potato roots demonstrated dose- dependent gastroprotective efficacy against aspirin-induced ulcers.[37] By reducing edema production and partially preserving gastric mucosa wrinkles, sweet potato root flour may be able to prevent ethanol-induced stomach ulceration.[38] Another in vivo investigation found that an ethanolic extract of sweet potato roots exhibits antacid-like properties against ulcers in animal models caused by cold restraint stress and pylorus ligation.[4][39]

Effect on cardiovascular system

Low-density lipoprotein oxidation can lead to problems that eventually produce atherosclerosis, which in turn causes cardiovascular disease.[40] The antioxidant activity of the phytochemicals found in sweet potato leaves was shown to be responsible for the inhibition of low density lipoprotein oxidation that was observed in both human subjects and in vitro. It has been suggested that the phytochemical anthocyanin, which is prevalent in purple-skinned sweet potatoes, can lower the risk of coronary heart disease.[4][40]

Anti-inflammatory potential

Numerous studies have shown that purple sweet potato extract has the ability to prevent inflammatory brain diseases by suppressing the inflammatory responses triggered by lipopolysaccharide (LPS). Pretreatment with purple sweet potato extract was found to be effective in preventing the production of pro-inflammatory molecules in LPS-activated BV-2 microglial cells. By inhibiting phosphorylated extracellular signal-regulated kinase (ERK), phosphorylated c-Jun n terminal kinase (JNK) expression, and nuclear factor kappa B (NF- kB) activation in a group of LPS-stimulated mice, purple sweet potato color extract was able to suppress the proinflammatory molecules.[4]

Effect on immune system

Additionally, studies on sweet potato extracts' modulatory effects on immunity and health have been published. Mice splenocytes treated with ethyl acetate fractions of bioactive derived from two distinct cultivars of sweet potatoes demonstrated cultivar-dependent immunomodulatory effects.[41] feeding purple sweet potatoes to chickens increased their immune response following vaccination. In a similar vein, a study involving 16 healthy adult humans found that consuming purple sweet potato leaves could alter T-cell activities, the lytic activity of natural killer cells, and the creation of antibodies.[43] The majority of sweet potato cultivars with purple skin are the subject of reports on immunomodulatory investigations. Purple sweet potato extracts have been suggested to alleviate immunological dysfunction, presumably through the modulation of antioxidant defense mechanisms. In the LP-BM5 murine leukemia virus-induced murine acquired immune deficiency syndrome, a dietary supplement containing purple sweet potato extract boosted the activity of the antioxidant enzymes, superoxide dismutase and glutathione peroxidase.[44] After being cooked, sweet potato leaves also had an immunomodulatory effect on basketball players when they consumed them during a training session. The athletes saw a notable rise in their plasma concentration of polyphenols during this period, which coincided with a notable increase in the cytotoxic activity of natural killer cells and interferon (IFN)-γ release.[4][45]

Antimicrobial effects

While there are few reports of sweet potato root's antibacterial properties, several research have documented the leaves' antimicrobial properties [46]. sweet potato leaf extracts in acetone and ethanol had antibacterial action against Salmonella typhimurium and Pseudomonas aeruginosa, respectively, but extracts in n-hexane and ethyl acetate exhibited no antimicrobial activity against the aforementioned organisms. The antibacterial efficacy of peptone, water, and ethanol extracts of sweet potato leaves was investigated by Mbaeyi-nwa and Emejulu against the following bacteria: E. coli, S. typhi, S. aureus, A. niger, Penicillium spp., P. aeroginosa, and K. pneumonia. According to their findings, at various extract concentrations[47].

Morphological and physicochemical properties of sweet potato starch

The primary constituent of sweet potato roots is thought to be starch, which is followed by simple sugars like fructose, sucrose, glucose, and maltose. Starch is added to soups, meat sauces, candies, puddings, salad dressings, medicinal compositions, natural resins, and biodegradable thermoplastic materials in the food sector to enhance their functional qualities.[5]

Starch structures

It is inexpensive and has functional qualities in both raw and modified forms, starch is the principal ingredient in most diets. It is also a common ingredient in food manufacturing. It is a non-toxic, renewable, and biodegradable raw material mostly composed of α-D-glucose polymers.

The most significant reserve material found in superior plants is called starch. It is found in small white granules and is distributed throughout the plant, primarily in the aerial storage organs of plants like peas, beans, corn, rice, wheat, barley, oats, and sorghum; also found in the roots and tubers of plants like sweet potatoes, cassava, arrowroot, and yams; and in the stem of plants like sago.[5]

Composition, size and shape of the starch granules

Each plant's unique granules are mostly composed of two α-polyglucans with distinct physicochemical characteristics: amylose and amylo-pectin. The starch's botanical source affects the ratio of amylase to amylopectin.

Depending on where the starch comes from, the granules' sizes range from 1 to 100 cm. Although some have round, spherical, polygonal, and irregular shapes, the majority of the granules are oval in shape. Under a scanning electron microscope (SEM), every granule exhibits a smooth, fracture-free surface. confirmed the dimensions and form of some tubers' starch granules. When it came to the sweet potato, the granules ranged in size from 2 to 42m and were categorized as circular, oval, or polygonal. The sweet potato's starch granules were spherical and ranged in size from 4 to 26 um. They had a maximum diameter of 45 to 52 um and a minimum diameter between 6 and 8um. The starch granules were polygonal and circular in shape. Using optical and scanning electronic microscopy, the cellular structure of the yellow sweet potato (Mona Lisa variety) was examined. The high percentage of carbs in the raw material attested to the large number of starch granules that were seen in the cells.

Functional properties of the starch granules

The water/starch ratio, heating rate, morphology, amylase/amylopectin ratio, shear forces, granule and size distribution, addition of sugar, salt, and protein, among other parameters, all affect the changes in starch structure that result from dissolution and gelatinization. noted that the physical state of the starches in the food is what mostly determines their characteristics. This condition varies as the granule goes through its heating and cooling cycle. In the cooking phase, it transforms from a granular structure to a dispersion, and in the cooling and storing phase, it becomes a gel. A sweet potato starch granule's gelatinization temperature ranges from 57 to 90°C, with 68% solubility at 90°C.The lack of starch polymer organization in the native granule is the cause of the granules' high water retention capacity. This characteristic is crucial for the manufacturing of extruded goods like biscuits and snacks.[5]

CONCLUSION

Sweet potatoes are a widely consumed food crop whose nutritional and therapeutic potential might be investigated. This review emphasizes how the cultivar type has a significant impact on the biological activities of sweet potatoes. Transgenic changes may not be as necessary if sweet potato genotypes with greater health-promoting and therapeutic qualities are cultivated. High biological activity cultivars can be used to produce high-value nutraceuticals or as a platform for the isolation and identification of specific bioactive constituents that could be used as a model molecule or starting point for the synthesis of novel or semi-synthetic drugs. The best investigation of the therapeutic potential of sweet potatoes will be facilitated by knowledge of the general pharmacological activities of the plant as well as the unique bioactivities of the many cultivars. Some producers manufacture and sell transplants through commercial channels while the Research Center for Agrobiodiversity's gene bank provides genotype samples. Although effective in vitro micropropagation investigations are underway, planting material is currently generated using conventional methods. However, as the growing area grows, more diseases and even pests like leaf and root infestations are likely to appear, sometimes very quickly. As a result, for sweet potatoes to stabilize among Hungary's cultivated plants, a PT system tailored to the nation's conditions will need to be established, maybe with oversight from the relevant supervisory body.

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