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Nutritional Supplement and Pharmaceutical Potential of *Ipomea batata* L. Leaves: A Review

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ABSTRACT

Sweet potatoes are an exceptionally essential crop in several parts of the world, being produced in more than 100 countries and positioned as sixth most major crop in the world. The world production of sweet potato have steady declined with the exception of America and Sub-saharan Africa in the last decade. The study was intended to provide latest information on the sweet potato leaves and its nutritional and medicinal potential. It was first introduced into Nigeria in the late 1694 through the early activities of Portuguese and Spanish explorers. Nigeria is one of the largest producers of sweet potato in sub-Saharan Africa with annual production estimated at 3.46 million tons per year. The sweet potato can, however, be harvested many times during the year considerably more than many other greens vegetables. It is one of the few vegetables that can be cultivated in both rainy and dry seasons. The sweet potato leaves are considered to be rich in protein, fibers, vitamin B, Vitamin C and minerals, such as iron, calcium, magnesium, zinc, dietary bioactive compounds, and contain more phenols than any other commercial vegetables. The pharmaceutical importance includes anti-inflammatory, anti-cancer, antioxidant, anti-diabetes and anti-mutagenic among others. Sweet potato leaves could serve as an additional leafy green vegetable and promote food security for sustainable growth.

Keywords: Nutrition; *Ipomea batata*; antioxidant; Potato; Phenol; Vegetable

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) originated from Central America, Asia and Africa and widely grown as important staple food in most parts of the world. It is a herbaceous and creeping plant that originated from Central America and Northwestern part of South America in about 300 B.C and later introduced into Europe in the 16th century (Ejechi *et al.*, 2020). The plant belongs to Convolvulacaea, and ranked the fifth most important food crop in the tropics and the seventh in the world food production after wheat, rice, maize, potato, barley, and cassava (Truong *et al.*, 2018). It is an important food, feed and vegetable crop in most tropical developing countries. In Nigerian markets, three varieties are in popular demands: the purple, yellow and white potato (Aguoru *et al.*, 2015). It is mainly cultivated for its tubers and nutritional valuable source of carbohydrates, lipids, proteins, minerals and vitamin. The leaves have a good taste and much higher contents of calcium and vitamin K than spinach. About 200 wild potato species exist, in addition to thousands of primitive varieties.

Potatoes are the fourth most grown crop in the world, after the cereals rice, wheat, and maize and are the only major food crop that is a tuber (Navarre *et al.*, 2009). It was first introduced into Nigeria in the late 1694 through the early activities of Portuguese and Spanish explorers and was encouraged by the British colonials during the Second World War as their tubers were needed to feed their armed forces in West Africa (Udemezue, 2019).

Nigeria is one of the largest producers of sweet potato in sub-Saharan Africa with annual production estimated at 3.46 million tons per year with Egypt number one in Africa, followed by Malawi and Nigeria is the fourth biggest producer in Africa (Udemezue, 2019).

It is an important food security and early maturity crop that can be intercropped with some crops like yam and maize. More than 85% of the sweet potato production in Nigeria is done by peasant farmers (Udemezue, 2019). The crop has been identified to be the fourth most important root crop in Nigeria after cassava, yam and cocoyam. It is consumed and processed in most parts of the tropics and subtropical countries either eaten boiled, fried, roasted or dehydrated into chips, canned, creamed, cooked and frozen, dried and ground into flour to make biscuits, bread and other pastries (Udemezue, 2019). Sweet potato leaves (SPL) are also consumed in Taiwan and China, and are prepared in various ways (boiled, fried, baked, dehydrated, and fermented) (Leticia *et al.*, 2023). It can be found in dishes in the Philippines, Japan, South Pacific, Taiwan, Cameroon, Nigeria, Malawi, Ghana, Côte d'Ivoire, Burkina Faso and the United States.

Figure 1: An image of sweet potato leaves

Potato tubers are highly specialized organs evolved to improve a plant’s chances of survival and to allow vegetative reproduction. Tubers are not derived from roots, but are modified stems, originating on stolons from axillary buds on the underground part of the stem (Navarre *et al*., 2009). Sweet potato is one of the most important food crops worldwide and its leaves (Figure 1) provide a dietary source of nutrients and various bioactive compounds. Sweet potato leaves (SPL) are considered to be a leafy vegetable consumed by human due to its dietary source of nutrients and various bioactive compounds with health benefits. It is one of the important food crops with high yield, drought tolerance, and the ability to grow in different climates and farming systems (Nguyen, *et al*, 2021). Green leaves are nutrient-rich foods that have been an important part of the traditional human diet, and their potential contribution to protein intake is often overlooked (Balfany *et al*., 2023). Sweet potato has a strong potential to contribute to better nutritional quality of our diets around the world. Therefore this review provides a contemporary information on nutritional quality and health benefit of sweet potato leaves.

Origin of sweet potato

The sweet potato is a herbaceous perennial that is grown as an annual by stem cuttings or plant sprouts from storage roots. Sweet potatoes originated somewhere in the region between the Yucatan Peninsula of Mexico and the mouth of the Orinoco river in north easternVenezuela (Austin, 1988).

Recent studies in chloroplast DNA and molecular phylogeny analyses confirmed the assertion (Roullier, *et al.*, 2013a, b).Europeans in the 1500s spread the sweet potato to Africa and India, with it arriving in China prior to 1600 (Truong *et al.*, 2018).

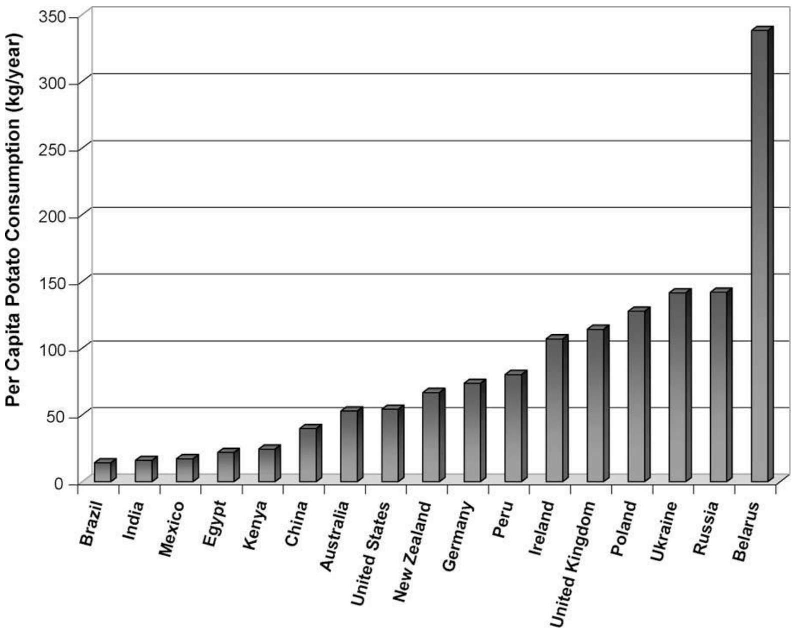

Figure 2: Consumption of potatoes in 17 countries in 2005 (Naverra *et al*., 2009)

Dietary Importance of Potatoes

Consumption of sweet potato leaves affects serum lipid profiles in both humans and animals, and thus shows potential for reducing the risks associated with the development of cardiovascular disease. With most crops, including potatoes, nutrient profiles are available only for a few varieties. Thus, surprisingly little is known about what vitamins and nutrients are in potatoes. In most of the developed world, potatoes are by far the most eaten vegetable (Figure 2) due to its valuable source of dietary vitamins, minerals, and phytonutrients while in the developing world, potato consumption is increasing at about 5% a year (Navarre *et al*., 2009). When incorporated into the diets of animals, sweet potato leaves have potential mechanisms to improve dietary protein and amino acid intake, as well as improve growth performance (Johnson and Ralphenia, 2010). Hotz *et al.* (2012) reported that increase in consumption of orange-fleshed sweet potatoes improved the vitamin A status of children, pregnant women, and lactating mothers. Sweet potato leaves are rich in crude protein, crude fat, crude fiber, carbohydrate, polyphenols, vitamin C, carotenoids, minerals, and have higher levels of polyphenols than the root, and flesh root tissue (Sun *et al.*, 2017; Makori *et al.*, 2022). The amounts of polyphenols in sweet potato leaves are higher than in most commonly consumed commercial vegetables (Figure 3) such as spinach, kale, amaranth, eggplant, cabbage, cauliflower, green peas, and lettuce (Tan *et al*., 2023).

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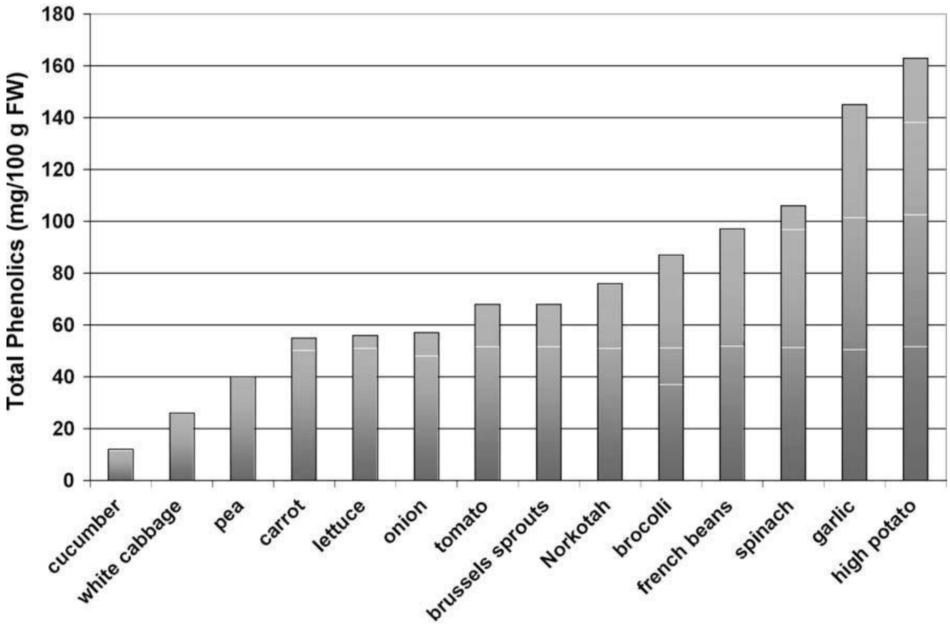

Figure 3. Total phenolic contents present in vegetables (Naverre *et al*., 2009)

Mineral Elements

All the sweet potato parts (roots, vines, and young leaves) are used as foods, animal feeds and traditional medicine around the world. Potatoes are an important source of different dietary minerals. A wide range of mineral elements occurs in fruits and vegetables, which are a primary dietary source. Fresh sweet potato provides about 50% more calories than Irish potatoes. Its tuberous roots contain about 27% carbohydrate and high concentrations of vitamin A, C, calcium and iron (Coleman and Morre, 2003). The sweet potato leaves (SPL) contains essential mineral elements such as Ca, K, Mg, Na, P, Fe, Cu, Fe, Zn, Niacin, Vitamin B_1, B_2, B_6, Vitamin C, Vitamin E, biotin and β-carotene (Table 1). Its leaves, stems and roots are a valuable source of bioactive carbohydrates, lipids, proteins, carotenoids, anthocyanins, phenolic acids and flavonoids. These bioactive metabolites possess many biological activities, such as antioxidant, antidiabetic, anticancer, hepatoprotective, antimicrobial, antiulcer and immunostimulant, anti-mutagenic, and anti-bacterial activity which may be helpful for maintaining and promoting human health (Yoshimoto *et al*., 2006). Promoting sweet potato leaves consumption in Africa is necessary because it can be a good alternative to reducing malnutrition and health problems caused by nutrients deficiency or poor eating habit.

Table 1: Mineral and vitamins composition of sweet potato leaves

Elements	Quantity (mg/100g DW)
Water	86.81
Energy (kcal)	42
Carbohydrate (g)	8.82
Protein (g)	2.49
Total fibre (g)	5.3
Total lipid (g)	0.51
Na	8.06 – 832.31
Mg	220.2- 910.5
P	131.1 – 2639.8
Ca	229.7- 1958.1
K	479.3 – 4280.6
Cu	0.7 – 1.9
Zn	1.2 – 3.2
Mn	1.7 – 10.9
Fe	1.9 – 21.8
Vitamin B3	0.856 – 1.498
Vitamin B6	0.12 – 0.329
Vitamin B2	0.248 – 0.254
Vitamin B1	0.053 – 0.128
Vitamin C	0.0627 – 0.081
Vitamin E	0.00139 – 0.00284
Vitamin B5	0.32 – 0.66
b-carotene	0.273 – 0.4
Biotin	0.003 – 0.008

Source: Ayeleso *et al*., 2016; Nguyen *et al*., 2021

Phenolics

Plant phenolics possesses great potential health-promoting compounds and are the most abundant antioxidant compounds in the diet that can have effects on cardiovascular disease, eye health, longevity and mental acuity and (Manach *et al*., 2004; Scalbert *et al*., 2005). These has been illustrated by many of the reports in the popular press about positive health benefit coffee, green tea, and wine due to phenolic content. Sweet potato leaves contains at least 6 biologically active polyphenolic compounds and 15 anthocyanin with remarkable multifaceted activity including antioxidation, antimutagenicity, anti-inflammation and anticarcinogenesis (Islam *et al*., 2014).

Vitamin B_6 (pyroxidine)

Vitamin B_6 is water soluble nutrient and may involve in many metabolic functions than any other nutrient (Tambasco-Studart *et al*., 2005), it also serve as a cofactor for many enzymes, especially those involved in protein and folate metabolism. It has anticancer and strong antioxidant activities involved in hemoglobin biosynthesis, lipid and glucose metabolism and immune and nervous system function (Denslow *et al*., 2005; Theodoratou *et al*., 2008). Very little research has been conducted on this vitamin in potato, thus little is known about how much its concentrations vary among genotypes; ranges of 0.26–0.82 mg/200 g FW have been reported (Rogan *et al*., 2000).

Recently much has been learned about vitamin B_6 synthesis in plants including identification of the key genes *PDX1* and *PDX2* (Tambasco-Studart *et al*., 2005). Such information should enable new approaches to further enhance vitamin B_6 concentrations in potatoes.

Vitamin B_9 (Folate)

Potatoes were the third most important overall source of folate in the Dutch diet (Table 2), providing 7% of the total folate intake (Konings *et al*., 2001), provided 9–12% intake in a Norway (Brevik *et al*., 2005) and ∼10% in Finland (Alfthan *et al*., 2003).

Table 2: Folate (Vit. B_6) content in various plant foods.

Crop	Folate content (µg 100/g FW)	Reference
Rice	6- 9	USDA,
Sweet potato	11	USDA
Onions	10- 19	Konings *et al.*, 2001; USDA
Tomato	8- 30	Konings *et al.*, 2001; USDA
Banana	13- 20	Vahteristo *et al.*, 1997; USDA
Carrot	16- 19	Vahteristo *et al.*, 1997; USDA
Corn (yellow)	19	USDA
Orange	18- 30	Konings *et al.*, 2001; USDA
Cassava	27	USDA
Peas (green)	25-65	Han and Tayler, 2003; USDA
Strawberry	13 -96	Tulipani *et al.*, 2008
Snap bean	37	USDA
Wheat	38	USDA
Lettuce	38-43	Konings *et al.*, 2001; USDA
Broccoli	63- 114	Vahteristo *et al.*, 1997; USDA
Spinach	100- 194	Konings *et al.*, 2001; USDA
Peanut	110-240	Holland *et al.*, 1996; USDA
Lentis	151- 479	Han and Tayler, 2003; USDA
Beans	143-525	Han and Tayler, 2003; USDA

Source: (Naverra *et al.*, 2009)

Vitamin C

Potatoes are a good source of many vitamins and minerals. The primary storage proteins in tubers are patatins, which account for 40% of the soluble protein content (Prat, 1990). The best known symptom of vitamin C deficiency is scurvy, which in severe cases causes loss of teeth, liver spots, and bleeding. Vitamin C has a major role in detoxifying reactive oxygen species in plants, which are the primary source of vitamin C in the human diet. Leafs and chloroplasts can contain 5 to 25 mM L-ascorbate, respectively (Wheeler *et al*., 1998). Plants may have multiple vitamin C biosynthetic pathways, with all of the enzymes of the L-galactose pathway recently characterized (Laing *et al*., 2007; Wolucka and Montagu, 2007). Vitamin C is a cofactor for numerous enzymes, functioning as an electron donor. Numerous studies have shown that vitamin C levels decrease rapidly during cold storage of potatoes and losses can approach a 60% decrease (Keijbets and Ebbenhorst-Seller, 1990).

Fried potatoes has a 10% decreased in vitamin C after 6 months of storage at −18°C while pre-freezing operations caused 51% loss (Duray *et al.*, 2009), however this sounds cautionary about the importance of how potatos are handled during processing.

Anti-bacterial

Islam (2008) reported the potent antibacterial activity of the leaf water extract of three sweet potato cultivars against *Staphylococcus aureus, Bacillus cereus,* and *E. coli*. In contrast, ethanol leaf extract of Brazilian sweet potato did not show any anti-bacterial activities against *S. aureus, S. mutans,* and *S. mitis* (Pochapski, *et al.*, 2011), and this could be attributed to differences in the methodology of antimicrobial assay and inherent difference in phytochemical compositions in the SPL due to difference in location. Acetone and ethanol extracts of sweet potato leaves showed antimicrobial activity against *Salmonella typhimurium* and *Pseudomonas aeruginosa* (Adsul *et al*., 2012), peptone, water and ethanol extracts of sweet potato leaves against *E. coli, Salmonella typhi, S. aureus, Aspergillus niger, Penicillium aeroginosa* and *K. pneumonia (*Ayeleso *et al*., 2016). There are still limited studies on the antimicrobial activity of SPL, therefore further studies are needed to elucidate the mechanism of activity.

Anti-cancer

Methanolic leaf extract of SPL inhibit proliferation of all human prostate cancer cells (PC-3, C4-2B, C4-2, DU145, and LNCaP), induce apoptosis, and reductions of chlorogenic survival. Leaves of sweet potato have been recognized as a potent anti-cancer food source against various cancer cells, including HCT-116 colon cancer, HeLa cancer, MCF-7 breast cancer, prostate cancer, colorectal cancer, and lung cancer (Ezekiel *et al.*, 2013; Gundala *et al.*, 2013; Lim *et al.*, 2013; Vishnu *et al.*, 2019). Chlorogenic acid one of the major phenolics compound in potato was reported to be a strong and selective inhibitor of angiogenic enzymes (matrix metalloproteinase-2, and matrix metalloproteinase-9), A549 human lung cancer cells responsible for tumor metastasis and invasion and (Feng *et al.*, 2005; Jin *et al.*, 2005; Chen *et al.*, 2011).

Anti-diabetes

Phenolic such as caffeoylquinic acid derivatives, and anthocyanins were found to be among the key hypoglycemic contributors in SPL (Table 3). Chlorogenic acid reduces the release of glucose into the blood-stream, lowering the glycemic index, thereby benefitting diabetic patients and reducing the risk of type II diabetes (Bassoli *et al.*, 2008). Polyphenol contents in leaves of 116 sweet potato cultivars grown in China showed anti-diabetic activity (Sun *et al.*, 2014).

Antimutagenic

Sweet potato leaves are a good supplementary resource of antioxidants and antimutagenic compounds (Table 3). An investigation was conducted to examine the effects of 82 kinds of vegetable juice and plant components on the division and multiplication of cancer cells, and it was found that sweet potato has especially high cancer checking rates (Islam, 2014).Sweet potato leaves contain a high content of polyphenolics including, 3-mono-O-caffeoylquinic acid (chlorogenic acid, ChA), 3,4-di-*O*-caffeoylquinic acid (3,4-diCQA), 3,5-di-*O*-caffeoylquinic acid (3,5-diCQA), 4,5-di-*O*-caffeoylquinic acid (4,5-diCQA), and 3,4,5-tri-*O*-caffeoylquinic acid (Yoshimoto *et al.*, 2006).

Antioxidant activity

Sweet potato leaf contain various antioxidant compounds which contribute to the physiological defense against oxidative stress (Figure 4) and free radical-mediated reactions, leading to an increase in antioxidant defense, suppression of low-density lipoprotein (LDL) oxidation and DNA damage in human lymphocytes (Nagai *et al.*, 2011; Chao *et al.*, 2013).

Polyphenol antioxidants, especially caffeoylquinic acid derivatives(3,4,5-tri-O-caffeoylquinic acid, 3,5-di-O-caffeoylquinic acid, 3,4-di-O-caffeoylquinic acid, and 4,5-di-O-caffeoylquinic acid), exhibit strong antioxidant capacity (Ghasemzadeh *et al*, 2012; Xi *et al.*, 2015; Zhang *et al.*, 2015). Polyphenols in SPL causes an increase in glutathione by facilitating the expression of –glutamylcysteine synthetase and inhibiting glutathione reductase (Zhange *et al.*, 1997; Moskaug *et al.*, 2005).

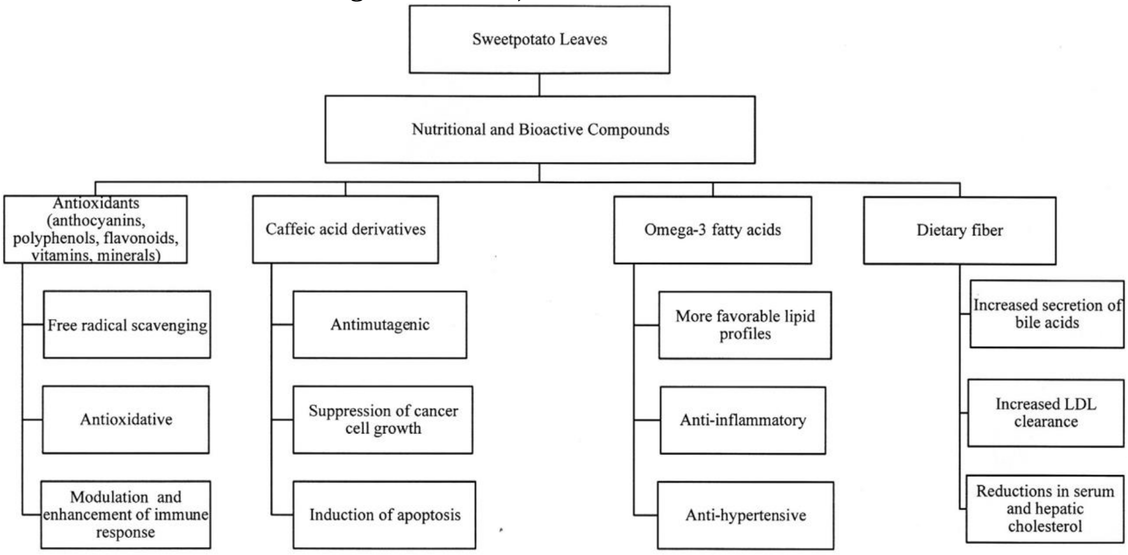

Figure 4: Synergy effects of the major nutritional and bioactive compounds within sweet potato leaves in disease prevention and health promotion (John and Ralphania 2010).

The antioxidant capacity of SPL was found to be much higher than that of other leafy vegetable, and the potato leaf antioxidants tend to vary with the color. Antioxidant capacity of purple SPL was significantly higher than other colored SPL red, yellow, and white (Ji *et al.*, 2015). For instance, purple SPL exhibited higher antioxidants capacity than *Celosia argente*, *Gynura bicolor*, *Perilla frutescens*, *Amaranthus tricolor* and *Houttuynia cordata*, and other commercial leafy vegetables, due to higher antioxidant (Chu *et al.*, 2000; Lako *et al.*, 2007; Tang *et al.*, 2013). The purple SPL extracts depress neuro-inflammatory responses in lipopolysaccharide-activated BV-2 microglia cells by inhibiting production of pro-inflammatory mediators, such as inducible nitric oxide synthase (iNOS), cyclooxygenase 2 (COX-2), nitric oxide (NO), and TNF (Nguyen *et al.*, 2012).

Table 3: phytochemical compounds present in potato leaf and their health benefit

Phytochemical class	Compound	Function	Reference
Phenolics	Caffeic acid derivatives	Antioxidant	Xi *et al.*, 2015; Jung *et al.*, 2006
		Anti-mutagenic	Yoshimoto *et al.*, 2002
		Antidiabettic	Jung *et al.*, 2006
		Anticancer	Gundala *et al.*, 2013; Tang *et al.*, 2013
		Anti-inflammatory	Ye *et al.*, 2009; Zieli *et al.*, 2021
	Caffeoylquinic acid derivatives	Antioxidant	Zhang *et al.*, 2016
		Anticancer	Kurata *et al.*, 2007; Ezekiel *et al.*, 2013; Taira *et al.*, 2014
		Anti-hypertension	Ishiguro *et al.*, 2007
		Antidiabetic	Zhang *et al.*, 2016
		Heart protection	Ezekiel *et al.*, 2013; Chao *et al.*, 2013
	Chlorogenic acid	Antidiabetic	Bassoli *et al.*, 2008
		Anticancer	Ezekiel *et al.*, 2013; Gundala *et al.*, 2013; Chen *et al.*, 2011
	Quinic acid	Anticancer	Ezekiel *et al.*, 2013; Gundala *et al.*, 2013
Flavonoids	Anthocyanins	Antioxidant activity	Chao *et al.*, 2003; Reddivari *et al.*, 2007
		Anti-mutagenic	Islam *et al.*, 2000
		Anticancer	Konczak *et al.*, 2004; Reddivari *et al.*, 2007
		Hyppglycemic	Nagamine *et al.*, 2004
		Hepato-protection	Wang*et al.*, 2014; Olowu *et al.*, 2011
		Anti-inflammatory	Karlsen *et al.*, 2007; Lee *et al.*, 2015
	Quercetin	Antioxidant	Krochmal-Marczak *et al.*, 2020; Chao *et al.*, 2003
		Anticancer	Ezekiel *et al.*, 2013
		Anti-inflammatory	Lee *et al.*, 2015
	Apigenin	Anticancer	Liu *et al.*, 2005
	Kaempferol	Anticancer	Ezekiel *et al.*, 2013
	Myricetin	Anticancer	Knekt *et al.*, 2002
		Antidiabetic	Jung *et al.*, 2006
	Fisetin	Anticancer	Lu *et al.*, 2005
		Anti-inflammatory	Geraets *et al.*, 2009
	Morin	Anticancer	Kawabata *et al.*, 1999
		Anti-inflammatory	Galvez *et al.*, 2001
	Isorhamnetin	Cardioprotection	Sanchez *et al.*, 2007
	Luteolin	Anticancer	Lim *et al.*, 2007
		Anti-inflammatory	Jang *et al.*, 2008

Source: Nguyen, *et al*, 2021

CONCLUSION

Evidence has been provided on the nutritional benefits of sweet potato leave and its potential to improve human health including the reduction of oxidative damage and the prevention of some diseases. These health promoting benefits are attributed to the presence of various constituents having strong bioactivity. Therefore, SPL can be an alternative natural dietary source providing additional applications in the food supplement and nutraceutical industries.

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