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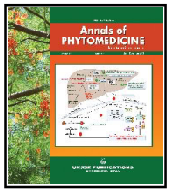

Review Article : Open Access

Solanum tuberosum L.: A review on traditional use, phytochemistry, pharmacological aspects, and health benefits

Govardhan Sahani◆, Pallavi Ghadage*, Antony Stephen Raj, Arun Prakash and Faiz Mohammed

Sri Sairam Ayurveda Medical College and Research Centre, Chennai-600044, Tamilnadu, India

**L. N. Ayurved College and Hospital, LNCT University, Bhopal- 462022, Madhya Pradesh, India*

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Abstract

Potato is a plant that gives us many medical and healing properties in raw, boiled, or mashed form. It is highly nutritious and contains starch, protein, alkaline salts, vitamins C, iron, calcium, manganese, magnesium, and phosphorus. Potatoes are famous for their wide variety of chips and fries in the food industry. Apart from that it is used in medical and cosmetic values. Recent research found potato contains kukoamine which helps to lower blood pressure and a class called flavonoids which help to protect from cardiovascular diseases. Raw potato juice is used to treat scurvy, rheumatism, digestive disorders like ulcers, gastritis, *etc*. Peeled potato skin acts as a natural coolant for burns and scalds. Raw potato slice is used to treat warts, freckles, common skin inflammation, swelling of the eyes, and headaches and helps to reduce itching. Consuming boiled potatoes along with the skin daily will act as estrogen replacement therapy and ease off menstrual problems, and gallbladder ailment, eliminate toxins from the body, and help in improving liver function as well. Cosmetically, it helps to get rid of dark pigmentation, mild to moderate acnes, reduces bacterial growth, and acts as a revitalizer. Drinking one glass of leaf juice helps the skin glow. In this review article, we will discuss the traditional uses, phytochemistry, pharmacological aspects, and overall health benefits.

1. Introduction

Solanum tuberosum L., commonly known as the potato, is one of the world's most important and widely consumed staple crops. This starchy tuberous plant has played a significant role in global agriculture and cuisine for centuries. Around the world, if the food varieties had to be divided into two, one would be with potatoes and the other would be without potatoes. It is dense with nutrients like carbohydrates, proteins, and a little fat with traces of vitamins and minerals. Being native to South America, potatoes have been cultivated for over 8,000 years, and they played a crucial role in the diets of various cultures around the world, also preventing malnutrition in impoverished regions (Hawkes *et al.*, 1990). They were introduced to Europe in the late 16th century, leading to significant dietary and agricultural changes, especially in Ireland. In terms of total production in the world among all food crops, it finds a place after wheat, rice, maize, barley, and cassava (Suchismita *et al.*, 2021). Potatoes are a major global food crop and have a significant economic impact on agriculture and the food industry (Pritpal and Amarjeet, 2023). *S. tuberosum*, the potato, is a fundamental crop that has shaped the diets and economies of nations around the world. Its adaptability and versatility make it a cornerstone of global cuisine and agriculture (Hijmans and David, 2001). Potatoes are primarily used as a food; it has been used historically for their medicinal value (Smith *et al.*, 1988), and it has been explained in the Table 1.

Potatoes are a good source of carbohydrates, dietary fiber, vitamin C, and several B vitamins. They are relatively low in fat and calories (Gibson and Kulirich, 2013). Along with key nutrients, they possess phytonutrients, alkaloids, phenolic compounds, anthocynins (Brown *et al.*, 2003), carotenoids (Crozier *et al.*, 2009), and flavonoids (Sahar *et al.*, 2017). *S. tuberosum* is the best source of phenolic acid (Farvin *et al.*, 2012) which contains an ester of caffeic acid, quinic acid (Mader *et al.*, 2009), and mostly gallic acid (Friedman *et al.*, 2004). Phenolic acid is directly linked with human health, it is rich in antioxidant (Ho *et al.*, 2004), helps to provide production against chronic diseases (Espin *et al.*, 2000), maintain blood pressure (Parr *et al.*, 2005), and protects against microorganisms (Chun *et al.*, 2005). Among widespread vegetables like tomatoes, onions, and carrots (Andre *et al.*, 2013), potatoes have a higher phenolic compound which is present in the skin and flesh (Ezekiel *et al.*, 2013). There are thousands of potato varieties, each with unique characteristics, including russet, red, fingerling, and yukon gold potatoes (Ciccone *et al.*, 2020). Potatoes can be adapted to different growing conditions, which has led to a wide range of varieties. Potatoes are incredibly versatile and can be prepared in numerous ways, including boiling, mashing, frying, baking, and roasting (Tian *et al.*, 2016) and also act as an anti-inflammatory, antioxidant, cytotoxic, and antitumor (Chung *et al.*, 2016).

The information collected for this article on traditional use, botany, phytochemistry, and pharmacological aspects of *S. tuberosum* was obtained through various electronic databases and search tools. Research Gate, PubMed, Science Direct, International journals, Wikipedia, and a few blogs were utilized. Other sources like books, journals, and periodicals were read and taken into consideration.

Corresponding author: Dr. Govardhan Sahani
Associate Professor, Department of Shalya Tantra, Sri Sairam Ayurveda Medical College and Research Centre, Chennai-600044, Tamilnadu, India
E-mail: gova.sahani@gmail.com
Tel.: +91-9629726841

Table 1: The results of traditional medicinal purposes in various cultures

S.No.	Compounds	Medicinal uses	References
1.	Digestive aid	Potato juice or extracts were sometimes consumed to relieve digestive issues, including indigestion, heartburn, and upset stomach.	Vlachojannis *et al*., 2010
2.	Fever	Potato slices or compresses were applied to the forehead or feet to help reduce fever in some traditional remedies.	White *et al*., 2009
3.	Pain	Potato poultices were applied to painful areas of the body to alleviate muscle or joint pain.	Basilicata *et al.,* 2019
4.	Wart	Some traditional remedies involved applying potato slices or juice to warts as a natural treatment for their removal.	Manivannan *et al*., 2013
5.	Skin-soothing	Potato slices or mashed potato pulp were used to alleviate skin conditions like sunburn, acne, and eczema.	Manivannan *et al*., 2013
6.	Decongestant	Inhaling the steam from boiled potatoes may help alleviate congestion and sinus problems.	Manivannan *et al*., 2013
7.	Sprains	Used in folk medicine, potato poultices have been applied to treat conditions like boils, arthritis, and sprains.	Manivannan *et al.,* 2013
8.	Gastritis	Drinking water in which potatoes have been boiled is believed to have mild health benefits, such as helping to reduce acidity in the body.	Manivannan *et al.,* 2013
9.	Wound	Potato slices or grated potatoes are sometimes used in traditional medicine to help heal wounds and reduce the risk of infection.	Basilicata *et al*., 2019
10.	Bone	Sliced potatoes are kept in broken bones and bandage which help in healing the bone.	Basilicata *et al*., 2019
11.	Inflammation	Potatoes were used topically as poultices to reduce inflammation and soothe minor skin irritations, such as burns, rashes, and insect bites.	Basilicata *et al*., 2019
12.	Cancer	Potatoes have rich phenolic compounds like anthocyanins which protect from cancer cells.	Lim *et al*., 2013
13.	Hypertension	Potatoes are a low source of potassium which helps to reduce hypertension.	Camire *et al*., 2009
14.	Skin allergy	Potatoes are rich in minerals and organic salts and it is applied as a paste that soothes the burns or rashes.	Subrahmanyam *et al*., 1996
15.	Dark pigmentation	Raw potato slices or juice help to reduce dark circles and wrinkles.	Umadevi *et al*., 2013
16.	Haemorrhoid	Streamed or boiled potatoes help to hydrate the stools which act as a natural stool softener and prevent haemorrhoids.	Umadevi *et al*., 2013
17.	Diarrhea	Boiled potatoes contain energy-rich diet which helps in diarrhoea.	Kshitij and Singh, 2017
18.	Stomach pain	Potato juice helps in gastric ulcers, and gastric acidity and gets rid of spasms.	Umadevi *et al*., 2013
19.	Liver disorder	Raw extract juice helps to reduce gallstones as well as hepatitis.	Umadevi *et a*l., 2013

1.2 Cosmestible uses

The potato is a highly versatile and widely consumed staple food around the world. Potatoes are often boiled and served as a side dish with various meals (Manivannan *et al*., 2013). They can be seasoned and buttered for flavor. Mashed potatoes are a popular dish made by boiling potatoes, mashing them, and mixing them with butter, milk, and seasonings. Potatoes are cut into strips, deep-fried, and seasoned to make French fries, a beloved snack, and side dish. Thin slices of potatoes are deep-fried and salted, creating the crispy and savory snack known as potato chips. Potatoes can be roasted in the oven with herbs and spices, creating a crispy and flavourful side dish. Diced, boiled potatoes are often combined with mayonnaise, mustard, and various other ingredients to make potato salad, a popular side dish. Potatoes are used to make creamy and hearty potato soups, sometimes combined with ingredients like bacon, cheese, and leeks.

Potato gnocchi is a type of pasta made from mashed potatoes and flour, often served with various sauces. In some cuisines, potatoes are used to make dumplings, which are served with stews or as a main dish. Potatoes can be used to make bread, adding moisture and texture to the dough. Grated potatoes are mixed with other ingredients to create savory pancakes, which are popular in many cultures. Sliced potatoes are layered with cheese and cream and baked to create a rich and creamy dish these are just a few examples of the many ways in which potatoes are used in cooking. Potatoes are valued for their versatility, affordability, and nutritional value, making them a staple in the diets of people worldwide (Kshitijparmar *et al*., 2017). Chemical composition of potatoes has been listed with their uses in the Table 2 and its structure of phenolic compound has been listed the Figure 1.

2. Chemical composition

Table 2: Chemical compositions and some key components found in potatoes

S.No.	Chemical composition	Uses
1.	Starch	Potatoes are primarily composed of starch, which can make up around 70-80% of their dry weight. Starch is the primary energy source in potatoes.
2.	Water	Fresh potatoes typically contain about 70-80% water by weight.
3.	Protein	Potatoes contain a moderate amount of protein, typically around 2-3% of their dry weight.
4.	Vitamins	Potatoes are a good source of several vitamins, including vitamin C, vitamin B6, and various B-complex vitamins.
5.	Minerals	Potatoes contain minerals such as potassium, magnesium, and small amounts of iron and calcium.
6.	Fiber	They contain dietary fiber, which can be found in the skin and contribute to digestive health.
7.	Phytonutrients	Potatoes also contain various phytonutrients like carotenoids and flavonoids, which have antioxidant properties.
8.	Glycoalkaloids	Potatoes contain natural toxins called glycoalkaloids, primarily solanine and chaconine, which are concentrated in the green parts and should be avoided in large quantities.
9.	Nutrients	Potatoes contain antinutrients like lectins, which can be harmful if consumed in excessive amounts but are typically neutralized by cooking.
10.	Fats	Potatoes are fat-free, containing only trace amounts of fat.
11.	Anthocyanins	These are responsible for the purple or blue colour of some potato varieties and act as an antioxidant.
12.	Carotenoids	Potatoes contain carotenoids like lutein and zeaxanthin, which are important for eye health and may reduce the risk of age-related macular degeneration.
13.	Chlorogenic acid	It is an antioxidant that has been linked to various health benefits, including potential effects on blood pressure and heart health.
14.	Folate	It is important for DNA synthesis and repair and is particularly important during pregnancy.
15.	Caffeic acid	It possesses antioxidant properties and may have anti-inflammatory effects.
16.	Ferulic acid	It is present in smaller quantities and it has antioxidant properties. These phenolic acids, along with other phytochemicals, contribute to the overall nutritional value of potatoes and their potential health benefits.
17.	Flavanoids	Its class of phytochemicals is known for its antioxidant and potential health-promoting properties.
18.	Quercetin	Quercetin is a common flavonoid present in the skin of potatoes and is known for its antioxidant and anti-inflammatory properties.
19.	Kaempferol	Kaempferol is another flavonoid present in potatoes. It, too, has antioxidant properties.
20.	Apigenin	Act as an antioxidant and anti-inflammatory effect.
21.	Myricetin	It exhibits antioxidant properties.

Source: Kita *et al*., 2002; Leoneal *et al*., 2017; Karpukhin and Keita, 2020.

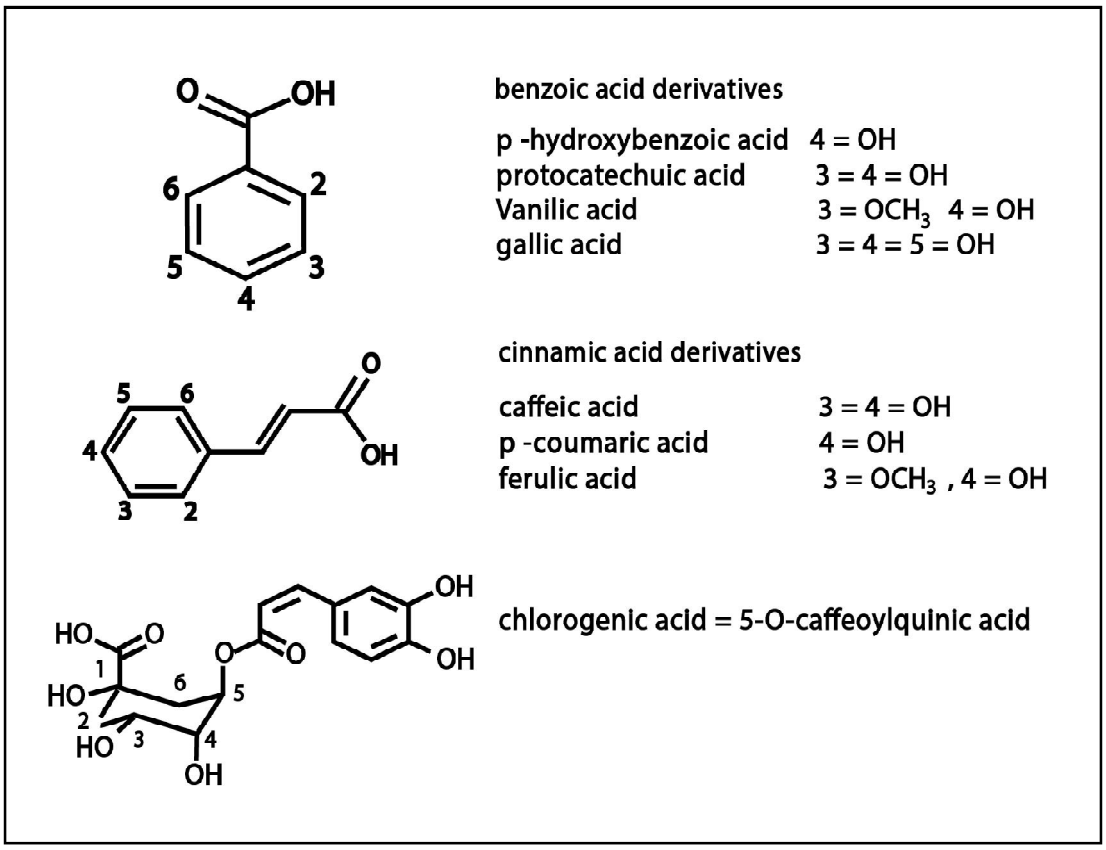

Figure. 1: The structure of phenolic compounds in potato.

3. Pharmacological aspects

Potatoes, while primarily known as a food source, also have some interesting pharmacological aspects (Basalingappa and Kanthesh, 2019).

3.1 Antioxidant property

Potatoes contain antioxidants, such as vitamin C, and phytonutrients like carotenoids and flavonoids. These compounds may help neutralize harmful free radicals in the body, potentially reducing the risk of chronic diseases.

3.2 Anticancer property

Studies show reduction in proliferation of cancer cells with extract of potato. Antioxidants such as anthocyanins, fiber, glycoalkaloids, and proteinase inhibitors have been implicated in the suppuration of cancer cell division (Hanif *et al.*, 2006). Anthocyanins and phenolic acid of potato possess anti-carcinogenic activity (Hayashi *et al.,* 2006). Chlorogenic acid is effective against human colon, liver, and prostate cancer (Wang *et al.,* 2011).

3.3 Antihyperlipidemic effect

Retrograde starch of potato pulp lowered serum total cholesterol and triglycerides concentration (Hashimoto *et al*., 2006). It promotes the excretion of bile acids resulting in a low concentration of serum cholesterol (Kanazawa *et al.,* 2008). Peptide of potato reduces serum non-HDL cholesterol concentration and hypocholesterolaemia effect (Liyanage *et al*., 2008).

3.4 Antivascular effect

Flavonoids is closely linked to various chronic diseases, the most commonly cited being high blood pressure, diabetes and other various vascular diseases like cardiovascular diseases, atherosclerosis (Mohammed and Juan, 2008).

Flavonoids like quercetin or catechin influence the level of nitric oxide, increasing it and decreasing the expression of the glycoprotein IIB/IIIA complex, thus blocking the platelet aggregation thus preventing vascular diseases (Rolnik *et al*., 2020).

3.5 Antihypertensive effect

It is well known that nitric oxide (NO) from the endothelium plays a crucial role in regulating vascular tone and blood pressure. The mechanism of action of NO is based on the activation of the cGMP-protein kinase G cascade in smooth muscle cells in vessels. Once the cascade is activated, there is stimulation of potassium channels, a process that results in membrane hyperpolarization and inhibition of intracellular calcium influx, producing vasodilation. The action of protein kinase G is based on the phosphorylation of myosin light chains, a process by which the vasoconstriction of the smooth muscles in the vessels decreases (Gao *et al*., 2016).The antihypertensive capacity of flavones represented by kaempferol and quercetin is manifested by modulating the renin-angiotensin-aldosterone system, by improving endothelial dysfunction and by regulating the contraction of smooth muscle in vessels (Thamcharoen *et al*., 2016).

4. Pharmacokinetic and pharmacodynamics aspect of *S. tuberosum*

The term "pharmacokinetics" typically pertains to the study of how drugs or substances are absorbed, distributed, metabolized, and excreted within a living organism, usually focusing on the processes within the human body. *S. tuberosum* (potatoes), which is a food rather than a drug, we do not usually apply pharmacokinetic principles. Instead, we look at how the nutrients and phytochemicals in potatoes are processed by the human body. The nutrients and phytochemicals in potatoes are generally absorbed in the digestive system. Starches are broken down into glucose, vitamins, and minerals are absorbed, and phytochemicals like flavonoids and phenolic compounds may have various absorption rates and mechanisms (Karpukhin and Keita, 2020). The main phenolic acid in potatoes is cinnamic acid and its derivatives besides gallic and protocatechuic acid. They play a major role in the first kind of defense against microbes and insects. Nutrients from potatoes are distributed throughout the body through the bloodstream to be used for various metabolic processes. For example, glucose is distributed to provide energy to cells. Potatoes provide a source of carbohydrates, which are metabolized in the body to produce energy. Additionally, some phytochemicals may undergo metabolism by enzymes in the body. Polyphenols and anthocyanins are the important phytochemicals found. These significantly reduce the risk of chronic disease (Basalingappa and Kanthesh, 2019).

It is important to note that the pharmacokinetics of *S. tuberosum* as a food is different from a drug. Potatoes provide a source of essential nutrients and phytochemicals that are important for health and nutrition, and their processing in the body is part of normal physiological processes.

Pharmacodynamics primarily relates to how drugs or substances interact with the body and the resulting physiological and biochemical effects. Potatoes are a source of carbohydrates, which are broken down into glucose in the body. The consumption of potatoes can lead to an increase in blood glucose levels, especially if they are rapidly digested, which can be influenced by factors like cooking methods. They are known for their ability to induce a feeling of fullness (satiety). This can be attributed to their high fiber content, which can affect appetite and food intake. Potatoes provide essential nutrients like vitamins (*e.g.*, vitamin C and B vitamins), minerals (*e.g.*, potassium), and phytochemicals (Silva-Beltran *et al*., 2017). The pharmacodynamics effect here would be the delivery of these nutrients to support various physiological functions. Phytochemicals in potatoes, such as flavonoids and phenolic compounds, have antioxidant and potential health benefits.

Their pharmacodynamic effects would include their antioxidant properties and potential impacts on health. The dietary fiber in potatoes can have a positive effect on digestive health, promoting regular bowel movements and supporting gut health. The consumption of potatoes can have various physiological effects related to their nutrient content, fiber, and phytochemicals. These effects are part of normal metabolic and digestive processes in the body.

5. Toxicological studies

S. tuberosum possesses some potential toxicological constituents like glycoalkalaoids, proteinase inhibitors, and lectins (Damme *et al*., 2004).

5.1 Glycoalkaloids

It contains a toxic steroids and is referred to as saline or TGA (Sharma and Salunkhe, 1989). Natural colour of potatoes changes to green colour due to the accumulation of chlorophyll. It causes headaches, vomiting, abdominal pain, diarrhoea, and circulatory collapse. Sometimes, it can cause mental confusion, stupor, hallucination even death (Smith *et al*., 1988).

5.2 Proteinase inhibitors

It is a high concentration of proteinase inhibitors that inhibits or prevents the activities of pancreatic digestive proteinase including trypsin, elastase, and chymotrypsin (Ryan *et al*., 1991), and rich in plasma kallikrein inhibitors (Richardson, 1987).

5.3 Lectins

Lectins or hemagglutinins are carbohydrate-binding cell-agglutination. Proteins which is used in the development of immunology and potentially used in cancer chemotherapy (Goldstein and Hayes, 1988).

6. Conclusion

Potato which a plant and used as a staple food. It contains kukoamines, flavonoids, *etc*., which help to reduce blood pressure and protect against cardiovascular diseases. It contains many health benefits and acts as an anti-ageing agent, pain reliever, soothing effect in mild degrees of burns, scurvy, arthritis, digestive system disorders like ulcers, and gastritis, skin cleanser, and revitalizer. Cosmetically, it is used to reduce dark pigmentation, mild to moderate acnes, and as a thickening agent. Therapeutically it promotes a healthy intestine, eliminates toxins from the body, and helps to improve the liver and spleen. So eating potatoes daily can lead to many health benefits.

Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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