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Review Article

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Bioactive Compounds in *Pyrus pashia*, Their Bioactivities, and Associated Health Benefits: A Review

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Abstract

Pyrus pashia commonly known as wild Himalayan pear is a medium-sized deciduous tree belonging to the Rosaceae family. The fruit is characterized by its distinctive wild aroma and astringent taste, which remains unexplored in flavor profile and nutritional composition. All parts of *P. pashia* including bark, leaves, and flowers are rich sources of functional components that possess different biological activities such as antioxidant, anti-inflammatory, anti-diabetic, antimicrobial, and hepatoprotective activity. From ancient times the *P. pashia* wild Himalayan pear was used to cure many human ailments. Due to the presence of many functional components, this fruit can be used for the preparation of novel culinary and medicinally rich food products. In this study, we studied the different bioactive components that are present in *P. pashia* and their biological activities, along with this the health benefits of *P. pashia* are discussed.

Keywords

Pyrus pashia, Wild Himalayan pear, Bioactive compounds, Health benefits

Introduction

P. pashia (Wild Himalayan pear) belongs to the family Rosaceae and subfamily Maloidae. *P. pashia* is a deciduous tree characterized by its ragged leaves and small edible fruits. From ancient times *P. pashia* has been utilized as folk medicine and healthy food [1, 2]. *P. pashia* is locally known as kainth, Indian pear, Himalayan pear, melu, and shegal [3]. The fruit plant is generally used as a rootstock for pears; however, the leaves of this fruit were also used in a tonic for hair loss and help in digestion. The leaves of *P. pashia* are rich in polyphenolic compounds like chlorogenic acids, flavan-3-ols and arbutin exhibit a wide range of physiological activities and are used for the development of several therapeutic agents [2]. Different varieties of pear have been harvested for medicinal purposes in many countries including Korea, Japan, and China [4]. The *P. pashia* is primarily found in the Himalayan region and northern Indian states such as Himachal Pradesh, Uttarakhand, and Punjab [3]. The plants are best grown in the height range of 750 to 2600 m. The immature fruits are usually willow green in colour with light brown spots on the outer surface, the fruits turn black and soft when they mature or ripe. The fruits are rich in nutrients, containing several essential vitamins including vitamins A, B1, B2, B3 and C, significant amounts of minerals including calcium, magnesium, iron, sodium, and potassium and phytochemicals such as alkaloids, terpenoids, tannins, steroids, saponins, and glycosides [3, 5, 6]. Additionally, the significant fiber content contributes to effective relief from constipation and intestinal inflammation [7, 8]. Traditionally it has been used as folk medicine for the treatment of various ailments such as cough, cold,

fever, skin diseases, epilepsy, fertility disorders, and diabetes [9, 10]. Several bioactive and phenolic components present in *P. passia* flowers make them beneficial in the treatment of heart disease and cancer [11]. The bark is used in some ancient remedies for the treatment of skin disorders and helps in wound healing [12-14]. The leaves are utilized as a health beverage in the Tawang district of Arunachal Pradesh [7]. The leaf extract is used as a tonic for hair loss. Twigs of the tree are used in toothache problems by the indigenous people of Jammu and Kashmir and the Ladakh region of India [15-18]. The wood of trees is used as a major fuel source in the central Himalayan region [19, 20]. To date, many studies have been conducted on the pharmaceutical and therapeutic qualities of *P. pashia* fruit, however, there has been limited research on the value addition of *P. pashia* fruit. Fruits have a very short shelf life, and it can be extended with the help of food processing techniques. The fruit contains various health-promoting components such as phytochemicals, bioactive compounds, minerals, and vitamins, therefore it has tremendous potential for the development of value-added and novel food products with therapeutic benefits. The present review aims to discuss in depth the current knowledge on the nutritional value, bioactive components, health benefits and value addition of *P. pashia* fruits.

Bioactive compounds in *P. pashia* fruit

Incorporating fruits and vegetables into our diet not only adds vibrancy and joy but also imparts vital nutrients to our body because they contain large number of health-promoting substances such as polyphenols, carotenoid, vitamins, fiber, and anthocyanins [20]. A diet rich in fruits and vegetables can slow the ageing process and reduce the chances of cancer, and heart-related diseases [21, 22].

Ascorbic acid content

Ascorbic acid is considered a potent antioxidant and its significance in various physiological processes. As humans are unable to synthesize ascorbic acid internally due to the absence of the gulonolactone oxidase enzyme, therefore, an insufficient intake of dietary ascorbate can lead to the development of a clinical syndrome known as scurvy [23]. Therefore, it is crucial to incorporate ascorbic acid-rich foods into our diet through supplementation to maintain optimal health and prevent deficiencies like scurvy. Vitamin C plays a vital role in supporting immune reaction, detoxification, iron absorption, wound healing, orthogenesis, collagen biosynthesis, preventing the formation of blood vessel clots and participating in various essential metabolic processes within the body [12]. Indeed, the levels of ascorbic acid commonly known as vitamin C vary significantly depending on factors such as specific species of the organism, the environmental conditions in which it grows, harvesting time, the methods used in its production, the stages of development it undergoes and the conditions during storage. Different extraction strategies also affect reliability, stability, and vitamin C content [24]. Ascorbic acid has an essential function in human health including the prevention of chronic human diseases such as scurvy, oxidative stress-induced DNA mutations, certain tumors, myocardial infarction, atherosclerosis, glaucoma, and renal disease [25]. In addition to its immune-boosting effects, vitamin C plays a crucial role in inhibiting the formation of nitrosamines and thwarting the activation of carcinogens [24]. Vitamin C has a pivotal role in various body mechanisms that cannot be overstated and one of its significant functions is supporting the abundant collagen, which serves as a protective shield against illness and infections. By aiding in collagen formation, vitamin C not only strengthens the body's defense mechanisms but also contributes to the synthesis of hemoglobin, potentially offering a remedy for scurvy. Moreover, this essential vitamin plays a vital role in carbohydrate promotion and integration of fats, and proteins within the body [26]. Vitamin C is a well-versed antioxidant, it can protect crucial molecules including amino acids, lipids, carbohydrates, nucleic acids, and other vital constituents against the damaging effects of free radicals and reactive oxygen species generated due to exposure to toxins and pollutants. Furthermore, vitamin C exhibits the potential to rejuvenate various antioxidants and is capable of resuscitating different cancer-preventing agents such as vitamin E. Chaya et al. [27] in his study showed that the *P. pashia* fruit contains a 9.62 mg/100 g pulp of ascorbic acid. Similarly, Khanal et al. [28] investigated the ascorbic content of *P. Pashia* fruit and found it to be 8.19 ± 0.13 µg/ml. Moreover, the research findings revealed that these indigenous wild edible fruits possess a greater vitamin C content compared to commonly available fruits in the market [27].

Total phenolic contents

Phenolic compounds play vital functions in plant reproduction and development, act as important defense mechanisms against pathogens, and parasites contribute significantly to the vibrant colors displayed by various plant species [29]. The phenolic compounds are primarily driven by the need to understand their influence on sensory qualities such as color, antioxidant potential and nutritional value in foods. The radical-scavenging ability of phenolic acids is intricately influenced by substituents on their aromatic ring thereby impacting their overall stabilization this in turn, underpins their dominant model of antioxidant potential, centred on hydrogen atom donation in the radical scavenging process, complemented by other mechanisms like singlet oxygen quenching and electron donation. It has been reported that the flowers of *Pyrus* genus contain a certain amount of phenolics such as arbutin, chlorogenic acid, and flavonoids [30]. The phenolic content of plant materials and their antioxidant activity highlight the significant role in stabilizing lipid oxidation. Furthermore, beyond their antioxidant properties, these compounds offer a diverse array of medicinal benefits, including anti-inflammatory, anti-microbial, anti-allergic, anti-thrombotic, and vasodilator effects, thus attributing the control of various diseases to the constituents of medicinal plants [31]. The phenolic content of plant materials is intrinsically linked to their antioxidant activity, alongside a diverse range of medicinal properties and fulfils a crucial role in stabilizing lipid oxidation. Siddiqui et al.[32] determined the phenolic content of different components of *P. pashia* plant such as fruit, bark, and leaf. The extract was prepared in four organic solvents including hexane, chloroform, ethyl acetate, and n-butanol. The total phenol in different parts of plants is expressed as mg of gallic acid equivalent mg/g of fraction. The results showed that the extract prepared in ethyl

acetate gave the highest phenolic content of bark (393.19 ± 0.72), leaf (321.23 ± 0.74), and fruit (237.32 ± 0.89), followed by extract prepared in chloroform n-butanol, methanol, and n-hexane had the lowest phenolic content [32].

Flavonoids

Flavonoids, such as flavones, flavanols and condensed tannins are the secondary metabolites that exhibit antioxidant properties primarily due to the presence of unbound hydroxyl groups. These compounds not only demonstrate antioxidant efficacy *in vitro* but also function as antioxidants within living organisms [33]. In various plants, flavonoids are also contained in high amounts. These compounds exert various biological effects, including antioxidant, anticancer, cardiovascular protection, and anti-inflammation. Total flavonoid contents in the 80% ethanol extracts of pear fruits were measured using the colorimetric method with aluminum chloride [34]. A diverse array of edible plants, fruits, vegetables, and grains contain flavonoids. Their presence in food such as wine, tea, soybeans, and liquor ice has explored their potential health benefits due to their notable antioxidant properties and the ability to delay or mitigate various conditions believed to be associated with oxidative stress, including atherosclerosis, cancer, Parkinson's disease, and diabetes. The total flavonoid content in leaves and fruits of *P. pashia* was found to be 150 ± 20 and 10.30 ± 10 mg quercetin equivalents as per the study conducted by Rawat et al. [29]. Similarly, the concentration of flavonoids in the leaves and flower extract of *P. pashia* was found to be 371 ± 12 and 130 ± 10 mg of quercetin equivalent [33].

Bioactivities of *P. pashia* fruit

Antioxidant activity

In several regions, indigenous plants that thrive naturally are harnessed for their medicinal properties, as they contain an array of photochemicals with potent antimicrobial capabilities [26]. The difference in the antioxidant level within the fruit, influenced by factors such as solvent type, phenolic concentration, and interactions among extract components, contribute to its exceptional potential as a natural source of health-enhancing antioxidants. The phosphomolybdenum method serve as a valuable technique for assessing the overall antioxidant capacity of diverse *P. pashia* extracts, operating through the reduction of by the antioxidants present. Under acidic conditions, this process generates a distinctive green phosphate molybdenum complex, characterized by its peak absorption at 695 nm [35, 36]. Substances like ascorbic acid, phenols, tocopherols, and carotenoids are commonly identified using the phosphomolybdenum method. Siddiqui et al. [32] assessed the antioxidant activity of *P. pashia* by using different solvents including methanol, hexane, chloroform, ethyl acetate, n-butanol, and aqueous extracts. The fruit extract prepared in chloroform exhibited the highest antioxidant activity followed by the extract prepared in ethyl acetate, n-butanol, methanol and aqueous. In another study, it showed the bark and leaves extract of *P. pashia* prepared in butanol showed high antioxidant activity [4].

Antimicrobial activity

The extracts prepared from different parts of the *P. pashia* plant have demonstrated antimicrobial properties against a wide range of pathogenic bacteria and fungi. Particularly, the ethanolic extract of the fruit skin displayed remarkable antibacterial activity against *Klebsiella pneumonia, Shigella flexneri,* and *Escherichia coli* while the chloroform and ethanolic extracts from the fruits exhibited strong antifungal activity against *Candida albicans*, *Aspergillus flavus,* and *Aspergillus parasiticus* [18]. Besides antioxidant potential plant secondary metabolites also exhibit multiple pharmacological activities including anti-inflammatory, antimicrobial, anticancer, etc, and play Play significant role in disease prevention, health promotion and aesthetic properties.

Anti-inflammatory activities

Inflammation usually develops when infectious microorganisms, such as bacteria or viruses, enter the body and are present in certain tissues or circulate through the blood. Eating a diet rich in fruits and vegetables lowers the risk of cancer due to the presence of natural polyphenol in fruits and vegetables. The regular intake of phenolic-rich fruits and various plant components not only associates with anti-inflammatory properties but also correlates with a lowered susceptibility to the specific forms of cancer and cardiovascular conditions [37-39]. Chandra et al. [40] effectively demonstrated the anti-inflammatory potential of methanolic extract of *P. pashia* The oral doses of *P. Pashia* extract i.e., 100 and 150 mg/kg body weight significantly reduced the amount of inflammation caused by carrageen in adult albino rats, by 56.6% and 61.12%, respectively. The anti-inflammatory response is due to the presence of flavonoids, terpenoids and phenolic compounds in the extract [3]. Saini et al. [41] observed the anti-proliferative potential of methanol and acetone extracts ranging from 0.667 to 6.67 mg/ml from *P. pashia* fruit. Furthermore, the extracts showcased substantial anticancer effects with IC_{50} values of 13.97 and 10.72 mg/ml for the methanol and acetone extracts, respectively. Additionally, it unveiled the presence of notable quantities of gallic acid, caffeic acid, catechin and ellagic acid traces in the extracts. This anti-proliferative activity is likely attributed to the elevated phenolic and flavonoid content as well as the presence of ellagic content. These findings collectively enhance the diverse traditional uses of *P. pashia* extract including its historical applications in the treatment of typhoid fever, cough, and other various inflammatory ailments.

Hepatoprotective activity

The aqueous extract of *P. pashia* leaves proved possible hepatoprotective capabilities against induced liver damage caused by exposure to carbon tetrachloride. The study highlighted that both pre- and post-treatment with the aqueous leaf extract contributed to a noteworthy decrease in enzyme levels (including serum transaminase, phosphatase, and bilirubin). This observation suggests that the leaf extracts could find practical application in the pharmaceutical and food industries, due to the presence of substantial content of phenolics and flavonoids.

Health benefits and value addition of *P. pashia* fruit

P. pashia fruit is high in nutrition and is a good source of various minerals, vitamins, phytochemicals, antioxidants, and

bioactive compounds with promised health benefits. Figure 1 illustrates the many health advantages of *P. pashia* fruit. The traditional medicinal systems, namely ayurvedic, unani, siddha, and tribal medicines have a rich history since ancient times in India. They heavily rely on the use of over 400 plant-based formulations or extracts, out of which 75% of these plants were sourced from tropical forest regions. The regions where synthetic drugs are financially inaccessible to many, particularly in rural areas the preparation of medicinal formulations using locally available plants continues to serve as a vital component of health care. Among these valuable resources, wild fruit species hold potential, not only for medicinal purposes but also as catalysts for economic development, meeting nutritional needs and other desirable attributes [42, 43]. An excellent example lies in the Himalayan region where the distribution of *P. pashia* brings significant ethnic advantages. Many indigenous peoples have utilized this plant, for the treatment of a variety of health conditions, such as gastrointestinal, respiratory, and vascular disorders. From ancient times, the ripe fruits of *P. pashia* have been employed by the local populations as a remedy for constipation. Chettri et al. [44] have shown the beneficial application of wild edible fruit extracts, for the treatment of dysentery. Additionally, the fruit juice of *P. pashia* is recognized for its astringent qualities, as well as its diuretic properties, further enhancing its potential contributions to traditional medicine. *P. pashia* fruit extract has found historical usage in a wide array of health applications such as eye-related issues, digestive ailments such as dyspepsia, relief from headaches, induction of body sweating as a diaphoretic, hysteria and epilepsy, alleviation of sore throats, mitigation of irritability, addressing anemia, lowering blood cholesterol levels, and providing relief from abdominal pain [26]. Diverse methodologies are employed in the extraction of biologically active compounds of medicinal significance, encompassing processes like decoctions, infusion, maceration, and percolation. The preparation of a decoction using dried fruits in combination with other plant components of *P. pashia* has been shown to enhance the functioning of spleen and stomach [4]. The fruits are employed as fodder for milk-producing animals, effectively boosting their milk production. The drinking of leaf decoction as a non-fermented health beverage is significant in the traditional rituals of tribal people. The fresh leaves of *P. pashia* exhibit astringent, laxative and sedative properties [45, 46]. Crushed leaves are also used to make a variety of cosmetic products. In addition, the leaf extract of *P. pashia* is used as a tonic in treatments of hair loss [47, 48]. *P. pashia* fruit roots have anti-inflammatory and antibacterial effects. Because of their qualities, they have traditionally been used to treat a variety of diseases such as sore throat, fever, and gastrointestinal disorders such as peptic and gastric ulcers [49-51].

P. pashia fruit is an essential wild fruit that contains a higher number of antioxidants, and phenolic compounds and can be used for the development of value-added products. The fruits have a short shelf life, and they can be preserved better using food processing techniques. Therefore, the conversion of *P. pashia* fruits to different value-added products such as jam, candy, powder, and juices could help in the prevention of wastage, increase its consumption, and make it valuable in fighting against various diseases [52, 53]. The developed product might help to solve the gap in food supply and nutrition safety and serve as pre-commercialized formulations.

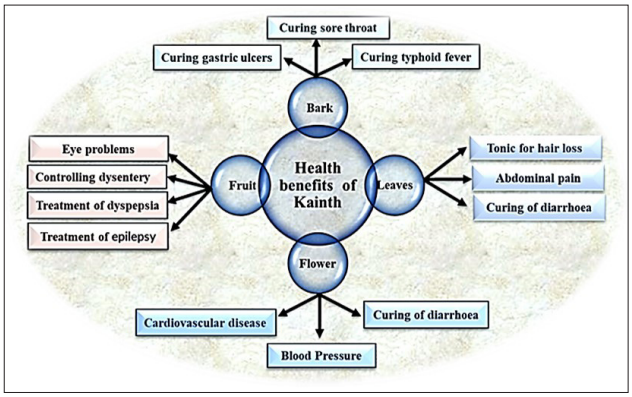


Figure 1: Health benefits of *P. pashia* fruit.

Conclusion

P. pashia fruit is high in nutrition and is a rich source of various phytochemicals, antioxidants, and bioactive compounds with promised health benefits. The fruit has also proved to possess anti-diarrheal, antioxidant, anti-diabetic, hepatoprotective and anti-cancerous properties. Since ancient times, local people used *P. pashia* fruit for the treatment of many human diseases, but till date the development of value-added products from this fruit has not been explored, this may be due to a lack of knowledge and technology among the people. The fruits having short shelf life can be preserved better using food processing techniques. Therefore, the conversion of *P. pashia* fruits to different value-added products by using food processing techniques could help in the prevention of wastage, increase its consumption, and make it valuable in fighting against malnutrition, and other human diseases.

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Conflict of Interest

None.

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