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Psidium Fruits: Endemic Fruits of Latin America with a Wide Variety of Phytochemicals

*Carolina Rojas-Garbanzo**

Department of Food Science and Technology, University of Costa Rica, Costa Rica

Abstract

Main causes of death globally are stroke, ischemic heart and respiratory diseases, no making distinction among regions of the world, nor income economies. The incidence of these diseases may be reduced by consumption of fruits and vegetables. These foods play an important role in human nutrition attributed to the action of phytochemicals such as polyphenols and carotenoids contained in the fruits and vegetables. Among fruits, those of the genus *Psidium* have gained attention due to their use as a traditional medicine and many polyphenols and chemicals have been reported. The main edible *Psidium* fruits are the pink guava, Costa Rican guava, strawberry guava, and Brazilian guava, which are cultivated in Latin America but also in India and Pakistan. Main carotenoids present in these fruits are all-*trans*-lycopene, all-*trans*-β-carotene, and all-*trans*-β-crytoxanthin, the two latter with provitamin A activity. These fruits contain mainly polyphenols such as proanthocyanidins, monomeric flavanols, and ellagitannins, for which many bioactivities have been reported. This report summarizes the main phytochemicals present in the four edible Psidium fruits and describes some bioactivities attributed to these compounds. The compiled information highlights the importance of considering Psidium fruits as good sources of phytochemicals and their consideration for further development of functional fruits.

Keywords: *Psidium*; Costa Rican guava; Pink guava; Strawberry guava; Brazilian Guava; Phytochemicals

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Correspondence:
Carolina Rojas-Garbanzo, Department of Food Science and Technology, University of Costa Rica, Postal address 11501-2060 San José, Costa Rica, Tel: (506)-2511-7227; Fax: (506)-2253-3762;
E-mail: carolina.rojasgarbanzo@ucr.ac.cr

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Main Edible *Psidium* Fruits and Their Main Phytochemicals

For 2015, stroke, ischemic heart and respiratory diseases were the main causes of death globally, no making distinction among regions of the world, nor income economies [1]. It is well known that consumption of fruits and vegetables play an important role in human nutrition preventing the development of such diseases. Individuals eating five or more servings of fruits and vegetables daily have approximately half the risk of suffering from some diseases [2]. Therefore, consumption of fruits and vegetables is no longer just a matter of taste; it is nowadays also a matter of health. These benefits on health are attributed to the action of secondary metabolites found in fruits and vegetables such as such as polyphenols and carotenoids. These micronutrients are associated with positive health effects in the prevention of cardiovascular, neurodegenerative diseases, and different types of cancer [2].

Among fruits, tropical and subtropical fruits such as *Psidium* fruits, have gained popularity due to their attractive sensory properties but also due to their putative health benefits. They are very important fruit crops in countries such as Costa Rica, Mexico, Brazil, Pakistan, Thailand, China, and India [3], and have been used as a traditional medicine in Mexico, Central America, Brazil, Taiwan, Japan, China, and Korea [4-6]. These plants have been used for the treatment of diabetes, caries, wounds, diarrhea, inflammation, and hypertension. Besides, anti-plasmodic, hepatoprotective, anti-cancer, and antioxidant, antimicrobial, anti-allergy, antigenotoxic, cardioprotective, and anti-cough, among others, are some activities reported for leaves and fruits of these plants [5,7].

The genus *Psidium* is native to Central America and nowadays it is grown throughout the tropical and subtropical regions [8-10]. *Psidium* belongs to the Myrtaceae family and comprises more than 150 species. The most widely cultivated edible fruits in Latin America include the pink guava *(P. guajava L.)*, the Costa Rican guava *(P. friedrichsthalianum Nied.)*, the strawberry guava *(P. cattleianum Sabine)*, and the Brazilian guava *(P. guineense Sw.)* [10]. The fruits of these plants are suitable for fresh consumption and some typical preparations are juice, ice cream, and jellies. Their processing has gained attention due to their high nutritional value, availability at a moderate price, and a pleasant aroma [11]. In 2014, India was considered the largest guava producer worldwide, followed by China and Thailand. They export guava concentrate which is used in the production of beverages in industries of North America and Europe [12].

Despite the many health benefits attributed to these plants, just a few reports have described the biological activities of the fruits together with their phytochemical composition; and those that have been centered about evaluation of leaves. Nevertheless, it is clear that *Psidium* fruits are a potential source of phytochemicals for which many bioactivities have been proved. Therefore, it would be also considerable to introduce nutritionally valuable fruits and their products not only in the region of origin, but also in other countries in order to increase the consumption of putative health promoting compounds.

Bioactivities Reported For Phytochemicals Found In *Psidium* Fruits and Health Perspectives

Among phytochemicals, carotenoids, phenolic compounds, and triterpenoids are the main phytochemicals characterized in leaves and fruits [13-21]. In the case of ripe pink guava, all-*trans*-lycopene is the main carotenoid followed by all-*trans*-β-carotene [17,22]. Based on the limit set by Britton & Khachik [23], i.e., > 2 mg/100 g few, pink guava has been recognized as a very good source of all-*trans*-lycopene and as good source of all-*trans*-β-carotene, the latter also with provitamin a activity [24]. Strawberry guava has been also recognized as a source all-*trans*-β-carotene and all-*trans*-β-crytoxanthin [18].

The provitamin A value in 100 g of ripe pink guava and in strawberry guava corresponds to 7.5% and 3,2%, respectively, of the Recommended Daily Intake (RDI) of vitamin A, which is 5000 IU [22,25]. This fact has been given particular attention because vitamin A deficiency today is a worldwide public health issue in more than half of the countries. Between 250000 and 500000 children having vitamin A deficiency develop blindness every year [26].

Regarding bioactivities attributed to carotenoids, recently an *in vitro* study demonstrated the anti-inflammatory activity of a lycopene rich extract as well as the purified lycopene from pink guava that shows protective anti-oxidative stress activity by down regulating inflammatory mediators and inhibiting the gene expression involved in inflammation [27]. In general, lycopene has been shown to be twice as effective as β-carotene in protecting lymphocytes from NO_2 radical cell death and membrane damage [28]. Fonseca demonstrated the positive effect of all-*trans*-lycopene and all-*trans*-β-carotene by decreasing the number of viable breast cancer cell *in vitro* [29]. These carotenoids also promoted cell cycle arrest followed by decreased cell viability in the majority of cell lines; an increase in apoptosis was also observed. It has been reported that all-*trans*-lycopene is a more potent scavenger of oxygen radicals than other dietary carotenoids [30].

Pink guava is also a source of proanthocyanidins and monomeric flavanols; representing more than 50% and 30%, of the quantified polyphenols, respectively [10]. Among 60 polar phenolic compounds, a B-type proanthocyanidin, i.e., (epi) catechin-(epi) catechin, was the main compound. Other phytochemicals reported for pink guava are guavin B, (epi) catequin, (epi) gallocatechin, and quercetin derivatives.

These compounds are also present in Costa Rican guava, but proanthocyanidins, i.e., B-type, and ellagitannins represent more than 50% and 20% of the quantified polyphenols, respectively. Main ellagitannins present in Costa Rican guava are geraniin, vescalagin, and castalagin [26]. Whereas, in Brazilian guava the main polar compounds are the ellagitannins hexahydroxy-phenyl-glucose (HHPP-glucose) and di-HHP-glucose [15], and in strawberry guava, ellagic acid, ellagic acid deoxyhexoside, and the flavanol epicathequin gallate are the predominant polyphenols [18].

Regarding to the bioactivity of polyphenols, the fruits have excessively been evaluated in *in vitro* and *in vivo* studies [2,7,8,13,31-34], it seems worthwhile to examine the bioactivity of the polyphenolic compounds from *Psidium fruits*. A cinnamic acid derivative, presumably cinnamoyl-*O*-glucopyranoside is reported in *Psidium* fruits. *In vivo* studies with cashew apple extract in rats confirmed the hypoglycemic activity of this compound. Decreased levels of glucose, promotion of growth of lactobacilli in fecal material, and an increase in catalase activity in liver were observed when a cashew apple beverage was consumed [35]. The authors attributed the positive effects to the presence of cinnamoyl-*O*-glucopyranoside. The thermal stability of this compound is of special attention due to the antimicrobial activity against *Staphylococcus aureus, Salmonella typhimurium*, and *Bacillus cereus* [36].

Some bioactivities reported for guavin B are inhibition of lipid peroxidation, mutagenicity of carcinogens and tumor promotion, and host-mediated antitumor. In addition, antiviral and antibacterial properties have been attributed to guavin B [37]. Another ellagitannin reported in *Psidium* species is myrciaphenone B. When this compound was extracted from *P. guajava* leaves and used in *in vitro* studies, a potent inhibitory activity on Aldose reductase and α-glucosidase was reported; that is, this compound inhibits the increase of serum glucose levels in glucose loaded rats and in alloxan-induced diabetic mice [38]. *In vitro* studies have demonstrated an inhibitory effect of geraniin on the bone absorption ability of osteoclasts [39]. Also, activity against methylglyoxal-induced inflammation and carbohydrate metabolic disorders were confirmed for vescalagin when *in vitro* studies were performed [4].

Some flavanols and derivatives are present in *Psidium* fruits, e.g., (epi) catechin and (epi) gallocatechin. These flavanols were found to be effective in reducing cholesterol absorption and in decreasing lymphatic absorption of triacylglycerols by reducing their solubility [40]. Moreover, the intake of (epi) catechin is inversely associated with the risk of coronary heart disease. It has been reported that consumption of cocoa products containing (epi) catechin are related to a reduction of the blood pressure in humans [41,42]. Also, some positive effects are related to the B-type dimer of (epi) catechin. This compound has been related to a decreased formation of advanced glycation end products in plasma, that is, preventing glycation of proteins present in blood. As a result, some disease such as retinopathy, cataract, neuropathy, atherosclerosis, nephropathy, embryopathy, and delayed healing of wounds can be prevented in diabetic patients [43].

Abscisic acid, also detected in *P. guajava* and *P. friedrichsthalianum,* is a hormone key related to the development and growth of plants and has been inversely correlated with the accumulation of plastids and content of lycopene [44]. *In vivo* studies demonstrated that intake of abscisic acid decreased fasting blood glucose concentrations, ameliorated glucose tolerance, and increased mRNA expression of PPARg and its responsive genes, i.e., adiponectin, aP2, and CD36, in white adipose tissue. Adipocyte hypertrophy, tumor necrosis factor-α expression, and macrophage infiltration in white adipose tissue was attenuated in abscisic acid-fed mice [45].

Although most of the bioactivities mentioned above were reported for the compounds obtained from other food sources, it can be suggested that consumption of *Psidium* fruits may help preventing such human health diseases. Nevertheless, *in vitro, in vivo,* and *ex vivo* analyses are recommended in order to prove the positive effect on human health when these fruits are consumed. Based on the phytochemicals profile reported for these fruits, they may be recognized as sources of Phytochemicals, which could be used further in the development of functional foods.

Conclusion

In the last years great progress has been made in the discovery of functional foods and potential pharmacological agents from natural sources. Many chemical and biological studies have been focused on the identification of sources of phytochemicals, elucidation of the parameters associated to their bioaccessibility and bioavailability, as well as on deciphering their mechanisms of action once they are absorb in the body. Most of the research has been performed with fruits from the temperate regions, studies focusing on tropical fruits are still scare. However, some attempts have been made and some phytochemicals, e.g., carotenoids and polyphenols, have been reported, also bioactivities such as antidiarrheal, antimicrobial, and antioxidant have been proved.

One of the goals of identifying fruits with high content of phytochemicals is to increase the offer of phytochemical-rich fruits and fruit products. Among tropical fruits, those of the genus *Psidium* have received more attention over the past 10 years and a variety of potential beneficial effects have been reported. Studies focusing on the phytochemical profile in these fruits are limited to few main compounds and most of the research has been done using leave extracts. *Psidium* plants have mostly been used in the preparation of infusions but the fruits are mainly consumed fresh; juice, ice cream, and jellies are also very often in the local market.

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