



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

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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 -cryptoxanthin, 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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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 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 -cryptoxanthin [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 NO₂ 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) galocatechin, 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 epicatechin 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 myricaphenone 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) galocatechin. 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 PPAR γ 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 absorbed in the body. Most of the research has been performed with fruits from the temperate regions, studies focusing on tropical fruits are still scarce. 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.

References

- World Health Organization - WHO. Micronutrient deficiencies. 2015.
- Dembitsky VM, Poovarodom S, Leontowicz H, Leontowicz M, Vearasilp S, Trakhtenberg S, et al. The multiple nutrition properties of some exotic fruits: biological activity and active metabolites. *Food Res Int*. 2011;44(7):1671-701.
- Mani A, Rachana M, Thomas G. Elucidation of diversity among *Psidium* species using morphological and SPAR methods. *J Phytol*. 2011;3(8):53-61.
- Chang CH, Hsieh CL, Wang HE, Peng CC, Chyau CC, Peng RY. Unique bioactive polyphenolic profile of guava (*Psidium guajava*) budding leaf tea is related to plant biochemistry of budding leaves in early dawn. *J Sci Food Agric*. 2013;93(4):54-94.
- Díaz-de-Cerio E, Verardo V, Gómez-Caravaca AM, Fernández-Gutiérrez A, Segura-Carretero A. Determination of polar compounds in guava leaves infusions and ultrasound aqueous extract by HPLC-ESI-MS. *J Chem*. 2015;44:1-9.
- Matsuzaki K, Ishii R, Kobiyama K, Kitanaka S. New benzophenone and quercetin galloyl glycosides from *Psidium guajava* L. *J Nat Med*. 2010;64(3):252-6.
- Flores G, Wu SB, Negrin A, Kennelly EJ. Chemical composition and antioxidant activity of seven cultivars of guava (*Psidium guajava*) fruits. *Food Chem*. 2015;170:327-35.
- Cuadrado-Silva CT, Pozo-Bayón MA, Osorio C. Targeted metabolomic analysis of polyphenols with antioxidant activity in sour guava (*Psidium friedrichsthalianum* Nied.) fruit. *Molec*. 2016;22(1):11-20.
- Flores G, Dastmalchi K, Wu SB, Whalen K, Dabo AJ, Reynertson KA, et al. Phenolic-rich extract from the Costa Rican guava (*Psidium friedrichsthalianum*) pulp with antioxidant and anti-inflammatory activity. Potential for COPD therapy. *Food Chem*. 2013;141(2):889-95.
- Rojas-Garbanzo C, Zimmermann BF, Schulze-Kaysers N, Schieber A. Characterization of phenolic and other polar compounds in the peel and flesh of pink guava (*Psidium guajava* L. cv. "Criolla") by ultra-high performance liquid chromatography with diode array detector and mass spectrometric detection. *Food Res Int*. 2017;100(3):445-53.
- Mitra S, Irenaeus T, Gurung M, Pathak P. Taxonomy and importance of Myrtaceae. *Acta Horticult*. 2012; 959(959):23-34.
- Food and Agricultural Organization of the United Nations - FAOSTAT. Production of mangoes, mangosteen and guava for the year 2014. 2016.
- Borges LL, Conceição EC, Silveira D. Active compounds and medicinal properties of *Myrciaria* genus. *Food Chem*. 2014;153:224-33.
- Fracassetti D, Costa C, Moulay L, Tomas-Barberan FA. Ellagic acid derivatives, ellagitannins, proanthocyanidins and other phenolics, vitamin C and antioxidant capacity of two powder products from camu-camu fruit (*Myrciaria dubia*). *Food Chem*. 2013;139(1-4):578-88.
- Gordon A, Jungfer E, da Silva BA, Maia JGS, Marx F. Phenolic constituents and antioxidant capacity of four underutilized fruits from the Amazon region. *J Agric Food Chem*. 2011;59(14):7688-99.
- Mercadante A, Steck A, Pfander H. Carotenoids from guava (*Psidium guajava* L.): isolation and structure elucidation. *J Agric Food Chem*. 1999;47(1):145-51.
- Padula M, Rodríguez-Amaya DB. Characterization of the carotenoids and assessment of the vitamin A value of Brazilian guavas (*Psidium guajava* L.). *Food Chem*. 1986;20(1):11-9.
- Ribeiro AB, Chiste RC, Freitas M, da Silva AF, Visentainer JV, Fernandes E. *Psidium cattleianum* fruit extracts are efficient *in vitro* scavengers of physiologically relevant reactive oxygen and nitrogen species. *Food Chem*. 2014;165:140-8.
- Santos SAO, Vilela C, Freire CSR, Neto CP, Silvestre AJD. Ultra-high performance liquid chromatography coupled to mass spectrometry applied to the identification of valuable phenolic compounds from *Eucalyptus* wood. *J Chromatogr B Analyt Technol Biomed Life Sci*. 2013;938:65-74.
- Setiawan B, Sulaeman A, Giraud DW, Driskell JA. Carotenoid content of selected Indonesian fruits. *J Food Comp Anal*. 2001;14(2):169-76.
- Wilberg VC, Rodríguez-Amaya DB. HPLC quantitation of major carotenoids of fresh and processed guava, mango and papaya. *Food Sci Tech*. 1995;28(5):474-80.
- Rojas-Garbanzo C, Gleichenhagen M, Heller A, Esquivel P, Schulze-Kaysers N, Schieber A. Carotenoid profile, antioxidant capacity, and chromoplasts of pink guava (*Psidium guajava* L. cv. 'criolla') during fruit ripening. *J Agric Food Chem*. 2017; 65(18): 3737-47.
- Britton G, Khachik F. Carotenoids in food. In: Britton G, Liaen-Jensen S, Pfander H, editors. *Carotenoids Nutrition and Health*. Birkhäuser Verlag: Basel, Switzerland. 2009;25: 45-66.
- Rodríguez-Amaya D. Assessment of the provitamin A contents of foods — The Brazilian experience. *J Food Comp Anal*. 1996;9:196-230.
- Food and Drug Administration (FDA). Guidance for industry: A food labelling Guide (14. Appendix F: Calculate the Percent Daily Value for the Appropriate Nutrients). 2016.
- Rojas-Garbanzo C. Morphological and chemical characteristics of fruits of the genus *Psidium* with special reference to bioactive compounds.

- Cuvillier Verlag Göttingen, Germany. 2017;11-101.
27. Vasconcelos AG, Amorim A das GN, dos Santos RC, Souza JMT, de Souza LKM, Araújo T de SL, et al. Lycopene rich extract from red guava (*Psidium guajava* L.) displays anti-inflammatory and antioxidant profile by reducing suggestive hallmarks of acute inflammatory response in mice. *Food Res Int.* 2017; 99(2):959-68.
 28. Tinkler JH, Böhm F, Schalch W, Truscott TG. Dietary carotenoids protect human cells from damage. *J Phytochem Photobiol B.* 1994;26(3):283-5.
 29. Gloria NF, Soares N, Brand C, Oliveira FL, Borojevic R, Teodoro AJ. Lycopene and beta-carotene induce cell-cycle arrest and apoptosis in human breast cancer cell lines. *Anticancer Res.* 2014;34(3):1377-86.
 30. Miller NJ, Sampson J, Candeias LP, Bramley PM, Rice-Evans CA. Antioxidant activities of carotenes and xanthophylls. *FEBS Lett.* 1996;384(3):240-2.
 31. Cheng FC, Shen SC, Wu JSB. Effect of guava (*Psidium guajava* L.) leaf extract on glucose uptake in rat hepatocytes. *J Food Sci.* 2009;74(5):H132-8.
 32. Bender C, Graziano S, Zimmermann BF. Study of *Stevia rebaudiana* Bertoni antioxidant activities and cellular properties. *Int J Food Sci Nut.* 2015;66(5):553-8.
 33. Manach C, Scalbert A, Morond C, Rémésy C, Jiménez L. Polyphenols: food sources and bioavailability. *Am J Chem Nut.* 2004;79(5):727-47.
 34. Eidenberger T, Selg M, Krennhuber K. Inhibition of dipeptidyl peptidase activity by flavonol glycosides of guava (*Psidium guajava* L.): A key to the beneficial effects of guava in type II diabetes mellitus. *Fitoterapia.* 2013;89:74-9.
 35. Dionísio AP, de Carvalho-Silva LB, Vieira NM, de Souza Goes T, Wurlitzer NJ, Borges MF, et al. Cashew-apple (*Anacardium occidentale* L.) and yacon (*Smallanthus sonchifolius*) functional beverage improve the diabetic state in rats. *Food Res Int.* 2015;77(2):171-6.
 36. Miranda-Cruz E, Espinosa-Moreno J, Centurión-Hidalgo D, Velázquez-Martínez JR, Alor-Chávez M. Actividad antimicrobiana de extractos de *Psidium friedrichsthalianum* L., *Pterocarpus hayesii* L., *Tynanthus guatemalensis* L. Y *Spondias Purpurea* L. *Boletín Latin Caribe Plan Med Arom.* 2012;11(4): 354-61.
 37. Okuda T. Systematics and health effects of chemically distinct tannins in medicinal plants. *Phytochemistry.* 2005;66(17):2012-31.
 38. Yoshikawa M, Shimada H, Nishida N, Li Y, Togushida I, Yamahara J, et al. Antidiabetic principles of natural medicines. II. Aldose reductase and α -glucosidase inhibitors from Brazilian natural medicines, the leaves of *Myrcia multiflora* DC. (Myrtaceae): structures of myrciacitrins I and II and myrciaphenones A and B. *Chem Pharm Bull.* 1998;46(1):113-9.
 39. He B, Hu M, Li SD, Yang XT, Lu YQ, Liu JX, et al. Effects of geraniin on osteoclastic bone resorption and matrix metalloproteinase-9 expression. *Bioorg Med Chem Lett.* 2013;23(3):630-4.
 40. Ikeda I, Imasato Y, Sasaki E, Nakayama M, Nagao H, Takeo T, et al. Tea catechins decrease micellar solubility and intestinal absorption of cholesterol in rats. *Biochimica et Biophys Acta,* 1992;1127(2):141-6.
 41. Ellinger S, Reusch A, Stehle P, Helfrich HP. Epicatechin ingested via cocoa products reduces blood pressure in humans: a nonlinear regression model with a Bayesian approach. *Am J Clinic Nut.* 2012;95(6): 1365-77.
 42. Ferri C, Desideri G, Ferri L, Proietti I, Di Agostino S, Martella L, et al. Cocoa, blood pressure, and cardiovascular health. *J Agric Food Chem.* 2015;63(45):9901-9.
 43. Chinchansure AA, Korwar AM, Kulkarni MJ, Joshi SP. Recent development of plant products with anti-glycation activity: a review. *RSC Advances.* 2015;5(39):31113-38.
 44. Galpaz N, Wang Q, Menda N, Zamir D, Hirschberg J. Abscisic acid deficiency in the tomato mutant high-pigment 3 leading to increased plastid number and higher fruit lycopene content. *Plant J.* 2008;53(5):717-30.
 45. Guri AJ, Hontecillas R, Si H, Liu D, Bassaganya-Riera J. Dietary abscisic acid ameliorates glucose tolerance and obesity-related inflammation in db/db mice fed high-fat diets. *Clinic Nut.* 2007; 26(1):107-16.