Iberian-American Fruits Rich in Bioactive Phytochemicals for Nutrition and Health

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Prólogo

Las plantas con flores que dar lugar a frutos se estiman en más de 350.000 especies (Angiospermas), la mayoría de las cuales no se han investigado y los frutos que son parte de la dieta humana y tienen un cierto nivel potencial para ser beneficiosos para la salud se van documentando en la literatura científica. La mayoría de las evidencias obtenidas a nivel del tubo de ensayo indican que los ingredientes activos de los frutos tienden a tener una gran capacidad de secuestro de radicales libres, pero en términos de su relevancia para las funciones biológicas en el organismo, estamos muy lejos de conocer todas sus capacidades, funciones y aplicaciones.

En los años recientes, cientos de publicaciones sobre estudios preclínicos y clínicos han demostrado que el consumo de variedad de frutas y hortalizas ayuda a aumentar la capacidad antioxidante de nuestras células. Estos estudios se han focalizado en los polifenoles así como en los carotenoides y otras clases de bioactivos de origen vegetal, con efectos antioxidantes y antiinflamatorios. Existe un interés creciente en el estudio del potencial de alimentos ricos en fitoquímicos para prevenir la neurodegeneración y el declive cognitivo asociado a la edad adulta y el envejecimiento. Estamos dando los primeros pasos de un largo camino de investigación científica sobre el impacto del consumo de frutos ricos en bioactivos sobre muchas enfermedades crónicas no comunicables que se derivan del envejecimiento como son la degeneración neuronal, el aumento de estrés oxidativo, los desequilibrios en el metabolismo celular a nivel de mitocondria, la activación de la muerte celular de las neuronas, la deposición de agregados de proteínas y el daño neuronal por exceso de activación, etc. El uso de los frutos como principales fuentes dietéticas de fitoquímicos y de los productos alimentarios derivados de los mismos, ricos en compuestos bioactivos, pueden ser parte de la solución.

La caracterización y evaluación de la funcionalidad y seguridad de los compuestos bioactivos de frutos iberoamericanos para su uso en ingredientes alimentarios acerca a un grupo de investigadores, profesores, técnicos, estudiantes, productores y asociaciones en una red de cooperación proactiva dentro del programa CYTED (Red Temática 112RT0460 “CORNUCOPIA”). Esta red incluye 24 grupos de 11 países de la región Iberoamericana (www.cyted.org).

El consorcio de la red temática CORNUCOPIA persigue potenciar la cooperación y la interacción entre investigación y desarrollo tecnológico acercando participantes de entidades públicas y privadas para generar conocimiento sobre las interrelaciones existentes entre alimentos, nutrición y salud en la Región Iberoamericana, por medio de un trabajo colaborativo y multidisciplinar y de actividades de formación en las áreas de ciencias agroalimentarias, química, nutrición y salud, para desarrollar nuevos productos alimentarios con un alto valor
nutritivo, seguros y ricos en bioactivos obtenidos de bayas, frutos y productos vegetales derivados, obtenidos en las regiones participantes (www.redcornucopia.org). La interacción cooperativa en educación e investigación es una línea para el futuro desarrollo y conocimiento en ciencias agroalimentarias para una población más saludable, mediante la intervención en su nutrición y metabolismo, no sólo en el área Iberoamericana, sino también con perspectiva global.

En el presente libro, investigadores científicos y tecnológicos, personal técnico, profesores universitarios, y estudiantes graduados y postgraduados, de Colombia, Ecuador, México, Portugal y España participan como contribuyentes o autores unificando la información actual disponible de las características botánicas, agrícolas, nutricionales y saludables de frutos de las regiones que participan en la red, que también incluyen a Brasil, Chile, Costa Rica, Guatemala, Perú y Uruguay. Los frutos son excelentes fuentes de bioactivos, que pueden impactar en la salud de nuestro organismo y su funcionamiento. Además, los frutos de especial interés para el desarrollo de nuevos productos seguros de valor añadido y formulaciones enriquecidas en bioactivos saludables con capacidad de acceder a los órganos diana en el cuerpo humano, donde ejercer su potencial beneficio en la salud más allá de su papel nutritivo, en muchos casos no se han estudiado en profundidad o no tienen resultados que se apoyen en evidencias científicas para mostrar su bioactividad o potencial para un efecto beneficioso en la salud. Por lo tanto, en el presente libro, incorporamos el conocimiento actual sobre frutos iberoamericanos de interés, con potencial para nutrición y salud, destacando la necesidad de una perspectiva global en el estudio y entendimiento de las conexiones entre alimento, nutrición y salud.

Nos gustaría agradecer a todas y cada una de las personas que han contribuido a culminar este compendio y al programa CYTED por darnos la oportunidad de colaborar e interactuar entre los grupos, entidades y regiones implicadas, gracias a la financiación de la acción CYTED 112RT0460 CORNUCOPIA, que nos ha permitido dar este primer paso de un largo recorrido en cooperación, formación, intercambio de experiencias y conocimientos, que persigue un mejor futuro para Latinoamérica, la sostenibilidad de sus recursos, la competitividad de sus equipos e instituciones y el bienestar de sus ciudadanos.

Diego A. Moreno, Ph.D.
Preface

The plants with flowers that grow fruits are estimated in more than 350,000 species (Angiosperms), most of them have not been researched, and fruits that are part of human diet and have some level of potential health benefits are documented in the scientific literature. Most of the recent evidences from the test tube indicate that fruits active ingredients tend to be powerful free radical scavengers but in terms of their relevance to biological functions in the body we are far from knowing their capabilities, functions and applications.

In the recent years, hundreds of publications on studies involving preclinical and clinical studies have demonstrated that the consumption of various fruits and vegetables tends to increase the antioxidant capacity of our cells. These studies tend to focus on polyphenols as well as carotenoids and other classes of bioactives from plant origin, with antioxidant and anti-inflammatory effects. There is intense interest in the study of the potential of phytochemical-rich foods to prevent age-related neurodegeneration and cognitive decline. We are just in the initial steps of a long road of scientific research about the impact of bioactive-rich fruit consumption in the many chronic non-communicable diseases derived from ageing such as neuronal degeneration, increased oxidative stress, impaired mitochondria functions, activation of neuronal apoptosis, deposition of aggregated proteins and excitotoxicity, etc. The use of major dietary sources of phytochemicals such as fruits and derived food products from fruits rich in bioactives may be part of the solution.

The characterization and evaluation of the functionality and safety of bioactive compounds from Iberian-American fruits for food ingredients moved a group of researchers, professors, technicians, students, producers and associations to a proactive cooperation network funded under the CYTED Programme (Action 112RT0460 –’CORNUCOPIA’ Thematic Network). The network includes 24 groups from 11 countries in the region (www.cyted.org).

The CORNUCOPIA network partnership aims to potentiate the cooperation and interaction between research and technological development bringing together public and private actors pursuing the generation of knowledge in the interrelationships between food, nutrition and health in the Iberian-American Region by means of multidisciplinary collaborative work and training activities in the areas of agri-food sciences, chemistry, nutrition, and health to develop new food products with a high nutritive value, safe and rich in bioactives obtained from berries, fruits and derived plant products from the participating regions (www.redcornucopia.org). The cooperative interaction in education and research is a line for future developments and knowledge in agrifood sciences for a healthier population through the interventions in nutrition and metabolism not only in the Iberian-American area but also with global perspective.
In the present work, scientific and technological researchers and technicians, university professors and graduated and postgraduated students, from Colombia, Ecuador, Mexico, Portugal, and Spain participating as contributors brought together up to date information on botanical, agricultural, nutritional and health-related characteristics of fruits from the regions participating in the network, that also include Brazil, Chile, Costa Rica, Guatemala, Peru, and Uruguay. The fruits are excellent sources of bioactives, which impact on human body health and performance. Besides, the fruits of special interest for developments of new safe and valuable products and formulations enriched in health-promoting bioactives with capacity of access the target organs in the body where they can exert their potential benefit beyond nutrition are in many cases understudied or without scientifically-backed results of their bioactivity or potential benefits on health. Therefore, in the present book we incorporated the current knowledge about interesting Iberian-American fruits with potential for nutrition and health highlighting the necessity of a global perspective in the study and the understanding of the connections between food, nutrition and health.

We would like to thank the many individuals who have contributed to accomplish this work and the CYTED Programme for giving us the opportunity to collaborate and interact between the groups, entities, and regions involved, through the funding to the Action 112RT0460, CORNUCOPIA Network, that allowed us to take this first step of a long road of cooperation, training and exchange of experiences and knowledge aiming for a better future of Latin America, the sustainability of its resources, the competitiveness of its teams and institutions and the wellbeing of its citizens.

Diego A. Moreno, Ph.D.
AÇAÍ

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³Colombian agricultural research corporation (CORPOICA)

Scientific name: *Euterpe oleracea* Mart. (Family Arecaceae); *Euterpe badiocarpa* Barb. Rodr.; *Catis martiana* O.F. Cook; *Euterpe beardii* L.H. Bailey; *Euterpe cuatrecasana* Dugand.

Common names:
- **English**: euterpe palm, assai palm, cabbage palm, multistemmed assai palm, palisade palm (Suriname), wapoe (Suriname).
- **French**: palmier pinot, pinot, pina (French Guiana), pinau (French Guiana)
- **German**: kohlpalme, açaí-palme, euterpepalme.
- **Portuguese**: açaí, açaí de touceira, açaí do baixo Amazonas, açaí do Pará, palmito açaí, açaí-da-várzea, açaí-do-igapó, açaí espada,
- **Spanish**: asái, palmiche de rio negro, acai, acaí, euterpe, manaca (Suriname, Venezuela), morroke (Venezuela), palmera de la col, uassí (Venezuela), palmito, naïdi, huasaí, palmiche de Rio Negro
- **Chinese**: shu shi ai ta zong

Origin
Açaí palm is native of the Southern America: **Caribbean**: Trinidad and Tobago; **Mesoamerica**: Panama; **Northern South America**: French Guiana; Guyana; Suriname; Venezuela (Bolivar, Delta Amacuro, Sucre); Brazil (Amapa, Maranhão, Pará, Tocantins); **Western South America**: Colombia (Antioquia, Cauca, Choco, Cordoba, Nariño, Santander, Valle); Ecuador (Esmeraldas, Pichincha); Peru. However, it is in the region of the Amazon River estuary which is the largest and densest natural populations of this palm tree with an area
estimated of 10,000-25,000 km² (Lima, 1956; Calzavara, 1972), adapted to the elevated temperature, rainfall and relative humidity (Nogueira, 2006).

**Production**

The main world producer is the state of Pará in Brazil, being responsible for the 85% of the world production, although under current conditions of production and marketing, obtaining accurate data is almost impossible due to the lack of control in sales as well as the lack of a streamlined production. Between 1996 and 2002 the production area of açaí palm in Brazil changed from 9,223 to 18,816 hectares, 92.1% corresponding to the State of Pará. The annual production in Brazil is around 160 000 tons of açaí berries and the 20% is for local consumption (Nogueira, 2006).

The commercialization of frozen pulp to other Brazilian states has grown significantly with annual rates above 30%, reaching up to about 12 tons. The exports of pulp or mix for other countries are beyond the thousand tons per year. Since de 90’s the açaí is exported from Brazil to U.S.A. (60%), Europe (30%, mainly Italy and Holland), Japan (7%) and Southern Cone countries (3%) (Santana et al., 2006), reaching in 2009 the 12,507 tons (Sanches, 2010). The main export product is a mixture of açaí juice blended with other fruits such as acerola (*Malpighia emarginata*) and guaraná (*Paullinia cupana*) (Heinrich et al. 2011).

The tree is a palm of the rainforest that require a warm, sheltered and moist position. Fruits can be harvested throughout the year with higher yields and better organoleptic qualities during the ‘dry months’ (August - December in the area of the Amazon delta), the high harvesting season (Clay and Clement, 1993).

**Varieties**

Açaí palm can be found both wild and cultivated. Because it is a cross pollinating specie it has a wide variation of types for different traits of interest such as earliness, fruit yield, pulp yield and production time. The various types of açaí were defined according to the fruit color, forms clumps and clusters, number of fruits per bunch and diameter of stems. From these characteristics resulted different “ethnovarieties”, calling açaí-purple or black, white açaí (remain green in their mature stage), açaí-assu, açaí-sword and açaí-ox-blood. Black and purple
açaí are considered the most common (Nogueira, 2006; Sanabria and Sangronis, 2007; Cymers et al., 2012).

The breeding program of “Embrapa Amazônia Oriental”, based on phenotypic selection of açaí in the germplasm collection, release in 2004 a cultivar named BRS-Pará, with good levels of fruit production (Nogueira, 2006).

Nutrition

Açaí fruit is known as "The magic fruit of Amazon or the fruit of the life."

Açaí pulp has a high nutritional value: lipids can account for up to 50%, proteins for about 10% of the dry matter and calories up to 247 calories/100 g (Rogez, 2000). Açaí juice is also rich in calcium, fiber and minerals like zinc, magnesium and potassium, vitamin E and in antioxidants, specifically anthocyanins.

Schauss et al. (2006a) reported that total polyunsaturated fatty acid, total monounsaturated fatty acid, and total saturated fatty acids contributed to 11.1%, 60.2%, and 28.7% of total fatty acid in a standardized freeze-dried açaí fruit pulp/skin powder analyses. Oleic acid (53.9%) and palmitic acid (26.7%) were found to be the two dominant fatty acids. Nineteen amino acids were found; the total amino acid content was determined to be 7.59% of total weight.

Culinary uses

E. oleracea Mart. produces a wide variety of market and subsistence products (Anderson, 1988). From the açaí fruit is extracted pulp, juice or wine. The principal use of açaí fruit to local people is for the preparation of a thick, dark purple liquid obtained by maceration of the pulp of the ripe fruits (Bovi and De Castro, 1993).

The juice and pulp of açaí fruits are used in various juice blends, smoothies, sodas, and other beverages. In northern Brazil, açaí is traditionally served in cuias with manioc flour or tapioca and sometimes served with fish, shrimp or meet, being

<table>
<thead>
<tr>
<th>Açaí</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>85 g</td>
</tr>
<tr>
<td>Energy</td>
<td>79 Kcal</td>
</tr>
<tr>
<td>Protein</td>
<td>1.95 g</td>
</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>Cholesterol</td>
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<tr>
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</tr>
<tr>
<td>Ash</td>
<td>0.45 g</td>
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<tr>
<td>Sodium</td>
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<td>14 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>2.6 mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.7 mg</td>
</tr>
<tr>
<td>Copper</td>
<td>1.8 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>15 mg</td>
</tr>
<tr>
<td>Vitamin B1</td>
<td>0.25 mg</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>45 mg</td>
</tr>
</tbody>
</table>

Food values on 100g of fresh weight
the staple food for the populations of riverine origin. The frozen pulp, jam and juice are used to flavour ice cream and other frozen treats, cakes, porridges and bonbons (Cymerys et al., 2012). Açaí pulp has become a trend in southern Brazil where it is consumed cold in the bowl. Processed powder from the fruit pulp is beginning to be sold as a health food in loose powder or capsule form. The powder can also be used as natural food coloring additive.

Açaí pulp has become a vogue in gyms in the south of Brazil. Athletes enjoy açai mixed with guarana and oats to give them a burst of energy (Shanley et al., 2012). Various açai products are now widely available (and heavily marketed) in the natural products market of North America (mainly the United States), Europe and Japan - from liquid fruit drinks and freeze-dried or powdered juice extracts in capsules and tablets, to ingredients in natural energy bars, energy drinks and snacks (Engels, 2010).

**Phytochemicals and health**

Açaí fruit is being marketed in U.S.A. and Europe as a “super food” because of its high antioxidant capacity, potential anti-inflammatory effects, rapid weight loss, improving digestion, fighting cardiovascular disease and preventing the process of ageing (Schreckinger et al., 2010; Heinrich et al., 2011; Honzel et al., 2008; Schauss et al., 2006a). The dark purple color of the fruit is due to the presence of anthocyanins (polyphenolic compounds) that are a group of flavonoids widely distributed in plants and lending a red to purple color to fruits. Generally, anthocyanin-rich fruit juices have proved to possess high antioxidant capacities (Kähkonen et al., 2001; Zheng and Wang, 2003) associated with a decreased risk of mortality from cardiovascular diseases, cancer preventative and anti-aging (Wiseman and Halliwell, 1996).

Anthocyanins (ACNs), proanthocyanidins (PACs), and other flavonoids were found to be the major phytochemicals in freeze-dried açai fruit pulp/skin powder. Two ACNs, cyanidin 3-glucoside and cyanidin 3-rutinoside were found to be predominant ACNs; andpeonidin, 3-rutinoside and peonidin 3-glucoside were also found as minor ACNs (Schauss et al., 2006a; Lichtenthaler et al., 2005; Pozo-Insfran et al., 2004). Cyanidin 3-glucoside values range from 11.1 mg/100 g to 117 mg/100 g. Cyanidin 3-rutinoside values range from 193 mg/100 mg to 241.8 mg/100 mg (Ribeiro et al., 2010). The total anthocyanin content of açai frozen pulp
ranged from 282 to 303 mg/100 g (De Rosso et al., 2008). Polymers were found to be the major PACs. The concentration of total PACs was calculated as 12.89 mg/g DW. Other flavonoids, namely, homoorientin, orientin, isovitexin, scoparain, and taxifolin deoxyhexose, along with several unknown flavonoids, were also detected. Resveratrol was found but at a very low concentration. The total sterols accounted for 0.048% by weight of powder. The three sterols B-sitosterol, campesterol, and sigmasterol were identified (Schauss et al., 2006a).

The antioxidant capacities of all purple açaí samples were found to be excellent against peroxyl radicals, good against peroxynitrite and poor against hydroxyl radicals compared with common European fruit and vegetable juices recently analyzed (Lichtenthäler et al., 2005). Del Pozo-Insfran et al. (2004) correlated Cyanidin 3-glucoside to antioxidant content, nevertheless Schauss et al. (2006b) and Ribeiro et al. (2010) reported low to moderate phenolics content in açaí (13.9 mg/g GAE). Extraction methods play an important role when evaluating total phenolic content.

Certain flavonoids isolated from açaí fruit pulp, such as luteolin, apigenin and velutin, were found to be potential NF-jB inhibitors as assessed by the SEAP reporter assay in RAWBlue™ cells (Kang et al., 2011).

Kang et al. (2012) analyzed the antioxidant and anti-inflammatory activities of *Euterpe oleracea* Mart. (EO) collected from Pará State, Brazil. The antioxidant and anti-inflammatory activities of fruit pulps were evaluated by different assays including a series of oxygen radical absorbance capacity (ORAC) based assays, the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, the cell-based antioxidant protection in erythrocyte (CAP-e) assay, as well as the nuclear factor-kappa B (NF-jB) secreted embryonic alkaline phosphatase (SEAP) assay. The fruits showed a Total ORAC of 2649.1 μmol TE/g (dry weight), DPPH of 133.4 ± 11.2 μmol TE/g (dry weight), Total phenolics of 31.2 ± 2.6 mg GAE/g (dry weight) by Folin–Ciocalteu and 92.9 ± 8.9 mg GAE/g (dry weight) by FBBB (Fast Blue BB method). The IC50 of the EO fruit pulp extract was 0.1 to 10 g/l. The EO fruit pulp did not significant inhibited lipopolysaccharide (LPS)-induced NF-jB activation in the SEAP reporter assay.

A sustained vasodilator effect was observed in açaí fruit extracts in rat mesenteric tissue (Rocha et al., 2007). In 2006, a study found that extracts from açaí fruit initiated a self-destruct response in up to 86% of the leukaemia cancer
cells tested in the lab (Del Pozo-Insfran et al., 2006). These effects have not yet been demonstrated on cancer in humans. Hogan et al. (2010) concluded that the anthocyanins normally found in açai are unlikely to contribute to the antiproliferative activity of açai extracts on C6 carcinoma cells. Açai may serve an adjunct role in the treatment of cancer to aid in the prevention of cardiotoxicity which is one of the main reasons for stopping DXR-based cancer treatments (Ribeiro et al., 2010). Heinrich et al. (2011), in this review about phytochemical and pharmacological assessment of açai fruit, concluded that there is insufficient and unconvincing scientific evidence to promote açai as an exceptional health supplement.

Bibliography


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ANDEAN RASPBERRY

Susana Espín Mayorga and Beatriz Brito Grandes
Quality and Nutrition Department, National Agricultural and Research Institute INIAP
Quito, Ecuador

Scientific name: *Rubus glaucus* Benth
(genus Rubus, family Rosaceae)

Common names: mora, mora blanca, mora de Castilla, zarzamora azul. It is known as Andean blackberry, Andes-berry, Andean raspberry (English), amora-preta (Portuguese), mûre des Andes (French), andenhimbeere (Germany).

Origin

This plant grows wild. There are around 400 species in the whole planet, all of them pertain to blackberry and raspberry genus (*Rubus sp*), and most of them are native from temperate and cold zones from North America and Euro Asia. Despite many species are still gathered from the wild in Central America it is not possible to assure that they are native to that region, probably they were introduced and were not completely domesticated. According to the German botanist W.O. Focke who studied systematic the blackberries, most species are native to the temperate zones from Northern hemisphere. Most of European and American species might be separated by glacier movements (Bejarano, 1992).

Production

Although common in the wild plants of genus *Rubus sp*, in special Mora de Castilla has been found in Ecuadorian Andes growing individually, disperse or in groups with other varieties. In 1921 they were already found as small plantations in Ecuadorian towns Ibarra, Otavalo, Ambato, and in Quito (Popenoe, 1921). Mora de Castilla (*Rubus glaucus*) discovered by Hartw and described by Benth is native to high tropical zones from America; it is cultivated mainly in Ecuador,
Colombia, Panama, El Salvador, Honduras, Guatemala, Mexico and the United States (Franco and Giraldo, 1999).

Varieties

Since 1840 it started the works to obtain *Rubus* varieties with better characteristics, and they managed for temperate zones. At the end of 19th century the first crops were introduced in the United States. The first known varieties are Dorchester, Snyder, Evergreen and Himalaya (OIRSA, 2003; Bejarano, 1992). In Ecuador the most important commercial varieties are mora de Castilla, Brazos from Texas for exportation due to its high productivity and Olallie from California that was introduced in 1987 (Martínez *et al*., 2007).

There is a variety of berry without thorns (*Rubus glaucus* Benth) named INIAP ANDIMORA 2013, that comes from a natural somatic mutation of mora de Castilla plants with thorns, used for vegetative multiplication by terminal layer, that was presented in Pillaro-San Miguelito, Tungurahua Province in 2007. These plants without thorns were multiplied and distributed to several locations of the province in order to observe their agronomic behavior and the permanent absence of thorns. In 2008 INIAP started a series of experiments in farm and laboratory related to characterization agronomic, molecular, physico-chemical and quality of the fruit from a collection of moras, where mora without thorns corresponded to accession MA-0100, collected in San Luis-Tisaleo-Tungurahua and after five years of research it was selected in 2012 due to its high productivity and quality having also the property of thorns absence which is important for farmers since it facilitates trimming and harvest that are periodic in this crop. Finally sensory and agroindustrial tests led to conclude that this variety has properties demanded by the market for fresh and industrial consumption.

Nutrition

The fruit is a berry formed by 110 to 120 drupes with their seeds inside, representing 10% of the weigh. Mora without thorns, variety INIAP ANDIMORA 2013 has a comparative advantage since it compensates the 2.62% of acidity with 12.60 °Brix which corresponds to a high content of soluble solids.
The variety shows an interesting source for human diet, according the values for the Total Polyphenols 6.08 mg/g fresh basis and 57.25 μmol Equivalent Trolox/g fresh basis of Antioxidant Activity, is related to the compounds capable of protecting a biological system against the potential harmfull effect of processes or reaction involving reactive oxygen and nitrogen species (ROS and RNS). INIAP ANDIMORA 2013 is also rich in minerals as Potassium (264 mg/100 g fresh weight).

### Culinary uses

The Andean blackberries are native from Mexico to Ecuador and are widely cultivated in South America for their edible fruits, which are eaten fresh or processed products (Mertz, 2007). At present there is a growing trend of consumption. Mora de Castilla is not only found as fresh fruit but it is also widely commercialized as frozen and processed products (jelly, juice, pulp among others).

The main processed product is the juice, in addition to pulp and frozen concentrates which are treated by IQF (Individual Quick Freezing). Halves and pieces are frozen by IQF and also used in different kind of preserves, ice creams, desserts, candies when dehydrated and osmodehydrated. It is considered an exotic ingredient for gourmet dishes also used with all kind of meats, fruit and vegetable salads and for decoration.

### Mora variety INIAP ANDIMORA 2013

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Value</th>
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<tbody>
<tr>
<td>Moisture (%)</td>
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<tr>
<td>pH</td>
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<tr>
<td>Titrable Acidity (%) citric acid</td>
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<tr>
<td>Soluble solids (Brix)</td>
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<tr>
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<tr>
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<td>Reducing Sugars (%)</td>
<td>5.11</td>
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<td>Vitamin C (mg)</td>
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<td>Total Polyphenols (mg)</td>
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<td>Phosphorus (mg)</td>
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</tr>
<tr>
<td>Iron (mg)</td>
<td>0.2</td>
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<tr>
<td>Zinc (mg)</td>
<td>0.6</td>
</tr>
<tr>
<td>Manganese (mg)</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Food values on 100 g on fresh basis. Source: Departament of Nutrition and Quality, INIAP, 2011
Phytochemistry and health

Blackberries are currently promoted as being a rich source of polyphenols, which are compounds of interest because of their antioxidant activity as radical scavengers and possible beneficial roles in human health, such as reducing the risk of cancer, cardiovascular disease, and other pathologies (Mertz, 2007). Phenolic compounds include several classes such as hydrobenzoic acids, hydroxycinnamic acids and flavonoids. The major phenolic compounds in berries are hydrolysable tannins (gallo and ellagitannins) and anthocyanins, hydroxycinnamic acids, flavonols, flavan-3-ols, including proanthocyaninidins being present in lower amount (Mertz, 2007).

Ellagitannins and ellagic acid derivates were detected in Rubus species, but amounts reported were closely dependent in the analytical conditions (Lei, 2011). Ellagitannins were the major compounds with sanguin H-6 and lambertianin C being the predominant one. The anthocyanin composition as well as the presence or absence of kaempferol glycosides can be used to distinguish the Rubus species studied. Flavonol hexoside-malonates is identified in Rubus glaucus and Rubus adnotrichus. Hydroxycinnamic acids were the minor compound found as ferulic, caffeic, and p-coumaric acid esters (Mertz, 2007).

Currently, the compounds formed from hydrolysis of elagic tannins have received much attention due to their biological active properties such as antimutagenic, antiviral, anticarcinogenic, antitumoral, quimioprotective and antioxidant.

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BLACKTHORN

Amadeo Gironés-Vilaplana, Debora Villaño, Nieves Baenas, Diego A. Moreno, and Cristina García-Viguera
Food Science and Technology Department, CEBAS-CSIC, Spain.

Scientific name: *Prunus spinosa* (Family Rosaceae)

Common names: Sloe berry (England), blackthorn (USA), slaes, bair, sleuwe, slee, slewa (Germany), endrinas, endrino (Spain)

Origin

*Prunus spinosa* (blackthorn, bair or sloe) is a species of *Prunus* native to Europe, western Asia, and locally in northwest Africa (Rushforth, 1999). It is also locally naturalised in New Zealand and eastern North America. *Prunus spinosa* is a large deciduous shrub or small tree growing to 5 metres (16 ft) tall, with blackish bark and dense, stiff, spiny branches. The leaves are oval, 2–4.5 centimetres (0.79–1.8 in) long and 1.2–2 centimetres (0.47–0.79 in) broad, with a serrated margin. The flowers are 1.5 centimetres (0.59 in) diameter, with five creamy-white petals; they are produced shortly before the leaves in early spring, and are hermaphrodite and insect-pollinated. The fruit, called a "blackthorn", is a drupe 10–12 millimetres (0.39–0.47 in) in diameter, black with a purple-blue waxy bloom, ripening in autumn, and harvested—traditionally, at least in the UK, in October or November after the first frosts. Blackthorns are thin-fleshed, with a very strongly astringent flavour when fresh (Rushforth, 1999).

Production

Blackthorn is widespread across temperate Europe and also occurs in the Near East and northern Africa. It often grows in hedgerows or thickets, where it can form dense stands. However, their production is limited only to small industries of liquors or jams elaboration, so is not possible to estimate the world production.

Varieties
Prunus spinosa is frequently confused with the related *P. cerasifera* (cherry plum), particularly in early spring when the latter starts flowering somewhat earlier than *P. spinosa*. They can be distinguished by flower colour, creamy white in *P. spinosa*, pure white in *P. cerasifera*. They can also be distinguished in winter by the more shrubby habit with stiffer, wider-angled branches of *P. spinosa*; in summer by the relatively narrower leaves of *P. spinosa*, more than twice as long as broad; (Vedel & Lange, 1960) and in autumn by the colour of the fruit skin—purplish-black in *P. spinosa* and yellow or red in *P. cerasifera*. *Prunus spinosa* has a tetraploid (2n=4x=32) set of chromosomes (Weinberger, 1975).

**Nutrition**

Blackthorn berries have an important nutritional value, containing carbohydrates, proteins, fats as macronutrients. Fruits also have good values of vitamin C, vitamin E, and vitamin A, representing a good source of these healthy vitamins. Moreover other vitamins of B complex are also present in minor quantities.

Minerals are very important to maintain the good balance hydric and saline of bones, muscles, tissues, and organs. In this sense, blackthorn berries contain a considerable percentage of Potassium, Sodium, Phosphorus, Calcium, Iron and Magnesium.

**Culinary uses**

It is commonly used in the manufacture of jams or beverages. Moreover, blackthorn is also used in the elaboration of alcoholic drinks, for example Pacharán (Gironés-Vilaplana 2013). This digestive drink is a traditional alcoholic beverage obtained by maceration of blackthorn berries in an aqueous ethanol liqueur (25% alcohol by volume, approximately) that contains sugar and essential oils of aniseed (*Pimpinella anisum* L. or *Illicium verum* H.) (Fernández-García et al., 1998). Nowadays, industrial production is located in northern Spain, primarily

<table>
<thead>
<tr>
<th>Blackthorn</th>
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</tr>
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<tbody>
<tr>
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<td>383 Kcal</td>
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<tr>
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<tr>
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<td>0.8 mg</td>
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<tr>
<td>Tocopherols</td>
<td>9.25 mg</td>
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</tbody>
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*Food values on 100g of fresh weight
Source: ETSIA (UPM, SPAIN), 2011*
Navarra, where it has been a typical and traditional digestive drink since the 1400s (Barros et al., 2010).

The fruit is similar to a small damson or plum, suitable for preserves, but rather tart and astringent for eating, unless it is picked after the first few days of autumn frost. This effect can be reproduced by freezing harvested blackthorns.

The juice is used in the manufacture of spurious port wine, and used as an adulterant to impart roughness to genuine port ("Sloe" New International Encyclopedia, 1905). In rural Britain, so-called sloe gin is made from the fruit, though this is not a true gin, but an infusion of vodka, gin, or neutral spirits with the fruit and sugar to produce a liqueur. In France a similar liqueur like Pacharán called épine ("spine") is made from the young shoots in spring. In Italy, the infusion of spirit with the fruits and sugar produces a liqueur called bargnolino (or sometimes prunella). Wine made from fermented sloes is made in Britain, and in Germany and other central European countries. Sloes can also be made into jam and, used in fruit pies, and if preserved in vinegar are similar in taste to Japanese “umeboshi”. The juice of the berries dyes linen a reddish color that washes out to a durable pale blue ("Sloe" New International Encyclopedia, 1905).

**Phytochemicals and health**

Although their phytochemical composition remains too understudied, is known that blackthorn berries present four anthocyanins (two cyanidin-glycosides and two peonidin-glycosides), quercetin derivatives, and hydroxycinnamic acid derivatives (3-caffeoylquinic acid in exceptional amounts), in accordance with previous researches (Ganhão et al., 2010; Gironés-Vilaplana et al., 2012). This phytochemical composition is directly correlated with their health benefits.

Blackthorn is an excellent astringent. It can be used in treatment of diarrhea. Its pectin components have a soothing and relaxing effect on stomach inflammations. Sloe berries can be used for stimulation of our metabolism, and can be of very good use in cases of eczema, herpes, allergies, colds, catarrh, indigestion, kidney stones, and skin and bladder disorders. Steeped in boiling water, the flowers have a mild diuretic, tonic and laxative properties. Used in form of an infusion, flowers can ease menopausal symptoms and help in cases of skin conditions such as acne, pimples and dermatitis. The liquid from the boiled leaves can be helpful as a mouthwash in cases of sore throat, tonsillitis and laryngitis. Blackthorn fruit is also
cited as diuretic and purgative (Barros et al., 2010), and have recently been proved as antioxidant (Ganhão et al., 2010) and anticholinergic (Gironés-Vilaplana et al., 2012).

The significant amount of alcohol in beverages prepared with this fruit, combined with the previously mentioned properties attributed to the berry fruit, results in an improvement in digestion, among other pharmacological properties (Fernández-García et al., 1998; Navarro Pacharán Regulatory Council, 2012). These beverages have intense and attractive red color, owing to the anthocyanin contribution of the sloe berries during maceration. This group of naturally occurring pigments is of growing interest, not only for technological reasons and due to their organoleptic properties but also because of their potential health-promoting effects, as suggested by the available experimental and epidemiological evidence (Castañeda-Ovando et al., 2009; de Pascual-Teresa et al., 2010).

**Bibliography**


CAMU-CAMU

Debora Villaño, Nieves Baenas, Amadeo Gironés-Vilaplana, Cristina García-Viguera, and Diego A. Moreno

Food Science and Technology Department, CEBAS-CSIC, Spain

Scientific name: Myrciaria dubia (Family Myrtaceae)

Common names: cacari, araca d’agua (Brazil), guayabo (Colombia), camu-camu, camo-camo (Peru), guayabito (Venezuela), camu-plus (US).

Origin

Camu-Camu is a riverside tree native to the Amazonian rain forest. The tree is small and bushy with red/purple colored cherry-like edible berries that average 2 to 5 cm in diameter. The distribution extends from the center of Brazil, along the mid and upper Amazon River to the eastern part of Peru. Camu-camu is an endemic species, meaning it is a native plant species that is exclusive to the Amazonian regions of Colombia, Ecuador, Peru and Brazil.

Production

Camu-camu is considered a non-wood forest product (NWFP), according to FAO defined as “products of biological origin other than wood, derived from forests, other wooded land and trees outside forests”. It implies a sustainable development of production for both the conservation of forests as well as poverty alleviation of populations (FAO).

Camu-camu is mainly used as a commercial product in the food, pharmaceutical and cosmetic sector. The major producer country is Peru, followed by Brazil. Bolivia is also stepping up the production and export. It is processed as pulp, extract and juice; Japan is one the major purchasers (1.600 tonnes between 2006 and 2011) of camu camu, followed by the Netherlands (372 tonnes), the
United States (82 tonnes) and Canada (8.6 tonnes) (SIPPO, 2012). Products include candies, jams, powdered drink mixes, ice creams, yogurts, vitamin capsules, frozen concentrates and juice.

**Varieties**

Camu-camu belongs to the genus Myrciaria and the tree is close relative to the jaboticaba (*Myrciaria jaboticaba*) and the guavaberry or rumberry (*Myrciaria floribunda*). No varieties of camu-camu have been reported up to date.

**Nutrition**

The extraordinarily high vitamin C content is the most important nutritional characteristic of the fruit; vitamin C content varies from 1.9 to 2.3 g/100 g fresh matter depending on the maturity stage, and values of 52 mg in 100 mL of juice (da Silva *et al.*, 2012) being always higher than other Brazilian fruits such as acerola (1300 mg/100 g FW) and acai (80 mg/100 g FW) (Rufino *et al.*, 2010).

Camu-camu fruits are also good source of potassium, iron, calcium and phosphorous and various kinds of amino acids such as serine, valine and leucine (Zapata & Dufour, 1993). Glucose and fructose are the major sugars. Different organic acids such as citric acid, isocitric acid and malic acid also have been identified in camu-camu fruits (Zapata & Dufour, 1993). Pulps also contain fatty acids mainly stearic, linoleic, oleic, γ-linolenic, α-linolenic, tricosanoic, eicosadienoic (Justi *et al.*, 2000).

**Culinary uses**

Camu-camu fruits have a significant use history as edible and as traditional medicines with different ethno botanical uses throughout the tropical and subtropical world (Flores, 1998). Camu-camu consumption as fresh fruit is limited due to its high acidity and bitterness. In the food sector the pulp is processed and used as additive for juices, drinks, yoghurt or jam. It is mainly consumed as juice,

<table>
<thead>
<tr>
<th>Camu-camu</th>
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<tr>
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<td>Manganese</td>
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</table>

*Food values on 100g of fresh weight*

Source: Akter *et al.* (2011)
or as an ingredient for jellies, ice-creams, liquors, wines or other foods (Villachica, 1997). Its commercial interest has particularly increased due to its high vitamin C content.

**Phytochemicals and health**

Total phenolic content of camu-camu fruits has been reported to be higher than acerola (Rufino et al., 2010) and seed and peel have also shown higher values than those of other fruit residues such as acerola, pineapple and passion fruits (Myoda et al., 2010).

Different types of flavonoids such as flavanols, flavonols, flavanones, anthocyanins are found in camu-camu fruits. Total flavonoids have been reported as 20 mg/100 g fresh material (Rufino et al., 2010) and stands out the quercetin concentrations, that reaches up to 42 mg/100 g dry weight, higher than other tropical fruits (Goncalves et al., 2010).

Anthocyanin content of camu-camu varies between 300-600 mg/100 g dry weight, with cyanidin-3-glucoside representing almost the 90 %, followed by delphinidin-3-glucoside (Zanatta et al., 2005; Goncalves et al., 2010).

Ellagic acid has also been identified upon acid hydrolysis of ellagitannins of camu-camu fruits (De Souza et al., 2010), as well as the conjugates and ellagitannins by UPLC-QTOF-MS-MS, mainly the c-glycosides of ellagitannins vescalagin and castalagin in the seeds (Fracassetti et al., 2013).

All-trans lutein is the main carotenoid of camu-camu, ranging from 45 % to 55 % of the total carotenoid content, followed by β-carotene, violaxanthin and luteoxanthin (Azevedo & Rodriguez-Amaya, 2004; Zanatta et al., 2007), with total carotenoid content of 0.4 mg/100 g fresh material (Rufino et al. 2010).

Camu-camu has exhibited a high antioxidant activity with ABTS, DPPH and FRAP methods, mainly due to the contribution of vitamin C (70 %) (Akter et al., 2011). ORAC values have been reported as the highest of 16 native fruits from Brazil and similar to other fruits as lemon, plum, cranberry and blueberry. However, medium or low inhibitory activities have been reported against α–amilase and α –glucosidase enzyme activities implicated in glycaemia control (De Souza et al., 2010).
Camu-camu fruits are rich in bioactive compounds which could be used to retard or prevent various human diseases. However, there is little evidence in in vivo studies on the polyphenol of camu-camu fruits.

Studies on animal models have shown that oral administration of Myrciaria dubia seeds extract suppressed experimental edema formation in mice (Yazawa et al., 2011). On the other hand, the extracts from seed and peels have shown antimicrobial activity against *Staphylococcus aureus* (Myoda et al., 2010).

No genotoxic activity of camu-camu juice has been observed in mice using the comet assay (Da Silva et al., 2012), instead a significant reduction on the genotoxicity induced by H$_2$O$_2$ in the 28-day sub chronic toxicological study. This antigenotoxic effect can be associated to the elevated levels of to the elevated levels of vitamin C as well as the phenolic compounds present in this fruit that are able to remove free radicals.

Inoue et al. (2008) found powerful antioxidative and anti-inflammatory properties of camu-camu in vivo in humans. In a clinical trial performed with male smokers, daily intake of 70 mL of camu-camu juice for 1 week reduced significantly oxidative stress markers as 8-hydroxy-deoxyguanosine and inflammatory markers as high sensitivity C reactive protein, IL-6 and IL-8, with stronger effects than equivalent vitamin C pills (1050 mg/day). Authors suggest a combined positive effect se effects of the high vitamin C levels as well as phenolic compounds and carotenoids.

Camu-camu fruit is an excellent promising source of different bioactive compounds, particularly on vitamin C, phenolic compounds and carotenoids. In vivo studies are needed to confirm its potential benefits for its inclusion in food products or supplements for disease prevention.

**Bibliography**


**On-line additional resources**

www.fao.org
CAPE GOOSEBERRY

Katalina Muñoz¹, Julián Londoño², Stella Sepulveda³, Melisa Gómez³, Ana Isabel Tabares³, and Catarina P.P.Carvalho¹.
¹VIDARIUM, Grupo Nutresa
²Corporación Universitaria Lasallista (UL)
³Colombian agricultural research corporation (CORPOICA)

Scientific name: Physalis peruviana L. (Family Solanaceae). Synonyms: Physalis edulis Sims, Physalis esculenta Salisbury

Common names
· English: cape gooseberry, giant groundcherry, golden berry, jam fruit, Peruvian groundcherry, physalis, poha, gooseberry-tomato, Peruvian-cherry, strawberry tomato, winter-cherry.
· Portuguese: batetesta, camapú, camapum, groselha do Perú, herva noiva do Perú, tomate inglês, physalis, alquenqueje amarelo.
· Spanish: aguaymanto, amor en bolsa, bolsa de amor, capuli, cereza del Perú, cuchuva, motojobobo, motojobobo embolsado, sacabuche, tomate silvestre, tomate verde, topotopo, uchuva, uvilla, yuyo de ojas, alquenqueje amarillo.

Origin

Physalis peruviana L. is native to the Andean region of South America, mainly from Peru, Colombia, Ecuador, Venezuela and Bolivia (USDA 1997; Medina, 1991), although there is evidence that it may become from Brazil and be adapted in the highlands of Peru and Chile (Ángulo, 2011). According the Germplasm Resources Information Network (GRIN) of the United States Department of Agriculture (USDA), Physalis peruviana L. was native in: Macaronesia; Northeast Tropical Africa; East Tropical Africa; West Central Tropical Africa; West Tropical Africa; South Tropical Africa; Southern Africa; Western Indian Ocean; China; Eastern Asia; Indian Subcontinent; Malaysia;
Production

The main producers of world are South Africa and Colombia. In small scale is commercially produced in Ecuador, Kenya, Zimbabwe, Australia, New Zealand, Hawaii, India, Malaysia, and China (Rodriges et al., 2009). In 2005 Chile started to introduce the “ecotype Colombia” and the “ecotype Ecuador”. Among the leading importers of this species are the Netherlands, Germany, France, England, Spain, Belgium, Switzerland, Canada and Brazil (Novoa, et al., 2006). In Brazil, physalis is popular in the Northern and Northeastern regions and novelty in the Southern and Southeastern regions. It can be found in local markets mainly in São Paulo and Rio de Janeiro, but it has still been imported from Colombia at high prices since the Brazilian production is still small.

Cape gooseberry grows well in the tropics (USDA 1997). It may be found in mesic to wet forests, subalpine woodland and disturbed sites on mountain slopes at altitudes of 450 to 2020 meters (PIER 2002). Is an annual plant at temperate regions and a perennial in the tropics, although is best grown as an annual. It can also be grown in temperate regions in glasshouses or similar facilities (Valicek, 1989).

Varieties

*P. peruviana* L. has been classified into ecotypes or plants from different regions or countries, which are differentiated by size, colorant taste, shape of the flower head and the height and size of the plant. Three types are currently grown originating from Colombia, Kenya and South Africa (Almanzay Espinosa, 1995). The “ecotype Colombia” is characterized by the production of higher number of fruits per plant, smaller berries, attractive color and higher sugar content than African ecotypes (Calvo, 2009), making it more competitive in international markets. According to different sources (Mazorra, 2006), there are some commercial varieties of cape gooseberry in U.S. and New Zealand: ‘GialloGrosso’, ‘Giant’,

**Nutrition**

Cape gooseberry fruit is highly valued for its unique flavor, texture, color, and nutrients. This fruit is an excellent source of provitamin A (especially β-caroteno) and vitamin C. It also has significant amounts of B vitamins such as thiamine, niacin and vitamin B12, as well as fiber, protein, phosphorus, iron, potassium and zinc (Rodriguez, 2007; Fischer et al., 2005).

Its high fructose content makes it appealing to diabetics and is also an excellent source of low-calorie and dietetic products (Ramadan, 2011).

Although the yield pulp/peel oil is low, the oil is a rich source of essential fatty acids, phytosterols, carotenes and high levels of vitamin K1 (fat-soluble vitamins also called phyloquinones) and vitamin E (Ramadan and Mörsel, 2003).

<table>
<thead>
<tr>
<th>Uchuva</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (g)</td>
</tr>
<tr>
<td>Protein (g)</td>
</tr>
<tr>
<td>Fat (g)</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
</tr>
<tr>
<td>Fibre (g)</td>
</tr>
<tr>
<td>Ash (g)</td>
</tr>
<tr>
<td>Energy (Kcal)</td>
</tr>
<tr>
<td>Calcium (mg)</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
</tr>
<tr>
<td>Iron (mg)</td>
</tr>
<tr>
<td>Vitamin A</td>
</tr>
<tr>
<td>Thiamine (mg)</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
</tr>
<tr>
<td>Niacin (mg)</td>
</tr>
<tr>
<td>Ascorbic Acid</td>
</tr>
</tbody>
</table>

**Food values on 100g of edible portion**

According to analyses of husked fruits made in Ecuador.

Sources: Morton (1987); National Research Council (NRC) (1989).

The diversity of applications to which cape gooseberry can be put gives this fruit great importance. This fruit can be used fresh, dehydrated or frozen. The food industry has used Cape gooseberry in different products, including beverages, yoghurts, jams, ice creams, candies and jellies (USDA-ARS 2003; Ramadan, 2011). It can also be enjoyed as an ingredient in salads, cooked dishes, desserts, natural snacks, frozen mix berries and fruit preserves (Ramadan and Mörsel, 2003).

The juice yield is 72.6% of berry weight. The total acid content in cape gooseberry juice is 0.9–1.0% and its pH of is low(3.79–3.86). The juice is also a rich source of sugars, water and fat-soluble bioactives (Ramadan, 2011) and pectinase, which
 reduces costs in the production of jams and other similar preparations (Calvo, 2009). The preparation of new alcoholic, nonalcoholic and alpha-tocopherolbeta-carotene drinks based on the cape gooseberry could greatly extend the distribution and marketing of this delicious fruit (Ramadan, 2011).

**Phytochemicals and health**

Cape gooseberries are widely used in folk medicine as anticancer, antimycobacterial, antipyretic, strengthener for the optic nerve, and immunomodulatory and also for treating diseases such as asthma, hepatitis, dermatitis, throat affections, and rheumatism (Wu et al., 2005). It has an anti-ulcer activity and it is effective in reducing cholesterol level (Arun and Asha, 2007).

The antioxidant activity of the fruit juice has been associated to high levels of polyphenols and high in vitamins A and C (Rop et al., 2012; Rockenbach et al., 2008; Wu et al., 2005; Bravo, 2010). Some of these compounds have a strong antioxidant property and prevent peroxidative damage to liver microsomes and hepatocytes (Wang et al., 1999).

Ethanol extracts of *Physalis peruviana* L., exhibited higher antioxidant action in the liver rat homogenate model system, which could be contributed by the flavonoids and other compounds yet to be discovered (Wu et al., 2005).

Twenty too compounds of carotenoids have been identified for cape gooseberrie: all trans-β-Carotene was the major carotenoid (76.8%), followed by 9-cis-β-carotene (3.6%) and all trans-α-cryptoxanthin (3.4%) (De Rosso and Mercadante, 2007). Breithaupt and Bamedi (2001), reported levels of 0.5 mg/100 g for lutein dimyristate in physalis.

The extracted cape gooseberrie oils are rich in phytosterols, which give them antioxidant and hypocholesterolemic effects. The presence of three specific phytosterols: campesterol, β-sitosterol and stigmasterol would be responsible for reducing blood cholesterol levels (Ramadan, 2011).

An insect-antifeedant property of withanolide E isolated from cape gooseberry has been demonstrated against *Spodopteralittoralis larvae* (Ascher et al., 1980) and withanolide E and 4β-hydroxywithanolide E have been tested as anticancer agents (Cassady and Suffness, 1980). Vaisberg et al. (2006)
demonstrated that the ethanol extract of leaves and stems of cape gooseberry has the ability to inhibit tumor cell growth rate, possibly due to the presence of bioactive compounds such as physalinas.

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**CHERIMOYA**

*Susana Espin Mayorga and Beatriz Brito Grandes*

Quality and Nutrition Department, National Agricultural and Research Institute INIAP

Quito, Ecuador

**Scientific name:** *Annona cherimola* Mill (Family Annonaceae)

**Common name:** cherimoya, annona

**Origin**

Cherimoya (*Annona cherimola* Mill.) is known to be native to the Andes, probably in a zone between the south of Ecuador and the north of Peru, where it is found growing at altitudes between 1300 and 2200 meters above sea level.

**Production**

Its fruit has commercial importance in Andean countries, mainly Ecuador, Peru and Chile. It is also commercially grown in the subtropical region from Australia, Spain Italy and California (USA). Production in Ecuador is estimated only around 2000 tons in a cultivated surface of around 1500 hectares.

**Varieties**

Five fruit shapes are known: plain, tuberculata, printed, umbonate and mamillata. Four varieties known as Fina de Jete, Campa, Lanca and Bays are grown in Peru. There are no established cultivars with only one variety in Ecuador, the major ones have trees developed by seedling, in some cultivars grafted plants with ecotypes known by farmers as Jaramillo, Chumina (Viteri, *et al.*, 2007) are found. The Fruit Farming Program has defined that five ecotypes may be recommended for propagation due to their major potential based on outstanding pomological characteristics like: size, flavor, fruit shape, fruit color, seed content, skin thickness and yield, they are identified as M4 San José de Minas, T61 MAG- Tumbaco, L5 Loja, F3 Fabulosa and P3 Paute (Sosa and Albuja 2006). The cherimoya fruit is a fleshy whole (syncarpous) of native form with the carpels spyrally arranged which are joined after fructification. Each segment of
flesh, in other words each of the fruits contains a unique hard seed bean shaped of black color. The fruit is conic or heart shaped, having between 10 and 25 cm long, reaching a maximum of 15 cm wide and weighing around 250 to 800g. When it is ripe the fruit turns into a pale or cream green color; it is considered too ripe when the skin presents a dark brown or black color. The skin thin or thick, may be soft with marks similar to finger prints or maybe covered soft with marks similar to fingerprints or may be covered with conic or circular protuberances that are left from the flowers (Van Damme and Scheldelman 1998).

Their seeds have been found in peruvian archeological places hundreds of kilometers from its native habitat where the fruit has been well used by pre-incaic populations. Wild trees generally have been found at the south east from Loja in Ecuador. Cherimoya is a climacteric fruit, very soft and delicate, with fast ripening and tendency to skin scald mainly due to the enzymatic activity of polyphenoloxidases.

**Nutrition**

Cherimoya is a fruit rich in protein, minerals, vitamin C, carbohydrate and aminoacids. The content of vitamina C (12.6 mg/ 100 g fresh basis) is an interesting source for human diet. (Barreca et al., 2011; Brito, 2006).

According to the National Nutritional Mineral Data (USDA, 2013), the cherimoya is rich in potassium and phosphorus and low in sodium, it is adequate for persons with anemia due to its iron contribution, for decalcified persons or osteoporosis its calcium is important, to improve memory of students and old people its phosphorus content also contributes.

Its subtle aroma, its flavor and its white pulp are the main attributes of the fruit, giving them a high commercial potential mainly for exportation markets.

<table>
<thead>
<tr>
<th>Cherimoya</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy</strong></td>
<td>75 kcal</td>
</tr>
<tr>
<td><strong>Protein</strong></td>
<td>1.57 g</td>
</tr>
<tr>
<td><strong>Carbohydrates</strong></td>
<td>15.4 g</td>
</tr>
<tr>
<td><strong>Fat</strong></td>
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</tr>
<tr>
<td><strong>Cholesterol</strong></td>
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</tr>
<tr>
<td><strong>Fiber</strong></td>
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</tr>
<tr>
<td><strong>Ash</strong></td>
<td>0.87 g</td>
</tr>
<tr>
<td><strong>Sodium</strong></td>
<td>7 mg</td>
</tr>
<tr>
<td><strong>Potassium</strong></td>
<td>287 mg</td>
</tr>
<tr>
<td><strong>Magnesium</strong></td>
<td>17 mg</td>
</tr>
<tr>
<td><strong>Calcium</strong></td>
<td>10 mg</td>
</tr>
<tr>
<td><strong>Iron</strong></td>
<td>0.27 mg</td>
</tr>
<tr>
<td><strong>Zinc</strong></td>
<td>0.36 mg</td>
</tr>
<tr>
<td><strong>Copper</strong></td>
<td>0.07 mg</td>
</tr>
<tr>
<td><strong>Phosphorous</strong></td>
<td>26 mg</td>
</tr>
<tr>
<td><strong>Manganese</strong></td>
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</tr>
<tr>
<td><strong>Zinc</strong></td>
<td>0.16 mg</td>
</tr>
<tr>
<td><strong>Folates</strong></td>
<td>23 μg</td>
</tr>
<tr>
<td><strong>Niacin</strong></td>
<td>0.64 mg</td>
</tr>
<tr>
<td><strong>Pantothenic acid</strong></td>
<td>0.35 mg</td>
</tr>
<tr>
<td><strong>Pyridoxine</strong></td>
<td>0.26 mg</td>
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<tr>
<td><strong>Riboflavin</strong></td>
<td>0.13 mg</td>
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<td><strong>Thiamin</strong></td>
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<tr>
<td><strong>Vitamin A</strong></td>
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<tr>
<td><strong>Vitamin C</strong></td>
<td>12.6 mg</td>
</tr>
<tr>
<td><strong>Vitamin D</strong></td>
<td>0.27 mg</td>
</tr>
</tbody>
</table>

*Food values on 100g of fresh weight*

Sources: USDA (2013), Brito et al. (2006)
Cherimoya is a fruit much smaller than its close relative soursop (Annona muricata L.), which is considered to have more flavor.

**Culinary uses**

The cherimoya is the finest fruit of all the Anonna species and is considered one of the most exquisite fruits in the world. The subacid flesh is creamy white, soft, juice, sweet and very fragrant with a custard-like consistency. The flavor is reach and aromatic, a blend of sweetness and mill acidity resembling a cross between banana, passion fruit, papaya and pineapple (Barreca et al., 2011).

Cherimoya is eaten fresh, besides it may also be puréed and used in sauces, merengues, custards and as natural flavoring in yogurt; in production of essences, aromas, concentrates, ice creams, juices and nectars, the flesh may be mixed with milk to get beverages. The white color of the flesh gives an extra potential since it may be added to numerous foodstuffs without change of its color.

Cherimoya flesh is consumed whole alone or in salads; juices, ice creams and home made milk shakes may be prepared. The fruit may ferment and an alcoholic beverage may be obtained. The flesh may be dehydrated and frozen.

**Phytochemistry and health**

It is the fruit of Annona cherimola Mill, a subtropical tree indigenous to Ecuador and Peru cultivated in Taiwan, Spain and south of Italy too. The cherimoya and its relatives are becoming increasingly important exotic fruit on tropical and subtropical regions, due to its implication in commercial and folk medicine, especially for the treatment of the skin disease. This latter is also supported by its richness in health promoting compounds, as cherimoline, cherinonaine, kauranes, lignans, lactam amide, purines, p-quinone, benzenoids and polyammine among the main bioactive compounds (Barreca et al., 2011).

It has been used since pre-hispanic times for therapeutic purposes: the ground seed was used as antiparasitary, infusion of leaves and skin to treat skin diseases and cancer, in addition to its behaviour as plaguicide. It is convenient to ingest in the growing age, during pregnancy and during old age.

Cherimoya is also recommended for slimming diets since it has effects of satiating and of glucose level regulation in the blood due to the fiber content which acts as an intestinal laxative and at the same time increases the time to assimilate
sugars, by this way eating cherimoyas retards the hungry feeling. Vitamin C together gives an antioxidant effect, important to maintain a smooth skin and unwrinkled. Cherimoya has a tonic action which avoids tiredness and fatigue, also helps to fight with depressions. This fruit is credited with an action to equilibrate the nervous system, so it would be an excellent ansiolitic and tranquilizer adequate for the treatment of compulsive persons.

Its fiber content provides laxative properties. Fiber prevents constipation, contributes to reduce cholesterol content in the blood and to a good control of blood sugar in diabetics. It is convenient to select small fruits or have only a portion in the case of diabetes or obesity.

Since it is rich in potassium and low in sodium, cherimoya is recommended for persons with arterial hypertension or affected by blood vessels and heart. Potassium contribution must be considered by persons with renal failure that are under controlled diets of this mineral. However those who take diuretics which eliminate potassium will be benefited of this consuming since cherimoyas are plenty of this mineral.

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COCOA

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2Corporación Universitaria Lasallista (UL)
3Colombian agricultural research corporation (CORPOICA)

Scientific name: Theobroma cacao (familia Sterculiaceae)

Common names: chocolate, “Cacao manjar de dioses”.

Origin

The theories about cocoa origin are focused on Native American cultures. The initial findings on its use have been reported from the years 600-460 BC in Mayan culture, which like the Aztecs used it as a commodity, currency and drink. In 1502, Christopher Columbus brought as gifts cocoa fruits for Spanish kings, and years later, about 1520, Hernan Cortez met chocolate when the Aztec emperor Moctezuma gave him a drink called Xocolatl, producing energy and vitality; was Cortez who promoted the knowledge and expansion of this food in Western culture. In the eighteenth century, the naturalist Carl von Linnaeus made the first botanical determination of cacao tree and called Theobroma cacao (Posada et al., 2006).

Production

The five most important cocoa growing countries are Ivory Coast, Ghana, Indonesia, Brazil and Nigeria, which supply 80 percent of the global demand (Vélez, 2003). The warm and humid climate is suited to the cultivation of cocoa. This is why cocoa is grown with success mainly in humid tropical regions, within 20 degrees of latitude North and South, with respect to the Equator (Vélez, 2003).
Varieties

In the *Theobroma cacao* specie some varieties are distinguished: Criollo, Forastero and Trinitario. The Criollo variety is native to southern Mexico and Central America, is elongated pods and seeds white or light violet, while not very fertile is considered higher quality cocoa. The Forastero variety is native to the rainforests of South America, most of the world's production of this type of cocoa. The pods are round and thick bark; seeds are flattened shape and purple. Finally, the variety Trinitario is a hybrid resulting from the Criollo and the Forastero with a good taste and good productivity (Vélez, 2003).

Nutrition

The cocoa bean is subjected to different processes before becoming its final products. A piece of dark chocolate (100 g) provides around 228 calories. Chocolate energy is derived primarily from its content of fatty acids, of which 40% are represented by the fatty acids oleic and linoleic, associated with decreased risk of cardiovascular disease (3), 35% by stearic acid, which exerts a neutral or reducing cholesterol levels, and 25% for palmitic acid, which has been associated with increased cholesterol and LDL (Jebb *et al*., 2010). For the characteristics of the fat, chocolate can be included as part of a daily diet, without health risks.

Other nutritional component of interest in the chocolate includes fiber. A bar of 8 g of dark chocolate may provide 1-1.4 g fiber, mainly insoluble (Posada *et al*., 2006). As for the content of minerals, chocolate and cocoa powder contains, among others, copper and magnesium, which are involved in different processes and contribute to reduce the risk of vascular disease (Kris-Etherton *et al*., 1994).

The methylxanthines such as theobromine, caffeine and theophylline recognized as central nervous system stimulants, are present in small amounts in chocolate, so a controlled drinking has no pharmacological effects and is not habit forming (Smit, 2011). Besides these substances, chocolate contains over 30

<table>
<thead>
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<tbody>
<tr>
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<td>3 g</td>
</tr>
<tr>
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<tr>
<td>Caffeina</td>
<td>230 mg</td>
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<tr>
<td>Folate</td>
<td>32 mg</td>
</tr>
</tbody>
</table>

*Food values on 100g of fresh weight Source: USDA, 2013*
different phytosterols, containing approximately 216 mg of sterols per 100 g of product. The most representative in chocolate are beta-sitosterol and stigmasterol. Actual absorption of these sterols is very low and therefore, the main mechanism of action in the body is exerted to the gastrointestinal tract by reducing the absorption of cholesterol, so that they have been assigned a cholesterol-lowering effect (Kris-Etherton et al., 1994, Steinberg et al., 2003).

Culinary uses

As a cold or hot drink, as part of pastries or ethnic culinary specialty; chocolate, cocoa and chocolate coatings have multiple applications (Vélez, 2003). There are several types of chocolate, depending on the amount of solids or cocoa mass, fat, sugar addition and some micronutrients and phytochemicals (Posada et al., 2006).

In order to offer greater variety to consumers, some of the chocolates have been added with flavorings, which do not change their nutritional value, but they offer different organoleptic odor and flavor. Unsweetened chocolate or bitter is 100% cocoa solids. The instant chocolate with sugar whose fundamental characteristic is it eases of preparation (Posada et al., 2006).

Additionally, there is dietary chocolate bar which contains no sugar, but are sweetened with non-caloric sweeteners, which has a very low fat, 1%, because in their preparation is cocoa butter removed leaving a higher concentration of cocoa solids like cocoa, whose calorie content is about 20 per teaspoon of 5 g (Posada et al., 2006).

Phytochemicals and health

In the last decade the chocolate has been the subject of numerous scientific investigations that have provided evidence to say that the type of fat and the antioxidants it contains, may be included in a balanced diet without posing a health risk and can even have beneficial effects in the processes associated with oxidative stress (Posada et al., 2006).

Chocolate antioxidants belong to a group of compounds known as polyphenols, which have proven to be effective antioxidants in a wide range of chemical oxidation systems, being able to stabilize lipophilic and hydrophilic radicals (Arlorio et al., 2008). The main sub-group of polyphenols in cocoa are the
Flavonoids and within the flavanols, which comprises monomeric structures such as (-)-epicatechin and (+)-catechin, as well as their dimeric, oligomeric and polymeric, among which are the procyanidins (Wollgast et al., 2000, Cooper et al., 2008, Ding et al., 2006).

Flavonoids have been identified by their antioxidant and beneficial implications for human health (Corti et al., 2009); reviews of the effect of these substances contained in the chocolate and cocoa highlight different functions in vitro and in vivo. Within the observed antioxidant in vitro studies indicate its ability to stabilize both oxygen free radicals and nitrogen prooxidant, also chelate metal ions to protect against oxidation of low density lipoproteins (LDL), protecting against oxidative damage to DNA, regenerate vitamins E and C to continue exerting its antioxidant capacity, modulate the activity of some enzymes such as cytochrome P-450-nitric oxide synthase, cyclooxygenase (COX I and COX II) and lipoxygenase (Posada et al., 2006, Corti et al., 2009). In clinical studies in humans, consumption of dark chocolate and cocoa, has been associated with a decrease in LDL oxidation, reduced oxidative stress, inhibition of platelet activation and aggregation, increase in the concentration of high density lipoprotein (HDL), antioxidant capacity, nitric oxide bioactivity and improved endothelial function (Corti et al., 2009, Engler et al., 2004).

The total amount of soluble polyphenols (percentage dry mass, fat free) present in fresh cocoa beans can vary between 15 and 20%, but this concentration is reduced to 5% in fermented seeds. However, there are differences between varieties and in some seeds can be found about 2/3 of the amount of polyphenols from other varieties (Wollgast et al., 2000).

During fermentation and processing, transformations occurs in many of the phenolic compounds insoluble polymeric compounds, leading to reductions of up to 90% in the level of soluble polyphenols (Crozier et al., 2009). The best way to keep a higher polyphenol content in cocoa or chocolate is by selecting seeds rich in polyphenols, using low fermentation and alkalinization and reductions in time and / or temperature of the heat treatment, either to roasting or to the heating of the cocoa liquor (Wollgast et al., 2000). By controlling the processes involved in the preparation of chocolate, can be obtained a product that retains up to 70% of flavonoids (Jalil et al., 2008).
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CUPUASSÚ

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²Corporación Universitaria Lasallista (UL)
³Colombian agricultural research corporation (CORPOICA)

Scientific name: Theobroma grandiflorum (Willd. ex Spreng.) K. Schum. (Family Malvaceae); Theobroma macrantha Bernoulli.

Common names:
- **English**: wild cacao.
- **Portuguese**: copoasu, cupuaçú, cupuassú, cupuaçu, cacau, cupuacu verdadeiro.

Origin

Cupuassu is an Amazonian native fruit from the states of southern and southeastern of Pará and Maranhão in Brazil and is one of the most consumed fruits in that region (Duarte et al., 2010; Vasconcelos et al., 1975). These species are incipiently domesticated populations or very recently domesticated populations, rapid pre- or post-conquest dispersal and lack of phylogeographic population structure (Clement et al., 2010).

Production

The cupuassu is currently one of the most important native fruits in Amazonia, with about 35,000 ha of orchards planted over the last three decades (Souza et al., 2009) and is grown mainly in Brazil from Sao Paulo State in the south to Romaira in the north. It is grown occasionally in Ecuador, Guyana, Martinique, Costa Rica, Sao Tome, Trinidad, Tobago, Ghana, Venezuela and Colombia. Brazil is the most representative in international market share (IBCE, 2010).
Expansion of cultivation to Brazilian Amazonia does not present any serious limitations. With extension into Colombia, Costa Rica, Ecuador, Peru, Venezuela and Mexico, it is likely to become recognized as one of the best tropical fruit-trees (FAO, 1994).

Varieties

Cupuassu is incipiently domesticated as it lack of systematic programs of artificial selection and breeding (Varón et al., 2001). The countries that produce this fruit, mainly Brazil, are collecting, identifying and characterizing some creoles, clones and hybrids (Silva et al., 2008).

Nutrition

Cupuassu is high nutritional expressed mainly by its higher acid and vitamin C in the flesh and fat and high protein content in the seed (FAO, 1999). The highest concentration of nutrients was observed in the seed (N, P, Ca, Mg and Zn), pod (Zn and Mn) and pulp (K) (Lopes da Costa, 2006).

The Cupuassu seed contains significant levels of total fat and significant concentrations of unsaturated fatty acids oleic and linoleic acids, important in the human diet and other physical attributes for developing processed food (Escobar et al., 2009).

With respect to the daily requirements of children and adults, the amino acid profile of cupuassu proteins presented a better performance than cocoa proteins (Lopes et al., 2008).

The cupuassu peel flour (CPF) is a potential source of dietary fiber (79.81%), mainly insoluble fiber (78.29%), and breads made with added CPF present high dietary fiber content (5.40 and 6.15g/100 for inclusions with 6 and 9% CPF, respectively) and phytochemical values (Salgado et al., 2011).

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<p>| | |</p>
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<tr>
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Food values on 100g of fresh weight
```
**Culinary uses**

The pulp and seeds are the usable parts of the fruit. The first, which constitutes the largest part of economic value, is mainly used in the manufacture of juices, nectar, ice cream, sweets, creams and liquor, while the second is used, although on a small scale, in developing a product similar to chocolate, called "cupulate" (FAO, 1999).

Cupuassu pulp can be extracted directly, frozen or processed as syrup, with water and sugar (Chaar, 1980) or could be used to produce fruit wines with acceptable organoleptic characteristics (Duarte *et al.*, 2010). The seeds can be used to make chocolate and show a great potential to substitute cocoa in chocolate products. Cupuassu fat is very similar to cocoa butter, although with a different fatty acid profile and its application for confectionery industry is very promising (Medeiros, 2006). On the basis of the high linoleic acid content, the seed "butter" of cupuassu would be expected to have a lower melting point than cocoa butter (Cabral *et al.*, 1990).

**Phytochemicals and health**

According to Galeano and Paladines (2012), extracts of methanol from cupuassu beans presented high antioxidant activity with interest for the pharmaceutical and cosmetic industry. The results showed that the methanol extract, subjected to the degreasing by pressing, showed a higher DPPH radical scavenging capacity (3080.6 ± 0.004 μmol Tx/g dry sample) and a reducing capacity (2780.1 ± 0.006 μmol AA/g dry sample); while the total extract showed a higher total phenolic content (525.1 ± 0.003 mg GA/g dry sample).

Genevese and Lannes (2009) reported that the phenolic contents of cocoa and chocolate powders are more than three times higher than those of cupuassu powder. However, flavonoid contents were significantly lower. The DPPH scavenging capacity varied hugely among the different samples, from 0.5 (white cupuassu “chocolate”) to 120 (cocoa powder) μg of Trolox equivalent per 100 g (FW), and presented a significant correlation ($r = 0.977$) with the total phenolic contents but not with the flavonoid contents ($r = -0.035$).

Böhm *et al.* (1998) reported the following flavonoids for cupuassu: (+)-catechin, (-)-epicatechin, quercetin and kaempferol, and theograndins I (1) and II (2). Theograndin II (2) displayed antioxidant activity (IC(50) = 120.2 microM) in the 1,1-
diphenyl-2-picrylhydrazyl (DPPH) free-radical assay, as well as weak cytotoxicity in the HCT-116 and SW-480 human colon cancer cell lines with IC\textsubscript{(50)} values of 143 and 125 microM, respectively.

**Bibliography**


USDA, ARS, National Genetic Resources Program. *Germplasm Resources Information Network* - (GRIN).

**On-line additional resources**
http://www.ars-grin.gov/
http://www.plantnames.unimelb.edu.au/
FEIJOA

Debora Villaño, Nieves Baenas, Amadeo Gironés, Cristina García-Viguera, and Diego A. Moreno
Food Science and Technology Department, CEBAS-CSIC, Spain

Scientific name: Acca sellowiana, Feijoa sellowiana
(Family Myrtaceae)

Common names: guayabo, Brazilian guayabo, guayaba, pineapple guava, guavasteen

Origin
Acca sellowiana is a perennial shrub or small tree, 1-7 m height, with white and red flowers and sweet-smelling leaves. It is closely related to the guava (Psidium guajava L.). It is native of the highland of southern Brazil, eastern Paraguay, Uruguay, northern Argentina and Colombia. Feijoa prefers cool winters and moderate summers (80° to 90° F), and is generally adapted to areas where temperatures stay above 15° F.

Production
It is widely cultivated as garden plant in New Zealand, Australia, south part of Russia, South Africa, as well as in Turkey and Azerbaijan. Feijoa was introduced to Europe in 1890s, in New Zealand in 1908 and in Turkey in 1988 by Yalova Ataturk Horticultural Research Center (Beyhan et al., 2011). New Zealand has established the New Zealand Feijoa Growers Association in 1983. In New Zealand, feijoa is considered as a minor seasonal crop that has significant potential for export expansion as exports have grown almost fourfold since 2008.

It is reported that the domestic sales and exports of New Zealand feijoas in 2010 were valued at about $1.7 million and $0.2 million, respectively (Plant and
Food Research Institute of New Zealand Ltd 2011). The feijoa production volume of New Zealand has grown from 473 tonnes in 1981 to around 1,200 tonnes annually, which could reach as high as 1,650 tonnes. However, feijoa fruit is a minor crop in the consumer market due to its short harvest season and limited storage life and half of the production goes to further processing in food products as juices, alcoholic beverages and preserves. Attempts are being made for the use of fruit waste material as skin and flesh near, to produce value-added bioactive ingredients (Sun-Waterhouse et al., 2013).

Varieties

Different cultivars of feijoa have been developed, in order to adapt the plant to different growing conditions, regions and climate: Apollo, Bambina, Choiceana, Coolidge, Edenvale Improved Coolidge, Edenvale Late, Edenvale Supreme, Gemini, Mammoth - Named for its relatively massive fruits, Moore, Nazemetz, Pineapple Gem, Smilax, Trask, Triumph, Vista Long.

Nutrition

The fruit ripens in autumn and is green, ellipsoid, 5–8 cm long and weighs 20–30 g, with a sweet aromatic flavor that reminds that of pineapple, apple and mint. The flesh is juicy with a clear gelatinous seed pulp in the center and a firmer, slightly granular and opaque flesh nearer the skin. The fruit pulp resembles the closely related guava The strong characteristic aroma of feijoa is related to volatile compounds such as terpenes, tannins, quinones, steroidal saponins, flavonoids and methyl- and ethyl-benzoates (Sun-Waterhouse et al., 2013).

There were 29 aroma components identified by GC-MS, the major constituents are: esters 50.64%, aldehydes 26.04%, alcohols 5.84%, hydrocarbons 3.85%, ketones 3.14% and phenol 0.77%. Methyl benzoate is of the highest content 36.56% (Zhang et al.,

<table>
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<th>Feijoa</th>
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<td>Folate</td>
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<td>Vitamin E</td>
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<tr>
<td>Vitamin K</td>
<td>3.5 mg</td>
</tr>
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</table>

Food values on 100g of fresh weight
Source: USDA, 2013.
Differences on volatile fraction composition have been reported depending on the fruit origin. The intensities of the aromas of the essential oils of feijoa fruit clearly indicate their potential commercial value as food flavors, but the yields and isolation technology need further research in order to produce oil with consistent composition and aroma (Weston, 2010).

Feijoa fruit is a good source of vitamin C, with low calories and a rich source of minerals and fiber (Table). High concentrations of iodine have been reported (Vuotto et al., 2000). The main fatty acid shown in the seed oil is linoleic acid (84.44 g/100 g) (Andrade et al., 2012).

**Culinary uses**

*Feijoa sellowiana* fruit is widely used for human consumption, for its good nutritional characteristics and for its pleasant flavor and aroma. The skin is sour and bitter but the feijoa skin can be eaten with the pulp, as the skin balances the sweetness of the pulp. Besides its consumption in natural form, feijoa jam and compote is prepared and produced both in home and on industrial scales. Feijoa is used as additional ingredient in fruit drinks, ice cream, fruit smoothies and may be used to make wine, cider or feijoa-infused vodka. It is a popular ingredient in chutney.

**Phytochemicals and health**

Ethanolic extracts of the fruit have demonstrated higher antioxidant activity in DPPH assay than other tropical fruits, greatly correlated to total phenolic content (59 mg/100 g edible fruit) (Isobe et al., 2003). McGhie et al (2004) reported that proanthocyanidin tannins are responsible of this antioxidant activity. Acetonic and aqueous whole fruit extracts of feijoa fruits decrease significantly the chemiluminiscence emission by activated phagocytes, inhibiting the metabolic activation of these cells, with ultimate effects on inflammation and tissue damage (Ielpo et al., 2000; Vuotto et al., 2000). Anti-inflammatory effects have also been due in part to the suppression of nitric oxide production (Rossi et al., 2007).

Animal studies have demonstrated that 50 mg/kg feijoa fruit extracts administered daily for 4 weeks are able to decrease MDA and increase glutathione levels and plasma antioxidant activity (Keles et al., 2012).
Feijoa has shown high antimicrobial activity against Gram-positive and Gram-negative bacterial strains such as *Pseudomonas*, *Enterobacter* and *Salmonella* (Vuotto *et al.*, 2000) as well as fungal strains, being especially active against *Helicobacter pylori*, due to the content of flavones (Basile *et al.*, 2010). Feijoa extract also inhibited *Listeria monocytogenes* and *Bacillus cereus* (Hap & Gutierrez, 2012).

Studies performed in different cancer cell lines have shown that feijoa fruit extracts exert anti-tumoral activities with low toxicity in normal cells (Bontempo *et al.*, 2007). This activity is related to the flavone content that are able to induce block of proliferation and apoptosis by inhibition of deacetylase enzymes thus hyper-acetylating histones.

A clinical study performed with type 2 diabetic subjects has demonstrated that doses of 150 mg/daily of feijoa during 12 weeks results on a decrease of blood pressure, compared to control group, as well as on a decrease of fasting blood sugar, glycosylated hemoglobin, cholesterol and triglycerides (Taghavi *et al.*, 2012). These results pose feijoa as a promising food ingredient for the control of hyperglycemia and hypertriglyceridemia.

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On-line additional resources
New Zealand Feijoa Grower’s Association: http://www.feijoa.org.nz
USDA nutrient database: http://www.ndb.nal.usda.gov/ndb/search/list
GUAVA

Liliana Vargas-Murga and Nancy Vargas-Murga
BIOOTHANI, Spain

Scientific name: *Psidium guajava* L.
(Family Myrtaceae)

Common names: guava, common guava, apple guava, lemon guava, yellow guava, koejawel, goyavier, amrood, goiaba, araçá-guaçú, guaíaba, goyave, guyaba, guayaba, poor man’s fruit, apple of the tropics, jambu batu, bayabas, makuai, ma-man, oi, kuava, perala, bayabas, pichi, posh, enand.

Origin

The place of origin of the guava is uncertain, but it is considered native to American tropics. Archaeological evidence shows that guavas were in use in Peru by around 800 B.C.E. It was in Peru that they were likely domesticated, but they quickly spread through South and Central America. By about 200 B.C.E. they had reached as far north as Mexico, and from there spread by man, birds and other animals to all warm areas of tropical America and in the West Indies. Centuries ago, European adventurers, traders and missionaries in the Amazon Basin took the much enjoyed and tasty fruits to Africa, Asia, India and the Pacific tropical regions. Guavas are now widely cultivated and naturalized in tropical and subtropical regions around the world (Africa, Southeast Asia, the Caribbean, North America, Hawaii, New Zealand, Australia, etc.).

Production

World ranking production of major tropical fruits is expected to expand over the next decade. Mango is the dominant tropical fruit produced worldwide. While other fruits, such as guavas are referred to as minor tropical fruits. Asian and American countries are the main producers of guavas. According to FAO statistics India, China, Thailand and Pakistan are the four largest producers of mangoes, mangosteen and guavas, followed by Mexic and Brazil (FAOSTAT, 2011).
Varieties

As the guava ripens, the outside skin changes color from green to light green or yellow. The flesh of the fruit may be white (white guavas), yellow, pink or red (red guavas). Apple guava is the most commonly traded internationally variety. Its fruits are medium sized and pink colored. They are sweet in taste with good keeping quality. Lucknow 49, also known as Sardar, has large fruits, roundish ovate in shape, skin primrose yellow and pulp white, very sweet and tasty. The trees are vigorous. Allahabad Safeda, the most famous variety of Allahabad, has large fruits, round in shape, skin smooth and yellowish white. The flesh is white, firm, soft having pleasant flavour. Both varieties have high total soluble solids (TSS) and vitamin C content. Chittidar, whose fruits are characterized by numerous red dots on the skin, high sweetness, and small and soft seeds, is a very popular variety in western Uttar Pradesh. It has higher TSS content than Allahabad Safeda and Lucknow 49 but lower vitamin C content.

Nutrition

The guava fruit has high water content with lesser amount of carbohydrates, proteins and fats. This tropical fruit is one of the best sources of vitamin C and pectin, as well as variable content of vitamins (thiamine, riboflavin, niacin), minerals (potassium, calcium, phosphorus, magnesium, iron, cupper, selenium and manganese), sugars (glucose, fructose, sucrose), and acids (oxalic, phosphoric, malic and citric) (El Bulk al., 1997; Jimenez-Escrig et al., 2001; Kubola et al., 2011; McCook-Russell et al., 2012; Oliveira et al., 2010; Padula et al., 1986; Soares et al., 2007). The nutrient content varies across guava cultivars, depending on its stage of maturity, the season and where it is grown.

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<td>Manganese</td>
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<td>Thiamine (Vit B1)</td>
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<td>Riboflavin (Vit B2)</td>
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</table>

Food values on 100g of fresh weight
Source: USDA, 2013.
The common guava fruit contains about four or five times the amount of vitamin C as an orange (Hassimoto et al., 2005). Ascorbic acid—mainly in the skin, secondly in the firm flesh; and little in the central pulp—varies from 56 to 600 mg. It may range up to 350 – 450 mg in nearly ripe fruit. Guava fruits are also a good source of pectin (0.1 – 1.8 g %) - a dietary fiber. Green mature guavas can be used as a source of pectin, of more and higher quality than ripe fruits.

Culinary uses

In many countries, guava is consumed as a fresh fruit, typically cut into quarters or eaten like an apple, whereas in other countries it’s eaten with a pinch of salt and pepper, cayenne powder or a mix of spices (masala). But, it's also preferred seeded and served sliced as dessert or in salads. Guava juice is popular in many countries. In Mexico, the guava “agua fresca” beverage is popular. It is known as the winter national fruit of Pakistan. In the Philippines, ripe guava is used in cooking sinigang. Guava is a popular snack in Taiwan, sold on many street corners and night markets during hot weather, accompanied by packets of dried plum powder mixed with sugar and salt for dipping. Due to its high level of pectin, guavas are extensively used in many recipes for making pies, cakes, puddings, sauce, ice cream, chutney, relish, catsup, candies, preserves, jellies, jams, marmalades, juices, aguas frescas, etc. On the other hand, red guavas can be used as the base of salted products such as sauces, substituting for tomatoes, especially to minimize acidity.

Phytochemicals and health

The beneficial effects of the guava fruit are due to its variable chemical composition, including bioactive compounds e.g. polyphenols, carotenoids, sesquiterpene alcohols, triterpenoids acids and essential oils; and also nutrients e.g. pectins, vitamins, minerals, sugars.

The main carotenoids found were β-carotene, lycopene, lutein, rubixanthin, cryptoxanthin, neochrome and β-cryptoxanthin (Oliveira et al., 2010; Ordóñez-Santos et al., 2010; Padula et al., 1986; Ramirez et al., 2011); while phenolic compounds and flavonoids were the major classes of polyphenols in the guava pulp. The polyphenols, most of which are flavonoids, are present mainly in ester and glycoside forms (Fleuriet et al., 2003). Rutin, myricetin, luteolin and apigenin
have been reported in green fruits. Among phenolics, gallic, protocatechuc, vanillic, syringic and p-cormanic acids were found in green fruits (Kubola et al., 2011; Lim et al., 2007). Peel and pulp could also be used to obtain antioxidant dietary fiber, a new item which combines in a single natural product the properties of dietary fiber and antioxidant compounds. Ascorbic acid is recognized for its important antioxidant effects (Monárrez-Espino et al., 2011).

Ursolic acid, oleanolic acid, arjunolic acid and other triterpenoids were isolated from guava fruit and are associated with anti-cancer properties (Chang, 1982; Shanmugan et al., 2012; Shu et al., 2009). The characteristic fruit odor is attributed to its essential oils grouped into four classes: carbonyl, esters, monoterpenes and sesquiterpenes. Some compounds isolated from essential oil extracted from fresh white-flesh guava fruit were 3-caryophyllene, nerolidol, 3-phenylpropyl acetate and caryophyllene oxide; whereas from pink guava fruit, β-caryophyllene and nerolidol (Jordan et al., 2003; Paniandy et al., 2000, Soares et al., 2007).

Guava fruit is rich in natural antioxidant compounds, such as carotenoids, polyphenols and vitamin C, identified in white and red guavas, and responsible of its antioxidant effect (Haida, et al., 2011; Kubola et al., 2011; Lim et al., 2007; McCook-Russell et al., 2012; Thuayton et al., 2011; Stangeland et al., 2009; Vasco et al., 2009). Carotenoids and polyphenols are the principal classes of antioxidant pigments whose are mainly present in the skin and flesh fruit, that is why red-orange guavas are better antioxidant pigment source than yellow-green ones (Jimenez-Escrig et al., 2001). The antioxidant property of guava helps to reduce the incidence of degenerative diseases such as arthritis, arteriosclerosis, cancer, heart disease, inflammation and brain dysfunction. In addition, antioxidants were reported to retard ageing (Bontempo et al., 2012; Feskanich et al., 2000; Gordon, 1996; Halliwell, 1996) besides preventing or delaying oxidative damage of lipids, proteins and nucleic acids caused by reactive oxygen species. These include reactive free radicals such as superoxide, hydroxyl, peroxyl, alkoxy, and non-radicals such as hydrogen peroxide and hypochlorous acid.

The health potential of guava fruit in the management of blood glucosa level in diabetic subjects might be associated with the presence of high levels of dietary fiber, flavonoids (Cheng et al., 2009; Huang et al., 2011) and triterpenoids compounds (Chang, 1982; Cheng et al., 1983).
The cardiovascular health will be improved by consumption of guava fruit as suggest some studies. Guava fruits exhibit excellent antiglycation effect and directly related to its polyphenolic content (Hsieh et al., 2005). Guava pulp juice had significantly lower body weight, glycemia, cholesterol and triglycerides levels and significantly augmented the levels of HDL-c when compared to the animals from the control group (Farinazzi et al., 2012). Human studies have found that the consumption of guava reduced blood pressure, total cholesterol levels, triacylglycerides and induced the levels of HDL-c (Singh et al., 1992; 1993); and could reduce the risk of disease caused by free radical activities and high cholesterol in the blood (Rahmat et al., 2004). Lycopene has been correlated with the prevention of cardiovascular damage because of its positive effects on dyslipidemia (Lorenz et al., 2012; Sesso et al., 2012).

Bibliography


**On-line additional resources**

www.ars-grin.go
www.ars.usda.gov
www.fao.org
www.faostat.org
LEMON

Nieves Baenas, Amadeo Gironés-Vilaplana, Debora Villaño, Raul Dominguez-Perles, Diego A. Moreno, and Cristina García-Viguera.
Food Science and Technology Department, CEBAS-CSIC, Spain

Scientific name: *Citrus limon*
(Family Rutaceae)

Common names: citro, limoe, limoi, lemon, lemon tart, sour lemon, cappuccino lemon, flesh lemon, confit lemon, San Francisco lemon, limes, pregnant lemons, imperial lemon, real lemon.

Origin
This fruit, which comes from the lemon tree, has its origin in the Southeast Asian countries (Malaysia, China, India) at least in 4000 B.C.E., although there are doubts regarding the specific geographical location. Arab traders brought the lemons to the Middle East and Africa sometime after 100 C.E. It is believed to have been introduced into southern Italy around 200 C.E.; and was being cultivated in Egypt and in Sumer, the southern portion of Mesopotamia a few centuries later.

Production
Main citrus fruit production is accounted for by oranges, but significant quantities of grapefruits, lemons and limes are also grown. India and Mexico are the largest producers of lemon and lime, with about 30% of world production, followed by China, Argentina, Brazil and Spain (FAO, 2011). FAO statistics encompass the lemon and lime, the productions of India and Mexico are mainly lime, not lemon.
Lemons are generally produced in temperate climates such as the western United States, Spain, Italy and Argentina, however, are also adapted to drier climates such as Egypt and Iran.

**Varieties**

The most common lemon variety is the *Eureka*, produced in South Africa, Argentina, Australia, California, Mexico, among others. Also *Lisbon* lemon is very marketed (as in California, Argelia, China, Mexico) and bears all year, which is slightly smaller and smoother skin than the first one, besides, it is commonly seedless and more resistant to cold once established. As regards flavor, there is not much difference between the two. Both varieties are abundantly juicy. Another variety, called the *Meyer lemon*, is a cross between a lemon and either an orange or a mandarin. It is quite small and significantly sweeter than the ordinary lemon varieties. In addition, the *Meyer lemon* is also more fragile, more widely available at farmers’ markets and in people's yards.

**Nutrition**

Lemon is a rich source of vitamins for human diet, vitamin C being the main one present in this Citrus (40mg/100g fresh weight). Other vitamins present in minor quantities are A and B-group (B1, B2, B3, B6 and B9) (Penniston *et al*., 2008). The main mineral present in lemon is potassium, although other minerals like calcium, magnesium and phosphorus are also present in minor levels. Moreover, lemon contains trace levels of copper, iron, manganese, selenium, sodium and zinc. Potassium constitutes an essential mineral for human health since it is essential to maintain the water–acid balance and it participates in the transmission of nerve impulse to muscle.

Lemon constitutes an interesting source of dietary fiber, also called non-starch polysaccharides (NSP), which may be classified as soluble dietary fiber (SDF) and insoluble dietary fiber (IDF). The SDF/IDF ratio is fundamental for dietary and functional properties. Lemon peel is

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*Food values on 100g of fresh weight*  
Source: USDA, 2013
the structure that presents the major content of dietary fiber and pectin is the major component of fiber present in lemon. A reasonable dietary fiber intake is considered 25–30 g/day and Citrus lemon may constitute a valuable contribution to meeting the daily fiber requirements.

Essential oils are aromatic and volatile compounds present in several plant materials (flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits and roots). Of the essential oils group from lemon, we can find about sixty individual components. The major component is d-limonene (45–75%). The aldehyde-citral has been also shown to be present in lemon, in the form of stereoisomers neral and geranial. Linalool shows concentrations of 0.015%. Citral and linalool are thought to be the most potent aroma compounds in *C. limon*.

Citric acid is the most representative organic acid in lemon, comprising as much as 8% in dry weight, that represents 5–6 g/100 mL.

**Culinary uses**

Regarding culinary purposes, lemons differ from other citrus varieties in that they are typically consumed with other foods as flavoring ingredient. These acid fruits are grown primarily for the fresh market, but also are used to make marmalade, lemon liqueur and juice, which is used primarily as flavouring in beverages (lemonade, soft drinks and cocktails) because of its distinctive sour taste. The juice of the lemon is about 5% to 6% citric acid, which gives lemons a sour taste. The pulp and rind (zest) are also used in cooking and baking. Rind is the shiny, yellow outermost layer of the peel, which has to be scrubbed before use and contains powerful flavor compounds used to add flavor to baked goods, puddings, rice and other dishes. The white part of the peel just beneath the rind is quite bitter and should not be used. It is used in marinades for fish, where the acid partially hydrolyzes collagen fibers, tenderizing the meat. Lemon juice is also used as a short-term preservative on certain foods that tend to oxidize and turn brown after being sliced, such as apples, bananas and avocados, where its acid denatures the enzymes that cause browning and degradation. Lemons will keep for several days at room temperature, obtaining from them more juice than one that is cold. Nonetheless, the best way to store lemons is in the refrigerator, avoiding the appearance of mold.
Phytochemicals and health

Lemon fruit contains many important natural chemical components, including phenolic compounds (mainly flavonoids) and other nutrients and non-nutrients (vitamins, minerals, dietary fiber, essential oils and carotenoids). Their health-promoting effects and properties have been associated with their contents, namely vitamin C and flavonoids, due to their natural antioxidant characteristics (Proteggente et al., 2002). Overall, lemon fruits, rich in flavonoids, are a very important part of a balanced diet, particularly for their role in prevention of diseases, such as obesity, diabetes, blood lipid lowering, cardiovascular diseases, neurodegenerative disorders and certain types of cancer (Benavente-García et al., 2008; Del Rio et al., 2004; Lin et al., 2007; Miyake et al., 2006; Reddy et al., 2003; Schroder, 2007; Hwang et al., 2012).

More than sixty individual flavonoids have been identified in Citrus sp. and most of them can be classified into three groups: flavanones, flavones and flavonols. In addition, other phenolic compounds (phenolic acids, etc.) are also present in Citrus species.

Eriocitrin and hesperidin are the major lemon juice flavanones (Dugo et al. 2005, Miyake et al.; Wang et al., 2008) but two isomers of hesperidin, named neohesperidine and homoeriodictyol 7-O-rutinoside have also been identified (Gil-Izquierdo et al. 2004; Dugo et al. 2005b). Lemon peel is also rich in neoeriocitrin, neohesperidin and naringin. Moreover, the flavonoid concentrations in lemon fruits depend on the cultivar, maturity stage, etc.

Miyake et al. isolated two C-glucosylflavones from lemon fruit: diosmetin 6,8-di-C-glucoside and diosmetin 6-C-d-glucoside. These flavones are also present in limes, but not in other Citrus fruits. Lower amounts of vicenin-2, and diosmin were determined in lemon juices (Gil-Izquierdo et al., 2004). In addition, chrysoeriol 6,8-di-C-glucoside, apigenin 7 (malonylapiosyl)-glucoside, and diosmetin 8-C-d-glucoside have been also identified (Abad-García et al., 2008). There are no studies on flavone composition in seeds. On the other hand, lemon peels contain the three most abundant flavones: diosmetin 6,8-di-C-glucoside, vicenin-2, and diosmin (Baldi et al., 1995).

Rutin and myrecetin are the most abundant flavonols identified in lemon juice, while quercetin and kaempferol are in both peel and juice (Dugo et al.,
Iso/limocitrol 3-β-glucoside, limocitrin 3-β-d-glucoside and limocitrol were identified, as polymethoxylated flavonols, in peel. Other phenolic compounds such as hydroxycinnamic acids are also known to be present in very low concentrations (caffeic, chlorogenic, ferulic, sinapic and p-coumaric acids) (Gironés-Vilaplana et al., 2012), in addition to benzoic acids (protocatechuic, p-hydroxybenzoic and vanillic acids)

**Vitamin C.** Is important to note that lemon fruits are a rich source of vitamin C, with numerous health benefits beyond nutrition. Vitamin C is highly bioavailable and is the most important water-soluble antioxidant in cells as well as an efficient scavenger of reactive oxygen species with two biologically active forms: ascorbic acid (l-AA) and dehydroascorbic acid (l-DHAA). The antioxidant function of vitamin C is based on its ability as hydrogen donor that lets it inactivate free radicals preventing proteins, lipid and DNA damages. Vitamin C has also been related with the formation of collagen as part of the connective tissue.

**Bibliography**


On-line additional resources
www.anthos.es
www.fao.org
www.citrusvariety.ucr.edu
MANDARIN

Liliana Vargas-Murga and Nancy Vargas-Murga
BIOTHANI, Spain

Scientific name: Citrus reticulate
(Family Rutaceae)

Common names: Mandarin orange, mandarin, mandarine, tangerine,
Cleopatra mandarin, clementine, Satsuma orange, culate mandarin, kid-glove orange, mandarini, jeruk keprok, jeruk jepun, limau kupas, sintones, som lot, liou, tangerina, santara, gan ju, ma baang, cam sanh, cay quit, narangi, nartjie, moli saina, moli peli, mandarina, bergamota, ponkan.

Origin

The mandarin orange is considered native to south-eastern Asia and the Philippines. It was extensively planted in China, India, and Japan in the 16th century, but was not introduced to Europe and North America until the 19th century. The mandarin has a wide range of adaptability and is grown under desert, semi-tropical and sub-tropical Mediterranean climatic conditions. At present, it is widely cultivated in tropical and subtropical areas. It gravitated to the western world by small steps taken by individuals interested in certain cultivars. Therefore, the history of its spread can be roughly traced in the chronology of separate introductions. Two varieties from Canton were taken to England in 1805. They were adopted into cultivation in the Mediterranean area and, by 1850, were well established in Italy. Sometime between 1840 and 1850, the 'Willow-leaf' or 'China Mandarin' was imported by the Italian Consul and planted at the Consulate in New Orleans. It was carried from there to Florida and later reached California. The 'Owari' Satsuma arrived from Japan, first in 1876 and next in 1878, and nearly a million budded trees from 1908 to 1911 for planting in the Gulf States. Six fruits of the 'King' mandarin were sent from Saigon in 1882 to a Dr. Magee at Riverside, California. The latter sent 2 seedlings to Winter Park, Florida. Seeds of the 'Oneco' mandarin were obtained from India by the nurseryman, P.W. Reasoner, in 1888. In
1892 or 1893, 2 fruits of 'Ponkan' were sent from China to J.C. Barrington of McMeskin, Florida, and seedlings from there were distributed and led to commercial propagation. The commercial cultivation of mandarin oranges in the United States has developed mostly in Alabama, Florida and Mississippi and, to a lesser extent, in Texas, Georgia and California. Mexico has overproduced tangerines, resulting in low market value and cessation of plantings. The 1971-72 crop was 170,000 MT, of which, 8,600 MT were exported to the United States and lesser amounts to East Germany, Canada and Argentina. There is limited culture in Guatemala and some other areas of tropical America. These fruits have never been as popular in western countries as they are in the Orient, Coorg, a mountainous region of the Western Ghats, in India, is famous for its mandarin oranges.

Production

World production of mandarins is currently increasing. China, Spain, and Brazil are the world’s leading producing countries of tangerines, mandarins, clementines and satsumas, representing close to two-thirds of global production. Other major producers in descending order of production are Japan, Turkey, Italy, Egypt and Iran. While production by Japan has decreased around 40% over the last decade, that of Mediterranean countries has increased by 50% (FAOSTAT, 2011).

Varieties

The mandarin varieties are divided into the following groups: mandarin, common mandarin, clementines, tangerines, satsumas, Mediterranean mandarin and King mandarins. Ponkan is a variety of common mandarin, also called 'Chinese Honey Orange'. Ponkan is probably the most widely-grown mandarin in the world, being heavily-grown in China, India, and Brazil. Clementines, also called Algerian Tangerine, was introduced into Florida by the United States Department of Agriculture in 1909 and from Florida into California in 1914. In Spain it has been found that a single application of gibberellic acid at color-break, considerably reduces peel blemishes and permits late harvesting. Clemenules, a Clementines variety, is the most commonly cultivated in the world and originated from Nules, Castellón. Dancy, a Tangerines variety, may have come from China. This is the
leading tangerine in the United States, mainly grown in Florida, secondarily in California, and, to a small extent, in Arizona. Class III, Satsuma, sometimes marketed as "Emerald Tangerine", is believed to have originated in Japan about 350 years ago as a seedling of a cultivar, perhaps the variable ‘Zairi’. Mediterranean mandarin is the common mandarin of the Mediterranean basin.

**Nutrition**

Mandarin fruit has low amount of protein and very little fat content. It also contains sugars, such as sucrose, glucose, and fructose, that provide energy. Fresh mandarines are good source of dietary fiber, pectin, which is associated with gastrointestinal disease prevention and lowered circulating cholesterol. Pectin content is lower in juice than in pulp. Mandarin orange is good source of other essential nutrients, e.g. vitamins and minerals. Ascorbic acids, being higher in peel than in pulp, is the most abundant nutrient with antioxidant activity. B-group vitamins include thiamin, pyridoxine, niacin, riboflavin, pantothenic acid, and folate. With regards to minerals, potassium and calcium are the most abundant, followed by phosphorus, magnesium, sodium, iron, copper, manganese and zinc. Citric and malic acids are also present in mandarin orange (Goulas *et al*., 2012; Liu *et al*., 2012; Ramful *et al*., 2011).

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*Food values on 100g of fresh weight
Source: USDA, 2013*

**Culinary uses**

Mandarins of all kinds are primarily eaten out-of-hand and peel much easier than oranges. Its sections are utilized in fruit salads, gelatins, puddings, or on cake. Mandarine juice is another alternative for this fruit. Very small types are canned in sirup. The essential oil expressed from the peel is employed commercially in flavoring hard candy, ice cream, chewing gum, and bakery goods. Mandarin essential oil paste is a standard flavoring for carbonated beverages. They can also be utilized to prepare liqueurs due to the aromatic characteristics.
Phytochemicals and health

The health promoting effects of mandarin have been mainly attributed to the presence of bioactive compounds, such as carotenoids, phenolics (e.g. flavonoids and phenolic acids), essential oil and its essential nutrients (pectin, vitamins, and minerals).

The major carotenoids present in mandarin are β-cryptoxanthin, lutein, zeaxanthin, and α- and β-carotene. Although α- and β-carotene are a minor portion of carotenoids in some mandarins, β-cryptoxanthin is the main vitamin A precursor. Higher amount of carotenoids are present in pulp compared with peel (Goulas et al., 2012; Liu et al., 2012).

Mandarin fruit contains considerable amounts of two important classes of phenolic compounds: flavonoids and phenolic acids. The beneficial effect of the fruit is associated to one group of phenolic compounds, flavonoids. Flavanones, flavones and flavonols are the three classes of flavonoids found. Among all of them, flavanones are the main group in mandarins, and hesperidin is the major flavanone, followed by narirutin, eriocitrin, and other minor flavanones, such as taxifolin, naringenin, neohesperidin, eridictyol, didymin, poncirin, naringenin, and hesperetin. Nobiletin is the most abundant flavone, followed by tangeretin, sinensetin, quercitrin, luteolin, diosmetin, and rhoifolin (Goulas et al., 2012; Liu et al., 2012; Meiyanto et al., 2012; Peterson et al., 2006; Ramful et al., 2011; Zhang et al., 2014). Concerning phenolic acids present in mandarin fruit, there are three classes (benzoic and cinnamic acids and chlorogenic acid). Protocatechuic, p-hydroxybenzoic, and vanillic are naming benzoic acids. Cinnamic acids derivates include caffeic, p-coumaric, ferulic, and sinapic acids. Chlorogenic acid is also present in mandarin fruit. Among all phenolic acids, ferulic acid is mostly found, followed by caffeic acid, p-coumaric acid and sinapic acid. Phenolic compounds content of mandarin peel are higher than those of mandarin pulp (Zhang et al., 2014).

Mandarin fruit flavor is a combination of its delicious taste, distinct aroma and mouth-feel sensations that are perceived simultaneously by the brain during the eating of foods. Other non-volatile compounds may induce a physical sensation, such as phenolic compounds or some limonoids that may be perceived as astringent. Macromolecules such as pectin in mandarin juice may create a
certain mouth-feel, interact with volatile compounds and change flavor perception. The characteristic aroma profile of peel mandarins is derived from a wide range of volatile molecules consisting of alcohols, aldehydes, ketones, terpenes/hydrocarbons and esters. These volatiles include linalool, α-terpineol, terpinen-4-ol, nonanal, decanal, carvone, d-limonene, α-pinene and myrcene (Liu et al., 2012; Tietel et al., 2010).

Mandarin juices and peel also contain the decongestant synephrine, an ephedrine-like alkaloid. Nevertheless, synephrine is mainly present in mandarin peel and is used as raw material for obtaining this amine (Chen et al., 2002; Uckoo et al., 2011).

Mandarin fruit has an important antioxidant activity due to a possible synergism among its compounds (carotenoids, flavonoids, phenolic acids and ascorbic acid). Hesperidin, nobiletin and tangeretin showed antioxidant activity in various antioxidant assays (Goulas et al., 2012; Ramful et al., 2011; Sun et al., 2013; Zhang, 2014). The presence of phenolic compounds confers to mandarin fruit chemopreventive properties and estrogenic effects. Flavonoids have been shown to possess inhibition activity on certain cancer cells’ growth through various mechanisms. Moreover, mandarin flavonoids also perform promising effect in combination with several chemotherapeutic agents against the growth of cancer cells. Some mechanisms involved in those activities are through cell cycle modulation, antiangiogenic effect, and apoptosis induction. Mandarin flavonoids also present estrogenic effect. Hesperidin has the ability to decrease lipid concentration and reduce osteoporosis (Maiyanto et al., 2012). Among various carotenoids, β-cryptoxanthin has a unique anabolic effect on bone mass due to stimulating osteoblastic bone formation and inhibiting osteoclastic bone resorption, thereby increasing bone mass (Yamaguchi, 2008). Thus, mandarin fruit is a promising natural product to be developed as not only as the source of co-chemotherapeutic agents, but also phytoestrogens. As an important source of β-cryptoxanthin, mandarin fruit has a great potential to maintain healthy bones and prevent osteoporosis.
Bibliography

On-line additional resources
http://www.citrusvariety.ucr.edu
http://www.ars.usda.gov
Scientific name: Aristotelia chilensis (Family Elaeocarpaceae)

Common names: Maqui, maquei, quedrón, quedón, clon, coclón, koelon (Argentina, Chile), maki (Mapuche), Chilean blackberry (England), Chilean wineberry.

Origin

Interest in berries from South America has increased due to their potential health benefits. Aristotelia Chilensis, commonly referred to as the “Maqui Berry”, is a part of the elaeocarpaceae family. These plants are native to the temperate rain forests found in Southern Chile as well as part of neighboring Argentina, the South America, known as Patagonia. The plant is both medicinal and edible and can be found at all altitudes. It generally grows near streams or valleys, and prefers slightly acidic, humid environments, moderately fertile and well-drained soils. The tree stands up to 5 meters in height, but generally appears as a bush or shrub (http://allmaquiberry.com/botany-and-history-of-aristotelia-chilensis/). It grows rapidly with adequate moisture and readily colonises abandoned, burned or over-exploited soils, thus protecting them from erosion. Aristotelia chilensis yields a small edible purple/black berry averaging 5 mm in diameter with typically 3–4 seeds (Schreckinger et al., 2010).
Production

Knowing that it is a wild fruit, its world industrial production is still in growing. According to the Chilean production, the estimated area of Maqui from Coquimbo Region in the north of the country to the Aysen Region in the south is 170,000 hectares, including the islands of Juan Fernandez and Chiloe. This data was determined from the Annual Forest Cadastre 1997 (CONAF-CONAMA-BIRF), which considered the presence of Maqui according to its dominance in the forest, which was registered the area occupied by Maqui for the first, second and third dominance. Thanks to harvest studies conducted over the Cadastre between the regions of Bio-Bio and Los Lagos was able to estimate production rates for fully occupied sites with maqui and sites with maqui present in second tier. Considering an average of 220 kg / ha along with the estimated area of 170,000 ha of maqui in Chile, was estimated a potential production of 37,400 tons of fresh fruit per year. However, the real potential of harvesting the fruit of maqui is much lower than this figure since most of the total estimated 37,400 tons is very difficult to access.

The time of collection of the fruit occurs from December to March each year. The time depends directly on the geographical distribution, being the earliest collection while further north is the tree. In relation to the productivity of the Macal (name given to trees of Maqui), it is known that a plant on average at age 7 can produce up to 10 kg of fruit, which would be directly related to the quality of each site (http://www.maquinewlife.com/agriculture.php).

Varieties

By the present date, we could not find records of different varieties.

Nutrition

Maqui berry contain vitamin B, minerals, omega-3, 6, as well as 9 fatty acids, and also protein. But the best part of it is that maqui berry powder and other products are full of fiber that keep the consumers on to a low calorie diet thereby helping them to lose weight by fat burning.

<table>
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<tbody>
<tr>
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<td>296 mg</td>
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</tbody>
</table>

Source: Alonso, 2012; Damascos et al., 2008
Berries also contain a considerable percentage of vitamin C and trace elements, highlighting the presence of Br, Zn, Cl, Co, Cr, Vn, Tn, and Mo. It is important to note that the content of magnesium, chlorine, calcium, titanium and vanadium ranging from leaves of different sites annual rainfall (Alonso, 2012; Damascos et al., 2008).

**Culinary uses**

Fruits are usually eaten fresh or used for juice and jams. The seeds (berries) have been used for generations to brew wine and chicha (and alcoholic beverage common in Chile). Chicha is a light fermented drink (similar to a cider). Fermentation occurs in large open vats, similar to how beer is produced. When using Maqui Berries, the Chicha is dark in color (similar to the berries). Production of Chicha is how Maqui Berries received the name “Wine Berries”. Chicha produced with Maqui Berries generally has between 1-3% alcohol content (http://allmaquiberry.com/botany-and-history-of-aristotelia-chilensis/). Furthermore, owing to the presence anthocyanins, maqui berries can also be used as natural colourants (Escribano-Bailón et al., 2006), giving an attractive red colour to new mixed-juices, and other food products.

**Phytochemicals and health**

In the traditional native herbal medicine, infusions of maqui fruits and leaves have long been used to treat sore throats, kidney pain, digestive ailments (tumors and ulcers), fever, and scarring injuries (Suwalsky et al., 2008). This traditional health benefits were associated to their alkaloids content (Céspedes et al., 1990). More recently, therapeutical properties of maqui have been related to their high polyphenols content, concretely anthocyanins: delphinidin 3-sambubioside-5-glucoside, delphinidin 3,5-diglucoside, delphinidin 3-sambubioside, delphinidin 3-glucoside, cyanidin 3-sambubioside-5-glucoside, cyanidin 3,5-diglucoside, cyanidin 3-sambubioside, and cyanidin 3-glucoside (Gironés-Vilaplana et al., 2012a).

Moreover, other flavonoids have been recently described such as flavonols (quercetin and myricetin derivatives), ellagic acid derivatives (hexosides), chlorogenic acid derivatives (5-O-caffeoylquinic acid) and ellagitannins (granatin B and dehydrogalloyl-hexahydroxydiphenoyl hexoside) (Gironés-Vilaplana et al.,
This fruit has also been recently reported as one of the healthiest berries, due to these bioactive components. Maqui berry have demonstrated to possess high antioxidant capacity (Rubilar et al., 2011), in vitro inhibition of adipogenesis and inflammation (Schreckinger et al., 2010), cardioprotective effects (Céspedes et al., 2008), neuroprotective activities (Fuentealba et al., 2012; Gironés-Vilaplana et al., 2012b), and in vitro and in vivo anti-diabetic effects (Rubilar et al., 2011; Rojo et al., 2011).

The berry of Aristotelia chilensis has been also shown to inhibit low-density lipoprotein (LDL) oxidation and to protect against intracellular oxidative stress in human endothelial cells and against acute isochemia/reperfusion in vivo in rat hearts (Miranda-Rottman et al., 2002).

**Bibliography**


**On-line additional Resources**


http://www.maquinewlife.com/agriculture.php
MAGELLAN BARBERRY CALAFATE

*Nieves Baenas, Amadeo Gironés, Debora Villaño, Cristina García-Viguera, and Diego A. Moreno*

*Food Science and Technology Department, CEBAS-CSIC, Spain.*

**Scientific name:** Berberis heterophylla  
(Family *Berberidaceae*).

**Common names:** Magellan barberry, Calafate.

**Origin**

Calafate, also known as Berberis, is native to the south of Argentina and Chile and is a symbol of Patagonia Argentina, especially in the city of El Calafate and in the capital of the Chilean Patagonia, Punta Arena, where is regarded as a symbol of the area.

**Production**

The production of this fruit is minimal in the Patagonia region of Chile and Argentina, this is due to the difficulty of cultivation, as plants have leaves with a serrated edge and spines up to 20 centimeters long. It presents a low reproductive rate and develops with a high density planting.

**Varieties**

Magellan barberry (*Berberis heterophylla*) consists on a branched shrub, whose height varies between one and three meters, showing spines and leathery whole leaves with yellow flowers. The fruit is an edible bluish-black berry. His affinity with *Berberis buxifolia*, also called calafate, can hinder the recognition of both species. Another species of Berberis is *B. darwinii*, known as “Michay”. Some cultivars and hybrids of Berberis have being specially selected for ornamental purposes. There is one cultivar Nana available in UK nurseries (slow-growing dwarf cultivar). It does not set fruit very well, though it flowers freely. The fruits have a pleasant acid flavour and often do not contain seeds. This cultivar also makes a good small hedge.
Nutrition

Magellan barberry is a good source of high quality fatty acids, when the fruit is wholly consumed, because the lipid contents in the seeds are very interesting, having an important fraction of unsaturated fatty acids which give proven benefits to human health when taken as part of a normal diet (Mazzuca, et al., 2005). This wild plant fruit enhance the food offer, representing a new source of vitamins and minerals. Considering the required human daily intake, the Calafate showed interesting levels of Ca, Fe and K content per kilogram of dry fruits (Damascos, et al., 2008).

Culinary uses

Its edible blue-black berries are harvested in summer for juices, jams, liqueurs, syrups, tea, ice cream, wine by fermentation, and also are eaten fresh. The fruit is hardly acid but do have some astringency. The green unripe fruits can be used like gooseberries in pies. The roots are a good source of the alkaloid berberine, which possess valuable medicinal properties. These are therefore used in pharmaceutical industry (www.pfaf.org).

Phytochemicals and health

Berry fruit consumption has become important in population health promotion, mainly due to their phenolic compounds. One of the most important groups is represented by anthocyanins, which confer the blue, red, violet and purple colors to the fruits and vegetables. The roots of this species have been used to control fevers and inflammations, stomach ache, indigestion and colitis, due to these natural pigments. Interest in Calafate is mainly focused in content of anthocyanins, which has been previously characterize, showing a predominance of 3-glucoside derivatives of delphinidin, petunidin and malvidin, 18 anthocyanins have been identified in total. It is one of the fruits with the highest total anthocyanin concentration (22.91–35.99 μmol/g fresh weight) (Ruiz, et al., 2012). The higher

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<td>0.7 mg</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>0.06 mg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>24 mg</td>
</tr>
</tbody>
</table>

Food values on 100g of dry weight Source: Healthy Supplies (UK), Damascos, et al., 2008 (Minerals)
antioxidant capacity shown by calafate compared with other berries such as murtilla (*Ugni molinae*) and blueberries has been attributed to their high anthocyanin content (Ruiz *et al.*, 2010). In a recent publication, the calafate fruit has been classified as the fruit with the highest antioxidant capacity measured by the oxygen radical absorbance capacity (ORAC) assay (Speisky, *et al.*, 2012). The use of anthocyanins in the development of natural dyes is being reconsidered by the food industry, due to increased consumer demand for more natural (Nachay, 2009). The Calafate represents an alternative source of anthocyanins against an artificial dye.

As for phenolic compounds, 20 hydroxycinnamic acids from calafate fruits have been studied. 5-Caffeoylquinic acid was the main compound found; other 13 hydroxycinnamoyl quinic acids and 6 caffieic acid esters with aldaric acid derivatives assigned as glucaric acid were also identified. Moreover, the glucaric-based hydroxycinnamic acid derivatives accounted for almost the half of total content of this kind of phenolic compounds. The total concentration of hydroxycinnamic acids derivatives ranged between 0.32±0.00. μmol/g and 8.28±0.01 μmol/g. Also the content of phenolic compounds is highly correlated with antioxidant activity, the synthesis of these compounds is favored by stress conditions against adverse weather conditions such as the Patagonia, so it is expected to exhibit higher antioxidant activity, associated with a reduction of the risk of chronic diseases, such as cancer, inflammation, cardiovascular and neurodegenerative disorders (Scalbert, *et al.*, 2005).

On the other hand, an interesting alternative for the control of diabetes is the inhibition of digestive enzymes α-glucosidase and α-amylase. The hypoglycemic activity (in vitro) of crude extracts showed that calafate fruit strongly inhibited α-glucosidase enzyme, which is effective because excessive inhibition of α-amylase generates an abnormal bacterial fermentation of carbohydrates in the colon, and generates flatulence, bloating and possibly diarrhea. The high content of polyphenols and the in vitro inhibition of digestive enzymes indicate that Calafate extract could be effective in the treatment of diabetes mellitus type II (Palma, *et al.*, 2010).

The principal alkaloid found in the Barberry, is called Berberine, which has antibacterial effects and anticancer effects, such as block the proliferation of breast and liver cancer cells (Tillhon *et al.*, 2012).
Bibliography


On-line additional resources

www.pfaf.org
MURUTILLA

Debora Villaño, Nieves Baenas, Amadeo Gironés, Diego A. Moreno, and Cristina García-Viguera
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Scientific name: Ugni molinae turcz (Family Myrtaceae)

Common names: Chilean guava, strawberry myrtile, murta, murtilla, uñi, ugni, ugniberry, New Zealand cranberry, tazziberry

Origin
It is a shrub from 30 to 170 cm tall native from Chile and southern Argentina. It has been traditionally used by Mapuche Indians from Chile. The fruit is a small red, white or purple berry of 1 cm diameter. It grows in sunny forests and it has low soil fertility requirements. The cordillera in the coast from the ninth region, south of Chile is the natural environment for the production of this native berry. It is distributed from the Maule Region to Chiloé Island, including the Juan Fernández Island chain (Hoffmann, 1991).

Production
Ugni molinae mainly grows in Chile in the coastal zone of La Araucania region and it has not been extensively introduced in Europe. It is also cultivated in Tasmania and commercialized as Tazziberry and in New Zealand as New Zealand cranberry.
Varieties

In 1996, a research project was initiated to domesticate murtilla and develop selections suitable for commercial production. Several new varieties of murtilla plant were identified and selected for advancement and commercialization, as the `South Pearl-INIA` and the “Red Pearl-INIA” varieties of murtilla plant. No other varieties are known up to date.

Nutrition

The murtilla fruit is known for its typical and surrounding aroma, which is produced by 24 volatile compounds that have been identified, with a concentration range from 1.2 to 250.5 μg/kg fresh weight (Scheuermann et al., 2008). The major concentrations of volatile compounds were methyl 2-methyl butanoate, ethyl butanoate, ethyl 2-methyl butanoate, methyl hexanoate, ethyl hexanoate, methyl benzoate and ethyl benzoate.

Murta fruit is a highly fibrous fruit with large postharvest life. Cell wall polysaccharides have been isolated from murta fruits, showing a high percentage of galacturonic acid.

Murta pectin, prepared by hot diluted acid extraction, showed high molecular weight, low neutral sugars content, and high degree of methoxylatation, with a chemical composition similar to that of commercial citrus pectin (Taboada et al., 2010). Hence, murtilla fruit can be considered a valuable source of high quality pectin.

Culinary uses and commercial products

Murtilla is most often consumed as a fresh fruit because of its organoleptic characteristics, described as a mixture of fruity, sweet and floral notes. Historically it became one of the favorite fruit of Queen Victoria when it was introduced in
England in 1844. The fruit is also processed commercially to make the traditional liqueur *Murtado*, as well as jams, and desserts of murta with quince.

**Phytochemicals and Health**

The medicinal uses of murtilla in folk medicine have been focused on leaves and had origin from Mapuche Indians from Chile, based on the astringent properties of leaves that are administered in the form of infusion. Most studies on biological activity have been focused on leaves; in general, the biological effects of fruits are less potent than leaves, in all the assays reported. Studies on leaf infusion have demonstrated antimicrobial activity against pathogens as *Pseudomonas aeruginosa*, *Enterobacter aerogenes*, *Staphylococcus aureus* and *Candida albicans* (Avello *et al.*, 2009). These antibacterial properties have stimulated the use of murta leave extracts in edible films to improve the food quality and safety (Ramírez *et al.*, 2012). Leaf extracts have also proven prebiotic effect in human gut bacteria (Shene *et al.*, 2012).

On the other hand, leaf extracts have shown analgesic effects in chemical and thermal pain animal models through a mechanism partially linked to either lipoxygenase and/or cyclooxygenase via the arachidonic acid cascade and/or opioid receptors. Flavonoid glycosides of quercetin, myricetin and kaempferol and triterpenoids (asiatic, corosolic, alphitolic, betulinic, oleanolic and ursolic acid) isolated from the plant have been associated with this effect (Delporte *et al.*, 2007).

Concerning murtilla fruit, myricetin glucoside, quercetin glucoside, quercetin glucuronide and quercetin dirhamnoside have been identified in the extract of murtilla fruits, but no flavan-3-ols, in contrast with leaves (Shene *et al.*, 2009). The concentration of flavonols observed in murtilla fruit was two times higher than the concentrations observed in maqui and calafate fruits, with quercetin derivatives being the most abundant flavonol (Ruiz *et al.*, 2010).

Total polyphenol content can vary from 280 mg GAE/100 g dw to 2100 mg GAE/100 g dw among the growing seasons, depending on the weather conditions as rainfall and frosts (Alfaro *et al.*, 2013). This total phenolic content has been well correlated to the antioxidant activity of crude extracts, measured by DPPH method and to the inhibition of linoleic acid oxidation (Rubilar *et al.*, 2011). The levels of antioxidant activity in the fruit are comparable to those of blueberry and lower than
those of maqui and calafate fruits (Ruiz et al., 2010). ORAC values (10770 μmol TE/100 g fw) are amongst the highest in a ranking of 27 fruits produced in South Andes region and higher than blackberries (Speisky et al., 2012). Crude extracts of murta fruits have shown mild activity on inhibition of α-glucosidase, α-amylase, enzymes related to the metabolism of glycosides (Rubilar et al., 2011). Inhibition of these enzymes could delay absorption of sugars and consequently reduce postprandial glycaemia in diabetic patients. Antimicrobial activity of fruits has also been reported against Staphilococcus aureus (Shene et al., 2009).

Bibliography


NARANJILLA

Susana Espín Mayorga and Beatriz Brito Grandes  
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Quito, Ecuador

Scientific name: Solanum quitoense Lam  
(Familia Solanáceae)

Common names: naranjilla, lulo, lulum,  
naranja chiquita, naranjilla de castilla, quito  
orange, morelle de Quito, gele terong, orange  
von quito, berenjena de olor.

Origin

This fruit is native to the inter-Andean región, incas called it “lulum” since it  
was identified as “small orange” (“chiquita orange”), later it was called naranjilla. In  
Ecuador it is a typical fruit being cultivated in the eastern región, mainly between  
the foothills of the Andes and the amazonic plains. The main production áreas are  
in the provinces of Morona Santiago, Pastaza, Tungurahua, Pichincha and  
Imbabura. This crop is found in the American continent in countries like Ecuador,  
Peru, Colombia, Bolivia, Venezuela, Panama, El Salvador, Costa Rica, Honduras  
and in the southern región of the United States whereas in Oceania continent it is  
found in New Zealand (Pastrana, 1998; Ochse et al., 1972).

Varieties

According to Soria (1989) there are two main varieties, Solanum quitoense  
var. Septentrionale with thorns and Solanum quitoense var. Quitoense without  
thorns. Since common varieties are sensitive to plagues attack that collapse  
production and productivity two inter-specific hybrids have been developed  
(Heiser, 1993). Two naranjilla varieties are known common or typical and  
commercial hybrids, in Ecuador the following are found (Revelo et al., 2010):

Common or typical varieties: Variety “agria” (Solanum quitoense Lamvar.  
quitoense), Variety Baeza “dulce” (Solanum quitoense Lamvar. quitoense), Variety

Commercial hybrids: Hybrid Puyo, obtained by cross-hybridization between naranjilla jibara from oriente or cocona (*Solanum sessiliflorum*) and naranjilla variety “agria” (*Solanum quitoense* Lam var. *quitoense*), Hybrid INIAP Palora, obtained by cross-hybridization between naranjilla variety Baeza (*Solanum quitoense* Lam var. *quitoense*) and cocona (*Solanum sessiliflorum*), Hybrid Mera or espinuda which has similar characteristics to Hybrid Palora, it could be one of its segregators.

One of the improvements is the variety for juice INIAP Quitoense-2009, obtained by grafting in plant patterns of *Solanum hirtum* and *Solanum arboreum*, from a selection of variety Baeza, carried out by the Fruit Farming Program during years 2005 and 2007, this variety has been improved by plant selection considering strength, coagulating capacity, productivity and physico-chemical quality of the fruit (INIAP, 2009). The varieties Lulo de Castilla and Lulo la Selva are found in Colombia.

It is a globelike berry covered of pubescence, with even skin, when mature is edible and of intense yellow-orange color. The interior is divided in four carpels that contain a juicy pulp of green or yellow color with many seeds.

**Nutrition**

The variety INIAP Quitoense 2009 when mature the flavor which corresponds to the relation between soluble solids and titrable acidity was 4.33, that value is also related to the major acceptability found in the sensory tests. It also has a low darkening index of 5.64% that corresponds to a minimum oxidation, together with the big size of the fruit and with its nutritional quality gives excellent properties for fresh use or for industry. It is important to consider the fruit specifications for commercialization: weight, relation length/diameter and pulp yield.
One of the properties of the fruit is acidity with values of 3.23% for variety Lulo de Castilla and 2.40% for variety INIAP Quitoense 2009 as citric acid, in this case there is a compensation by the solid solubles high content of 10.80 °Brix. The total sugars content is 59.69% and the total reducing sugars is 31.00% both as percent of total carbohydrates, it is also found a moderate amount of Vitamin C. Total carotenoids confer the yellow or orange color and antioxidant properties to this fruit. A considerable amount of calcium, phosphorus, potassium, iron and zinc is found. It also presents a moderate value of antioxidant capacity with 24.87 μmol/g.

### Culinary uses

The main processed product is juice in addition to pulp and frozen concentrates as well as several kind of preserves, ice creams, desserts, candies when dehydrated and osmodehydrated. It is an exotic ingredient for gourmet dishes also used with all kind of meats, fruit and vegetable salads and for decoration. It is also used acid desserts and in recipes that need a sour touch that is part of ecuadorian gastronomy, commonly consumed as fresh drink and it is particularly appreciated for its aroma (Gancel, 2008)

### Phytochemistry and health

The naranjilla to seems to have good antioxidants properties; bioactive compounds as all-trans-β carotene, 13-cis- β carotene, 9-cis-β-carotene and the lutein between the carotenoides was reported (Gancel, 2008), that are similar to (Acosta et al., 2009) who found that the major carotenoids in naranjilla are β-carotene, lutein and zeaxantine, present with 58.4%, 32.2% and 3.2% respectively compared to total carotenoids. Related to phenolics compounds, chlorogenic acids and their hexosides in the flesh and placental tissues, and flavonol glycosides in the skin and many

<table>
<thead>
<tr>
<th>Naranjilla</th>
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<tbody>
<tr>
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<td>90.4 g</td>
</tr>
<tr>
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<td>0.64 g</td>
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<tr>
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<td>14.76 g</td>
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<tr>
<td>Ash</td>
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<td>g</td>
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<tr>
<td>Fiber</td>
<td>0.46 g</td>
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<tr>
<td>Sodium</td>
<td>0.5 mg</td>
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<tr>
<td>Potassium</td>
<td>0.31 mg</td>
</tr>
<tr>
<td>Calcium</td>
<td>4.8 mg</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>9.5 mg</td>
</tr>
<tr>
<td>Magnesium</td>
<td>12.4 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>0.1 mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.2 mg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>53.33 mg</td>
</tr>
</tbody>
</table>

Food values on 100g of fresh weight  
Source: Departament of Nutrition and Quality, INIAP, 2011
dihydrocaffeoyl spermidines was found in the skin, flesh and placental tissues. The peel had the highest of total polyphenol. It contained 1.5 and 2.6 times more that the flesh and the placental tissues, respectively (Gancel, 2008). The fruit is an important source of vitamins and minerals as Potassium 3090 μg/g fresh basis that contribute to human health with several carotenoids which are Vitamin A precursors (Vasco et al., 2008). Naranjilla juice dissolves some toxins and is recommended for persons with gout disease since it decreases uric acid content in blood.

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NONI

Amadeo Gironés-Vilaplana, Debora Villaño, Nieves Baenas, Cristina García-Viguera, and Diego A. Moreno
Food Science and Technology Department, CEBAS- CSIC, Spain.

Scientific name: Morinda citrifolia (Family Rubiaceae)

Common names: Noni, Nono, Nonu, Mengkudu, Nhau, Painkiller bush, Cheese fruit, Nuna, Ach, Lada, Gran Morinda, Indian Mulberry, Bumbo.

Origin

Whether M. citrifolia comes originally from Polynesia or South East Asia is still not known. According to Johansson (1994), M. citrifolia was an endemic species of the Pacific. Herbal medicines like the seeds, fruit, roots and leaves of M. citrifolia have been used for a long time to treat both internal and external ailments by the pacific islanders. Therefore it is believed that M. citrifolia seeds were being distributed to Southeast Asia, India and Caribbean by fellow voyagers (Abbott, 1992). M. citrifolia have been used therapeutically for at least two thousand years in the Eastern pacific (i.e. in Hawaii and Tahiti). It is still used as an herbal medicine in many Pacific islands (Abbott, 1992). Some papers indicate that M. citrifolia is native to Southeast Asia (e.g. Malaysia) and is cultivated in India, Caribbean, Polynesia and the States but there are limited documentations to identify the origin of the plant (Nelson, 2006) thou herbal medicines are still common in the proposed countries. More recently, the plant has been introduced to other regions with tropical climates. The wide distribution of the Noni tree in the Indo-Pacific Islands can be explained, in part, by the migration of seafaring Polynesians.

Production

The largest markets for noni are North America, Europe, Japan, Mexico, Asia and Australia with the worldwide market for these products estimated at US$400 million. A recent M. citrifolia market report shows an exponential increase
in *M. citrifolia* juice production during the 2000s where the USA alone, 19 patents and trademark applications for production of both domestic and international market (USPTO, 2005) have occurred. Processed *M. citrifolia* products, especially juice has been marketed in the States in 1996, other countries/continents that were targeted recently include Canada, Japan, Australia, Mexico, Norway, Hong Kong (SCF, 2002), Africa, Pacific and Asia (Solomon, 1999).

**Varieties**

There are more than 80 Morinda species that have been discovered in the tropics (Cardon, 2003). The commonly grown commercial varieties are: *M. citrifolia* var. *citrifolia*, *M. citrifolia* var. *bracteata* and *M. citrifolia* var. *potteri*. These varieties have different morphological aspects but the chemical properties are similar (i.e. phenolic compounds, organic acids and alkaloids).

**Nutrition**

The complete physico-chemical composition of the fruit has not yet been reported and only partial information is available on noni juice. For that reason, nutrient composition of TAHITIAN NONI® Juice (100 g), as published by the European Commission document, Opinion of the Scientific Committee on Food on Tahitian Noni® Juice is shown in the Table. The chemical composition of noni juice depends majorly upon the method of juice extraction and also on the variability in growing composition. The fruit contains 90% of water and the main components of the dry matter appear to be soluble solids, dietary fibers and proteins. Minerals account for 8.4% of the dry matter, and are mainly potassium, calcium, sodium and phosphorus. Vitamins have been reported in the fruit, mainly ascorbic acid (24–158 mg/100 g dry matter) (Chan-Blanco *et al.*, 2006).

<table>
<thead>
<tr>
<th>Food values on 100g Noni® Juice</th>
<th>Source: European Comission</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Noni</strong></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>39 - 79 kcal</td>
</tr>
<tr>
<td>Moisture</td>
<td>89-90 %</td>
</tr>
<tr>
<td>Protein</td>
<td>0.2-0.5 g</td>
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<tr>
<td>Carbohydrates</td>
<td>9.0-11.0 g</td>
</tr>
<tr>
<td>Fat</td>
<td>0.1-0.2 g</td>
</tr>
<tr>
<td>Fiber</td>
<td>0.5-1 g</td>
</tr>
<tr>
<td>Fructose</td>
<td>3.0-4.0 g</td>
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<tr>
<td>Glucose</td>
<td>15.5 g</td>
</tr>
<tr>
<td>Sucrose</td>
<td>&lt;0.1g</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>3-25 mg</td>
</tr>
</tbody>
</table>

**Culinary uses**

Commercialization of noni fruits as a medicinal food and dietary supplement has tremendously facilitated its availability worldwide, boosted its use, and brought
its benefits to more people. Since the first commercial noni fruit product, Tahitian Noni® juice, was launched in 1996, countless noni products have emerged in the global market. The quality of commercial noni fruit products may vary significantly, attributing to different geographical conditions (soil, sunlight, precipitation, and air) and post-growth factors (harvesting, storage, transportation, manufacturing processes, etc. (Deng et al., 2010). Noni fruit juice and juice products are processed and prepared in Hawai’i by a variety of methods. For example, noni juice may be fermented versus unfermented, or fresh-squeezed versus drip-extracted. The “traditional” juice is both drip-extracted and fermented/aged for at least two months. The “non-traditional” method of juice extraction is by pressing or squeezing the juice from ripe fruits. Noni juices may be amended with other additives or diluted, or bottled in its pure state. It may be bottled with or without pasteurization (Nelson, 2003). Other Noni products apart from juice are being commercialized: juice mixed with other fruits, fruit powder, dietetic supplement, cosmetic products, etc (Chan-Blanco et al., 2006).

**Phytochemicals and health**

Early phytochemical investigations on *M. citrifolia* focussed on secondary metabolites in leaves, roots and bark. The roots contain a wide spectrum of anthraquinones such as rubiadin, damnacanthal and alizarin-1-methyl ether, naphthoquinone derivatives and sterols, whereas several iridoids, flavonol glycosides and triterpenes were reported from the leaves. Plant cell cultures were analysed mainly for their capabilities for synthesis of anthraquinoid pigments. The interest in the constituents of the fruit was stimulated by the introduction of fruits juices as food supplement. Up to now, several classes of metabolites have been described, including polysaccharides, fatty acid glycosides, iridoids, anthraquinones, coumarins, flavonoids, lignans, phytosterols, carotinoids, and a range of volatile constituents including monoterpenes and short chain fatty acids and fatty acid esters (Potterat et al., 2007).

Traditional uses of Noni include the treatment of the digestive system (e.g. diarrhoea, intestinal parasites, indigestion and stomach ulcers), internal disorders (e.g. diabetes, high blood pressure, headache, kidney and bladder, tumours and fevers), eyes, mouth and throat (e.g. eye infections, inflamed and sore gums, sore throat with cough, gingivitis and toothache), bones and joints (e.g. arthritis, sprains
and broken bones), chest (e.g. cough, tuberculosis, asthma and respiratory
afflictions), gender-specific ailments (e.g. childbirth and pregnancy, menstrual
cramps, regulation of menstruation and prostate complaints), skin (e.g. abscesses,
boils, blemishes, wounds and infections), and as a tonic to slow aging (Chan-
Blanco et al., 2006).

The main proven functional properties of noni fruit are related to the control
of several diseases. Recently, significant health benefits have been attributed to
noni fruits, juice or extracts: hypolipidemic and antioxidative effects (Lin et al.,
2012), antiinflammatory activity (Akisha et al., 2007), cardiovascular (Chan-Blanco
et al., 2006), hepatoprotection (Wang et al., 2008), neuronal damage prevention
(Harada et al., 2009), antidiabetic effects (Sabitha et al., 2009), and anticancer
(Brown, 2012). In vitro research and limited experiments with lab animals have
shown that noni also has anti-microbial, analgesic and cardiovascular activities
(Chan-Blanco et al., 2006).

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On-line additional resources

http://www.businessopportunitiesconference.com
ORANGE

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BIO Thanl, Spain

Scientific name: Citrus sinensis (L.) Osbeck
(Family Rutaceae)

Common names: sweet orange, blood orange, navel orange, Valencia orange, tian cheng, Sinaasappel, navel, oranger, sanguine, Apfelsine, arancio dolce, orange douce, laranja-doce, naranjo dulce.

Origin

The orange plant is believed to be native to Southeast Asia, mainly to the southeast and northeast India, southern China, and Vietnam. They were first cultivated in China around 2500 BC. Arabo-phone peoples popularized sour citrus and oranges in Europe; Spaniards introduced the sweet orange to the American continent in the mid-15th century. They probably initiated orange cultivation in the 16th century in Cananeia, an island of the Sao Paulo coast in Brazil. Orange trees are widely grown and cultivated in tropical and subtropical climates for their sweet fruit.

Production

Oranges have been the most cultivated tree fruit in the world since 1987, and sweet oranges account for approximately 70% of the citrus production. Brazil is the world's leading orange producer, with an output almost as high as that of the next three countries combined (the United States (US), India, and China), and followed by Mexico and Spain (FAOSTAT, 2011). Orange groves are located mainly in the state of São Paulo, in the southeastern region of Brazil, and account for about one third of the world's total production of oranges. As almost 99% of the fruit is processed for export, 53% of total global frozen concentrated orange juice production comes from this area and the western part of the state of Minas Gerais. In US groves trees are located especially in Florida, California, Texas, and
Arizona. The majority of California's crop is sold as fresh fruit, whereas Florida's oranges are destined to juice products. Mid-south Florida produces about half as many oranges as Brazil, but the bulk of its orange juice is not exported. The Indian River area of Florida is known for the high quality of its juice, which often is sold fresh in the U.S. and frequently blended with juice produced in other regions because Indian River trees yield very sweet oranges, but in relatively small quantities.

**Varieties**

There are four orange varieties, e.g. common, navel, Valencia and blood. Popular varieties of the sweet orange include Valencia, Navel and blood. Common oranges (also called "white", "round", or "blond" oranges) constitute about two-thirds of all the orange production. The majority of this crop is used mostly for juice extraction. Navel oranges are primarily grown for human consumption for various reasons: their thicker skin make them easy to peel, they are less juicy and their bitterness – a result of the high concentrations of limonin and other limonoids – renders them less suitable for juice. Their widespread distribution and long growing season have made navel oranges very popular. Blood oranges were first discovered and cultivated in Sicily in the fifteenth century. Since then they have spread worldwide, but are grown especially in Spain and Italy—under the names of sanguina and sanguinella, respectively.

**Nutrition**

Juicy orange fruits are a good source of carbohydrates, dietary fiber, vitamins, and minerals. The fruit is characterised by its distinctive flavor, low in calories, contains no saturated fats or cholesterol, rich in vitamin C and pectin. Associations between orange fruit intake and prevention of chronic diseases make promotion of its consumption important in improved human health.

Orange fruit has low protein and very little fat content, and sucrose, fructose and glucose are the main sugars. Fresh orange fruits are also a good source of dietary fiber, which is associated with gastrointestinal disease prevention and lowered circulating cholesterol.
The white part of the rind, including the pith, is a source of pectin and has nearly the same amount of vitamin C as the flesh and other nutrients. In addition to vitamin C, which is the most abundant nutrient, the fruits are a source of B-group vitamins (thiamin, pyridoxine, niacin, riboflavin, pantothenic acid, and folate). Orange acidity not only impresses consumers as sourness, but also plays a key role in the criteria assessing the commercial acceptability of oranges, and together with appropriate sugar levels, provides the delightful and typical taste. Carboxylic acids, particularly citric, malic, and succinic acids, comprise the content of organic acids. The organic acids, in addition to the free form, also exist in the form of salts. Orange fruits and products are good sources of potassium, and could constitute up to 40% of the total ash. Calcium, magnesium, and phosphorus have relatively low amounts in orange fruits. Although not so juicy or tasty as the flesh, orange peel is edible and has higher contents of vitamin C and more fiber. The variability of vitamin C content in fresh oranges and their commercial products is greatly influenced by variety, maturity, climate, handling, processing, and storage conditions. Vitamin C in freshly extracted juice is quite stable during short storage periods and processing into the various juice products results in no serious loss of vitamin C potency if kept at refrigerator temperature for reasonable times (Kafkas et al., 2009; Liu et al., 2012; Roussos, 2011).

### Culinary uses

Orange, as a popular fruit, is widely used in culinary world. Its sweet and sour taste gives nice flavor to any dish it is added. It can be eaten fresh or processed to obtain juice, and for the fragrant peel. It also is used in certain recipes as a food flavouring or garnish. Usually, the thick skin of orange is peeled-off and discarded but sometimes it is grated to obtain orange zest. In many sweet and savory orange dishes, orange zest is used as it contains strong flavor of

<table>
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<tr>
<td>Vitamin E (alpha-tocopherol)</td>
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*Food values on 100g of fresh weight
Source: USDA, 2013*
Orange. Orange flesh is added to fruit salads and desserts. Orange flesh is squeezed to produce orange juice; this is one of the most popular orange recipes worldwide. The by-product obtained while taking out its juice is ‘sweet orange oil’. This oil is widely used as a flavoring agent in various foods and drinks. Orange blossom is the flower of orange tree and its leaves are a part of French and Middle Eastern cuisines to flavor several baked and dessert items. Like orange juice, orange marmalade is also one of the most common orange recipes. It is used as a spread on breads and pancakes. Tea is also made while using orange leaves.

**Phytochemicals and health**

Orange fruit has many phytochemicals such as carotenoids, flavonoids, phenolic acids and limonoids.

Carotenoids reported in oranges are α-carotene, β-carotene, lycopene, lutein, β-cryptoxanthin, and zeaxanthin, almost all contained in red orange in higher quantities than in other sweet oranges. Although α- and β-carotene are a minor portion of carotenoids in some oranges, β-cryptoxanthin is the main vitamin A precursor (Fanciullino *et al*., 2008; Liu *et al*., 2012; Roussos, 2011).

Orange fruits are a major source of flavonoids, e.g. flavanones, anthocyanins, flavones, and flavonols. One of the most common classes of flavonoids found are flavanones (hesperidin, naringin, narirutin, eriocitrin, neohesperidin, didymin, neoeriocitrin and poncirin). The most abundant flavonoid species that have been so far identified and quantified in *Citrus sinensis*, regardless of variety, is by far hesperidin, followed by narirutin and didymin. Hesperidin represents about 90 % of orange juice flavanones, the remainder being understood by narirutin. These are all flavanone-O-glycosides, which account for most of the flavonoid content in juice, although a higher content has been found in red orange varieties (Sanguinello, Moro, and Tarocco) compared with nonpigmented variants (Navel, Valencia, and Ovale) (Franke *et al*., 2005; Gattuso *et al*., 2007; Liu *et al*., 2012; Peterson *et al*., 2006; Proteggente *et al*., 2003; Roussos, 2011).

Anthocyanins are mainly present in pigmented oranges, especially cyanidins. Red oranges have shown that cyanidin-3-glycoside was the main anthocyanin. Some differences in anthocyanins content may occur considering different types of red oranges. Each cultivar shows a characteristic seasonal
variation of the content of anthocyanins: the cultivar Moro contains the highest amount of anthocyanins. Indeed, the primary anthocyanins in Budd blood orange, a red-colored blood orange typically grown in Florida, US, were inverted in content, cyanidin-3-(6''-malonylglucoside) followed by cyanidin-3-glucoside (Grosso et al., 2013; Kafkas et al., 2009; Riso et al., 2005).

Phenolic acids include hydroxycinnamic acids that can be found in red orange. The most common are caffeic, p-coumaric, ferulic, and sinapic acids. Free and bound ferulic acids represent the major component in all cases, followed by p-coumaric acid, sinapic acid, and caffeic acid. However, hydroxycinnamic acids have been found to be more abundant in red orange than in blond juices. Ferulic acids and caffeic acid are among the most studied hydroxycinnamic acids (Grosso et al., 2013; Rapisarda et al., 1998; Roussos, 2011).

The aroma-active volatile flavoring compounds contained in the peel oils characterize the aroma emanated by citrus fruits and are associated with their flavors. The volatile compounds include terpene hydrocarbons, such as monoterpenes and sesquiterpenes, esters, aldehydes, ketones, alcohols, and volatile organic acids. The largest fraction, representing approximately 90% of all orange oil compounds, is monoterpene hydrocarbons, e.g. d-limonene (Liu et al., 2012; Sun et al., 2013).

Orange fruit has small quantities of adrenergic amines (mainly synephrine) (Sun et al., 2013).

The antioxidant activity of orange juices has been attributed, in a significant part at least, to their content of phenolic compounds and carotenoids, whereas ascorbic acid seems to play a minor role. Orange flavonoids possess health-promoting properties and have been suggested as one of the possible cancer-preventing agents (Peterson et al., 2006; Rapisarda et al., 1999; Rapisarda et al., 2008; Roussos, 2011). Red oranges demonstrated both potent antioxidant activity and also cytoprotective effects that reflect their substantial role in preventing chronic pathological conditions such as cardiovascular diseases and in many forms of cancers (Grosso et al., 2013). In addition, fruits and peels are abundant in antioxidants and hold therapeutic potential for human skin topical antioxidant. Fruit skins have evolved over millennia to sufficiently protect the flesh from environmental exposure and desiccation (Cimino et al., 2007; Saija et al., 1998).
Orange juice shown a potential role in the prevention of inflammation and oxidative stress related to chronic diseases. The consumption of fruit juice can play a role in modulation of inflammatory markers (e.g. Nuclear factor kappa-B, C-reactive protein, Interleukin-1, Interleukin-6, Tumor necrosis factor alpha and Toll-like receptors) through bioactive compounds, such as the flavonoids (hesperidin, naringenin). It suggests that orange juice could be a dietary feature for prevention and treatment of chronic diseases (Coelho et al., 2013). Orange juice may also exert beneficial effects on some intermediate risk factors for cardiovascular disease, such as low density lipoprotein cholesterol, blood pressure, and endothelial function (Hooper et al., 2008).

Bibliography


On-line additional resources
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PAPAYA

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Scientific name: Carica papaya L.
(Family Caricaceae)

Common names: papayas, papaw, pawpaw.

Origin
This fruit is originally from Mexico according to some authors and from Peruvian Andes by other. It is believed that from Mexico, papaya cultivation spread to all tropical countries. Currently is grown in Florida, Hawaii, East Africa, South Africa, India, Canary Islands, Malaysia and Australia.

Production
After mango and pineapple, papaya is one of the major tropical fruits account for approximately 75 percent of global fresh tropical fruit production. Papayas are produced in about 60 countries, with the bulk of production occurring in developing economies. Global papaya production in 2010 was estimated at 11.22 Mtn, growing at an annual rate of 4.35 percent between 2002 and 2010 (global production in 2010 was 7.26% higher than 2009, and 34.82% higher than 2002). Asia has been the leading papaya producing region, accounting for 52.55 percent of the global production between 2008 and 2010, followed by South America (23.09%), Africa (13.16%), Central America (9.56%), the Caribbean (1.38%), North America (0.14%), and Oceania (0.13%).

Varieties
Papaya fruits are smooth skinned. They vary widely in size and shape, depending on variety and type of plant. Highlighted varieties: Solo, Bluestem, Graham, Betty, Fairchild, Rissimee, Puna and Hortusgred. The most common is the Solo, introduced into Hawaii from Barbados in 1911. Solo Papayas are valued

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for their productivity, uniform shape and size and excellent fruit quality. The fruit weighs about 450 grams, and are pear-shaped hard shell, with sweet taste. Pure variety is also widespread, both from Hawaii. Other papaya varieties produce variously shaped fruits, which may weigh up to 9.1 kg. The fruits usually contain many seeds surrounded by a smooth yellow to orange-red flesh that is sweet in good varieties. In Australia, Red papaya and Yellow papaw are commonly grown. The large-fruited, red-fleshed 'Maradol', 'Sunrise', and 'Caribbean Red' papayas often sold in US markets are commonly grown in Mexico and Belize.

Nutrition

The papaya fruit is about 88.8% water, 9.8 % carbohydrate, 0.8% fiber, 0.5% protein and 0.1% fat. A 100g (3.5 oz.) serving of papaya has 43 calories, compared to banana's 92 calories. Papaya is a rich source of vitamin C (62mg/100g fresh weight), containing 16% more vitamin C than oranges and are a good source of vitamin A (about half of that contained in mango). Other vitamins present in minor quantities are vitamin A (47μg per 100g), folate (B9) (47μg per 100g), and the rest of B-group (B1, B2, B3, B5, B6)(0.6μg per 100g). Vitamin A is required for maintaining healthy mucus membranes and skin and is essential for visual sight. The main mineral present in papaya is potassium, although other minerals like magnesium, calcium and phosphorus are also present in minor levels. Moreover, papaya contains trace levels of iron, manganese, sodium and zinc. Papayas (100 g) contained 6-8% of the dietary reference intake (DRI) for Mg, but less than 3% of the DRI for other minerals. Minerals are required for normal cellular function, and are critical for enzyme activation, bone formation, hemoglobin composition, gene expression, and amino acid, lipid and carbohydrate metabolism. Potassium constitutes an essential mineral for human health since it is essential to maintain the water–acid balance and it participates in the transmission of nerve impulse to muscle.
Culinary Uses

Ripe papaya is usually consumed fresh as a breakfast or dessert fruit, it can also be processed and used in a variety of products such as jams, fruit juices, and ice cream. Papaya is also consumed as a dried fruit and as an ingredient in a variety of cuisines throughout the world. Unripe fruits and leaves are consumed as vegetables. Papaya seeds are also used as an ingredient in salad dressings. Papain is a milky latex collected by making incisions in unripe papayas. The latex is either sun-dried or oven-dried and sold in powdered form to be used in beer clarifiers, meat tenderizers, digestion aids, wound debridement aids, tooth-cleaning powders, and other products. The ‘Solo’ papaya is not a good variety for papain production due to its low yield of papain. Consumption of the fruit is reported to aid digestion because of the papain content.

Phytochemicals and health

*Carica papaya* is widely cultivated in tropical and subtropical countries and is used as food as well as traditional medicine to treat a range of diseases. Papaya contains a broad spectrum of phytochemicals including enzymes (in the latex), carotenoids (in fruits and seeds), alkaloids (in leaves), phenolics (in fruits, leaves, shoots) and glucosinolates (in seeds and fruits). In the literature, phenolics, carotenoids, and glucosinolates founded in this fruit have been extensively researched in vivo and in vitro studies on many types of cell lines for their potential effects in cancer treatment and prevention (Nguyen, *et al.*, 2013). Experiments have also shown that papaya possesses antibacterial, antifungal, antiviral, antiinflammatory, antihypertensive, hypoglycemic and hypolipidemic, antitumor, free-radical scavenging, neuroprotective, diuretic, abortifacient, and antifertility activities. The aqueous fruit extract of *Carica papaya* has been studied as possibly useful in the treatment of obesity and related disorders, modulating weight control (Athesh, *et al.*, 2012). This extract also exerted a hypoglycemic and antioxidant effect, improving the lipid profile, in a study performed in diabetic rats. In addition, the leaf extract positively affected integrity and function of both liver and pancreas (Juárez-Rojop, *et al.*, 2012).

**Phenolic compounds** are aromatic metabolites, which provide the ability to neutralize reactive species, helping the body to protect itself from oxidative stress. Additionally, phenols contribute to fruits’ color and taste and have been described
as possessing anticarcinogenic and antimutagenic activity. Various studies have shown that phenolic compounds have high antioxidant potential, resulting in a beneficial effect to human health (Gayosso-García, et al., 2011). The major phenolic acids quantified in papaya were ferulic, p-coumaric, and caffeic acids. The contents of phenolic acids decreased with fruit ripening.

**Carotenoids** are bioactive compounds which have antioxidant properties, in addition to vitamin A activity. Lycopene, is the major carotenoid pigment in red-fleshed papaya cultivars (1828μg per 100g) (Wall, et al., 2006), which has important health implications as a potent antioxidant. Lycopene has the highest free radical scavenging ability among the carotenoids, followed closely by β-cryptoxanthin and β-carotene. During the last decade, numerous studies had screened the antiproliferative activity on cancer cell lines of pure lycopene and of both juice and extracted lycopene from papaya. In 2008, Morimoto et al. patented the extremely high effectiveness of a extract of different parts of papaya in water for the prevention, treatment, or improvement of many types of cancer: stomach, lung, pancreatic, colon, liver, ovarian, neuroblastoma, and other solid cancers or lymphoma, leukemia, and other blood cancers.

**Glucosinolates** are sulphur-containing glycosides compounds characteristics of the Brassicales and have been widely investigated because their hydrolysis compounds, isothiocyanates, potent inducers of detoxifying enzymes bestow the distinct anti-cancer properties of these plant-foods. The papaya seed contain >1 mmol of benzyl glucosinolate (glucotropaeolin) in 100 g of fresh seed. The papaya seed extract produced 460 micromol of the beneficial benzyl isothiocyanate in 100 g of seed. In contrast, papaya pulp contained an undetectable amount of benzyl glucosinolate. Several epidemiological and experimental studies have reported that dietary consumption of cruciferous vegetables containing ITCs, inversely correlates with the risk of developing cancers of various tissues and organs including lung, breast, and colon cancers (Dinkova-Kostova and Kostov, 2012).

Papaya seeds have been the proven natural remedy for many ailments in the traditional medicines. The seeds are found application as anti-inflammatory, anti-parasitic, and analgesic, and used to treat stomachache and ringworm infections.

**Vitamin C** (ascorbic acid) is a hydrophilic vitamin present in fruit. It plays an important role because it is required for several metabolic processes like
development of tissues and production of hormones and is also considered a powerful antioxidant reducing oxidative stress (Gayosso-García Sancho, et al., 2012). Papaya ranks first among 13–17 fresh fruits for vitamin C content per 100 g edible tissue. Fresh, ripe fruit is one of the fruits with the highest vitamin-C content, one cup of papaya cubes (140g) provides 86.8 mg or about 80% and 96% of the DRI for vitamin C for the average adult male and female, respectively (Wall, et al., 2006). Research studies have shown that vitamin C has many important functions like free radicals scavenging, immune booster, and anti-inflammatory actions. In addition, it has been observed that vitamin C can act synergically with other vitamins and play an important role to regenerate vitamin E.

Bibliography


**On-line additional resources**

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PITANGA

Liliana Vargas-Murga and Nancy Vargas-Murga
BIOTHANI, Spain

Scientific name: *Eugenia uniflora* L. (Family Myrtaceae)

Common names: Pitanga, Brazilian cherry, Surinam cherry, Barbados cherry, Cayenne cherry, Ñangapirí, capulí, cereza de cayena, pedanga, grosella, guinda, arrayán del norte, cereza cuadrada, cerisescotes, cerise carrée, ceremai belanda, dewandaru, mayom-farang, kafika, kafika palangi, menemene, monkie kersie, nagapiry, ramegaa, venevene, zoet kers.

Origin

Pitanga, Pitangera's fruit, is indigenous to the Amazon rainforest. It is native from Surinam, Guyana and French Guyana to southern Brazil (especially the states of Rio de Janeiro, Paraña, Santa Catharina and Rio Grande do Sul). It grows wild in thickets on the banks of the Pilcomayo River in Paraguay. At present it is cultivated and naturalized all over the tropical and subtropical regions of South America such as Guyana, Venezuela, Colombia, Brazil, Bolivia, Peru, Argentina, Paraguay and Uruguay; also along the Atlantic coast of Central America; and in some islands of the West Indies—the Cayman Islands, Jamaica, St. Thomas, St. Croix, Puerto Rico, Cuba, Haiti, the Dominican Republic, and in the Bahamas and Bermuda (Silva, 2006; Vizzotto, 2008). Due to its huge adaptability to different soil and climate conditions, this tree has spread to other locations, e.g. Central America, California, Florida, Caribbean Islands, Hawaii, China, Tunisia, Algeria and Sri Landa (Gomes, 2007). It was first described botanically from a plant growing in a garden at Pisa, Italy, which is believed to have been introduced from Goa, India. Portuguese voyagers are said to have carried the seed from Brazil to India, as they did with the cashew.

Production
The major production region, in a commercial scale, is the state of Pernambuco (Brazil), with an annual production of approximately 1700 tons of fruits (Silva, 2006).

Varieties

There are 2 distinct types, red and purple varieties, which depend on its color: the common bright-red and the rarer dark-crimson to nearly black, which tends to be sweeter and less resinous. The deep red, almost black fruited varieties produce sweeter fruit without that tart aftertaste that is specific for Surinam Cherry. During ripening, the epicarp evolves from green to red color, in the red variety and, from green to deep purple or almost black in color, in the purple variety.

Nutrition

Pitanga fruit is appreciated for its sensorial properties and as a rich source of antioxidant pigments. Its fruit has an exotic flavor, sweet and sour taste, very juicy and red to purple colors. It has a low lipid and caloric content and a wide range of nutrients such as proteins, pectin, vitamins (C, thiamin, riboflavin and niacine) and minerals. The pulp is a fair source of calcium, iron, phosphorus, magnesium, potassium, sodium, zinc (Aparecida de Assis et al., 2009; Freyre et al., 2002; Nzeagwu et al., 2010).

Culinary uses

Pitanga can be eaten fresh or used to make pies, sauces, puddings, jams, jellies, compotes, relish or pickles. In Brazil the juice is fermented into vinegar or wine; sometimes distilled liquor is prepared. Besides being highly desirable for fresh consumption, the Brazilian cherry fruits are also used for juice and ice cream production as flavoring due its taste ranging from sweet to sour. Children enjoy eating the ripe fruits out-of-hand. For table use, they are best slit vertically on one side, spread open to release the seed(s), and kept chilled for 2 or 3 hours to dispel most of their resinously aromatic character. If seeded and sprinkled with sugar
before placing in the refrigerator, they will become mild and sweet and will exude much juice and serve very well instead of strawberries on shortcake and topped with whipped cream.

**Phytochemicals and health**

Pitanga has high amounts of carotenoids and flavonoids (e.g. anthocyanin and flavonols). Its unique sweet and acidic characteristic flavor, with intense and peculiar aroma is due to the presence of its essential oil. Pitanga was found to be one of the richest fruit sources of carotenoids, particularly lycopene. The carotenoids identified were lycopene, lutein, β-cryptoxanthin, γ-carotene, β-carotene, rubixanthin, violaxanthin, zeaxanthin, and phytofluene. The presence of carotenoids is higher in peel than pulp; and more in purple variety than red one (Azevedo-Meleiro et al., 2004; Filho et al., 2008; Lima et al., 2002; Porcu et al., 2008; Rodriguez-Amaya et al., 2008).

Brazilian cherry fruit is a good source of antioxidant compounds, such as flavonoids e.g. anthocyanins and flavonols (Lima et al., 2002). Cyanidin-3-O-β-glucopyranoside and delphinidin-3-O-β-glucopyranoside were identified as anthocyanins; and myricetin, quercetin and kaempferol as flavonols (Celli et al., 2011; Einbond et al., 2004; Hoffmann-Ribani et al., 2009).

The unique sweet and acidic characteristic flavor, with intense and peculiar aroma of pitanga fruit (Gomes, 2007) is due to the presence of sesquiterpenes and ketones from its essential oil. The major volatile compounds are grouped into two categories: sesquiterpenoids (germacrene B, α-selinene, β-selinene) and monoterpenoids (β-ocimene, p-cimene and limonene); followed by oxygenated sesquiterpenes (globulol, spathulenol, β-damascenone) and hexadecanoic acid (Malaman et al., 2010; Marin et al., 2008). Monoterpenes were found to comprise the largest class of the pitanga fruit volatiles, including trans-β-ocimene, cis-ocimene, the isomeric β-ocimene, β-pinene with woody-green pine-like olor, curzene, and bergaptene. Selina-1,3,7(11)-trien-8-one was also found to be present in the fruit volatile extract, suggesting that the fruit may display therapeutic properties similar to leaf (Oliveira et al., 2006; Pino et al., 2003). Essential oil, characterized by the abundance of germacrone, selina-1,3,7(11)-trien-8-one, curzerene and oxidoselina-1,3,7(11)-trien-8-one, exhibited potent cytotoxic activity and varying antibacterial effects (Ogunwande et al., 2005).
Carotenoids are the most widespread pigments in nature, the most important being β-carotene, lycopene, lutein and zeaxanthin. The main roles of carotenoids in the human diet are as precursors of vitamin A and as antioxidants. Lycopene is not a vitamin A precursor but its capacity to quench singlet oxygen is about three times that of β-carotene and it also has a greater colour intensity compared to β-carotene (Di Mascio et al., 1989). There is a direct correlation of carotenoids, flavonoids, vitamin C and essential oil content with the antioxidant capacity (Aparecida de Assis et al., 2009; Celli et al., 2011; Einbond et al., 2004; Marin et al., 2008; Massarioli et al., 2013).

This tropical berry may contribute to a reduction in the risk of cardiovascular and neurodegenerative diseases and some forms of cancer, as well as to the promotion of other physiological.

Bibliography


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POMEGRANATE

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Scientific name: *Punica granatum*
(Family Punicaceae)

Origin

Pomegranate tree is native of the Middle East, Centre of origin IV of Vavilov, which includes interior of Asia Minor, all of Transcaucasia, Iran, and the highlands of Turkmenistan (Vavilov, 1951). Pomegranate is a very interesting fruit tree in arid and semiarid areas, even under desert conditions, since it possesses drought tolerance characteristics and ability to confront water stress (Rodríguez et al., 2012). This turns the pomegranate tree into a valuable option for fruit culture in regions that must face up to the need of coping with water scarcity and where the growing of other fruit species is unsustainable (Mena et al., 2012a).

Production

Nowadays, pomegranate is an important fruit crop of many tropical and subtropical regions of the world. Iran is the main producer, followed by India, China, and Turkey. Among the westernised countries, USA is the main producer and importer of juice concentrates whereas Spain is the main European producer (Jurenka, 2008).

Varieties

Owing to its wide distribution in many different world regions, pomegranate exhibits a broad array of diverse phenotypes and genotypes. Actually, more than 3000 pomegranate cultivars have been described. There are pink, red, green, and even almost black pomegranate varieties. Diversity among phytochemical profile of pomegranate cultivars has been widely reported for Spanish (Mena et al., 2011), Tunisian (Zaouay et al., 2012), Turkish (Ozgen et al., 2008), Iranian (Alighourchi et al., 2008), Egyptian (Hassan et al., 2012), Israeli (Tzulker et al., 2012).
2007), and Italian (Cristofori et al., 2010) pomegranates. Some important cultivars are: “Mollar de Elche” and “Valenciana”, two Spanish cultivars; “Dente di Cavallo”, the main Italian cultivar; “Española”, “Granada”, “Paper Shell”, and especially “Wonderful” account for the main cultivars in USA; “Dholka” and “Ganesh” are widely grown in India whereas important Turkish cultivars are “Hicaznar”, “Silifke”, “Asisi”, and “Izmir”, among others (Melgarejo & Salazar, 2003).

**Nutrition**

Juice is obtained from the juicy pulp, which comprises the 24-49% of the total fruit weight (Mena et al., 2011a). Aril juice contains 85% water, 10-12% total sugars, 0.2-2% organic acids, pectin, fatty acids, amino acids, and antioxidant phenolics (Fadavi et al., 2005; Melgarejo et al., 2000). The total phenolic content in pomegranate juice varies from 0.2 to 2.0% depending on cultivar and processing (Tzulker et al., 2007).

It is a point worth mentioning the high content in potassium contrary to the low one in sodium, conferring good opportunities on hypertensive population. Malic and citric acid have been described as the most abundant acids, whilst oxalic, succinic and fumaric are present in lower amounts (Mirdehghan et al., 2006). It also possesses small quantities of vitamin C. But, without any doubt, the main contributor to the unique composition of pomegranate juice is its high (poly)phenolic content. Finally, another interesting characteristic related to pomegranate juice is its high antioxidant capacity, which has been reported to be up to three fold higher than tea and red wine (Gil et al., 2000).

**Culinary uses**

Pomegranate fruits can be transformed into different food products: juices and beverages, wine, jams and jellies, dried arils, and fresh arils in modified atmosphere.
Phytochemicals and health

Pomegranate has been reported as an interesting source of essential vitamins as folate and vitamin K (USDA, 2010). Nonetheless, the most important added value of pomegranate is its large content in (poly)phenolic compounds, which are present in the edible part as well as in the rest of the fruit and, in fact, is precisely in the husk where they are found in higher concentration (Gil et al., 2000). Moreover, bioactive phenolics have been reported to be the major antioxidants of pomegranate and, hence, they have been established as main responsible for pomegranate healthy applications (Mena et al., 2011b). However, it is a point worth mentioning the increasing role of seed oil in establishing the pharmacological mechanisms of pomegranate.

Among different kind of phenolic compounds, pomegranate contains phenolic acids, anthocyanins, other non-coloured flavonoids, ellagitannins, and gallotannins (Mena et al., 2012b), being anthocyanins and ellagitannins those contained to a greater extent.

**Anthocyanins** are a group of natural pigments responsible for the red-blue colour of many fruits, including pomegranate. Pomegranate presents an anthocyanin profile characterized by six anthocyanins: cyanidin 3,5-di- and 3-O-glucoside, delphinidin 3,5-di- and 3-O-glucoside, pelargonidin 3,5-di- and 3-O-glucoside), and recently, three new cyanidin derivatives have been described in pomegranate juice: pentoside, pentoside-hexoside, and rutinoside (Fischer et al., 2011).

A broad array of **ellagitannin** structures have been found in pomegranate juice, doing of these hydrolysable tannins the main class of identified (poly)phenols in pomegranate juice (Mena et al., 2012b). Ellagitannins are extensively found in pomegranate husk, mainly punicalagins (Gil et al., 2000), and are usually extracted into juice during processing. These compounds, when exposed to pH variations, are hydrolyzed yielding the water-insoluble ellagic acid. After ingestion of ellagitannins, these polymeric structures are hydrolysed and metabolised into urolithins by gut microbiota. Then, urolithins appear in the circulatory system almost exclusively as glucuronide, sulphate and methylated metabolites as a result of phase II metabolism in amounts that rarely exceed nM
concentrations after absorption at the colonic region (González-Barrio et al., 2011).

Finally, pomegranate seed oil, which represents the 12-20% of the seed on a dry-weight basis (Lansky & Newman, 2007), displays an interesting lipid profile. Pomegranate seed oil consists of 65-90% polyunsaturated fatty acids being punicic acid (9-cis, 11-trans, 13-cis, 18:3) the predominant one (Hernández et al., 2011). Polyunsaturated fatty acids present in pomegranate seed oil could protect against diet-induced obesity and insulin resistance and inflammatory diseases (Asghari et al., 2012; Coursodon-Boyiddle et al., 2012; Vroegrijk et al., 2011). Pomegranate seed oil also contains vitamin E, sterols (daucosterol, camesterol, stigmasterol, and β-sitosterol), steroids (estrone, 17-α-estradiol, estriol, and testosterone), and tocopherols (especially γ-tocopherol) (Lansky & Newman, 2007; Mori-Okamoto et al., 2004).

On the whole, evidence suggests that phenolic phytochemicals of pomegranate fruit, mainly anthocyanins and ellagitannins, could exert multiple therapeutic properties on health management as playing an essential role in oxidative stress balance, preventing important cardiovascular diseases, and fighting as chemoprotective agent against several kinds of cancer. In addition, pomegranate antioxidant bioactives could possess a role as neuroprotectors in some neurological disorders just as broad antimicrobial activities among other beneficial implications.

Bibliography


PURPLE PASSION FRUIT

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Scientific name: Passiflora edulis Sims, Passiflora edulis, Passiflora edulis Sims f. edulis y Passiflora edulis f. edulis.

Common names:
• English: purple granadilla, purple passion fruit, sweet cup.
• French: gouzou, grenade, pomme-liane violette.
• German: granadilla, susze calabasch.
• Portuguese: maracujá comum, maracujá de comer, maracujá de doce, maracujá de ponche, maracujá mirim, maracujá pequeno, maracujá peroba, maracujá redondo.
• Spanish: ceibey, curuba redonda, granadilla china, maracuyá, maracuyá púrpura, parcha, parcha de monte, parcha morada.

Origin
The purple passion fruit is native of southern Brazil through Paraguay to northern Argentina and was thoroughly dispersed during the 19th century to other countries in South America, Caribe, Asia, Africa, India and Australia. Passion fruit is adapted today throughout the tropics and subtropics and has naturalized and escaped in many areas including North America, many islands of the Pacific Ocean, Australia, New Zealand, South Africa and SE Asia (Morton, 1987).
Production

The purple passion fruit has a large export market and high demand in European countries where consumers prefer it for its aroma and taste sweeter than passion fruit (FAO, 2001; Asohofrucol, 2005; Isaacs, 2009). Currently the main producers are Australia, New Zealand, Kenya, Zimbabwe and Colombia whose production volumes are far from meeting the increasing demand (Rodriguez and Bermudez, 2009). The mainly importing countries are United Kingdom, Germany and France, and others like New Zealand, Quebec, Singapore and Thailand.

According Rodriguez (2010), the appropriate altitudes for purple passion growth are between 1,400 and 2,000 meters, but for Zibadi and Watson (2004), the altitude and latitude do not appear to be a constraint to cultivation other than through the temperatures associated with them.

Purple passion fruit grows best in a subtropical climate and requires a lot of sun for optimal growth and fruit production. In very hot places, partial shade may be preferable. Generally, annual rainfall should be at least 35 inches (90cm). The vine and fruit also require a lot of water, especially when the fruits are maturing, so irrigation systems are often installed. This species is shallow-rooted but withstands drought by defoliating and roots can be protected by organic mulch (Schotsmans and Fischer, 2011). Passion fruit tolerates a wide variety of soils and grows best on well drained, sandy loams with pH of 6.5–7.5 (Morton, 1987). It needs protection from wind (Petry et al., 2001) as well as a large number of insects, nematodes, fungi and viruses (Morton, 1987).

Varieties

The commercial varieties of purple passion fruit known until now were developed by breeding programs especially by Australia. True varieties or genotypes with different characteristics have not been obtained or found naturally.

All commercial varieties are mainly materials developed through crosses between *P. edulis* f. edulis x *P. edulis* f. flavicapa or *P. edulis* f. edulis x *P. incarnata* (Ortiz, 2010). The use of grafts in commercial plantations of purple passion fruit in Australia is very common, therefore breeding programs are focused on developing patterns or improved rootstocks and alongside improved grafts or crowns in order to develop only commercial grafts.
The best known Australian commercial cultivars are the purple hybrids - ‘Misty Gems’ and ‘Sweethearts’ which are grown in the subtropical climates (APIA, 2012). Australia is working on the development of two cultivars called ‘Network’ and ‘Samba McGuffies’ which presented satisfactory results in terms of sugar and pulp, appearance and postharvest shelf life.

One cultivar known in Brazil as "Maracujá-Maca" was released by the Agronomic Institute of Campinas which was the result of a cross between a passion fruit material listed as IAC-277 and native purple passion fruit. The fruits are round with pink skin (Molina et al., 2005).

**Nutrition**

This fruit is valued for its taste aroma, nutritional content as a source of provitamin A, niacin, riboflavin, ascorbic acid, vitamins A, B, C and E, calcium, phosphorus, iron, protein and magnesium, while fats and calories are low (Wenkam, 1990; Schotsmans and Fischer, 2011). It also contains potassium (the same amount found in banana) and has a high level of fiber, with 100g providing 35% of an adult’s recommended dietary intake.

The purple passion fruit contains about 15 to 20% carbohydrates, mainly: fructose 33.5%, glucose 37.1% and sucrose 29.4%. Its pH is about 3 and has a high content of organic acids, being predominentes citric acid (13.1%), malic acid (3.9%), lactic acid (7.5%), the malonic acid (4.9%), succinic acid (2.4%) and ascorbic acid (0.05%).

<table>
<thead>
<tr>
<th>Purple passion fruit</th>
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<tbody>
<tr>
<td><strong>Energy</strong></td>
</tr>
<tr>
<td><strong>Water</strong></td>
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<tr>
<td><strong>Protein</strong></td>
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<tr>
<td><strong>Carbohydrates</strong></td>
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<tr>
<td><strong>Fat</strong></td>
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<tr>
<td><strong>Fiber</strong></td>
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<tr>
<td><strong>Ash</strong></td>
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<tr>
<td><strong>Sodium</strong></td>
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<td><strong>Potassium</strong></td>
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<tr>
<td><strong>Calcium</strong></td>
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<tr>
<td><strong>Phosphorous</strong></td>
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<tr>
<td><strong>Iron</strong></td>
</tr>
<tr>
<td><strong>Zinc</strong></td>
</tr>
<tr>
<td><strong>Copper</strong></td>
</tr>
<tr>
<td><strong>Selenium</strong></td>
</tr>
<tr>
<td><strong>Ascorbic acid</strong></td>
</tr>
<tr>
<td><strong>Riboflavin</strong></td>
</tr>
<tr>
<td><strong>Niacin</strong></td>
</tr>
<tr>
<td><strong>Vitamin B6</strong></td>
</tr>
<tr>
<td><strong>Folate</strong></td>
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<tr>
<td><strong>Vitamin A</strong></td>
</tr>
<tr>
<td><strong>Vitamin A</strong></td>
</tr>
<tr>
<td><strong>Vitamin E</strong></td>
</tr>
<tr>
<td><strong>Vitamin K</strong></td>
</tr>
</tbody>
</table>

*Food values on 100g of dry weight  Source: USDA, 2004.*
Culinary uses

The purple passion fruit is a promising and appetizing fruit for its organoleptic characteristics of taste and aroma (it is sweeter than the yellow passion fruit). The pulp and seeds are very nutritious and can be eaten directly from the fruit. The ripe aromatic fruit is allowed to wrinkle and develop sweetness, it is then eaten raw, juiced, or salads (without removing the seeds) and pulp sifted can be used to make jellies, jams, sauces, cocktails, ice cream, candy-making process and syrup. Passion fruit enhances the flavor of other fruits and makes a delicious topping for a pavlova or cheesecake.

The purple passion fruit, although generally a bit smaller than the yellow one, has an average juice yield of 45-50% and is also richer in flavor compared to the yellow passion fruit with only 30-33% juice yield (Nakasone and Paull, 1998). The seed not only contains edible oil, but also passiflora, a protein which has antifungal properties (Lam and Ng, 2009).

Phytochemicals and health

Plant chemicals include: alkaloids, ascorbic-acid, beta-carotene, calcium, carotenoids, catalase, citric-acid, ethyl-butyrate, ethyl-caproate, fat, fiber, flavonoids, harman, iron, malic acid, N-hexyl-butyrate, N-hexyl-caproate, niacin, pectin methylesterase, phenolase, phosphorus, potassium, protein, riboflavin, sodium, thiamin, water, xanthophylls (Taylor, 2013).

Various species of genus Passiflora have been used in folk medicine owing to their sedative and anti-hypertensive properties. *Passiflora edulis* Sims is used for treating both anxiety and nervousness in American countries, osteoarthritis and hypertension (Hoene, 1939).

The constituents of primary interest in passion fruit are flavonoids and alkaloids. Flavonoids are present in many parts of the plant, including leaves and juice, though extracts differ in flavonoid content (Zibadi and Watson, 2004). Flavonoids present in passion fruit include flavone glycosides (luteolin-6-C-chinovoside, luteolin-6-C-fucoside (Mareck et al, 1991), vitexin, isovitexin, orientin, isoorientin (Petry et al., 2001), homoorientin, saponarin and saponaretin (Lutomski et al., 1975) along with flavonols rutin (Lutomski et al., 1975; Moraes et al., 1997) and quercetin (Lutomski et al., 1975) and anthocyanidins. There are three basic
anthocyanidins in *P. edulis*’ fruit: pelargonidin (Kidoy et al., 1997) delphinidin (Harborne, 1967) and cyanidin, known to be the major anthocyanidine components of the passion fruit’s rind (Kidoy et al., 1997). Alkaloids present in *P. edulis*’ juice or leaf and stem are harman alkaloids, a group of β-carbolines, which includes harman (Slaytor and McFarlane, 1968), harmine, harmol and harmaline (Lutomski et al., 1975).

Large quantities of cyanogenic compounds are normally found in *P. edulis* species, particularly in the peel (Chassagne et al., 1996). The major cyanogens of the fruits are prunasin and sambunigrin (Seigler et al., 2002).

Cycloartane triterpenoid was one of the main compounds of *Passiflora edulis* and possess antidepressant-like activity (Wang et al., 2013). A number of animal studies support passion fruit’s anxiolytic effect on the central nervous system (Zibadi and Watson, 2004; Maluf et al., 1991). However, Maluf et al. (1991) evaluated the acute hypnotic effect *P. edulis* lyophilised leaf tea (at the same dose used in folk medicine) in nine healthy volunteers aged 20–35 years and the volunteers did not present significant changes in sleep induction or in quantity or quality of sleep after ingested four capsules of either placebo or *P. edulis*.

Ascorbic acid, total phenolic content (TPC) and total antioxidant activity (TAA) were significantly higher in vine-ripened purple than in yellow *P. edulis*; ranges were 0.22-0.33 g kg⁻¹, 342.80-382.00 mg gallic acid equivalent L⁻¹ and 409.13-586.70 μmol Trolox L⁻¹, respectively, when compared with fruit juices from seven passion fruit cultivars (Ramaiya et al., 2013).

Fruit decoction of *P. edulis*, in a dose dependent manner, inhibited *in vitro* the activity of matrix-metalloprotease-2 and matrix-metalloprotease-9, (Puricelli, et al., 2003) two gelatinases involved in tumour invasion, metastasis and angiogenesis (Garbisa et al., 2001). The inhibitory activity of the decoction was more efficient for matrix-metalloprotease-2.

Chlorogenic acid, rosmarinic acid and quercetin were highly found in ethyl acetate extract, whereas kojic acid and gallic acid were largely determined in the aqueous part. The most potent biologically active fraction was non cytotoxic in *vero* cells at the highest concentration evaluated (50 μg/mL). Passion fruit value and profitability in agribusinesses will be increased by the biochemical
transformation of the seed into active extracts appraisal for natural cosmetic as a multifunction ingredient (Lourith and Kanlayavattanakul, 2013).

Bibliography


**On-line additional resources**

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http://www.bioversityinternational.org
QUINCE


aFaculty of Science and Technology, University of Algarve, UALG, Portugal. bREQUIMTE. Pharmacognosy Laboratory, Faculty of Pharmacy, University of Porto, Portugal.

Scientific name: *Cydonia oblonga* Mill. (Family Rosaceae)

Common name: Quince

Origin

The quince tree is native to a wide area that includes Caucasus, Transcaucasia and Central Asia (Georgia, Armenia, Azerbaijian, Uzbekistan, Turkmenistan, Tajikistan, Iran, Afghanistan and Pakistan). Nowadays, there are still wild quince plants in Dagestan, Azerbaijan, Turkmenia and Iran (Zhukovsky, 1964; Postman, 2012).

During ancient times, quince spread from its centre of origin to the east, to the region of the Himalaya Mountains, and has been cultivated for thousands of years in central Asia and in the Middle East. It was also grown on the islands of ancient Greece. The name "Cydonia" was assigned to the quince probably due to the name of an ancient city-state ("Cydonia" or "KYDONIA") of Crete, where the quince was abundantly grown in the 1st century BC. The Romans cultivated quince on a large scale and studied the plant, having described different cultivars.

Quince is naturalized throughout the Mediterranean, temperate regions of Asia and southern and central regions of Europe. It is currently cultivated in many European countries (up to Scotland and Norway), North and South Africa, North and South America, Australia and Oceania.

It is the sole member of the genus *Cydonia*, but various subspecies and forms have been described (Lobachev and Korovina, 1981).
**Production**

Quince grows usually as a multi-stemmed shrub but can be pruned to form a small tree. The plant size can reach 5 to 7 m in height but in Mediterranean conditions does not exceed 3 m in height. In intensive orchards plants are even smaller.

The world production of quince has been increasing over the past decades and is currently around half a million tonnes. There are significant productions of this fruit in about 50 countries. The top two producers of quince are Turkey and China. Other major producers are Uzbekistan, Morocco, Iran, Argentina, Azerbaijan, Spain and Serbia (FAO, 2011).

Quince is grown in many countries for use as a dwarfing pear and loquat rootstock.

**Varieties**

Although the number of quince cultivars is quite lower than in other fruit crops, such as apple and pear, there is a great diversity of genotypes of quince. Usually we consider two groups of cultivars: apple-shaped and pear-shaped. Some authors consider a larger number of subspecies, botanical varieties and forms, based on fruit shapes: pyriformis or typical (pear-shaped), maliformis (apple-shaped), lusitanica (the so-called Portuguese ribbed, pear-shaped fruit), marmorata (variegated) and pyramidalis (pyramidal fruit) (Bell and Leitão, 2011).

The fruit pulp varies in colour, density, juiciness, flavour, presence of granulation (stony cells) and taste. Most varieties are too hard, astringent and sour to eat raw unless 'bletted' (softened by frost and subsequent decay). Some cultivars have little or no astringency and the fruit can be eaten fresh. Most cultivars are considered self-fertile but cross-pollination seems to increase the productivity of the orchards.

**Nutrition**

Quince fruit is a valuable dietary product. The fruit contains good amount of ascorbic acid (vitamin C), pectins (fibres) and minerals and low in calories, carbohydrates, lipids and proteins (Ronzio, 2003; Kumar *et al.*, 2013).
The fruit has several phenolic compounds that contribute for its antioxidant capacity along with ascorbic and citric acid (Silva et al., 2004), as well as a large number of volatile compounds responsible for its characteristic fragrance (Tateo and Bononi, 2010).

Besides ascorbic acid, quince fruits also have oxalic, citric, ascorbic, malic, quinic, shikimic and fumaric acids (Silva et al., 2002b, 2004b, 2005).

Concerning free amino acids, 21 are described in quince fruits. In peels and pulps, aspartic and glutamic acids, cysteine, serine and hydroxyproline are the most abundant ones (Silva et al., 2004a, 2004b), while seeds are rich in glutamic and aspartic acids and asparagine (Silva et al., 2005).

### Culinary uses

Quince fruits are consumed fresh, cooked, baked and frozen, in various dishes or as a condiment (Caucasus, Central Asia), good for drying, making jam, fruit puree, stewed fruit, jelly, marmalade and candied fruit. They are used to produce syrup, pasteurized juice, wines (mixed with apple) and room aromatization (China), and in medicine (seeds and broth from cooking the fruits).

The fruits have been used for centuries in the preparation of a cheese quince, made by prolonged cooking (several hours) of quince with water and sugar (initially may have been made with honey), called "marmelada" in Portuguese. “Marmelada” derived from the word "marmelo", which means quince. The terms "marmalade", "marmelade" and "marmelad", used in different European languages, with different meanings, derived from the Portuguese word "marmelada".

<table>
<thead>
<tr>
<th>Quince fruit</th>
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<tbody>
<tr>
<td>Energy</td>
<td>48 - 57 Kcal</td>
</tr>
<tr>
<td>Water</td>
<td>72.9 g</td>
</tr>
<tr>
<td>Protein</td>
<td>0.4 - 0.6 g</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>15.3 g</td>
</tr>
<tr>
<td>Fat</td>
<td>0.1 - 0.5 g</td>
</tr>
<tr>
<td>Fiber</td>
<td>1.9 - 3.6 g</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>0 g</td>
</tr>
<tr>
<td>Sodium</td>
<td>4 - 14 mg</td>
</tr>
<tr>
<td>Potassium</td>
<td>144 - 197 mg</td>
</tr>
<tr>
<td>Calcium</td>
<td>11 - 23 mg</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>17 - 24 mg</td>
</tr>
<tr>
<td>Iron</td>
<td>0.7 – 3.0 mg</td>
</tr>
<tr>
<td>Zinc</td>
<td>0.04 mg</td>
</tr>
<tr>
<td>Copper</td>
<td>0.13 mg</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.6 mg</td>
</tr>
<tr>
<td>Folates</td>
<td>3 μg</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.03 – 0.04 mg</td>
</tr>
<tr>
<td>Niacin</td>
<td>0.1 – 0.2 mg</td>
</tr>
<tr>
<td>Pantothenic acid</td>
<td>0.081 mg</td>
</tr>
<tr>
<td>Pyridoxine</td>
<td>0.04 mg</td>
</tr>
<tr>
<td>Thiamin</td>
<td>0.02 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>40 IU</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>15 - 23 mg</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>0.12 – 0.4 mg</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>4.5 μg</td>
</tr>
</tbody>
</table>

*Food values on 100g of dry weight*  
Source: USDA, 2013; Skurikhin and Tutelyan, 2007
Phytochemicals and health

Quince fruits contain several metabolites, including phenolic compounds, terpenes and other volatile compounds and organic acids.

Pulps are rich in caffeoylquinic acids (3-, 4-, and 5-O-cafeoylquinic acids and 3,5-dicaffeoylquinic acid) and quercetin-3-O-galactoside and quercetin-3-O-rutinoside (in low amount) (Silva et al., 2002a, 2004b), the major compound being 3-O-cafeoylquinic acid (45%). In peels, besides these compounds, kaempferol-3-O-glucoside, kaempferol-3-O-rutinoside, one kaempferol glycoside, two quercetin glycosides acylated with p-coumaric acid and two kaempferol glycosides acylated with p-coumaric acid are also present (Silva et al., 2002a, 2004b). Quercetin-3-O-rutinoside is the major compound in quince peels. Other phenolic compounds were also detected in the whole fruit by Wojdylo et al. (2013), including procyanidins dimers, trimmers and tetramers, (-)-epicatechin and quercetin-3-O-robinoside.

Seeds contain the same hydroxycinnamic acids plus lucenin-2, vicenin-2, stellarin-2, isoschaftoside, schaftoside 6-C-pentosyl-8-C-glucosyl chrysoeriol and 6-C-glucosyl-8-C-pentosyl chrysoeriol. 5-O-Caffeoylquinic acid and isoschaftoside are the most abundant hydroxycinnamic acid and C-glucosyl flavone, respectively (Silva et al., 2005).

The total phenolic content is in the range of 0.2-1.7 g/kg, 0.011-0.3 g/Kg and 0.1 g/Kg for peels, pulps and seeds, respectively (Silva et al., 2002a, 2005).

More than 160 volatile compounds have also been identified in quince fruit (whole fruit and peels), comprising hydrocarbons, esters, alcohols, aldehydes, ketones, lactones, monoterpenes, C_{13} norisoprenoids, among others (Schreyen et al., 1979; Umano et al., 1986; Winterhalter and Schreier, 1988; Winterhalter et al., 1990; Guldner and Winterhalter, 1991; Tateo and Bononi, 2010). According to Tateo and Bononi (2010), the whole fruit contains high amounts of α-farnesene, while Schreyen et al. (1979) and Umano et al. (1986) reported ethyl 2-methyl-2-propenoate and ethyl propionate as the major compounds, respectively.

The content of organic acids is 6.9-14.2 g/kg for pulps, 7.8-14.0 g/kg for peels and 0.5-0.8 g/kg for seeds (Silva et al., 2002b, 2004b, 2005). Pulps and peels contain oxalic, citric, ascorbic, malic, quinic, shikimic and fumaric acids, the sum of malic plus quinic acids representing more than 90% (Silva et al., 2002b,
Seeds does not contain oxalic acid and the content of malic acid plus quinic acid is lower (45-61%) (Silva et al., 2005).

Quince fruit has several medicinal usages, such as carminative, expectorant, anticancer (Duke et al., 2002), antibacterial (Fattouch et al., 2007), antidiabetic (Tahraoui et al., 2007) and laxative (Agelet et al., 2003), being also used for the treatment of skin lesions (Hemmati et al., 2012), migraine, cold, influenza (Hilgert et al., 2001), inflammatory bowel disease (Rahimi et al., 2010) and conjunctivitis (Siddiqui et al., 2002), among other disorders.

These bioactivities have been mainly ascribed to the high content of phenolic compounds. For instance, Fattouch et al. (2007) tested the antimicrobial activity of quince polyphenolic extracts and reported that peel was more active than pulp due to the highest amount of phenolics. Hamauzu et al. (2005) also observed a moderate anti-influenza activity of quince fruit extract due to the presence of polymeric procyanidins.

Concerning the antioxidant activity, the activity displayed by several extracts is correlated with the amount of caffeoylquinic acids and total phenolic content or with the content of ascorbic and citric acid (Silva et al., 2004; Magalhães et al., 2009). However, an extract rich in phytosterols, triterpenoic acids, glycerides of oleic and linoleic acids, n-aldehydes, n-alcohols and free n-alkanoic acids was more efficient at preventing the formation of thiobarbituric reactive species (Pacifico et al., 2012).

Moreover, the anti-allergic activity of phenolic rich extracts from quince fruit was demonstrated by their effect against IgE-mediated degranulation in basophilic cell line (RBL-2H3) and against the elevation of prostaglandins, leukotrienes, interleukins and tumor necrosis factor-α expression levels in different mast and basophilic cell lines (Shinomiya et al., 2009; Huber et al., 2012; Kawahara and Iizuka, 2012).

Phenolic rich extracts of quince seeds also displayed strong antiproliferative efficiency against cancer cell lines (Carvalho, 2010; Pacifico et al., 2012).

**Bibliography**


On-line additional resources
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SWEET GRANADILLA

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1VIDARIUM, Grupo Nutresa
2Corporación Universitaria Lasallista (UL)
3Colombian agricultural research corporation (CORPOICA)

Scientific name: Passiflora ligularis Juss.
(Family Passifloraceae)

Synonyms: Passiflora bigulavis

Common names:
- English: sweet granadilla, water lemon, yellow passion fruit, sweet passion fruit, sugar fruit
- French: grenadelle, grenadille de montagne, grenadille douce, granadilla
- German: süßes Grenadille, zigengeschmackige Passionsblume
- Portuguese: maracujá, maracujá-urucú, granadillo andino
- Spanish: granadilla, granadilla de china, granadita, parcha dulce, parcha importada, parchita amarilla, cranix, granada China, granadilla

Origin
Sweet granadilla is native to the Andes Mountains in Southern Mexico: Mexico - Chiapas, Colima, Michoacán, Oaxaca, Puebla, Veracruz; Mesoamerica: Costa Rica; El Salvador; Guatemala; Honduras; Panama; Nicaragua; Northern South America: Venezuela; and Western South America: Bolivia; Colombia; Ecuador; Peru; Costa Rica. Throughout this region, it is popular and abundant in the markets. It has been grown in Hawaii since late in the 19th Century. In 1916, the United States Department of Agriculture received seeds from Quito, Ecuador. The vine is not suited to California, has been grown in greenhouses in Florida but has never survived for long. Northern gardeners sometimes plant it as a summer
ornamental. It is grown to some extent in Papua New Guinea. Trial plantings in Israel were killed by cold weather. It is cultivated and naturalized in Jamaica and, in recent years, has been blooming and fruiting prolifically in mountainous Haiti (Morton J. 1987). It also occurs in Kenya, Ivory Coast, South Africa and Australia (Miranda, 2009).

Production

Sweet granadilla fruit is now cultivated commercially all over the world and is manly sold as fresh fruit. Colombia is one of the most important producers of fruit worldwide, along with Venezuela, South Africa, Kenya and Australia (Miranda, 2009). Sweet passion fruit exports from Colombia have increased, because the increased consumption in countries such as Netherlands, Germany and Venezuela. The main destinations are the Netherlands with 18.5%, Germany 12% and 11% Ecuador, followed by Venezuela, France, UK, Canada and Portugal (Garcia, 2008).

Sweet granadilla is naturally adapted to high rainforests. In its natural range, it is wild and cultivated at elevations of 900-2700 m. In Hawaii, it finds sufficiently cool temperatures at 900 m. In Jamaica, the vine volunteers freely at altitudes between 1000-1200 m. At 1500-2500 m in Colombia, the vine fruits well. At higher altitudes, it flourishes and blooms but will not fruit. An elevation of 1828 m, where the clouds descend on peaks in the afternoon, has proven ideal in Haiti. Reported temperature range for growth is 16-31°C with the optimum between 22-26°C whereas Fischer et al (2009) mention optimum temperature range for commercial growth in Colombia between 16 and 18°C. The vine is intolerant of heat. It will do well over the winter in Florida but declines with the onset of hot weather. Reported annual rainfall range for growth is 650-1800 mm with the optimum between 1000-1200 mm. It thrives in humid conditions, but needs full sunlight. It has a short day response. It is not particular as to soil type and thin, volcanic soils do not discourage it, providing they are moist. Reported soil pH range for growth is 5.1-7.5 with the optimum between 6 and 7. It can grow on infertile soils but will not withstand salinity. At about 18 months after planting the crop should have reached its full bearing potential.
Varieties

Because the cross-pollinated, there is a wide genetic variability in the genotypes evaluated (Miranda, 2009). There are no commercial varieties of sweet granadilla fruit, but they can be distinguished according to the size, shape and bark (García, 2008).

Nutrition

Sweet granadilla fruit is valued for its organoleptic characteristics of taste and color and nutritional properties. It has 40–55% of edible part, 72–80% moisture content, and 7.0–8.0 °Brix (Vasco et al., 2008). It is known for its low fat content and high contribution in fiber, vitamins A, C, K, P and niacin. Also contains phosphorus, iron and calcium (FAO, 2006).

According the Operational Plan of the Ministry of Trade and Tourism of Peru (2006), sweet granadilla fruit has a lot of carbohydrates; thence its caloric value is very high. It supplies potassium, phosphorus and magnesium necessary for nerve impulses, muscle activity, bone formation, energy metabolism, and bowel functioning nerves.

Valente et al. (2011), reported $3.02 \pm 0.056 \text{ mg/100 g}$ edible portion of ascorbic acid in sweet granadilla obtains from Brazil, meaning 3.4% and 4.0% for diary ingest in man and woman, respectively. However, Vasco et al. (2008) reported 16–25 mg/100 g.

Leterme et al. (2006) analyzed the macro-mineral content of the Colombian sweet granadilla and find 26.3 DM (%), 1239 Ash, 37 Ca, 50 P, 379 K, 27 Mg, <0.1 Na, 44 Cl and 16 S (mg/100 g edible portion); and the micro-mineral content was 0.18 Mn, 0.42 Zn, 0.66 Fe, 0.13 Cu, nd Se, nd Co, 0.03 Ni, 0.03 Cr (mg/100 g edible portion). The daily requirements of an adult man are as follows (mg/d): 800–1200 Ca, 700–800 P, 300–400 Mg, 500 Na, 10–15 Fe, 12–15 Zn, 2–3 Cu (Wildman & Medeiros, 2000). Sweet granadilla has a thick skin and a large

<table>
<thead>
<tr>
<th>Sweet granadilla</th>
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</thead>
<tbody>
<tr>
<td><strong>Energy</strong></td>
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<tr>
<td><strong>Water</strong></td>
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<td><strong>Protein</strong></td>
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<td><strong>Carbohydrates</strong></td>
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<td><strong>Fat</strong></td>
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<td><strong>Cholesterol</strong></td>
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<td><strong>Fiber</strong></td>
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<td><strong>Calcium</strong></td>
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<td><strong>Iron</strong></td>
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<td><strong>Magnesium</strong></td>
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<td><strong>Potassium</strong></td>
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<td><strong>Sodium</strong></td>
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<tr>
<td><strong>Zinc</strong></td>
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<tr>
<td><strong>Vitamin C</strong></td>
</tr>
<tr>
<td><strong>Niacin</strong></td>
</tr>
<tr>
<td><strong>Vitamin A</strong></td>
</tr>
</tbody>
</table>

*Food values on 100g of fresh weight*

Source: USDA, 2013
number of seeds. The mesocarp of their fruit has a good mineral content but it represents a very thin part of the whole fruit (Leterme et al., 2006).

**Culinary use**

Sweet granadilla fruit has a sweet taste, which is derived from sugars and shows low juice yield by what has been used especially for fresh consumption, being an important factor for the acceptance consumers the pleasant fruit aroma. The passion fruit is used as raw material in the production of jams, jellies, concentrated, juice, nectars, and syrups. The seed and skin have high fiber content, and the seed is rich in protein and fat, so it could be used in animal feed (FAO, 2006; Bristles, 2003; Cabrera, 2006).

**Phytochemicals and health**

Sweet granadilla fruit was use in Pre-Inca and folk medicine as hypoallergenic laxative, which is one of the best known properties (Malca, 2001).

Water is the main component of the sweet granadilla fruit, the abundance of water and low sodium concentration make this fruit a diuretic food. For its appreciable content of carbohydrates, mainly fructose, glucose and sucrose, is a major source of energy (diabetics should moderate their consumption). Regarding its antioxidant, several studies show preventive effect on many diseases (López, et al., 2006).

Flavonoids, glycosides, alkaloids, phenolic compounds and volatile constituents have been reported as the major phyto-constituents of the *Passiflora* species (Dhawan et al., 2004). Health promoting properties are attributed to the phytochemicals (e.g., phenolic antioxidants, vitamins, minerals, fiber among others) present in these natural sources (Konczak et al., 2010; Krishnaiah et al., 2011).

Chirinos et al. (2013) reported for Peruvian sweet granadilla total phenolic compounds 6.4 ± 0.1 mg GAE/g DW, total flavonoids 0.22 ± 0.00 mg CE/g DW, total flavonoids 0.05 ± 0.00 mg QE/g DW, other phenolic compounds 6.11 ± 0.14 mg/g DW and antioxidant activity in DPPH 43.1 ± 0.7 μmol TE/g, DW, in ABTS 83.1 ± 1.1 μmol TE/g, DW and in ORAC 50.3 ± 4.2 μmol TE/g, DW. The authors observed high correlations between total phenolic content and antioxidant activity.
Seventeen fruits from Ecuador were analyzed for total soluble phenolic compounds content (Folin–Ciocalteu method) and for antioxidant capacity, using three different methods (DPPH, FRAP and ABTS). Sweet granadilla fruit showed 16–25 mg/100 g FW of ascorbic acid; 91 ± 43 mg GAE/100 g sample FW of total soluble phenolic compound content; and 0.5 ± 0.2 μmol Trolox/g sample FW of antioxidant capacity DPPH. Sweet granadilla showed “low” phenolic content < 100 mg GAE/100 g FW compared to Andean blackberry (2167 mg GAE/100 g FW), capulí cherry peel (1494 mg GAE/100 g FW) and banana passion fruit (1010 mg GAE/100 g FW); and low antiradical efficiency typical of fruits with low total soluble phenolic content. This might be due to bound of the phenolic compounds in these fruits to other molecules, such as carbohydrates, which considerably reduce the activity, or are weak antioxidants per se (Vasco et al., 2008).

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SOURSOP

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\textsuperscript{b} Medical Research Unit in Neurological Diseases, National Medical Center XXI Century, Mexico City
\textsuperscript{c} Directorate of Research in Neurosciences of the National Institute of Psychiatry ‘Ramón de la Fuente Muñiz’, IMSS, Mexico City

\textsuperscript{c} Eastern Biomedical Research Center, CIBIOR, Puebla

Scientific name: \textit{Annona muricata} L. (Family \textit{Anonaceae}). Synonyms: \textit{A. bonplandiana} Kunth; \textit{A. cearensis} Barb. Rodr., \textit{A. macrocarpa} Werckle; \textit{A. muricata} var. \textit{borinquensis} Morales; \textit{Guanabanus muricatus} Gómez

Common names: Graviola, soursop, Brazilian paw paw, Guanábanas (Spanish), mamon (Spanish, Philippines), durian belanda (Malaysian), graviola (Portuguese), mullanchakka, vilathinura (Malayalan), corossolier (French), zuurzak (German), munolla (India).

Origin

The name \textit{annona} derives from the Latin “annual harvest” (Lizana and Reginato, 1990). Soursop most likely originated in Central America (Ochse \textit{et al.}, 1974), the Antilles or Northern South America and is found in the Andean valleys in Peru, presumably as an ancient introduction. Spanish colonizers distributed it to other tropical regions of the world (Popenoe, 1939; Purseglove, 1968). The existence of several wild types of soursop in the Amazon region suggests that this may be a primary centre of diversity, but the types could be remnants from cultivated introductions (Pinto \textit{et al.}, 2005). Wild populations of soursop are well known in the West Indies and on Barro Colorado Island, Panama (Smith \textit{et al.}, 1992). In south-eastern Brazil, cultivated soursop was introduced during the sixteenth century. Nowadays it is found in almost all Brazilian states, except in the southernmost states, where low temperatures and occasional snowfall do not allow the tree to grow and produce (Pinto and Silva, 1996). Soursop is now a popular fruit in Cuba, Mexico, and Central America and throughout South America.
It is also found in Sri Lanka up to elevations of 460 m, in China and many parts of Polynesia. In the USA it is grown in southern Florida.

**Production**

Soursop is cultivated in many tropical areas in countries such as Angola, Brazil, Colombia, Costa Rica, Cuba, Jamaica, India, Mexico, Panama, Peru, USA (Puerto Rico), Venezuela and Asia (Pinto and Silva, 1996). There is a dearth of production data for most of the South, Central and North American countries, except Mexico, Venezuela and Brazil, which seem to be the major producing countries of this species.

Mexico is the most important soursop producing country in the Americas and in 1990 had an area of 598 ha, with production of 4,087 MT. The cultivated area in Mexico was estimated at 4,890 ha in 1996, which means that in six years the cultivated area had increased nine fold (Rebollar-Alviter *et al.*, 1997). Hernández and Angel (1997) stated that the Mexican area planted to soursop in the same year was equivalent to 5,915 ha with a production of 34,900 MT, easily the largest in the world. Nayarit, with approximately 380 ha, has been the most important province for soursop production in Mexico (Pinto *et al.*, 2005). Venezuela had a cultivated area of 3,496 ha in 1987, with a total production of 10,096 MT with Zulia as the most important producing state (Diego, 1989). Brazil with approximately 2,000 ha, has an estimated production of 8,000 MT of fruits per year (average of 4 MT/ha), almost totally devoted to the internal market. Ceará state, in the Northeast, with an estimated area greater than 500 ha (Bandeira and Sobrinho, 1997), is the most important producer of soursop in Brazil, largely because many juice industries operate in that region (Pinto *et al.*, 2005). Although Venezuela and Brazil have larger production areas than Peru, this country has a larger yield/ha; the cultivated
area of soursop in Peru was estimated at 443 ha in 1998, with a total production of 3,262 MT and a yield of 7.4 MT/ha (Pinto et al., 2005).

Nutrition

Annona pulps are useful foods because they contain proteins, fatty acids, fibre, carbohydrates, minerals and vitamins (Bueso, 1980; Leal, 190; Lizana and Reginato, 1990). However, annona fruits do not contribute many calories to the diet (kalil et al., 1979). Soursop pulp is considered to be aromatic and exotic, and is consumed mostly after processing into cold beverages or sometimes fresh. The edible portion constitutes 67.5% of total fruit weight (Bueso, 1980; Lizana and Reginato, 1990). The characteristic flavor of this fruit is produced by amyl and geranyl caproic acids (Bueso, 1980; Pinto and Silva, 1994). The processed pulp is used to prepare juices and ice creams (Pinto and Silva, 1994). In Cuba, the pulp is processed to prepare an alcoholic drink called champola (Popenoe, 1974). The most important sugars are fructose (1.8%), glucose (2.3%) and sucrose (6.6%). The most common acid in its pulp is citric, with some malic and, less commonly, isocitric acid. Soursop fruit contains vitamins A and B₅. Also, it is the only annona with tannins in its pulp (Castro et al., 1984).

Culinary uses

Soursop fruits are occasionally consumed fresh or more commonly made into juices, ice creams (Pinto and Silva, 1994) or sherbets (Popenoe, 1974). Most people consider it to be too acid for eating fresh, but it is esteemed for making refreshing drinks (Mowry et al., 1941), nectars, ice creams and similar foods. Nectar (sweetened pulp) can be prepared and used after dilution with 3 parts of

<table>
<thead>
<tr>
<th>Soursop</th>
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<tbody>
<tr>
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<td>64 - 71 kcal</td>
</tr>
<tr>
<td>Water</td>
<td>77.9 - 81.7 g</td>
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<tr>
<td>Protein</td>
<td>0.69 - 1.7 g</td>
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<tr>
<td>Carbohydrates</td>
<td>16.3 - 18.2 g</td>
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<tr>
<td>Fat</td>
<td>0.3 - 0.8 g</td>
</tr>
<tr>
<td>Ash</td>
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</tr>
<tr>
<td>Fiber</td>
<td>0.78 - 0.95 g</td>
</tr>
<tr>
<td>Calcium</td>
<td>8.8 - 22 mg</td>
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<tr>
<td>Iron</td>
<td>0.6 - 0.8 mg</td>
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<tr>
<td>Phosphorus</td>
<td>27.1 - 29 mg</td>
</tr>
<tr>
<td>Sodium</td>
<td>23 mg</td>
</tr>
<tr>
<td>Postassium</td>
<td>45.8 mg</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>8.9 - 20 mg</td>
</tr>
<tr>
<td>Vitamin B₁</td>
<td>348 mg</td>
</tr>
<tr>
<td>Vitamin B₁₂</td>
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</tr>
<tr>
<td>Vitamin B₅</td>
<td>0.9 - 1.5 mg</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>16.4 - 22 mg</td>
</tr>
<tr>
<td>Tannins</td>
<td>85.3 mg</td>
</tr>
</tbody>
</table>

*Food values on 100g of fresh weight*  
Source: USDA, 2013
water. In Java, Indonesia, fruits of soursop are added to soup (sajoer). Soursop pulp or nectar can be frozen, processed and used industrially (Beneto et al., 1971). It is perhaps the best annona for industrial processing and commercialization because of its exotic taste and agreeable aroma (Pinto et al., 2005). The processed pulp can be preserved by pasteurization or freezing (Zayas, 1966). Another industrial application involves the extraction of essential oils present in soursop pulp. These oils, such as esters of aliphatic acids, have potential to improve the flavor of processed fruit products (Jirovetz et al., 1998).

Phytochemical and health

Leaves, roots, bark, fruits and seeds of annonas contain numerous bioactive chemical substances, such as acetogenins, alkaloids, terpenes, flavonoids and oils. Alkaloids, terpenes and flavonoids are potentially useful in medicine (Pinto et al., 2005). Soursop: roots, stems and leaves of soursop have different kinds of acetogenins. Some of them have antitumoral activities and act preferentially against human cancer cell lines (Wu et al., 1995; Zeng et al., 1996; Kim et al., 1998); acetogenins with citotoxic effects are panatellin, uvariamicin I, uvariamicin IV, reticulatacin, reticulatacin 10-one and solamin (Gleye et al., 1998). Acetogenins found in soursop leaves and stems are used to prepare extracts that have insecticidal activities. These compounds are similar to anonins and muricins (Pinto and Silva, 1994).

Additionally, biogenetic intermediaries of acetogenins are found (Gleye et al., 1997). In soursop seeds, there are amyloids (Kooiman, 1967), acetogenins (Myint et al., 1991; Pinto and Silva, 1994; Yu et al., 1998), and unsaturated and saturated fatty acids (Castro et al., 1984; Pinto and Silva, 1994). The main types of unsaturated fatty acids found in soursop seeds are oleic (41%), linoleic (33%) and palmitoleic (2%) acids, together making up 76% of total fats. The saturated fatty acids are palmitic (19%) and stearic (5%), together making up 24% (Castro et al., 1984; Pinto and Silva, 1994; 2005). The bark contains alkaloids. The leaves have essential oils with parasiticide, anti-diarrhoea, rheumatological and antineuralgic properties (Moura, 1988). Boiled water infusions of leaves have anti-spasmodic, astringent, gastric properties (Calzavara et al., 1987; Khan et al., 1997), and are used in kidney ailments (Duke, 1970). The cooked flowers and petals are used for healing eye inflammation; the treatment requires 2-3 washes a day (Calzavara et
Immature soursop fruits have medicinal properties against dysentery, diuretic, anti-thermical processes, skin diseases, rashes, fever, malaria, peptic ulcers, colic and oedema (Khan et al., 1987). The fruit also has properties on the biliary vesicle (Calzavara et al., 1987). The seeds have antispasmodic and anti-parasitic properties (Bories et al., 1991; Philipv et al., 1994). The wild soursop roots are used to treat cancer, convulsions, venereal disease, diarrhea, dysentery, fever, male impotency, and have anti-neoplastic and anti-protozoal activities (Fatope et al., 1996). The leaves are used for diseases of the eye, stomach and intestines (Philipv et al., 1995; You et al., 1995). Alcoholic leaf extracts have antispasmodic and relaxant activity on the smooth muscles; anti-ulcer activity against indomethacin induced ulcers and reduces the effect of stress on ulcer induction. These effects are produced by various compounds, including flavonoids, alkaloids, tannins and saponins (langason et al., 1994). The steam bark contains 4-entkaurenoids that have cytotoxic activity against tumour cell lines (Fatope et al., 1996). Other uses are as anticonvulsant in children and in the treatment of pain (You et al., 1995; Fatope et al., 1996; N’Gouemo et al., 1997; Pinto et al., 2005). Soursop fruit possesses anti-depressive effects, possibly induced by isoquinoline compounds acting on serotonin receptors (Hasrat et al., 1997).

Bibliography


TAMARIND

Scientific name: *Tamarindus indica* L.  
Belongs to the Dicotyledonous. Family leguminosae. Sub-Family Caesalpiniaceae  

Common names: Tamarindo (México, Brazil), Tetuli (India), Chincha (Ayurveda), Asam jawa (Indonesian)

Origin  
Originally from the dry savannas of tropical Africa; cultivated in America, in Asia and other tropical countries where it has often grown wild. It has been cultivated and often naturalized throughout the Antilles and from Mexico to Brazil. It has been planted in southern Florida, the Keys, Bermuda, Cuba and Puerto Rico. Introduced to the New World between 1700 and 1800, it was probably taken with the first shipments of slaves from West Africa. In Mexico, it is found growing wild along the Pacific coast, mainly in the states of Jalisco, Colima and Guerrero. It is widely cultivated in most tropical regions.

Production  
The major production areas are in the Asian countries of India and Thailand, but also in Bangladesh, Sri Lanka, Thailand and Indonesia. In America, Mexico and Costa Rica are the biggest producers. Africa on the whole does not produce tamarind on a commercial scale, though it is widely used by the local
people. Minor producing countries in Africa are Senegal, Gambia, Kenya, Tanzania and Zambia (El-Siddig et al., 2006). India is the country which most extensively exploits tamarind. It has commercial plantations that generate about 250,000 tons per year. In Tamil, Nadu, 9,521 hectares are cultivated. Fruit pulp produced is 29,880 tons annually. The Tamarinde has gained great importance under the cover of the Social Forestry Program in Dharmapuri, Tirunelveli and other districts, where they have established large-scale crops. Other countries with large commercial plantations are: Belize, Brazil, and Guatemala is also used in the agro forestry system. Contrary to pharmaceuticals, it is often freely and readily available. Almost all parts of the tree find some use or the other in food, chemical, pharmaceutical, and textile industries, and as fodder, timber, and fuel

Nutrition

Tamarind pulp constitutes 40% of the sheath and is a source of vitamins C and B. 100 g of ripe fruit contains 115 calories, 3 g of protein and 18 g of carbohydrates. Acidity is due to the presence of tartaric acid, acetic acid and ascorbic acid, whose concentration is 10 to 15%, in addition to containing acetic, citric, malic and succinic acids, as well as sugar and pectin (Amubode & Fetuga, 1983).
Additionally, the pulp is a rich source of vitamins, having a high content of vitamin B (thiamine, riboflavin and niacin) as well as small amounts of carotene and vitamin C, and important minerals. The amounts of Mg (25.6 – 30.2 mg) and Na (23.8 – 28.9 mg) were found to be highest, while the lowest amounts were recorded for Ca (0.8 – 1.2 mg) and Zn (0.8 – 0.9 mg) (El-Siddi et al., 2006). It contains more calcium than other fruits; young leaves, immature pods and flowers are served as a vegetable in salads without the need for vinegar because it is acidic.

The seeds are used as food, toasting, soaking and boiling them to remove the shell. Their content provides starch, protein and oil; its chemical composition is: water 11.3%, protein 13.3%, fat 5.4%, 57.1% carbohydrate, 4.1% ash, and crude fiber 8.8%. Seed protein is rich in acidic glutamic acid (18%), aspartic acid (11.6%), glycine (9.1%) and leucine (8.2%) but deficient in methionine, threonine, valine and cysteine, so it is considered a low quality protein source. Tamarind seed is also the raw material used in the manufacture of polysaccharide (jellose), adhesive and tannin. In 1942, two Indian scientists announced that decorticated kernels contained 46-48% of a gel-forming substance. This polysaccharide (pectin) with carbohydrate character and gel-forming properties, named ‘jellose’ (Rao,1948 and 1956 (cited in El-Siddig et al., 2006)), has been recommended for use as a stabilizer in ice cream, mayonnaise and cheese, and as an ingredient or agent in a number of pharmaceutical products (Morton, 1987; El-Siddig et al., 2006).

### Culinary uses

Tamarind is a versatile, nutritious fruit with a great variety of uses. Tamarind fruit pulp is used for seasoning, as a food component, to flavor confections, curries and sauces, and is a main component in juices and certain beverages. Tamarind fruit pulp is eaten fresh and often made into a juice, infusion or brine (El-Siddig et al., 2006).
al., 1999; El-Siddig et al., 2006), and can also be processed into jam and sweets (Figure 1). The refreshing drinks are popular in many countries around the world, though there are many different recipes. In some African countries, the juice obtained from the fruit pulp is mixed with wood ash to neutralize the sour taste of the tartaric acid. However, the most common method is to add sugar to make a pleasantly acidic drink. In Ghana, the pulp is mixed with sugar and honey to make a sweet drink. In Mexico the pulp is also mixed with sugar and sweet chili for commercial use. In fact, most of the producing countries manufacture drinks commercially. Sometimes pulp is fermented into an alcoholic beverage (FAO 1988, cited in El-Siddig et al., 2006). Tamarind leaves and flowers can be eaten as vegetables and are prepared in a variety of dishes (ICRAF, 2007). They are used to make curries, salads, stews and soups in many countries, especially in times of scarcity (Benthall 1933, cited in El-Siddig et al., 2006). Before consumption, leaves are sometimes boiled in water and prepared as tamarind fruits (Nordeide et al., 1996).

**Phytochemical and Health**

Medicinal uses of tamarind can be found in many cultures and for a wide array of applications. The medicinal value of tamarind has already been mentioned in traditional Sanskrit literature (El-Siddig et al., 2006). Reports of phytochemical investigation of *T. indica* have previously demonstrated the presence of phenolic compounds such as catechin, procyanidin B2, epicatechin. Other constituents like tartaric acid, mucilage, pectin, arabinose, xylose, galactose, glucose, uronic acid and triterpenes have also been identified in *T. indica*, most of them with medicinal properties, so an attempt has been made through the membrane stabilizing property of leaves extract to investigate the ability of *T. Indica* in the treatment of inflammatory disorders and its antinociceptive action (Santosh et al., 2012), the authors showed that the administration of leaves extract inhibited the edema starting from the first phase to second phase of inflammation, indicated that the anti-edematic effects of leaves extract were due to the inhibition of neutrophils and TNF-α synthesis. Moreover, the anti-inflammatory action of leaves extract may be related to the inhibition of prostaglandins and nitric oxide synthesis which is similar to the anti-inflammatory mechanism of diclofenac in carrageenan-induced inflammation (Santosh et al., 2012). *Tamarindus indica* also has been shown to
have anti-inflammatory activity, as a serine proteinase inhibitor, and high activity against human neutrophil elastase (HNE) was detected, isolated and purified from tamarind seeds (Fook et al., 2005). Proteinase inhibitors are widely distributed among bacteria, animals and plants. They are present in reproductive and storage organs, and the vegetative tissues of most plant families (Fook et al., 2005). They have regulatory and defensive roles, and act as storage proteins (Xavier-Filho (1993) cited in Fook et al., 2005). Among the various groups of proteinase inhibitors, serine proteinase inhibitors are the best studied and have been isolated from various leguminous seeds (Oliveira et al. (2002), Macedo et al. (2002), Mello et al. (2002) and Oliva et al. (2000) all cited in Fook et al., 2005).

Tamarind fruits are reported to have anti-fungal and anti-bacterial (Revised by El-Siddig et al., 2006). According to Al-Fatimi and collaborators (2007), in an agar diffusion assay, extracts from T. indica flowers showed antibacterial activity against four bacteria tested (Staphylococcus aureus, Bacillus subtilis, Escherichia coli and Pseudomonas aeruginosa). Antimicrobial activity of T. indica study has been attributed to lupeol by the stem bark and leaf extracts against both gram positive and gram negative bacteria, which may be indicative of the presence of broad spectrum antibiotic compounds. This gives a potential source of new classes of antibiotics that could be useful for infectious disease chemotherapy and control. The fruit of T. indica is used traditionally as a laxative, due to the presence of high amounts of malic and tartaric acids and potassium acid. The methanolic extract of leaves and bark (cooked) of T. indica Linn, exhibited significant antihistaminic, adaptogenic, and mast cell stabilizing activity in laboratory animals (Tayade et al., 2009), amenorrhea. Leaf and seed (cooked): worming and stomach ailments. Root (cooked): liver disease (bilious disorders), jaundice and bleeding. Seed (cooked) urine disorders. The pods are used as astringent and appetizer. An aqueous extract from T. indica seeds had a potent antidiabetogenic activity in Streptozotocin-induced diabetic male rats. The aqueous extract of T. indica seeds was given to mild diabetic and severe diabetic rats, and hyperglycemia was significantly reduced, measured by fasting blood glucose levels (Maiti et al., 2004), similarly, hyperlipidemia was found to be reduced, measured by different contents of cholesterol. This rat model may shed some light on the basis of ancient herbal therapy in India. In Mauritania, the tamarind pulp mixed with salt is used as a liniment for rheumatism. The bark of the tamarind tree is regarded as an effective
astringent, tonic and febrifuge (Morton, 1987; El-Siddig et al., 2006). It is used as a tonic and in lotions or poultices to relieve sores, ulcers, boils and rashes (El-Siddig et al., 2006). Fried with salt and pulverized to an ash, it is given as a remedy for indigestion and colic. A decoction is used in cases of gingivitis, asthma and eye inflammations. Lotions and poultices made from the bark are applied on open sores and caterpillar rashes (Morton, 1987). The bark of the tree should be peeled off if needed for medicinal purposes, during the time when the tree is not flowering or when the flowering season ends (El-Siddig et al., 2006). *T. indica* bark is used in the treatment of pain traditionally, and the present work was undertaken to prove this scientifically by using suitable animal screening models, such as hot plate test and acetic acid induced writing test at the dose of 50 mg/kg, i.p. Petroleum ether extract showed significant increase in reaction time as compared with other extracts. Preliminary phytochemicals test showed presence of sterols and triterpenes in the extract; hence these compounds might be responsible for analgesic activity (Dighe et al., 2009).

All parts of Tamarind tree have been used in traditional medicines to treat diseases as well as symptoms. Considering the overall benefits of the plant, it can be advocated as a safe, highly important, be used as a source of phytomedicines

**Bibliography**


**TREE TOMATO**

_Susana Espín Mayorga and Beatriz Brito Grandes_

_Quality and Nutrition Department, National Agricultural and Research Institute INIAP_  
_Quito, Ecuador_

**Scientific name:** _Solanum betaceum_  
_Cav. (Family Solanaceae)_

**Common name:** Its common name depends on the country: tree tomato (Ecuador, Colombia, United Kingdom); french tomato (Portugal); straiktomaad, terong blanda (Netherlands); tomate de arbre (France); tomatobaum (Germany); chili tomato (Spain); tamarillo (New Zealand and USA).

**Origin**

This fruit is native to the subtropical Andes and has been cultivated on mountainsides since long before Europeans arrived. The area of its origin is at present unknown, it is probably native to southern Bolivia (National Reserve Tucumano Boliviana, Department of Tarija) where it is found in wild status and northwestern Argentina (Provinces of Jujuy and Tucumán). Due to its genetic diversity northern Perú and southern Ecuador are considered the center of this plant domestication. As a native fruit it is found in Bolivia, Argentina, Venezuela, Ecuador, Perú and Colombia.

**Production**

This crop is commercially produced mainly in Colombia, Ecuador, Perú and in New Zealand where it was introduced and has been popular for more than 60 years. Countries where production is minor are U.S.A., México, countries of Central America and Africa. In Ecuador it is grown in subtropical Andean areas.
between 1500 and 2600 meters above sea level (m.a.s.l.) with average temperatures between 16 and 22 °C (Feicán et al., 1999; Santillán, 2001).

The rather acid taste arriving in international markets is hindering greater acceptance as a fruit to be eaten raw, sweeter fruit from selected cultivars will increase its popularity (National Academy of Sciences U.S.A., 1989).

Varieties

The tree tomato is related to a group of species that were included in the genus *Cyphomandra*. However, on the basis of morphological and molecular evidence, the species in genus *Cyphomandra* were transferred to the genus *Solanum*, nowadays used by the scientific community to refer to the tree tomato and wild relatives. Some wild species produce edible fruits which are harvested on occasion from the wild. Some other wild species are used for medicines and dyes, this indicates that some plants have a great potential for several purposes and should be explored (Acosta et al., 2013; Bohs, 1989).

Since genotype is specific for each individual, several denominations such as segregants, backcrossings and cultivars may be grouped within this term (Pierce, 2009). In New Zealand, where the most extensive selection has taken place, two strains are cultivated: red and yellow. Although there is much variety in the fruits and many local preferences are based on color, there are apparently at present few cultivars. Oratia Red was the first recognized cultivar. Growers normally select their own trees for seed selection.

In Ecuador tree tomato cultivars are not preserved pure due to crosslinking among materials that are grown in farmer orchards, presenting a great genetic variability and giving as result fruits with a wide range of tones, between yellow and purple (León et al., 2004; Revelo et al., 2004). Within genotypes grown in Ecuador the most representatives and that are found in producer farms are cultivars of End Pointed yellow, Round orange, Giant orange, Ecuadorian mora, Giant purple and New Zealand purple; the Giant orange being of major production since it is the most accepted in Ecuadorian market (León et al., 2004; Torres, 2006). The red-fleshed fruit is the most commercialized variety in Colombia (Osorio et al., 2012)
Nutrition

Tree tomatoes are excellent sources of provitamin A (carotene-150 International Units per 100g), vitamin B6, vitamin C (25 mg per 100g), vitamin E, and iron. They are low in carbohydrates; an average fruit contains less than 40 calories. Small, hard, irregular stones containing large amounts of sodium and calcium occasionally appear in the outmost layers of the fruit and do not present much of a problem in fresh fruits because those layers are not eaten (National Academy of Sciences U.S.A., 1989).

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Giant orange</th>
<th>Giant purple</th>
<th>Ecuadorian purple</th>
<th>End pointed yellow</th>
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<tbody>
<tr>
<td>Water</td>
<td>87.1 g</td>
<td>89.2 g</td>
<td>89.2 g</td>
<td>88.2 g</td>
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<tr>
<td>Carbohydrates</td>
<td>12.7 g</td>
<td>7.2 mg</td>
<td>7.0 mg</td>
<td>5.9 mg</td>
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<tr>
<td>Ash</td>
<td>0.8 g</td>
<td>0.8 g</td>
<td>0.8 g</td>
<td>0.8 g</td>
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<tr>
<td>Vitamin C</td>
<td>30 mg</td>
<td>28 mg</td>
<td>40 mg</td>
<td>20 mg</td>
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</table>

Food values on 100g of fresh weight
Source: Department of Nutrition and Quality, INIAP, 2006

Culinary uses

Ripe tree tomatoes have fine eating qualities and can be used in many ways. They are usually cut in half and the flesh scooped out. Seeds are soft and edible. The skin is easily removed, it peels off when dipped briefly in hot water. The fruits are especially good on desserts such as cakes and ice cream, on fruit salads or in green salads. The whole fruit can be liquidized and drunk. The richly colored juice (especially of the deep and red types) seems to have much potential for blending with grapefruit and other juices whose consumer appeal may be increased by the added color. In South America, such juices are frequently blended with milk, ice and sugar to make tasty drinks.

Tree tomatoes are also cooked and eaten in stews, soups, baked goods, relishes, sweet and savory sauces. In New Zealand, diced tree tomatoes, with onion, breadcrumbs, butter and appropriate seasonings, are popular as a stuffing for roast lamb—the national dish. Being high in pectin, tree tomatoes make good jellies, jams, preserves, or chutneys, but they oxidize and discolor unless treated. Preserves give a high yield of pulp, around 83% which is high compared with other fruits. The fruit may be processed to obtain chips and dehydrated products.
The fruit freeze well, either whole (peeled) or pureed, and can be stored this way almost indefinitely (National Academy of Sciences U.S.A., 1989).

**Phytochemicals and health**

Tree tomato is a promising source of natural colorants and has exhibited *in vitro* antioxidant activity that gives it an interesting added-value, anthocyanins chemical characterization were also performed (Osorio *et al.*, 2007 and 2012).

Vitamin A and carotenoids are often cited as members of antioxidant vitamins that can protective effects against oxidative stress and some chronic diseases and may be considered physiological modulators degenerative or cardiovascular diseases and are known for having antioxidant capacity (Olson, 1996). The possible protective action of carotenoids can be attributed to their properties as singlet oxygen quenchers and as antioxidants, whereas their cancer-enhancing actions in lung can be ascribed to the prooxidant action of carotenoid free radicals in damaged cells (Olson, 1999).

Total polyphenols content of the four presented cultivars are comparable to other published results for yellow and red tree tomato, where similar phenolic composition were found, however anthocyanins were absent in the yellow tree tomato as well as in the Giant orange and End Pointed yellow. Pelargonidin rutinoside (115mg/100g DM) and delphinidin rutinoside (33 mg/100g DM) were the two major anthocyanins in the red variety and hydroxycinnamic acids were higher in the red tree tomato than in the yellow one (Mertz *et al.*, 2009), anthocyanins also were only found in Giant purple and Ecuadorian purple tree tomatoes. Anthocyanins chemical characterization has also been performed in a red variety of tomato tree, obtaining five main components (Osorio *et al.*, 2012).

The carotenoid pigments of tree tomato fruit were identified and quantified. β-carotene, β-cryptoxanthin, ζ-carotene, 5,6-monoepoxy-β-carotene, lutein and zeaxanthin were detected in both the pulp and the peel. The quantitative patterns of the pulp and the peel were similar, with cryptoxanthin and β-carotene predominating. The high average vitamin A value (2475 IU/100 g edible portion) is due to the principal carotenoids that have provitamin A activity (Rodriguez-Amaya D. *et al.*, 1983). Carotenol fatty acid esters were abundant in tree tomato with β-cryptoxanthin esters being the major ones. β-carotene was the major hydrocarbon carotenoid, the carotenoid composition was similar in red and yellow tree tomato.
fruits (Mertz et al., 2009). Total carotenoids of Giant orange and End Pointed yellow tree tomato were about 0.23 mg/g, no carotenoids were detected in Giant purple and Ecuadorian purple tree tomatoes.

The antioxidant capacity of purple-red and golden-yellow tree tomato fruits were determined giving 4.2 and 2.6 μmol Trolox/g sample FW respectively (Vasco et al., 2009). It was also determined in several extracts of red and yellow tree tomato fruits (Mertz et al., 2009).

Tree tomato fruit is a source of polyphenols, known for their antioxidant activity, carotenoids, vitamins, and minerals. The antioxidant value is largely derived from polyphenolic, flavonol and anthocyanidin compounds and may help lower blood sugar levels in type-II diabetes mellitus. Yellow varieties contain more vitamin A and carotenoids than red varieties, however, red variety has more anthocyanin pigments. In addition, yellow ones are a good source of carotenones, and xanthins, compounds that are known to possess antioxidant properties and, together with vitamin A, are essential for visual health. Further, vitamin A is also required for maintaining healthy mucus membranes and skin. Consumption of natural vegetables and fruits rich in flavonoids may help to protect from lung and oral cavity cancers. They are indeed very good source of electrolyte, potassium that is an important component of cell and body fluids helps controlling heart rate and blood pressure; thus, counters the bad influences of sodium. In addition, the fruit contains a small amount of minerals such as copper, manganese, magnesium, phosphorus, zinc and iron.

Tree tomato has been traditionally used to reduce blood cholesterol levels and to treat respiratory problems. It is also known that its pulp prevents neurodegenerative diseases and arteriosclerosis, and has some antimicrobial activity.

Bibliography


TUNA

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Scientific name: Opuntia ficus-indica

L Miller, Family Cactaceae. Others: Cactus chinesis Roxb., Wild Cactus decumanus, Wild Cactus elongates, Opuntia parvula, Opuntia paraguayensis, Opuntia tuna-blanca, Opuntia undulate, Opuntia vulgaris Miller.

Common names: Cactus pear, prickly pear, tuna.

Origin

Opuntia ficus-indica is a close relative of a group of arborescent, opuntioid cacti from southern and central Mexico; the nucleus of domestication for this species in central Mexico (Griffiths, 2004). Opuntia ficus-indica is a long-domesticated cactus crop that plays an important role in agricultural economics throughout arid and semi-arid areas of the world. Cactus pear or prickly pear, a member of the Cactaceae family (Reyes Aguero et al., 2005), originated from arid and semi-arid regions of Mexico and was introduced into North Africa in the 16th century (Griffiths, 2004).

The coat of arms of Mexico depicts a Mexican golden eagle, perched upon an Opuntia cactus, devouring a rattlesnake. According to the official history of Mexico, the coat of arms is inspired by an Aztec legend regarding the founding of Tenochtitlan. The Aztecs, then a nomadic tribe, were wandering throughout Mexico in search of a divine sign that would indicate the precise spot upon which.
they were to build their capital. Their god Huitzilopochtli had commanded them to find an eagle devouring a snake, perched atop a cactus that grew on a rock submerged in a lake. After two hundred years of wandering, they found the promised sign on a small island in the swampy Lake Texcoco. It was there they founded their new capital, Tenochtitlan. The cactus (Opuntia ficus-indica; Nahuatl: tenochtli), full of fruits, is the symbol for the island of Tenochtitlan.

Production

Cactus pear or tuna is the most commonly known cactus and belongs to Opuntia spp., one of the most important members of the cactaceae. Cactus pear plant, a suitable plant to cultivate in arid and semiarid regions, provides an edible fleshy stem known as cladode or nopalito and a highly sweet nutritious fruit (Rodriguez-Felix, 2002; Rusell and Felker, 1987). Nowadays, cactus pear fruit is produced commercially in many regions of the world such as Mexico, South America, South Africa and the Mediterranean basin. In Mexico, the cultivated area for human consumption is around 10,000 Ha. Under optimal conditions, annual production can reach 50 tons of dry matter per hectare. The genus Opuntia covers about 1,500 species of cactus and many of them produce edible tender stems and fruits, (Hegwood DA, 1994)

The characteristics of the prickly pear are closely linked to the arid environment in which it has evolved. It is found throughout the American continent from sea level to altitudes of close to four thousand meters, and dominates in plant communities we call wild prickly pear fields. In Mexico, the Opuntia genus has a wide distribution, but the regions with the highest species richness are the central and northern highlands, the northwest, the Bajio, the Neovolcanic axis and the valley of Tehuacán-Cuicatlán. In the dry tropical regions and deserts of the north there is less richness, but it is there that endemic species of great importance can be found.

Brought to Europe by the Spanish, the dispersal of cactus through the world has been random since the sailors used to carry a plentiful supply of tunas with them to prevent scurvy (a disease caused by vitamin C deficiency). Selected varieties were subsequently taken to establish plantations for various purposes, such as arresting land desertification or for the production of forage. Today, wild prickly pear has been naturalized and cultivated in many semiarid regions of the
world. Some countries have plantations larger than those of Mexico, and with diversified genetic resources (Chávez-Moreno CK, 2009)

Cactus-pear productivity, as in other crops, is related to management practices. This is because plant productivity is an indicator of the cumulative effects of environmental factors that affect the growth (Nobel, 1988). Nutrient supply through the application of manure, fertilizer or both, coupled with irrigation, increases cladode production (Gonzaga and Cordeiro, 2005). In fact, it has been showed that under optimal conditions, cactus pear productivity can be equal to or higher than that obtained with highly productive crops as corn, alfalfa, sorghum and other (Nobel, 1988).

Nutrition

Cactus pear (Opuntia spp.), a member of the Cactaceae family, is a fruit crop used for subsistence agriculture in Mexico. Cactus pear is also cultivated worldwide on over 1,000,000 ha for fruits, forage and fodder consume. This data do not include the utilization of wild plants or those cultivated for self-consumption in the backyards of rural homes (Inglese et al., 2002). Cactus pear is a polyspecific fruit crop and Opuntia ficus-indica, O. megacantha, O. streptacantha and O. amyclaea are the most commonly cultivated opuntias (Bravo-hollis, 1978; Pimienta-Barrios, 1994). Cactus-pear cultivars produce clear-green, yellow-brown, yellow-orange, red-purple (Pimienta-Barrios, 1994) fruits, but the red-purple and yellow fruits are the most attractive in markets in the USA and Europe (Sáenz and Sepulveda, 2001).

Culinary uses

Cactus pear fruit is usually eaten fresh after peeling, varies in shape, size, color, and consists of a thick peel and the edible juicy pulp with many hard seeds. Different food products such as juices, dehydrated fruit sheets, jellies, jams, candies, ice cream and others are processed from cactus pear fruits (El-Samahy
et al., 2007; EL-Samany et al., 2009; Saenz, 2000). The tender young part of the cactus stems, or cladode, is frequently consumed as a vegetable in salads, while the cactus pear g/person/day) (Avila-Curiel A et al., 2003).

The fruit is a berry, varying in shape, size and color and has a consistent number of hard seeds. The fairly high sugar content and low acidity of the fruit (Joubert, 1993; Muñoz de Chavez et al., 1995) makes it very sweet and delicious.

It is considered as a good source of bioactive compounds such as betalains, polyphenols, vitamin C, minerals, proline, and taurine (Piga 2004; Stintzing et al., 2001)

Phytochemical and health

Chemical composition depends on variety, maturation stage and environmental conditions (Rodriguez-Garcia ME et al., 2007; Hernández-Pérez T et al., 2005; Betancourt-Domínguez MA et al., 2006). Previous studies on the chemical composition of the edible portion of cladodes and fruits from Opuntia ficus-indica show that these foods have a high nutritional value, mainly due to their mineral protein, dietary, fiber and phytochemical contents (Rodriguez-Garcia ME et al., 2007; Hernández-Pérez T et al., 2005; Ayadi MA et al., 2009; Rodríguez-Félix A and Cantwell M, 1988).

While quercetin glycosides are in most cases ubiquitous in fruits and vegetables (Hermann, 1976), cactus pear fruit is a unique source of isorhamnetin glycosides, especially isorhamnetin-3-O-rutinoside and isorhamnetin triglycosides (Galati et al., 2003).

Moreover cactus pear fruit containing betalain pigments is a good potential for use as a natural food colorant. This fruit contains red-violet betacyanins in addition to yellow betaxanthins (Merin et al., 1987; Tuker et al, 2001).

Also Kuti (2004) determined flavonols in fruit tissues of four different cactus pear species (O. ficus-indica, Opuntia lindheimeri, O. streptacanthaand O. strictavarstricta) and reported that quercetin is the dominant flavonol in all analyzed species.

Interestingly, antioxidant activity has also been reported (Kuti, 2004; Corral-Aguayo et al., 2008) besides being a traditional source of vegetables, cladodes, also have medical and animal breeding applications (Ayadi MA, 2009; Rodríguez-Félix A, 1988). In addition, Opuntia fruits and young stems have been traditionally
used in folk medicine to treat diabetes, hypertension, asthma, burns, edema, and indigestion (Castañeda-Andrade et al., 1997; Galati et al., 2003; Galati et al., 2001; Trejo-Gonzáleze et al., 1996).

Recently, there has been an increased interest in the antioxidant activity and health-improving capacity of cactus pear, and the antioxidant capacity of the pulp of cactus-pear fruits has been assessed (Arrizon et al., 2006; Butera et al., 2002; Galati et al., 2003; Lee et al., 2002; Stintzing et al., 2005). Since some by-product constituents may be extracted and used as additives in food preparations or in the pharmaceutical and cosmetic sectors, the use of processed fruit by-products for human consumption has increased significantly in recent years.

Bibliografy


Annex

Table I. Iberian-American fruits rich in health-promoting phytochemicals

<table>
<thead>
<tr>
<th>Fruit (common name)</th>
<th>Species</th>
<th>Country</th>
<th>Major Phytochemicals</th>
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<td>Euphorbe cereacea</td>
<td>Brazil / Colombia / Peru</td>
<td>Flavonoids, procyanidins and Benzoic acids</td>
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<td>Rubus glaucus Benh</td>
<td>Ecuador / Colombia</td>
<td>Flavonoids and phenolic acids</td>
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<td>Prunus spinosa</td>
<td>Spain</td>
<td>Flavonoids and vitamin C</td>
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<td>Camu-camu</td>
<td>Myrciania dubia</td>
<td>Brazil / Peru</td>
<td>Flavonoids, tannins and vitamin C</td>
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<td>Cape gooseberry</td>
<td>Physalis peruviana</td>
<td>Chile / Colombia</td>
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</tr>
<tr>
<td>Cherimoya</td>
<td>Annona cherimole</td>
<td>Chile</td>
<td>Phenolic acids</td>
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<td>Cocina</td>
<td>Theobroma cacao</td>
<td>Brazil / Colombia / Peru</td>
<td>Flavonoids and procyanidins</td>
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<td>Fajoa</td>
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