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Amazonian Small Fruits with Commercial Potential[1]

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Abstract

Although most native Amazonian fruit species are trees, a few are woody or herbaceous shrubs. The Myrtaceae is especially rich in small fruit species. The araçá-boi (*Eugenia stipitata* McVaugh) was domesticated in western Amazonia for its deliciously flavored, sour pulp. The araçá-pera (*Psidium acutangulum* DC) was managed in swidden second-growth and around village sites for its pleasantly flavored, sour fruit, frequently similar in flavor to the strawberry guava (*P. cattleianum* L.). The caçari or camu-camu (*Myrciaria dubia* (HBK) McVaugh) is a wild species that occurs in monospecific stands in flood-plains. It is an extremely sour, though pleasantly flavored fruit, with up to 4 g of ascorbic acid per 100 g of edible pulp, making it richer in this vitamin than the acerola(*Malpighia glabra* L.). The Solanaceae offers the cubiu or cocona (*Solanum sessiliflorum* Dunal), domesticated in western Amazonia and similar in appearance to the naranjilla (*S. quitoense* Lam.). Its potential yields are enormous and its pleasantly flavored fruits are used for juices or preserves. The Rubiaceae contains the purui (*Borojoa sorbilis* (Huber) Cuatre.) and several relatives. Another sour fruit with a pleasant flavor, the purui appears to have been at least semi-domesticated in western Amazonia also. These species offer the potential for development as processed juices or other products, as they are all too sour for out of hand consumption. This paper describes each species, presents available composition and yield data, and suggests the research necessary to develop them as small fruit crops.

Introduction

Amazonia is the last untapped frontier for the fruit explorer, geneticist and entrepreneur. When Francisco de Orellana descended the Napo and Amazon Rivers in 1540 he was amazed at the variety of fruit crops grown in and around the Amazonian villages (18, 19). Within 100-200 years, however, the native population was decimated by disease (9), and most of their selected fruits had disappeared into the returning forest (5). Nonetheless, the fruit selections and overall diversity that remain are impressive, so much so that they have been used to propose a center of crop genetic diversity in Amazonia (7).

Although most native Amazonian fruit species are trees, a few are woody or herbaceous shrubs. Some are currently collected from the wild, without any apparent management, e.g., *Myrciaria dubia*. Others are volunteers in ecosystems disturbed by humans and consequently are subject to some type of human management and selection, e.g., *Psidium acutangulum*. Some of these may have once been semi-

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domesticates, e.g., *Borojoa sorbilis*. Others occur principally in agroecosystems and are considered semi- or full domesticates, e.g., *Eugenia stipitata* and *Solanum sessiliflorum*. These five species offer potential for development as processed juices, purees or fruit sections, as they are all too sour for out of hand consumption. This paper describes these species, from three botanical families, presents available composition and yield data, and suggests the research necessary to develop each as a small fruit crop for monocultures or agroforestry in Amazonia and elsewhere in the humid tropics.

Myrtaceae

The Myrtaceae is especially rich in small fruit species and many are cultivated commercially or for subsistence throughout the tropics. *Psidium guayava* L. is regionally important in Brazil, Hawaii, Mexico, etc. Many others are locally important.

Eugenia stipitata

The araçá-boi or araza (*Eugenia stipitata* McVaugh) was semi-domesticated in western Amazonia for its deliciously flavored, sour pulp (7). The delightful flavor and easy acceptance of the araçá-boi, combined with precocity and high yields, make this species a very promising crop for the lowland humid tropics (6).

There are two subspecies (13, 14): *E. stipitata* subsp. *stipitata* is a small, undomesticated, forest understory tree that is ancestral to the domesticated subspecies, *E. stipitata* subsp. *sororia*, which has a larger fruit and is always found in an agroecosystem or as an escape.

E. stipitata subsp. *sororia* is a medium to large shrub, rarely a small tree, with dense, dark green foliage. The small inflorescences contain 3 to 8 flowers. Each flower has four white petals, 75 to 150 stamens and a single pistil, with a multi-locular ovary. The 30 to 800 g fruit is a berry, with a thin, velvety, lemon yellow skin with a delightful aroma. The juicy pulp has the same lemon yellow color, a delightful (though distinct) flavor and is very acid. The 3 to 20 fleshy seeds weigh 2 to 4 g (3). Mesocarp composition is presented in Table 1. There is considerable proximal variation in the species, which will surely be amenable to selection.

The araçá-boi is traditionally prepared as a juice (22), with potential for local and international markets. To date, however, no entrepreneur has taken advantage of this, although small quantities of frozen pulp are exported to Switzerland. Like many fruits, araçá-boi is also used to make preserves.

The araçá-boi fruits 2 to 4 times a year, depending upon rainfall (10). Araçá-boi yielded 20 to 25 Mt/ha/yr in the 5th year on a yellow oxisol near Manaus, Brazil (2), while 28 Mt/ha/yr were obtained near Iquitos, Peru (23). Swift & Prentice (28) discussed small-scale commercial operations in Ecuador and the difficulty of transporting the fresh fruit because it bruises so easily. They also mention that fruit picked green do not ripen normally, although fruit picked at color break do.

Given araçá-boi's yield potential, precocity and frequency of bearing, with its delightful, distinctive flavor, this species has potential worldwide. As with many 'new' tropical fruits, however, it has yet to be exploited on a commercial scale.

Psidium acutangulum

The araçá-pera (*Psidium acutangulum* DC) was managed as a volunteer in swidden second-growth and around village sites for its pleasantly flavored, sour fruit, the best of which recall the flavor of a good strawberry guava (*P. cattleianum* L.). The fruit looks exactly like a white guava and has been called goiaba Brasileña or cas Brasileña in Costa Rica, where it was introduced in the early 1980s.

The araçá-pera is a large shrub to small tree, 4 to 8 m tall, and more erect than the guava. Its young branches are squarish in cross-section, with bark wings arising on the corners (hence the specific name). Its leaves are distinctive, as the 8 to 10 lateral veins unite near the margin, leaving a veinless border around the leaf. The 5-petaled, white flowers arise in the leaf axils. The 30 to 250 g pear-shaped to spherical fruit is a berry. Like the guava, the placental cavity of the araçá-pera contains abundant seeds mixed with a fibrous mesocarp (3).

Although seldom commercially planted in Amazonia, an experimental plantation on an oxisol at Manaus permitted studies of phenology and growth under different fertilization regimes (11). The araçá-pera fruits abundantly from September through December. When fertilized with 25 kg/ha N, 50 kg/ha P_2O_5 and 60 kg/ha K_2O, it produced an average of 1100 fruits/plant during the 5th year from planting, but only 240 fruits when unfertilized. At an average fruit weight of 100 g, estimated yields vary from 9.6 to 44 Mt/ha (11).

The araçá-pera is commonly used to make a pleasantly flavored juice, which has gained wide acceptance in Costa Rica, as well as being popular in most of Amazonia. A preserve is also prepared occasionally. Given its pleasant flavor, abundant yields and response to agronomic management, the araçá-pera deserves an entrepreneurial effort to develop it as a juice or fruit section product for international markets. Proximal composition is not yet available.

Myrciaria dubia

The caçari or camu-camu (*Myrciaria dubia* (HBK) McVaugh) is a wild species that occurs in dense stands in the flood-plains of the white water rivers of Amazonia (21). It is an extremely sour, though pleasantly flavored fruit, and has up to 4 g of ascorbic acid per 100 g of usable pulp (mesocarp + exocarp) (J. Andrade, INPA, pers. com.), making it richer in this vitamin than the acerola (*Malpighia glabra* L.).

The caçari is a scraggly shrub or small tree, 3 to 8 m tall, with little detectable trunk. It is heavily branched from near ground level, although each branch has few secondary branches. The leaves are sparsely distributed except at the branch tips. The small inflorescences contain 2 to 12 flowers, arranged in pairs, each with four white petals. The spherical fruit is a berry, 2 to 3 cm in diameter, red to reddish-purple to purplish-black when mature. The white pulp is juicy, slightly fibrous, extremely acid but with an agreeable flavor. There are 1 to 4 flattened seeds (3).

The caçari is widely distributed in ecological Amazonia (15); it is found from the lower Amazon River to the Andean foothills and from the middle Orinoco River to Bolivia. Throughout this region it is a locally important component of the riparian vegetation, in some areas forming extensive nearly monospecific stands (21). In the floodplain the plants may be submerged in the muddy water for 4 to 6 months. Consequently, their phenology is intimately tied to the water level: flowering occurs just before and during the beginning of the flood season; fruiting occurs as the floods intensify but before their peak (20). In monospecific stands in its natural habitat, Peters et al. (21) reported 3000 fruiting plants/ha, yielding 9.5 to 12.6 Mt/ha/yr of fresh fruit.

Experiments to evaluate caçari's adaptation to the drier oxisols and ultisols that predominate in Amazonia are underway in Peru and Brazil. On an oxisol near Manaus only 2 to 3% of a moderately-fertilized, 10-year-old, experimental population (n = 360) yielded well (approaching the lower end of Peters et al.'s yield range) (4). A moderately-fertilized, experimental monoculture plantation (1667 plants/ha) in Pucallpa, Peru, however, yielded 7 to

8 Mt/ha/yr during the 10th year (8). It is clear, therefore, that the caçari can be adapted to a conventional agroecosystem, although Peters et al. (21) argue that the natural stands are a resource that should not be ignored.

The major potential of caçari is as a rich source of natural Vitamin C, that could be marketed as a concentrate or as a juice. The proximal composition of the fruit pulp is presented in Table 2. Juices and popsicles are prepared from caçari in Iquitos, Peru, and are avidly consumed by the local population.

The caçari was marketed experimentally in the US in 1967 (30), by Nutritional Specialties, Inc., of Puerto Rico, in collaboration with the Banco de Fomento Agropecuário del Perú. They marketed "organic" vitamin C tablets under the name "Camu-Plus" and experimented with other products. The reasons for the failure of this project are not clear, however. Chávez (4) speculates that this effort may have been ahead of its time, since the real boom in organic vitamins and the search for exotic natural foodstuffs started in the mid-1970s.

Solanaceae

The Solanaceae contains several species with edible fruits that are collected from the wild or from plants that volunteer in disturbed areas. Two of these species were domesticated by the Indians in Colombia and Ecuador. The naranjilla (*S. quitoense* Lam.) is the better known of these two, but is restricted to higher altitudes. The lowland species is discussed here.

Solanum sessiliflorum

The cubiu or cocona (*Solanum sessiliflorum* Dunal) was domesticated in western Amazonia from a small-fruited ancestor (*S. sessiliflorum* var. *georgicum*) (29). The cubiu was used extensively by the Indians of Amazonia. There are indications that a landrace complex is distributed in western Amazonia (7) and work is underway to define this. The cubiu's use has diminished during the last century as substitutes have become more common and as the number of immigrants has increased (16). Nonetheless, its potential is considerable, because it yields very well on poor soils with only minor amendments and has great processing potential.

The cubiu is an herbaceous, erect, branched shrub, attaining 1 to 2 m in height. The stems and leaves are covered by a lightgreen to white hairy tomentum; very rarely spines are present, although they are common on *S. sessiliflorum* var. *georgicum*. The leaves can attain 40 to 60 cm in length and width. The inflorescences are axillary, with 5 to 8 pale-green-petaled flowers. The fruit is extremely varied in exocarp color (yellow through red to russet), size (20 to 300 g), shape (from oblong through spherical to flattened), placental cavity size, juice volume and Brix (4 to 6) (27). As in other solanaceous fruit, the placental cavity is full of small seeds (17). There are two types of pulp, both with a light beige-yellow color: the placental pulp is soft, slightly fibrous, and has the richest flavor; the surrounding pulp is firmer, slightly fibrous, and with a milder flavor.

The fruit is used to prepare juice. The juice has the pulp color initially but slowly oxidizes to a darker beige color, without becoming bitter. Alternatively, it is processed into preserves or fruit sections (17). The pulp's proximal composition, mineral and vitamin content are presented in Table 3.

The cubiu is propagated from seed, which come true to type because the domesticated variety is autogamous (27). It requires full sun for maximum growth and yield, and is planted at 10,000 plants/ha. Good growth on various soils, from high sand to high clay, has been observed between 0 to 1200 m above sea level. Rainfall should be well distributed and abundant, between 2000 and 4000 mm (17).

On a sandy ultisol near Manaus, experimental yields of 20 to 30 Mt/ha vary by progeny, when using a dressing of composted city garbage. When the same progenies received additional fertilization (45 kg/ha N, 46 kg/ha P_2O_5 and 60 kg/ha K_2O at planting), experimental yields increased to 25 to 146 Mt/ha (17). Other progenies studied by Silva and colleagues have shown similar variation in yield potential at these conservative fertilization rates.

Of the 5 species discussed here, the cubiu has been most intensively studied in Brazil. Pahlen (17) collected and evaluated 35 accessions from Brazilian Amazonia and estimated heritabilities for important yield components. Silva et al. (25, 26) described another 12 accessions and studied correlations among morphologic and yield characteristics. Silva et al. (27) evaluated another 30 accessions from Brazilian, Colombian and Peruvian Amazonia and estimated heritabilities for yield components. With this knowledge base, cubiu improvement will be facilitated for any market and entrepreneurial requirement, as well as for varied edapho-climatic conditions in the humid tropics.

Rubiaceae

The Rubiaceae is best known for the genus *Coffea*. In the Americas, the genera *Borojoa, Thielodoxa* and *Albertia* are locally important and contain several species collected from the wild or protected in agroecosystems. At least one was probably semidomesticated by the Indians of Amazonia.

Borojoa sorbilis

The purui (*Borojoa sorbilis* (Ducke) Cuatre.) and several relatives are widely used in northern South America. Another sour fruit with a pleasant flavor that is reminiscent of tamarind (*Tamarindus indica* L.), the purui appears to have been semidomesticated in western Amazonia also, although it is seldom cultivated today. While not widely commercialized, purui merits attention because it produces good fruit on extremely poor soils with few inputs.

Table 1. Proximal composition and vitamin content of araçá-boi *(Eugenia stipitata)* fresh mesocarp (in 100g).

Component	Pinedo et al. (1981)	Aguiar (1983)	Pezo & Pezo (1984)
Water[1]	—	90	94.3
Protein[2]	9.5 ± 1.4	6	10.1
Carbohydrates[2]	70.2 ± 1.3	89	80.6
Fats[2]	3.2 ± 0.6	2	0.5
Ash[2]	—	3	2.5
Fiber[2]	6.1 ± 0.5	—	6.3
Vitamin C (mg)	7.68	23.3	74

[1]% fresh weight; [2]% dry weight.

The purui is a large shrub or small tree, 4 to 6 m tall, with a slender erect trunk and opposite branching. The large leathery leaves are also oppositely arranged. The terminal, staminate inflorescence contains several white flowers. The terminal, pistillate white flowers are solitary. The 50 to 800 g fruit is a berry. The thin exocarp encloses a brown, pasty, moist mesocarp, which surrounds a placental cavity with a brown, somewhat fibrous, juicy mesocarp embedded with many seeds (3). No proximal analysis is available.

This species has a more restricted distribution than the others discussed here. It is found in central-western Amazonia, along the middle Amazon River and two of its major southern tributaries, the Madeira and the Purus Rivers. In this region it occurs both wild and cultivated. At the western limit of this area, one of us (CRC) observed purui with 800 g fruit cultivated by the Ticuna Indians, who claim it as a traditional crop.

The purui is grown experimentally on an oxisol in Manaus, with no inputs. It yields regularly, but yields have not been recorded. A near relative, *B. patinoi*, is the object of an intensive

Table 2. Proximal analysis and vitamin content of caçari *(Myrciaria dubia)* fresh pulp (in 100g) (24).

Component	(g)	Vitamins	(mg)
Water	94.4	Carotene	trace
Protein	0.5	Thiamin	0.01
Oil	—	Riboflavin	0.04
Carbohydrates	4.7	Niacin	0.62
Fiber	0.6	Reduced ascorbic acid	2,880
Ash	0.2	Total ascorbic acid	2,994

research and development program in Colombia (V. M. Patiño, pers. com.). The purui certainly merits similar attention, but is not currently receiving any.

Present Research and Future Requirements

Both Peru and Brazil have active research on the araçá-boi and caçari (8). Peru has collected more than 20 distinct araçá-boi accessions, including samples of the wild sub-species, and more than 40 caçari accessions and is evaluating them at Iquitos. Brazil has a smaller collection of araçái-boi (5) from the middle Amazon River basin. Brazil currently has more than 30 accessions of cubiu, and a few each of araçá-pera and purui. More germplasm of all species should be collected throughout western Amazonia, and closely related species with similar fruit types should be sampled also.

The agronomic research mentioned above must be repeated when high quality lines or clones have been selected. This should be done both in monocultures and in agroforestry systems, as the different species may have more potential in one or the other system (8). Additionally, experimental management of the monospecific caçari populations in western Amazonia may result in a low cost, sustainable system that would increase the usefulness of many currently underutilized floodplain areas (21).

Fruit physiology, post-harvest handling and processing research are essential for all species. The latter must be guided by market surveys, both in Amazonia and internationally, to prepare high quality products that will find ready acceptance. Without a direct stimulus from the business community, however, institutions will maintain these species on their list of potential crops but research will advance slowly. Given the potential of these five small fruits, entrepreneurial interest could result in many new products in a short time.

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Table 3. Proximal analysis and range of mineral and vitamin contents of cubiu *(Solanum sessiliflorum)* fresh pulp (in 100g).

Component[1]	g	Minerals[1,2]	mg	Vitamins[1,2]	µg
Water	92	Calcium	12-16	Carotenes	20-140
Protein	0.6	Phosphorous	14-30	Thiamin	10-25
Oils	1.4	Iron	0.6-1.5	Riboflavin	tr-10
Fiber	0.4			Niacin	230-500
Carbohydrates	5.7			Ascorbic acid	450

[1]Pahlen 1977; [2]INN 1977.

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