FUNCTIONAL FRUITS IN THE ARAUCARIA FOREST/BRASIL

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MOF – A NEW PERSPECTIVE

The Mixed Ombrophilous Forest (MOF) woodlands are common in the southern Brazilian states below the Tropic of Capricorn. The combination of latitude and altitude - a temperate climate within a subtropical region - creates a unique mixture of trees. The best known member of this group is the Araucaria pine tree, also known as *Pinheiro-do-Paraná*. The Araucaria pine is definitively linked to the local culture as a *leitmotif* for paints, draws, dances and songs. Other components of the MOF provide top-quality wood for furniture making, essence sources for phyto-chemistry and phytotherapy, unique ornamental trees and certain unnamed small fruit with functional appeal.

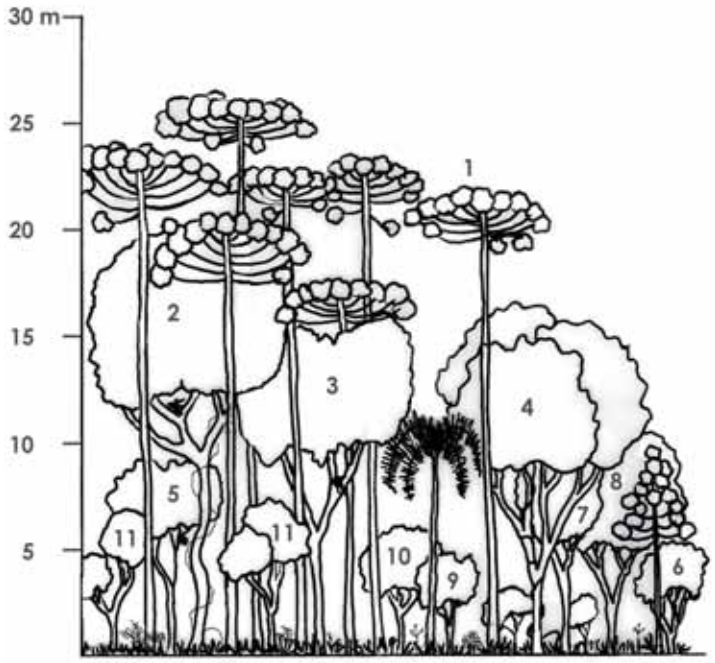

Fig. 1: The Araucaria forest is composed of three vertical strata: A first stratum of araucaria, a second stratum of species of the Lauraceae family and a third, of the Myrtaceae family. © Wosiacki

THE ARAUCARIA FOREST

The Araucaria forest belongs to a class of woodlands known as MOF, an acronym for mixed climate (subtropical and temperate) ombrophilous ("rain-loving") forest (CARMO *et al.*, 2007). It is located west of the Serra do Mar scarp on the plateau portions of the state of Paraná, Brazil, (on average between 800 and 1200 m above sea level. It has no direct contact with the ocean and it receives well-distributed rains throughout the year. The floristic composition is strongly influenced by the low temperatures and the regular occurrence of frosts in the winter (RODERJAN *et al.*, 2002). These ambient factors, along with diverse geological conditions, result in some variety in the forest's floristic composition; generally speaking, though, the Araucaria forest is composed of three vertical strata (Figure 1): a first stratum of araucaria, a second stratum of species of the *Lauraceae* family and a third, of the *Myrtaceae* family.

Araucaria angustifolia[1], the highest, tallest and predominant tree, occupies the emergent stratum, reaching heights of 30 to 40 m. The next stratum features trees that grow 10 to 20 m high, including *Cedrela fissilis*[2] (cedro), *Ocotea odorifera*[3] (Brazilian sassafras), *Ocotea porosa*[4] (imbuia). The stratum at 5 to 15 m or below is composed of *Syagrus romanzoffiana*[5] (jerivá), *Eugenia uniflora*[6] (pitanga), *Eugenia involuncrata*[7] (cereja), Campomanesia xanthocarpa[8] (guabiroba), *Psidium cattleianum*[9] (araçá), *Eugenia pyriforms*[10] (uvaia) and *Ilex paraguariensis*[11] (yerba mate) (Figure 1).

ARAUCARIA OR PARANA PINE

Araucaria angustifolia (Bertol.) Kuntze (Figure 2), also known as Araucaria or Parana pine, has a cylindrical and rectilinear trunk that can grow to one meter in diameter or larger. When young, the tree is cone-shaped, but it develops an umbrella shape as it matures (KOCH e CORREA, 2002). The aciculas are sharp-pointed, hard and perennial and vary between 2 and 6 cm in length and between 4 and 10 cm in width (MARCHIORI, 1996). The dark green color of the leaves explains the term "mata preta", an old-

er name for the Araucaria forest. This forest was exploited by the wood industry for decades, causing some tree species to be declared threatened in the state of Paraná, Brazil. These endangered species included Araucaria angustifolia, *Ocotea odorifera* and *Ocotea porosa*, which were placed in the "Rare" category (PARANÁ, 1995). Currently, there is an increasing awareness of how to preserve these trees. After around 30 years, the Araucaria pine starts bearing strobili, also called pinha, which can reach weights of 1 to 2 kg. Strong winds may help establish a natural harvest by blowing down even unripe pinha allowing them to ripen naturally on the humid and shaded forest floor. Pinhas may fall on their own when ripe; they may remain intact or break on the ground. After ripening is complete, the undamaged ripened strobilus releases its seeds and bracts from its fecundated and unfecundated forms, respectively (Figure 3). The fecundated seed is known as pinhão (Figure 4). The pinhão seeds may be sold after April 15 of each year. Once the hulls are removed, the opalescent (CEREDA e WOSIACKI, 1985; WOSIACKI e CEREDA, 1985) white nut is still covered by a thin reddish peel that must be removed because of its highly bitter taste. The chemical composition of pinhão flour and the rheological proper- ties of its starch have been reported in previous studies (CEREDA and WOSIACKI, 1985; CORDENUNSI *et al.*, 2004; WOSIACKI e CEREDA, 1985).

PINHÃO – THE FOOD

The rheological properties of the paste of pinhão are unique and unusual for cereal and tuber sources (CEREDA and WOSIACKI, 1985; WOSIACKI and CEREDA, 1985), and its glucose index is 43% (CORDENUNSI *et al.*, 2004).

SOME FRUITS FOUND IN THE ARAUCARIA FOREST

The Araucaria forest is home to many kinds of tree that bear good-tasting fruits or fragrant bark. *Acca sellowiana, Campomanesia xanthocarpa, E. involucrata, E. pyriformis, E. uniflora, Myrciaria cauliflora* and *P. cattleyanum* are some of the species of the Myrtaceae family that can be used for fruit production, for phytotherapy and phytochemistry and as ornamental plants. Because they are native species, they offer high productivity with low cost of implantation and maintenance and require minimal use of pesticides. This makes them an alternative within familiar agriculture, and they are excellent options for organic farming, with their consumer appeal and high content of bioactive compounds (VUOTTO *et al.*, 2000). The fruits, each species with proper flavors and aromas, present potential for the consumption in natura and for industrial use in the form of juices, candies, jellies and liquors (BARBEDO *et al.*, 1998). Regarding the functional appeal of fruits from the Araucaria forest, the organic and aqueous extracts of 145 Brazilian plants (538 extracts) from 34 families were evaluated for anti-tumor activity against two human cell lines, and 22 % were effective against one or both (MONKS *et al.*, 2002).

Fig. 2: Araucaria or Parana Pine © Wosiacki

Fig. 3: Pine (strobilus): female reproductive organ of the Araucaria © Wosiacki

Fig. 4: Pinhão conserve © Wosiacki

Fig. 5: Goiaba-serrana fruits. © Wosiacki

Fig. 6: Guabiroba fruits. © Wosiacki

Fig. 7: Different maturation phases of the cherry.

Fig. 8: Uvaia fruits. © Wosiacki

GOIABA-SERRANA
Acca sellowiana (O. Berg) Burret

A semideciduous shrub 3-5 meters in height, with green foliage in the superior part and white/ash grey (silver-plated) in the inferior part and solitary flowers. When mature, it produces small, yellow, many-seeded fruits that may be eaten raw or used in compotes and juices (LORENZI *et al.*, 2006). The fruit (Figure 5), also known as feijoa, goiaba-do-mato or goiaba-da-serra has a sweet-acidulous flavor and penetrating aroma, and is hardly known in the Brazilian market (DUCROQUET *et al.*, 2000).

The fruit contains 25-30 mg of vitamin C/100 g (DEGENHARDT et al., 2003; HOFFMANN *et al.*, 1994) and possesses antibactericidal, antioxidant and anti-allergenic properties, in addition to flavonoids that promote immunological activity and may regulate inflammatory processes (BASILE *et al.*, 1997; VUOTTO et al., 2000) The goiaba-da-serra can reach diameters of 3-5 cm, lengths of 4-10 cm and weights of 20-250 g (MATTOS, 1990) and contain 15-50 % pulp (DEGENHARDT *et al.*, 2003).

GUABIROBA
Campomanesia xanthocarpa O. Berg

A tree of vast and expressive distribution throughout the entire region of the Pinhais of southern Brazil, 10-25 m tall, with leaves that are simple, opposite, entire and long with pedicles (6-20mm). It has a dense pyramid-shaped crown that makes it an attractive ornamental plant. The flowers, grow individually or in groups, whites and axillary meet in the extremities of the bloom. The fruits are yellow (Figure 6), globular (about 2 cm) and crowned by a sepal, and contain as many as 32 flattened-oval-shaped seeds (MARCHIORI e SOBRAL, 1997). The fruits can be consumed raw to take advantage of their high vitamin value, or they can be used for liquor processing. In the forest, these fruits are an important food source for some species of animals (KOCH e CORREA, 2002). The guabiroba fruit has 233.56 mg/100 g of vitamin C - more than six times the amount found in oranges.

CEREJA
Eugenia involucrata DC.

The tree that produces cereja (cherry) is an attractive species native to southern Brazil, particularly the Araucaria forest. It reaches about 15 m in height, its leaves are bright dark green, and it features white flowers about 1-3 cm in size, located in the extremity of a grain stalk. The cereja tree is important for the wild fauna and is valued as an ornamental plant because of its flowers and

shape. The fruits (10-25 mm in size) are oblong, smooth and crowned with sepals that look like small leaves (7-15 mm long) with average weight of 6.76 g. The fruits vary in color from red to dark purple as they mature (Figure 7), and they contain a high anthocyanin content (MARCHIORI and SOBRAL, 1997). Cereja fruits contain 76.6 % pulp, have a sweet-acid taste and a distinctive aroma, high contents of phosphorus (15.20 mg/100 g), potassium (230,00 mg/100 g), phenolic compounds (1365 mg/L) and antioxidants (12141.40 µM/g) (SILVA, 1991).

UVAIA
Eugenia pyriformis Cambess.

This fruit tree, originally from southern Brazil, is a deciduous component of ombrophilous forest. The name uvaia is derived from ubaia or ybá-ia, which means "sour fruit" of the uvaia tree reaches heights of 5 to 15 meters. Budding occurs between the months of August and December, and the trees bear fruit between September and February (LORENZI *et al.*, 2006).

The uvaia fruit has a high vitamin C content (four times more than in oranges). It has a very succulent pulp and a fine peel, yellow-gold in color with a slightly velvety texture (Figure 8). The aroma is soft and pleasant. Some problems with this fruit is that it requires sensitive handling, it oxidates and dries up easily, and it does not respond well to after-harvest techniques. As a result, it is not widely available commercially and is usually eaten in natura under the tree. The fruits present a transverse diameter of 3.57 cm, longitudinal diameter of 2.91 cm and weigh 17.75 g on average. Their water content is around 90.7 %; vitamin C content varies between 33.00 and 39.52 mg/100g; acidity is 1.53 %; soluble solids are 7.5º; Brix and relation SST/ATT are 4.90 (DONADIO et al., 2002). Uvaia is a source of phenolic compounds (205.62 mg/100g) and carotenoids (28.07 µg of β–caroten/g). Its fruits can be processed, with respect for their highly perishable nature, and are very appreciated in juice, jellies and ices cream. The fruit has great potential for vinegar processing. These products are of excellent quality due to the intense flavor and aroma of uvaia, which is widely cultivated in domestic orchards (ALMEIDA e VALSECHI, 1952). The fruits are also consumed by some species of birds. Uvaia is beneficial for use in heterogeneous reforestations designed to restore degraded areas (ALMEIDA e VALSECHI, 1952; ANDRADE e FERREIRA, 2000; LORENZI, 1998) and in landscaping (ornamental and domestic orchards). *E. pyriformis* leaves contain flavonoids with the inhibiting properties of xantino-oxidase, which are used to treat human gout (SCHMEDA-HIRSCHMANN *et al.*, 1987; THEODULOZ *et al.*, 1988).

Fig. 9: Pitanga fruits. © Wosiacki

Fig. 10: Jabuticabeira tree with ripe fruits © Wosiacki

Fig. 11: Red araçá fruits © Wosiacki

PITANGA
Eugenia uniflora L.

The pitangueira is native to the Brazilian Atlantic Woodlands, especially in Brazil's southern states; however, it is now found all over the world because it is easily adjustable to almost all edaphoclimatic conditions. Its fruit (Figure 9) goes by many names, including red or white pitanga (Brazil), cereza de cayena (Spain), pedanga (Venezuela), guinda (El Salvador), ñanga-piré (Argentina) and cereza quadradra (Colombia) (Morton, 1987). The word pitanga came from the native language Tupy-guarani, meaning "red" or "red skin". It is known as the Brazilian or Surinam cherry. In Brazil, it is found from São Paulo down to Rio Grande do Sul, especially along the Paraná River. The tree is most often found in open and clear woodlands and is one of the most common and important components of the region.

The pitanga is a semi-deciduous, heliophylic and selective higrophylic tree. It may be as short as 3 m high or as tall as 15 m, reaching a maximum diameter of 50 cm. The flower is small and white, and fructification is fairly abundant. The fruit is quite small, with a diameter of 1.5-5.0 cm. It has an amazing pumpkin shape, with colors ranging from green, orange, red and dark purple during ripening and a unique intense sweet and acid taste (BEZERRA *et al.*, 2000). It contains high levels of vitamins A, C and B-complex, plus calcium, iron and phosphorus (DONADIO *et al.*, 2002) and considerable total phenolic contents (325.0 mg/100g) and carotenoids (225.9 µg/g), making this fruit an excellent source of antioxidants. With thermal treatment for enzyme denaturation, pitanga pulp can be conserved at -18 °C for 90 days. The unique and strong taste points to a large potential for utilization and growth in the domestic and export market, especially for ice cream, juices, refreshing drinks, gel, liqueur and vines. An alkaloid called pitanguin (a chinin derivatin) supports the utilization of the fruit in home medicine as teas aiming a treatment for persistent diarrhea, hepatic and throat infections, rheumatism and gout. It has relaxing action and anti-inflamatory properties, stimulates diurhesis, prevents morbid obesity and has high antioxidant activity. Pitanga leaves have been used as anti-inflammatories to treat diverse diseases; as sedatives to treat bronchitis; as diuretics (CONSOLINI *et al.*, 1999) to treat diabetes and obesity; and as antioxidants to improve cardiovascular activity. Eugenia uniflora clearly has a functional and technological appeal (CONSOLINI *et al.*, 1999).

JABUTICABA
Myrciaria cauliflora (Mart.) O. Berg

The jabuticabeira, the tree that produces jabuticaba, varies from 3-6 m in height and produces flowers agglomerated on stem and branches, with short bloom and globose succulent pulp fruits (Figure 10) (LORENZI *et al.*, 2006).

The different native and cultivated varieties can be consumed raw or used industrially. The main varieties in Brazil are the *Myrciaria cauliflora* (jabuticaba açu, jabuticaba paulista or jabuticaba ponhema), which produces large, slightly astringent-tasting fruits, and the *Myrciaria jabuticaba* (Vell.) O. Berg (jabuticaba sabará), the most commonly cultivated because of its flavor. The fruit of jabuticaba consists of a smooth, black berry, about 1.6 to 2.2 cm in diameter, containing 1-4 seeds. The peel is fine and very fragile, with a high pectin content and peonidina, peonidina-3-glucosida and anthocyanin (314 mg/100 g) that is responsible for its dark blue coloration. The pulp is translucent white, sweet (containing glucose, fructose and saccharose), with low acidity (from citric and oxalic acid) and with an excellent flavor. Jabuticaba is a good source of iron, phosphorous, vitamin C and niacin. Jabuticaba fruit is popular in all countries, but its extreme perishability has limited its commercial value, even with assured sales. Jabuticaba has a useful life of only three days after harvest. The pulp can be consumed in natura or as jelly, juice, liquor, distilled products, wine, vinegar and teas. The decoction of the peel is mentioned as an asthma treatment, and the consumption of the pulp aids in the digestion and intestinal mobility of the alimentary cake.

THE SOLITARY TREES THAT EMERGE ABOVE THE HIGHEST STRATUM OF FOREST ARE KNOWN BY THE NAME SENTINELA, MEANING GATEKEEPER

ARAÇÁ
Psidium cattleianum Sabine

In Brazil, *P. cattleianum* occurs from Bahia State down to Rio Grande do Sul State and is especially abundant in restinga vegetation and moist soil places such as the Araucaria forest. The Araçá tree reaches 3-6 m in height and features a smooth stem. The fruits are either yellow or red. This suggests that the specie can be split in two morphotypes, denominated as araçá-amarelo and araçá-vermelho.

The fruits (Figure 11), known as araçá, are small and round, with seeds and flesh varying from green to bright yellow to dark red in color. The pulp is yellowish white or reddish, moist, soft and sticky, and contains many seeds. Among the native species of the Brazilian forest the araçá is known as one of the most aromatic, with around two hundred compounds (PINO *et al.*, 2001). Araçá may have harmonious acidity, bitter taste and good smell, but it can also be too acid and bitter, leaving it suitable only for structured foods. Its high ascorbic acid content accounts for its antioxidant capacity, and its essential oils account for its antibiotic activity. These oils are used largely as laxatives and treatments for infections. The acid polysaccharides and the rheological properties of araçá were recently reported (VRIESMANN *et al.*, 2009) as was the characteristics of its juice when extracted and treated with industrial pectinolytic preparation (SANTOS *et al.*, 2007). The fruit is usually acid, with a pH of 3.3 and total soluble solids as 9 Brix, but minimally sweet, as the total sugar is only 5.8 g/100 g. Citric acid may reach 1.56 %, which is deeply sour. In yellow and red varieties there are many polyphenolic profiles. The yellow araçá contains total polyphenols of 1342 ± 3,64 mg/100 g and total bioflavonoids of 87.50 ± 0.05 mg/100 g, plus 4500 µg equivalent trolox/mL juice of antioxidant activity. Samples of the red variety featured total polyphenols of 2926.5 ± 1.57 mg/100 g and total flavonoids of 106.25 ± 0.06 mg/100 g, plus 8400 µg equivalent trolox/mL juice of antioxidant activity. These compounds are bioactive in that they reduce the risk of disease by sequestering free radicals. The extract and the active compound of the fruit, along with the branches and the leaves, have been subjects of scientific research because of their antibiotic, analgesic, anti-inflammatory and hypoglycemic properties. Results of these studies suggest many possible uses for this fruit from one of the Earth's richest biomes.

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