



Morphologic Characterization of Ten Commercial Mango Cultivars (*Mangifera indica* L.) with Potential for the Pulp Industry in Colombia

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A study was conducted on 10 cultivars of *Mangifera indica* at the Fairchild Tropical Botanic Garden living collection located in Homestead, Florida. A detailed description was made of the different commercial cultivars with the purpose to determine their suitability for the Colombian pulp industry. Mango production in Colombia is used mainly for fresh fruit for the local market, which represents 95% of the total mango production (Agronet 2016). 'Hilacha' is the main mango cultivar used for processing. New alternatives are needed for the industry to extend the season and production. The mango cultivars 'Miklet', 'Fairchild', 'Espada', 'Bullock's Heart', 'Totapuri', 'Zebda', 'Mallika', 'Panchadarakalasa', 'Royal Special', and 'Tong Dam' were characterized following international standards of IPGRI (IPGRI, 1989 and Ledesma 2016). Evaluations of fruit morphology were done during the months of June and July. Fruit of the ten cultivars were randomly selected from each tree, photographed and sketched for evaluation of fruit structure.

The mango belongs to the family Anacardiaceae, which is characterized by numerous fruit species some of which, Mango and Marañón, are of great economic importance. From its area of origin in Southeast Asia, the mango is now found in more than 100 countries of the tropics and sub-tropics. (Galán, 1999).

It is believed that the mango arrived in Colombia in two ways. First, the Portuguese stopped in India before reaching the Americas in the fifteenth century. Another possible introduction may have occurred in the 16th century by the Spaniards, when they stopped in the Caribbean and then in mainland America. Years later, with the discovery of gold and silver in the region of Ibagué, a new development opened the borders of the Magdalena River to connect Tocaima and Carthage. Mango trees were planted in this valley. There is still a legendary mango tree in front of the Government Center in the city of Ibagué planted by Delfin Varon in 1861 (Ledesma, 2016).

Mango production in Colombia is mainly for fresh fruit, which accounts for more than 95% of the national production. Colombia exports processed mango and is third place in mango pulp production in the world. The main variety used for mango pulp is 'Hilacha' or mango Crioyo ("native" mango). Other varieties can be included in processing in small amounts as is the case with 'Sugar', used to increase color. The mango industry in Colombia is interested in introducing new cultivars for processing (Ledesma, 2016).

'Hilacha' is found in all mango areas in Colombia from sea level to 1667 m, including the regions of Tolima, Cundinamarca, Magdalena, Cesar, Córdoba, Bolívar, Huila, and Antioquia. It

is a polyembryonic cultivar, which is found individually and in commercial plantations. There are many selections and adaptations of 'Hilacha' in the country because it is propagated from seed. The trees are highly productive and some are tolerant of disease. The fruit has a rich flavor with sweet notes of melon and citrus. 'Hilacha' mango should be allowed to ripened on the tree to develop the best flavor. On the Atlantic coast, 'Hilacha' grows in flooded conditions and the fruit falls to the ground when the water level drops. Trees grown from seeds start to produce fruit in years 6–8 (Ledesma, 2016).

'Hilacha' is also used as a rootstock in Colombia, mostly due to compatibility with other commercial cultivars such as 'Tommy Atkins' and 'Keitt'. The rootstock enhances vigor and productivity. 'Hilacha' is available throughout Colombia almost year-round, and it is adapted to different growing conditions and areas. (Ledesma, 2016). The harvesting period for 'Hilacha' in Colombia has two seasons. The first and the main harvest is from April to August and the second is from November to January. In the Caribbean region, the harvest period has a great advantage with the greatest production being when there is no other mango for the international market (Ledesma, 2016).

'Hilacha' has small fruit with a low percentage of pulp; it is susceptible to diseases and phytosanitary problems (García et al, 2010). Other cultivars, such as 'Sugar', can be included in small quantities when processing to increase color and flavor.

The demand for pulp is growing, with emphasis on the organic market. Mango processing industries in Colombia require cultivars that are adapted to different climates and conditions and are able to extend the season to provide the international market with fresh product. The introduction of new mango cultivars with desirable characteristics for the mango pulp industry can

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be the answer. This study evaluated ten mango cultivars with potential for this market. Cultivars selected for the study are: 'Maklet', 'Fairchild', 'Espada', 'Bullock's Heart', 'Totapuri', 'Zebda', 'Mallika', 'Panchadarakalasa', 'Royal Special', and 'Tong Dam'. This study of the morphological characterization of new mango cultivars allows for detailed descriptions and obtains basic information of these varieties.

'Maklet' originates from Africa. Ghana produces this cultivar for local consumption and for the production of juices and mango pulp. It is a medium-sized, productive tree. Flowers and fruit post-harvest are resistant to anthracnose. The fruit weighs approximately 380 g and has a greenish-color that ripens to slightly yellow. The pulp is orange-yellow, with some fiber and a good taste (Ledesma, 2018).

'Fairchild' was selected at the beginning of the 1900s in the Panama Canal Zone. The fruits are small, weighing an average of 240 g. They are oblong with a flattened base. The fruits are green to lemon-yellow, with a thin, soft skin and an intense orange pulp. The taste is rich, aromatic and exotic. The tree and fruit are highly tolerant to disease, fruiting very well under rainy conditions and high humidity, making it optimal for production in humid tropical areas. The growth habit of the tree is compact and small (Campbell et al., 2002).

'Espada' is of Brazilian origin. The tree is vigorous and dense and very productive. The fruit is elongated and medium-sized with greenish skin. When mature, it has a slightly yellowish color. The skin is soft and thick, with orange-yellow pulp and quite aromatic fiber. It is also used as a rootstock. The seed is oblong with a thick crust and enough fiber. (Ledesma, 2018).

'Bullock's Heart' was selected in Egypt, where it is a medium-important cultivar for the production of juices. The tree is small with a round shape. The fruit is rounded with pale green skin that turns yellow when fully ripe. It weighs 390 g and has very juicy orange yellow pulp with no fiber. The fruit harvest season is early. It is resistant to anthracnose. (Ledesma, 2018)

'Totapuri' is originally from India and is also known as 'Bangalora' or 'Sandersha'. The tree is vigorous with large fruit (1100 g), which are long and large with sharply tapering shoulders and thick, adherent skin. The pulp is firm and juicy, somewhat fragrant with little fiber. It is a fruit used in India for the juice, chutney and sauce industries. The seed is thin and monoembryonic. It is very productive and consistent. The fruit is susceptible to changes in moisture and may exhibit stress cracking. (Ledesma, 2018)

'Zebda' was selected in Egypt, where it is very important for local consumption. The tree is vigorous and productive with consistent production. The fruit is large (660 g), flattened and green-colored even when ripe. It has a soft skin with very visible lenticels. It is resistant to anthracnose. The pulp is fiber-free, very sweet and juicy. The seeds are polyembryonic, small (50 g). It is a late season variety. (Ledesma, 2018)

'Mallika' is among the best of the new generation of Indian mangos. The tree is small, which makes it very attractive for domestic and commercial growers. The fruit is bright yellow, averages 425 g when mature. It has a deep orange color, a very sweet, pleasant flavor and is highly aromatic. The fruit of 'Mallika' must be harvested when physiologically ripe before it changes its color. It can be stored without refrigeration at a temperature below 21°C for two or three weeks to mature properly. (Campbell et al., 2002)

'Panchadarakalasa' is of Indian origin and is a vigorous open and dense tree. The fruit is medium sized (300 g) with a yellow skin. The pulp is orange-yellow, very juicy, sweet and good tast-

ing, without fiber. In India it is used for juice production. The harvest season is intermediate (Ledesma, 2018).

'Royal Special' is of Indian origin, selected for its high productivity and tolerance to different microclimates. The fruit is round with a cavity at the base of the peduncle. It weighs 280 g and has a soft, regular yellow-colored shell when ripe. It sometimes has a reddish blush if exposed to the sun. Its pulp is orange-yellow with a good taste and fiber. It is used in the preparation of chutneys and sauces. It tends to produce fruit outside the main season and is tolerant to anthracnose (Ledesma, 2018).

'Tong Dam' is an ancient Thai cultivar with multiple uses, suitable for use at both the green stage and when fully ripe. It is used in the preparation of chutney. The fruits are 397 to 510 g, and are long and slender. 'Tong Dam' is an early season variety. It is best to eat the fruit while the meat remains firm, as the fruit is soft when fully ripe (Campbell et al., 2002).

Materials and Methods

The study was conducted on ten commercial varieties of mango (*Mangifera indica* L.) with potential for the Colombian mango industry. The varieties selected for the study were: 'Miklet', 'Fairchild', 'Espada', 'Bullock's Heart', 'Totapuri', 'Zebda', 'Mallika', 'Panchadarakalasa', 'Royal Special', and 'Tong Dam'. The selection of the varieties was based on mango sections already used for the pulp industry in India, Egypt, and others countries. The evaluations took place at the germplasm bank of Fairchild Tropical Botanical Garden, located in Homestead, FL. This farm is located at geographic coordinates: 25°32'12.91" north and 80°25'55.17" west. The area is classified as a sub-tropical wet forest according to the Holdridge life zones, and is about three feet above sea level.

The collection is composed of a single tree per cultivar, with an average age of 12 years old. Trees are grafted on 'Turpentine' rootstock. Trees have been hand pruned every year after harvest. Fertilization and disease control are with very low input of chemicals. No irrigation is applied.

The evaluations are based on a wide range of descriptors both qualitative and quantitative, including characteristics of the tree and the fruit. The study follows standards for mango by the International Plant Genetic Resources Institute (IPGRI) and the United States Department of Agriculture (USDA).

Descriptors utilized

- Tree—fruit crop, growth of the tree, type of tree, leaves, severity of anthracnose.
- Fruit—size (length, width, and thickness), weight; shape, surface, base, peduncle, cavity, appendix and beak.
- Epidermis of the fruit—detachment of the epidermis, texture, color of the base of the epidermis, lenticels, fruit blush and the percentage of anthracnose in the post-harvest period.
- Seed—form, size, weight, texture and number of embryos.
- Pulp—texture, color, flavor, °Brix, aroma, and fiber. This parameter was calculated by means of a formula described as follows:

1. WT = total weight of the fruit.
2. WS = seed weight.
3. WE = epidermis weight.

Pulp color, and epidermis color were evaluated with the Royal Horticultural Society (RHS) Color Chart.

Table 1. Relevant characteristics of selected mango cultivar fruit for pulp processing.

Cultivar	Pulp (%)	Flesh color	Fiber (%)	°Brix	Fruit wt. (g)	Anthrachnose susceptibility	Seed wt. (g)
Bullock's Heart	75.96	Yellow-Orange	10	15	235	5% slight	17.9
Espada	42.83	Yellow-Orange	38	16	240	75% Very severe	31.5
Fairchild	69.41	Yellow-Orange	10	17	204	1% No disease	27.4
Hilacha	44.94	Yellow	38	17	170	5% slight	29 \
Mallika	81.25	Yellow-Orange	10	16	400	1% No disease	20.7
Miklet	76.54	Yellow-Orange	10	14	379	9% Moderate	36
Panchadarakalasa	75.67	Yellow-Orange	10	15	356	1% No disease	36.5
Royal Special	49.22	Yellow-Orange	25	16	128	9% Moderate	18.9
Tong Dam	73.45	Yellow-Orange	10	21	284	5% slight	32
Totapuri	63.14	Yellow-Orange	25	13	447	9% Moderate	38.9
Zebda	58.96	Orange	25	13	318	1% No disease	36

SUSCEPTIBILITY OF ANTHRACNOSE. Based on the anthracnose scale, using percentage of areas affected with necrotic spots.

EXPERIMENTAL DESIGN. was random sampling with ten repetitions per cultivar from one single tree.

SAMPLES. The fruits were harvested when they reached their physiological maturity based on the weight of the fruit, shoulder development and color characteristics. Fruits were stored at room temperature (75° F) to desired ripeness. Evaluations were made when fruits reach the desired maturity state for processing (80%). Additional digital photographs of fruits were taken for further analysis. Qualitative and quantitative descriptions have been used as well.

Results and Discussion

The results are preliminary and include data for years 2017 and 2018. Anthracnose susceptibility in the fruit is an important criterion for the production of organic mango pulp. 'Espada' is the most sensitive to anthracnose with 70% of fruit affected. Cultivars 'Mallika', 'Fairchild', 'Panchadarakalasa' and 'Zebda' are the most resistant with 1% affected (Table 1).

Fiber percentage is very high in 'Hilacha', which has an efficiency of 45% pulp based on total weight. 'Hilacha' also has a large seed compared to its total weight. The aim of this study is to increase efficiency since transportation and waste increase the cost of production of mango pulp.

The growth of the mango pulp industry is increasing. Efficiency in the production of mango pulp is affected by the percentage of residues such as the skin or epidermis of the fruit, the weight of the seed and the fiber content. Reports show amounts of mango pulp residues ranging from 10% to 40%.

Mango fiber also can have commercial applications. Fiber has the potential to be used in the mango juice industry. This fiber is rich in natural bioactive compounds that play an important role in the prevention of diseases. Studies have used dried mango pulp fiber to replace wheat flour. Evaluations of the physical, sensory and bioactive components show promising results for the baking industry (Lakshminarayan, 2015). This fiber percentage parameter was used as a reference to estimate percent fiber in the evaluated cultivars.

Fiber content of 'Hilacha' is very high at 38% compared with the other mango cultivars evaluated, except for 'Espada' which has the same amount. 'Totopuri' and 'Royal Special' follow and

Table 2. Fruit season and yield of selected mango cultivars.

Cultivar	Harvest time	Yield (# fruit/tree)
Bullock's Heart	June	70
Espada	June	75
Fairchild	July	70
Hilacha	July	40
Mallika	June	70
Miklet	May	76
Panchadarakalasa	June	50
Royal Special	June	52
Tong Dam	May	73
Totapuri	July	49
Zebda	June	20

the ones with the least fiber are 'Mallika', 'Zebda', 'Tong Dam', 'Miklet', 'Fairchild', 'Bullock's Heart', and 'Panchadarakalasa'.

From the mango cultivar study, are all more efficient in terms of percent pulp than 'Hilacha'. The most efficient are 'Mallika' with 81.25%; 'Miklet' with 76.54%; Bullock's Heart with 75.96%; and Panchadarakalasa with 75.67%.

Brix and color are the most important qualities for mango pulp. Orange and deep yellow pulp are most appealing colors for the market. All the evaluated cultivars have good color. 'Tong Dam' has the highest Brix levels with an average of 21. 'Mallika', 'Espada', and 'Royal Special' have an average of 16 °Brix.

Anthrachnose control can be a challenge especially for organic production. Resistant varieties can be a solution. 'Mallika', 'Fairchild', 'Zebda' and 'Panchadaracalasa' were the least susceptible to the disease.

Season was estimated under production conditions in South Florida. This can change in different latitudes and growing conditions, but serves as a reference for future studies and the introduction of these cultivars to Colombia. (Table 2.) 'Ton Dam' and 'Miklet' have the earliest season. Fruit yield was evaluated under Fairchild Farm growing conditions, and corresponds to the number of fruit per tree (Table 2.). The most productive were 'Espada' and 'Tong Dam'. Studies in situ are necessary to stablish the adaptability and productivity of these cultivars under different Colombian regions and conditions. The utilization of different

rootstocks also can affect the productivity of these cultivars. A field test must be designed and evaluated for further results.

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