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Quality attributes of FHIA hybrids fruit (*Musa*) on three harvest cycles

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Abstract

As an alternative of Musaceae production tolerant to Sigatoka Negra (*Mycosphaerella fijiensis* Morelet) fruit of FHIA 01, 02, 03, 17 and 23 varieties of field plants on testing grounds of Centro Nacional de Investigaciones Agropecuarias (CENIAP) *Maracay*, Venezuela (10º13' N and 67º37 W) has been analyzed. The quality of the physiological and organoleptic maturity was determined by three consecutive production cycles. For the sample were chosen three middle bananas from: the second hand of the first third, half of the mid third and the next to the last hand of last third of the bunch, were selected. The weight of the bananas, density, external and internal length, perimeter, diameter, pulp and peel thickness, color, firmness, starch and carotenoid concentration, total soluble solids (TSS) and pH, were determined. The results showed that FHIA 03 (cooking banana) expressed the best fruit quality. FHIA 01 and 02 (dessert banana) presented minor size and weight, and pH that allow a taste lightly acid. FHIA 17 and 23 (dessert banana) presented the minor attributes of appearance, although FHIA 23 could possibly be consumed when peel has green color traces. In organoleptic maturity all the varieties presented soft pulp, weight loss between 10.73% (FHIA 03) and 21.46% (FHIA 23) and carotenoid concentration in the peel between 20 $mg.100g^{-1}$ (FHIA 17) and 54 $mg.100g^{-1}$ (FHIA 03).

Key words: Banana; quality; ripening; FHIA varieties

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Introduction

Edible musaceae are located as the first fruiticulture item in Venezuela. It is a versatile crop that can be consumed fresh or cooked; it can be presented in the diet of a person in different ways, proportioning important quantities of essential nutrients, such as, carbohydrates and minerals like potassium, besides, fiber, whose benefits are more and more important as time pass (15).

Since Sigatoka Negra (*Mycosphaerella fijiensis* Morelet) got into the country, producers have had the necessity to apply different combinations of chemical products to avoid this fungus to cause any harm to crops and can provoke the total loss of the plantation. This management, a little exaggerated and expensive, has motivated the proposal of projects of investigation direct to improve the natural resistance to Sigatoka Negra. About this, since 1985 the CIID (Centro Internacional de Investigación para el Desarrollo), has sponsored investigation projects in Honduras (Fundación Hondureña de Investigación Agrícola), towards the improvement of the natural resistance to Sigatoka Negra in bananas of all sizes and from medium and small agricultures, for local consume or to export (22).

In such way, through programs of genetic improvement, the production of new hybrids has been possible with desirable agronomic characteristics that have to be evaluated according to post-harvest quality, under different agroecological conditions of the national productive zones.

Until today, the industry of banana for exportation is limited because it depends on a genetic base extremely small. "Cavendish" variety is, at the moment, the only, widely, available for this market and presents a high susceptibility towards Sigatoka Negra and other important sicknesses (22).

The presence of new hybrids and varieties potentially commercial, tolerant to fitosanitary problems, demand certain adaptation of the post-harvest system referent to topics such as, post-harvest values, conditions and storage temperatures, transport and conditions of ripening, duration, organoleptic characteristics and optimal maturation to consume (22, 23).

Ripening processes of banana initiate when the fruit is still stick to the plant but in those circumstances cannot be fulfilled "normally" (24), thus, it is important to determine what happens physiologically after the hands are harvested and, like this, obtain quality standards proper for clones. This kind of information will led the application of pre and post-harvest management's techniques, more appropriate to obtain the best quality and conservation of fruits.

There are precious characterizations of hybrids FHIA (11) and some references of management, like Monalisa case or FHIA 02 (22), which need to be checked under different agroecological conditions of the different productive zones.

Therefore, to guarantee the best quality to the market in these products, it is necessary to know the physiological behavior of the fruit and the influence of the pre-harvest factors over post-harvest characteristics of fruits.

Materials and methods

Obtaining the Fruits

The used fruits for this trial were harvested in an established plantation of clones of FHIA 01, 02, 03, 17 and 23 in the experimental field of the CENIAP (Centro Nacional de Investigaciones Agropecuarias) *Maracay, Aragua* State, in a *Fluventic Haplustolls* soil, at 445 msnm, with the following coordinates: 10º13' LN and 67º37' LO; and in a zone classified as subhumid dry tropical forest (8) with an annual precipitation of 1100 mm approx., the average temperature is of 24.5°C and an annual evaporation of 1750 m approx.

The hands recollection began when the beards of the fruits got softer. Once harvested, the second hand of the first third, half of the mid third and the next to the last hand of last third of the bunch were selected. These hands were transferred to the post-harvest lab of the CENIAP, where were chosen two mid hands of each one of the previously separated by hand. Corresponding analyses of physiologic maturation were performed to the half of the sample, the other half was conserved under environmental conditions in the lab (26ºC± 2 y 60-65% RH) until reaching maturation to consume, when they were analyzed.

Variables

The methods to evaluate quality in bananas can be destructive or not destructive, depending on the studied variables (table 1). These include objective scales based on reading of instruments and subjective methods based on human judgments, using hedonic scales (14).

The evaluation of parameters of quality was carried out according to the suggested methodology by the International Network for the Improvement of Banana and Plantain (INIBAP) (6).

The weight of the bananas (W) was measured with an electronic precision scale with upper tray, model Sartorius 1213 MP. The volume (V) was obtained by direct water displacement when placing the fruits in a container previously evened. The specific gravity or density (GD) was calculated with the relation W/V. The external length (EL) came out measuring the exterior curve of the banana with a metric tape measure, since the distal point to the proximal, where is considered that the pulp ends.

The internal length (IL) was obtained measuring the internal curve following the same consideration as the EL. The perimeter (Pe) was obtained measuring the circumference in the middle part of the fruit. The peel thickness (PT1) and pulp thickness (PT2) were measured in the middle

Table 1. Measured variables in physiologic and organoleptic maturation of clones FHIA (*Musa*).

Physiologic Maturation Variables	Organoleptic Maturation Variables
Number and bananas weight (g)	Weight of bananas (g)
Density(g.mL^{-1})	Densidad (g.mL^{-1})
External and internal Length (cm)	External and internal Length (cm)
Perimeter y diameter (cm)	Perimeter y diameter (cm)
Thickness of pulp y peel (mm)	Thickness of pulp y peel (mm)
Color of peel	Color of peel
Firmness (mm)	Firmness (mm)
Content of starch (%)	Content of total soluble solids (%)
	pH
	Content of starch (%)
	Content of carotenoids (mg.100mL^{-1})

part of the banana without the peel, using a vernier. The diameter (D) came out summing PT1+PT2. The color of the peel (CP) was established according to a color table for bananas (figure 1). The firmness was measured by the covered distance of the penetrometer (Universal N° 73510) in the middle part of the fruit. The content of total soluble solids (TSS) was determined macerating from 20 to 30 g of pulp of the middle part of the fruits and reading a table refractometer ABBE-3L (1). The determination of pH was made from a macerated pulp solution and distilled water, read with a pHmeter Hanna-H18519.

The content of starch was determined with samples of the middle part of frits to physiologic and organoleptic maturity, previously dried in a stove at ± 80ºC (18). The content of carotenoids was determined in 100 g of fresh peel tissue, for fruits that were ready to consume (17).

Experimental Design, Sample Selections and Statistical Analysis

Evaluations were carried out in three consecutive years and the experimental design was at total random with arrangement in divided parcels and four replications.

The experimental unit consisted of six bananas from every one of the three selected hands for each maturity level. The bananas for the organoleptic evaluation in quality, were maintained at room temperature ((28±2ºC and around 68% RH) and the fruit was evaluated again when it was turning yellow or soft when touching.

The statistical process of data was made with the statistical program SAS version 8 (21) and consisted of: variance analysis by procedure GLM, comparing tests of means during Tukey test, correlation analysis and main components.

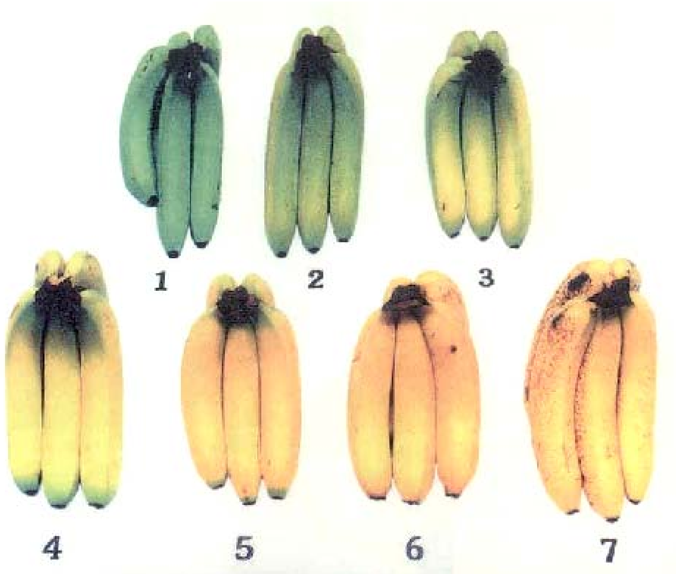

Figure 1. Table of colors for bananas (taken from Dadzie and Orchard, 1996).

Results and discussion

Physical Variables

Fruits Weight

For the variable fruit weight in physiologic maturity, three well-defined groups were formed. Fruits from FHIA 03 presented higher weight (peso (139.73 g.banana^{-1}) and were consistent during the three years, FHIA 17 and 02 with average weights of 115 and 108.67 g.banana^{-1}, respectively and fruits of minor weight that corresponded to FHIA 01 and 23 with 97.41 and 95.16 g.banana^{-1}, respectively (table 1). The weight of FHIA 03 and 02, coincided to obtained values of trials in Honduras, where for the first group were found weights between 125 and 140 g and 90 and 150 g for the second one, on the contrary for FHIA 01, for which it was obtained values between 150 and 240 g (7), which are over the ones obtained in this research; which could have been attributed to agroclimatic differences or to the management of the crop, but these causes are not mentioned in the trial.

To obtain a higher weight in fruits, it is important to know that in general terms the fruit growth provoke by multiplication of cellules is in a range of -20 to -30 days after the emergency of shoots (AES), and the length fill up from 30 to 85 days AES (13).

For organoleptic maturity the order of steps was followed (table 3), but when talking about the obtained loss between both levels of maturity, was higher in clone of fruits FHIA 23, with 21.46% and lower in FHIA 03, with a significant 10.73%, it means that the fruits with minor weight had higher losses than those with higher weight. Between banana clones, excepting FHIA 23, the loss was related to the initial weight, being higher in FHIA 17 (17.15%) and lower in FHIA 01 (13.97%). Fruit weight losses are possibly due to the interchange of gasses, to the process of respiration and the loss of water vapor (9). This could have been intensifies by environmental conditions in the lab, where high temperatures were registered and low relative humidity during the time the fruits were there (28 ± 2ºC and around 68% RH).

The peel of the banana contains stomas and these continue transpiring after the hand is cut down. The magnitude of transpiration depends on the temperature and the relative humidity. As a tendency, however, it shows a noticeable relation with ripening: the green fruit, immediately after cut down, shows a low initial transpiration intensity and then it stabilizes in a continuous level that depends on the temperature and humidity; in the climate room occurs a drastic increase and then, as the fruit ripens, a new constant state is followed, that in the curve of respiration, is a little bit higher than the pre-climacteric level (24).

Through transpiration, fruits lose water to the environment, as a mechanism of thermal regulation, among others, but being stick to the plant, this provides the fruit with water again, without showing any characteristic of deterioration of fruits. After the harvest, fruits continue transpiring; this brings as a consequence the loss of fresh weight that can be significant if the harvested fruits are not placed in adequate storage conditions (10). In trials, where weight loss has been studied in maturation under different conditions of relative humidity (RH), losses have been obtained by <2% under 95% RH and >14% with 30-40% RH and constant temperatures of 17°C, in a period of 15 days in banana fruits (*Musa* sp. Group AAA) (4).

On average, there is a final increase in the loss of water, which is related to degenerative changes of the peel caused by fungus; peel is gets old and this change cannot be attributed to transpiration (24). About this, it was found that the thicker the peel, the lesser the loss of weight (FHIA 03) and if the peel is thinner the loss is bigger (FHIA 23), which permit to think that, initially, the peel (physiologic maturity) could have represented a barrier against the accelerated loss of weight.

Length of Bananas

Length of bananas is not a differential parameter between the clones, excepting FHIA 23 that tended to show the minor length (13.16 cm) at the moment of the harvest; in their own way, FHIA 03 and FHIA 17 presented the biggest length with average values during the three cycles of 15.19 and 15.12 cm, respectively. Intermediate lengths were from FHIA 02 with 14.43 cm and FHIA 01 with 14.17 cm (table 2). It's been reported that FHIA 03 may show lengths between 15 and 18 cm, whereas FHIA 01 and FHIA 02values between 18 to 23 cm and 17 to 21 cm, respectively (7), this indicates that FHIA 03, under conditions of this trial, shows similar values of length to those presented by other investigators, being different for FHIA 01 and FHIA 02. In evaluations in Costa Rica, FHIA 01 reached length values between 18 and 26.7 cm, whereas FHIA 02 between the ranges of 20.5 and 21.8 cm, under organic and inorganic management conditions, respectively (16).

Diameter

The diameter of the fruit is directly proportional to its perimeter (R=0.956; P<0.0001). In this sense, FHIA 03 presented the highest value to the harvest (38.33 mm) and FHIA 23 the lowest value (30.76 mm), FHIA 02, 17 and 01 presented diameters of 33.00; 31.80 and 30.92 mm, respectively (table 2).

About organoleptic maturation, it was observed a decrease of diameter for every variety (table 3), which is directly proportional to the loss of thickness of the pulp (R=0.872; P<0.0001).

Perimeter

For this variable three groups were differentiated: FHIA 03 (14.22 cm), FHIA 02, 17 and 01 (12.33; 11.86 and 11.80 cm, respectively) and FHIA 23 (11.46 cm) (table 2). Perimeters of FHIA 01 and 02 coincided with other evaluations to these clones, while in the case of FHIA 03, during this trial, values were slightly higher than the reported (12 to 14 cm) (7). Subsequently, in organoleptic maturity, the perimeter tended to diminish proportionally to the values of the perimeter found for physiologic maturity in the different clones (table 3).

Firmness

Firmness is considered as the response to pressure against the fruit, and is directly related to the development of an adequate post-harvest management of the product, which brings the necessity to know the particular behavior of the pattern and the intensity of softness during maturation of diverse cultivars inside the fruiticultural group. Thus, its determination is important to evaluate the susceptibility of fruits towards physical or mechanical damages during the post-harvest management (6).

Firmness did not present significant differences between the clones during physiological maturity, obtaining penetration values of 1.70 and 2.04 mm (table 2). However, during the organoleptic maturity, fruits of FHIA 03 presented softer pulps (10.42 mm), followed by FHIA 17, 02 and 23 with 9.1 mm; 8.61mm and 8.45 mm, respectively, which presented intermediate firmness; and finally FHIA 01 presented fruits with higher values (7.62 mm) (table 3).

It was observed an inversely proportional correlation (R= -0.806; P<0.0001) between the peel thickness and mm of penetration of the pulp, denoting higher firmness in fruits, which can be explained with a more resistant peel to the loss of water, and as a result, maintenance of the turgidity in fruits.

The texture of dessert and

Table 2. Physiologic Maturity. Physical parameters of quality and content of starch in clones FHIA (*Musa*) for three production cycles.

Variety	Weight (g)	Density ($g.mL^{-1}$)	External length (cm)	Perimater (cm)	Diameter (mm)	Thickness peel (mm)	Thickness pulp (mm)	Firmness (mm)	Starch (%)
FHIA 01	97.41^{c*}	1.012^{a}	14.17^{b}	11.80^{bc}	30.92^{bc}	3.12^{b}	27.83^{b}	1.77^{a}	67.24^{ab}
FHIA 02	108.67^{bc}	1.018^{a}	14.43^{ab}	12.33^{b}	33.00^{b}	3.13^{b}	29.88^{b}	1.70^{a}	63.85^{ab}
FHIA 03	139.73^{a}	1.041^{a}	15.19^{a}	14.22^{a}	38.33^{a}	3.45^{a}	34.90^{a}	2.04^{a}	74.48^{a}
FHIA 17	115.00^{b}	1.047^{a}	15.12^{a}	11.86^{bc}	31.80^{bc}	2.75^{c}	29.05^{b}	1.90^{a}	58.05^{b}
FHIA 23	95.16^{c}	1.022^{a}	13.16^{c}	11.46^{c}	30.76^{c}	2.7^{c}	28.06^{b}	1.76^{a}	56.18^{b}
Value P	0.001	0.376	0.001	0.001	0.001	0.001	0.001	0.028	0.017
CV	12.77	4.82	4.43	4.43	5.35	7.09	5.85	17.20	19.94
R^2	0.77	0.54	0.79	0.87	0.85	0.76	0.83	0.65	0.59
DSH	17.32	0.06	0.78	0.67	2.16	0.26	2.14	0.38	15.65

*Letters in the same column indicate significant differences (Tukey α=0,05)

Value P= Probability; VC= Variation Coefficient; R^2= Variante explained by the model; HSD= Honest Significant Difference

Table 3. Organoleptic Maturity. Physical parameters of quality and content of starch in clones FHIA (*Musa*) for three production cycles.

Variety	Weight (g)	Density (g.mL^{-1})	External length (cm)	Perimater (cm)	Diameter (mm)	Thickness peel (mm)	Thickness pulp (mm)	Firmness (mm)	Starch (%)
FHIA 01	84.03^{bc*}	0.96^{b}	13.62^{bc}	10.93^{bc}	29.63^{bc}	1.34^{a}	28.30^{bc}	7.62^{c}	2.61^{b}
FHIA 02	92.90^{b}	0.98^{ab}	14.12^{ab}	11.44^{b}	31.20^{b}	1.29^{a}	29.90^{b}	8.61^{b}	3.98^{b}
FHIA 03	125.36^{a}	0.99^{ab}	14.49^{ab}	13.26^{a}	34.43^{a}	1.33^{a}	33.11^{a}	10.42^{a}	8.68^{a}
FHIA 17	96.25^{b}	1.02^{a}	14.63^{a}	10.81^{bc}	29.80^{bc}	1.47^{a}	28.34^{bc}	9.10^{b}	2.37^{b}
FHIA 23	74.96^{c}	1.00^{ab}	12.86^{c}	10.35^{c}	27.94^{c}	1.07^{a}	26.85^{c}	8.45^{bc}	3.47^{b}
Value P	0.001	0.076	0.001	0.001	0.001	0.580	0.001	0.001	0.001
CV	14.88	4.66	5.22	6.04	6.46	35.23	6.73	8.75	5.071
R^2	0.81	0.56	0.66	0.84	0.80	0.77	0.77	0.80	0.85
DSH	17.20	0.06	0.89	0.84	2.42	0.56	2.41	0.94	3.14

*Letters in the same column indicate significant differences (Tukey α=0,05)
Value P= Probability; VC= Variation Coefficient; R^2= Variante explained by the model; HSD= Honest Significant Difference

cooking bananas is a n attribute that results from the combination of diverse factors, such as, the turgidity by water and the structural components of tissues and cellules.

Density

Clones did not present density differences in the physiologic maturity, finding values slightly over 1 (table 2); however, in the organoleptic maturity, the FHIA 01 had less density (0.96 $g.mL^{-1}$) and the FHIA 17 higher value (1.02 $g.mL^{-1}$) (table 3). The importance of this value is its relation with the capacity of storage of fruits towards harvest maturation level.

At the beginning of the development of fruits, the value of volume is slightly superior to the value of fresh weight of fruits, keeping this tendency until the days near to the physiological maturation, when the fresh weight of fruits is slightly superior to the volume, since the increase of the accumulation of soluble solids (10).

It is consider that the fruits with less quantity of soluble solids will have lower specific gravity and will float in a recipient filled with water and will be considered as immature. Fruits that sink Hill have a higher specific gravity, which can be a practical way even though not very precise, to determine the fruits that have not reached the physiological maturity (10).

In the case of bananas, values for fruits in physiologic maturity have been reported: 1.014 $g.mL^{-1}$; and then in organoleptic maturity of 1.084 $g.mL^{-1}$ (10).

Peel and Pulp Thickness

Bigger differences were observed between the peel thickness of clones than in their pulp thickness for the physiological maturity, happening the contrary for the consume maturity, where the pulp thickness presented more differences between clones than when they were harvested. In this order of ideas, FHIA 03 presented the thickest peel (3.45 mm) at the moment of the harvest and FHIA 23 the thinnest (2.70 mm) (table 2). In organileptic maturity the thickness of peels did not present significant differences between clones and the values were around 1.07 mm and 1.47 mm (table 3). All these values are under the found in the bibliography, which oscillated for FHIA 03 between 4.0 and 4.5 mm, for FHIA 01 between 3.0 and 3.8 mm and for FHIA 02 between 2.5 and 3.0 mm (7).

About pulp thickness, in physiologic maturity, FHIA 03 presented average values of 34.90 mm, being the highest with marked differences with the other clones whose values of pulp thickness were between 27.83 and 29.88 mm (table 2). These parameters coincided with the reported in other evaluations (7); including the tendency of FHIA 03 presenting a thicker pulp than the other clones. However, when comparing found values in physiologic maturity with the values in organoleptic maturity, it was observed that the tendency of FHIA 03 and FHIA 23 is to lose pulp thickness, with 33.11 mm and 26.85 mm (table 3), respectively, given that this variable did not have, practically, any changes for the other clones.

The sugar increases faster in the pulp than in the peel; this difference is showed in a differential change of the osmotic pressure. The consequence is that the pulp extracts water from the peel and a proportional change in weight occurs (24). Measurements of the osmotic pressure, in several parts of the banana hand, showed that this pressure was noticeable constant in parts of the hand where bananas were not mature and that maturation was related to determine degrees of osmotic pressure that tended to provoke the movement of water, from the trunk to the fruit and, inside it, from the peel to the pulp (24). During normal maturation, the peel of bananas loses water to the environment and to the pulp (25).

Hence, the tendency of the watery content of the pulp in a mature banana, is a resultant of, at least, four procedures: *transpiration, hydrolysis* of the starch, that tend to diminish the watery content; penetration of water by *osmosis* from peel to trunk; and water production through *respiration,* that tend to augment it.

These procedures are predominant and the net result is translated in a slight increase, as the fruit grows and goes through the green state to the full maturity, fluctuating the values in five clones of 63-74% to 68-77% (24).

The high proportion of peel according to the weight of the fruit oscillate from 80% for green fruits, 40% for physiologically mature fruits and 33 % for mature fruits, without any doubt, it illustrates the significant contribution of the peel to the total metabolism of banana fruit (19).

Color of the peel

All fruits were harvested with green peels (1 in the table of color) (figure 1) and then analyzed in organoleptic maturity, when the fruit began to lose firmness. According to this appreciation, not every fruit reached the total yellow color (6 in the table of color) (figure 1), on the contrary, there were more clones with green peel. In this sense, FHIA 03, 02 and 01 presented the yellow color more even (6.42; 6.16 and 6.09, respectively) and FHIA 23 and 17 the presence of green lines in its final color (5.41 and 5.28, respectively) (table 4).

There are reports where bright yellow color could be difficult to reach when plantations of banana have been produced in conditions of nutritional unbalance (5).

Chemical Variables

Starch Content

Histological studies in *Musa* spp. AAA group "Gros Michel", showed that the synthesis of starch begins around the forth week AES (20).

When banana fruits are harvested in the physiological maturity, they have approx. from 20 to 25% of starch, which is hydrolyzed almost totally during organoleptic maturation to be transformed in soluble sugars, mainly sucrose, glucose and fructose (10). During this period, fruits lose firmness too, which was represented in this trial in a negative correlation between starch and the mm of penetration in the fruit ($R = -0.892$; $P < 0.0001$).

Table 4. Organoleptic Maturation. Chemical parameters of quality and color of the peel of clones FHIA (Musa) for three production cycles.

Variety	SST (°Brix)	pH	Color of peel	Carotenoids in peel ($mg.100mL^{-1}$)
FHIA 01	21.13[b*]	4.57[b]	6.09[abc]	26[b]
FHIA 02	21.23[ab]	4.65[b]	6.16[ab]	23[b]
FHIA 03	22.40[a]	4.34[c]	6.42[a]	54[a]
FHIA 17	18.04[c]	4.96[a]	5.28[c]	20[b]
FHIA 23	17.39[c]	5.00[a]	5.41[bc]	48[a]
Value P	0.001	0.001	0.001	0.001
CV	5.12	3.72	11.59	28.94
R^2	0.88	0.82	0.69	0.92
DSH	1.26	0.21	0.84	20

*Letters in the same column indicate significant differences (Tukey α=0,05)
Value P= Probability; VC= Variation Coefficient; R^2= Variante explained by the model; HSD= Honest Significant Difference

The content of starch diminishes from 20% in the green fruit and 1-2% in the ripe fruit; its proportion is higher for the ripe cooking banana (approx. 6%) than for banana fruit (24).

After evaluating the contents of starch during the three cycles of production of the clones FHIA in physiologic maturity, it was observed a tendency of FHIA 03 to maintain high concentrations of this carbohydrate in the fruit, but without significant differences between clones (table 2), however, when fruits pass to organoleptic maturation, it was observed an evident difference between cooking fruits and (FHIA 03) with residual contents of starch around 8.68%; whereas the rest of the dessert bananas presented concentrations of 3.98 and 2.37% for FHIA 01 and FHIA 23, respectively; without significant differences between these last ones (table 3).

Total Soluble Solids (TSS)

Most of ripe fruits, including cooking and dessert bananas, sugars are the main components of the soluble solids. The TSS are important postharvest attributes in the evaluation of new hybrids of bananas, and can be used as clue of ripening (6).

When fruits are yellow, the concentrations of TSS are higher; this is important to select materials to industrialize (2).

The content of sugars as the major component of TSS in organoleptic maturity of studied clones was of 22.40% for FHIA 03, followed by 21.23 and 21.13% for FHIA 02 and FHIA 01, and at last 18.04 and 17.39% for FHIA 17 and FHIA 23, respectively (table 4). In this case, the clone with the highest genetic intervention was the specie *balbisiana* (bananas) presented the highest content of sugars.

Acidity and pH

About variety FHIA 01 or "Goldfinger", even though results of an opinion poll to Australians consumers were positive, the lack of interest by Canadian distributors and a flavor a little sour for American market, restricted the commerce of this variety in particular (22).

In pH measurements to fruits in this research, it was obtained the higher pH of pulp in FHIA 23 (5.00) and the lowest in FHIA 03 (4.34) (table 4), coinciding with reported values for ripe fruit of the varieties "Titiaro, Pineo, Gigante, Martinico, Pineo Enano, Martinico, Cuyaco, Manzano and Topocho Cenizo",where ranges were in the order of 4.11 and 5.20; corresponding these two with "Topocho cenizo and Pineo Enano", respectively (26).

It is important to mention that the lowest value of pH coincided with the one reported for the cooking variety "Topocho Cenizo", same with the FHIA 03 (table 4).

The acidity of the pulp, expressed in pH, after it reaches the maximum value, generally, a slight descend happens as maturation progresses. Diverse measurements of pH gave values between 5.0 and 5.8 for the pulp of the green fruit and between 4.2 and 4.8 for the post-climateric fruit (24). However, found values for dessert banana were different, being the acidity two times higher for the pulp in ripe bananas (24).

In this sense, Dr. Rowe from the FHIA affirms that hybrids developed from "Prata Ana" could replace the "Cavendish" variety, if the consumer accepts a slightly sour fruit (14). However, these references may vary depending on locations; this is why tasting is so important.

Experiences in London, demonstrate that the acceptability of tetraploid bananas varied considerably, even though the best clones were similar to "Cavendish" clones, such as, "Valery"; the results showed a higher preference towards sweet bananas; and lower preference to astringent and wood flavor bananas; whereas, acidity does not seem to be determinant for the consumer's preference (3).

Carotenoid Content

Sysnthesis or visual apparition of carotenoids during maturation of fruits may follow different patterns depending on the considered fruiticultural specie (10).

In the case of carotenoids, bright yellow color on the peel of fruits FHIA 03 is related to the highest content of carotenoids (54 mg.100 mL^{-1}) and the observed less bright color in FHIA 17 is related to the lowest content of carotenoids (20 mg.100mL^{-1}), however, it was FHIA 23 that presented the highest concentrations of carotenoids in spite of green color lines compared to the fruits of other clones that were yellower (table 4), therefore, it is necessary to remember that carotenoids might be present in adequate concentrations to express a bright color, but the presence of chlorophyll avoids this to become evident. Thus, it can be inferred that a physiologic disorder in the moment of maturation may interfere to obtain the best color in fruits.

Deficiencies in potassium may originate "premature yellow colors", which is directly related to the lack of leaves at the moment of maturation and to small, oblique and deform racemes (24).

Main Components Analysis

It is important to define interrelations between every component of quality of a product and correlate objective and subjective methods of evaluation of this quality. This information is essential for selecting new cultivars, to select optimal production procedures, define the optimal maturation of the harvest and identify the adequate post-harvest management procedures (14).

In this order of ideas, based on the obtained results in this trial, it was determined that the physique variables: fruit weight, perimeter, pulp thickness, diameter, internal and external length; explain approx. the 78% of the found variability between clones for physiologic maturity (table 5), and these, joined to firmness, explain the 75% for organoleptic maturity phase (table 6).

About chemical variables: the TSS, the pH and the content of carotenoids; highly explain (77%) the variability between clones for organoleptic maturity (table 7).

Table 5. Main components for physical variables in physiologic maturity in clones FHIA (*Musa*).

	MC1	MC2	Component	Eigenvalue	%Variance	% Accumulative
Weight of banana	0.946	-0.163	1	4.923	61.538	61.538
External Length	0.805	-0.296	2	1.348	16.850	78.333
Internal Length	0.513	-0.710	3	0.843	10.539	88.927
Perimeter	0.955	-0.241	4	0.550	6.879	95.806
Thickness of peel	0.605	0.403	5	0.264	3.303	99.109
Thickness of pulp	0.955	-0.154	6	0.055	0.682	99.791
Diameter	0.962	0.185	7	0.017	0.209	100.000
Density	-0.025	0.681	8	3.1×10^{-5}	3.8×10^{-4}	100.000
Firmness	0.174	0.153				

Table 6. Main components for physical variables in organoleptic maturity in clones FHIA (*Musa*).

	MC1	MC2	Component	Eigenvalue	%Variance	% Accumulative
Weight of banana	0.963	0.032	1	4.996	62.456	62.456
External Length	0.789	0.110	2	1.021	12.766	75.221
Internal Length	0.753	0.035	3	0.829	10.365	85.586
Perimeter	0.927	-0.035	4	0.705	8.818	94.404
Thickness of peel	0.467	0.376	5	0.294	3.681	98.085
Thickness of pulp	0.927	-0.133	6	0.121	1.512	99.597
Diameter	0.962	-0.041	7	0.032	0.402	99.999
Density	-0.135	0.919	8	$4.1x10^{-5}$	$5.1x10^{-4}$	100.000
Firmness	0.238	0.840				

Table 7. Main components for chemical variables in organoleptic maturity in clones FHIA (*Musa*).

	CP1	CP2	Component	Eigenvalue	%Variance	% Accumulative
Total Soluble Solids	0.885	0.077	1	2.046	51.160	51.160
Starch	0.693	0.066	2	1.038	25.938	77.099
pH	-0.880	0.230	3	0.678	16.947	94.046
Carotenoids	0.089	0.987	4	0.238	5.954	100.00

Conclusions

Physical Variables

Evaluated fruits from clones FHIA were classified in high, medium and low quality, at the moment to make comparisons between them and to take referential values of commercial similar varieties.

During the process to obtain data for three consecutive years of production, significant differences were observed between some variables of quality between the clones. FHIA 03 (cooking banana) presented the best parameters of quality regarding the following variables: weight, length of the banana, perimeter and pulp thickness; with the tendency of a higher potential of post-harvest conservation because it presents the thickest peel in physiologic maturation and the lowest loss of weight to reach the organoleptic maturation.

FHIAs 02 and 17 (dessert bananas) presented medium quality and FHIA 01 and 03 presented low quality, including fruits with the lowest weight and the smallest size.

FHIA 17 and 23 presented the less bright yellow color at the moment of maturation with a certain heterogeneity under environmental conditions referred for the trial.

Chemical Variables

FHIA 03 presented the highest cintent of starch in orgamoleptic maturity, proper of a cooking banana; being the final content of total soluble solids in fruits, directly proportional to the initial content of starch, finding the highest malue in FHIA 03 and the lowest in FHIA 17 and 23. The values of pH denoted the presence of slightly sour fruits to the taste buds, and about contents of carotenoids in fruits' peel, this was the highest in the variety that reached the brightest yellow color (FHIA 03), even thogh it could be in high contents (FHIA 03) hidden by residues of green color or the presence of chlorophyll as a consequence of maturation process disorders.

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