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PHYSICAL, CHEMICAL AND MORPHOLOGICAL CHARACTERISTICS OF BANANA CULTIVARS DEPENDING ON MATURATION STAGES[1]

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ABSTRACT – The objective of this work was to morphologically characterize 15 banana cultivars and assess the physical and chemical characteristics of their fruits at two maturation stages, unripe (pre-climacteric) and ripening. The plants were evaluated regarding their pseudostem height and diameter, petiole length, leaf blade length, width and length-to-width ratio. The cultivar *Ouro* had fruits with lower diameter, total length, market weight and fresh weight at both stages, and also firmer pulp when they were unripe. The cultivar *Caru-Roxa* had higher fresh fruit and pulp weights, and the cultivar *Terrinha* had the highest percentage of pulp dry weight percentage in unripe and ripe fruits. The cultivars *Maçã* and *Ouro* had higher pulp-to-peel ratio in unripe fruits. The ripe peels had lower fresh weight and thickness and higher dry weight percentage compared to unripe peels. The fruit peel of the cultivar *Marmelo* had the highest fresh weight at both stages. The cultivars *Marmelo* and *Maçã* had higher percentage of peel dry weight percentage at both stages. The unripe pulp had lower soluble solids. The titratable acidity in the pulp increased with ripening. The average plant height ranged from 2.25 to 6.15 m. The cultivars that had the largest pseudostem diameters had also the highest heights, except the *Prata-Anã* and *Prata-Graúda*. The cultivar and maturity stage influenced all the characteristics evaluated in fruits, except the total and market lengths, which did not vary with the ripening of fruits.

Keywords: *Musa* spp.. Physical and chemical characteristics. Agronomic characterization. Production.

CARACTERIZAÇÃO DE 15 CULTIVARES DE BANANEIRA EM DOIS ESTÁDIOS DE MATURAÇÃO EM FUNÇÃO DE ASPECTOS MORFOLÓGICOS, FÍSICOS E QUÍMICOS

RESUMO - Objetivou-se caracterizar morfologicamente 15 cultivares de bananeiras em dois estádios de maturação. Determinaram-se as características físicas e químicas dos frutos na fase pré-climatérica e após o amadurecimento. Também avaliou-se as plantas quanto a altura e diâmetro do pseudocaule, comprimento do pecíolo e do limbo, largura do limbo e relação comprimento/largura do limbo. A cultivar *Ouro* apresentou os frutos com menor diâmetro, comprimento total, comercial e massa fresca nos dois estádios, além da polpa mais firme quando verde. A cultivar *Caru-Roxa* apresentou maior massa fresca dos frutos e da polpa e a '*Terrinha*', a maior porcentagem de matéria seca nas polpas verde e madura. As cultivares *Maçã* e a *Ouro* proporcionaram maior relação polpa/casca na polpa verde. Houve redução da massa fresca e da espessura da casca e acréscimo da matéria seca da casca madura em relação à casca verde. A casca da '*Marmelo*' apresentou a maior massa fresca nos dois estádios. As cultivares *Marmelo* e a *Maçã* apresentaram maior porcentagem de matéria seca em ambos os estádios de maturação da casca. A polpa verde apresentou baixo teor de sólidos solúveis. Houve acréscimo na acidez titulável na polpa com o amadurecimento. A altura média das plantas variou de 2,25 a 6,15 m. As cultivares com maior diâmetro do pseudocaule foram também os mais altos, com exceção da '*Prata-Anã*' e da '*Prata-Graúda*'. A cultivar e o estádio de maturação influenciaram todas as características avaliadas nos frutos, com exceção dos comprimentos total e comercial, que não variaram com o amadurecimento dos frutos.

Palavras-chave: *Musa* spp.. Características físico-químicas. Caracterização agronômica. Produção.

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INTRODUCTION

Quality is an important factor in the marketing of banana, especially when intended for fresh consumption. Banana physical and chemical characteristics are influenced by several factors, such as edaphoclimatic conditions, fertilization, cultivar and planting and harvest time, however, to analyze them, assessing the quality of marketed fruits and whether these are within the standards required by consumers, is important (CHITARRA; CHITARRA, 2005). Matsuura et al. (2004) reported that the most important attributes of the fruits, according to the consumer preferences at purchasing banana, are the flavor, shelf life and appearance (length, diameter and color). Therefore, studies on physical and chemical parameters related to fruit quality, such as length, diameter, weight, pulp and peel color, pulp firmness, soluble solids and titratable acidity, seeking to maintain the desirable characteristics required by market standards, is very important.

Researches describing physical and chemical properties of fruits of different banana cultivars are available in the scientific literature (GOMES et al., 2007; JESUS et al., 2004; NASCIMENTO JUNIOR et al., 2008; RAMOS; LEONEL; MISCHAN, 2009), however, these studies usually evaluate the pulp of some cultivars only from ripe fruits, not characterizing unripe pulp and peel, which is important due to the high starch content and other antioxidant compounds present in these parts of the unripe fruits that are components of the human diet (BORGES et al., 2014). According to Souza et al. (2011), most studies and technologies for banana crops in Brazil are directed to cultivars from the subgroups *Cavendish* and *Prata*, with little information on other subgroups such as *Figo* and *Terra*. The characterization of fruits of other cultivars that are known by the population, but little cropped, is important to support the diversification of crops and the supplying of these fruits.

The characterization of the different banana cultivars is also useful information for commercial development and breeding programs that seek cultivars that are resistant to diseases and present good fruit quality and quantity. Therefore, some parameters, such as plant height, pseudostem diameter and leaf blade length and width are important information. Plant height is an important phytotechnical factor for plant breeding, influencing the planting density, easiness of harvest operations, damping off of plants, pseudostem breakage by wind or due to its reduced diameter, and production of large clusters (SANTOS et al., 2006). Furthermore, banana plants need adequate leaf area to develop and, consequently, produce high quality bunches (RODRIGUES; DIAS; PACHECO, 2009).

In this context, the objective of this work was to morphologically characterize 15 banana cultivars and assess the physical and chemical characteristics of their fruits in two maturation stages, unripe (pre-climacteric) and ripening.

MATERIAL AND METHODS

Banana (*Musa* spp.) bunches of 15 cultivars were harvested in a 6-years-old experimental orchard (plant spacing of 3.5 x 2.5 m) of the Federal University of Viçosa, in Viçosa, State of Minas Gerais, Brazil (20°45' S, 42°52' W, and altitude of 648 m). The cultivars used were: *Ouro* (AA), *Nanica* (AAA), *Nanicão* (AAA), *Caru-Verde* (AAA), *Caru-Roxa* (AAA), *Caipira* (AAA), *Prata* (AAB), *Prata-Anã* (AAB), *Maçã* (AAB), *Mysore* (AAB), *Pacovan* (AAB), *Terrinha* (AAB), *Marmelo* (ABB), *Prata-Graúda* (AAAB) and *Caju* (unknown genomic group).

The banana crop was conducted in rainfed conditions in a clayey Oxisol (Red-Yellow Latosol; SiBCS, 2006), plain terrain. The plants were subjected to periodic thinning of leaves and sprouts. Single superphosphate (500 g), potassium chloride (600 g), ammonium sulfate (600 g), zinc sulfate (20 g) and of borax (20 g) were applied in each plant group, every year during the rainy season (October to March). Control of pests and diseases were not performed due to their low incidence.

The bunches were harvested when the first signs of yellow color appeared in the fruits, taken apart in clusters, weighed without the rachis, and the number of clusters per bunch and number of fruits per bunch were counted. The second, third and fourth cluster were taken from each bunch to the Fruit Analysis Laboratory of the Federal University of Viçosa, where the fruits were removed from the clusters, eliminating the damaged, diseased and malformed fruits. The fruits were washed in running water and left on absorbent paper for a few minutes to coagulate the latex. Then, 12 fruits at stage-1 color (dark green peel) were selected (DADZIE; ORCHARD, 1997), and six of them were immediately evaluated. The remaining six fruits were immersed in an ethephon solution (1.2 g L^{-1}) for 8 minutes to uniform the ripening, air dried for 15 minutes, immersed in a fungicide solution (Procloraz at 0.49 g L^{-1}) for 5 minutes, packed in plastic boxes and kept at room temperature (not controlled) until reaching the stage-6 color (completely yellow peal) (DADZIE; ORCHARD, 1997).

A completely randomized design was used, with 15 treatments (cultivars) and four replications (bunches), with six fruits per sample unit. Pulp and peel of unripe and ripe fruits of each cultivar were analyzed. Characterization of the plants was carried out using the same experimental design with 15 treatments (cultivars) and five replications (plants). Each part of the fruit (pulp and peel), and each color stage was considered as a separate experiment. The pulp and peel of six fruits in the two maturation stages were used for evaluation of all variables. Exceptions were the diameter (only for the whole fruit), firmness and soluble solids content (only for the pulp), and thickness (only for the peel of fruits at both maturation stages).

Fruit diameter was verified in the median area of each fruit, perpendicular to its larger axis, with a digital caliper. Fruit pulp length (market length) and total length (including stalk and style extremity) were measured in the convex face of the fruit with a metallic tape, and the data were expressed in millimeters. Pulp firmness was measured in the median area of each fruit, after removing part of the peel between two edges, using a penetrometer SHIMPO model DFS 100 (Digital Force Gauge), with tip diameter of 8 mm. Six fruits of each cultivar were weighed (g) together and separated into peel and pulp (the peels were weighed separately and the pulp weight was obtained by the difference).

Peel thickness was measured with a digital caliper in the middle part of the fruit peel, between two edges, and the data were expressed in millimeters. Pulp-to-peel ratio was obtained by dividing the pulp fresh weight by the peel fresh weight. Pulp and peel dry weight percentages of unripe and ripe fruits was evaluated by gravimetry.

Peel color was evaluated in the central region of the fruit. The peel was then removed, and the pulp was cut lengthwise to perform readings inside the fruit. A Konica Minolta colorimeter (CR 10) was used to assess the L*, a*, b*, C* and hº values. The coefficients C* and hue were used to express color differences between the peels and pulps of unripe and ripe fruits. Moreover, colors were attributed to the ripe pulps (AMORIM et al., 2009).

Soluble solids content was evaluated with a portable digital refractometer (Atago model N1), with readings in the range of 0 to 32 ºBrix. Titratable acidity was evaluated by titration up to pH 8.2, under constant stirring, with a NaOH (0.05 N) solution, previously standardized with potassium biphthalate. The results were expressed in grams of malic acid per 100 g of pulp or peel of each cultivar and maturation stages.

Five plants with emitted inflorescence of each cultivar were selected to evaluations of plant height, measured from the ground to the inflorescence insertion, and pseudostem diameter at 30 cm from the ground, with a ruler tape. The third leaf from the inflorescence of each cultivar was harvested to measure the petiole length, leaf blade length along the midrib, and maximum leaf blade width in the middle of the leaf. The leaf form (erect, bent or curved) and leaf blade length-to-width ratio were also evaluated.

The data of the variables were compared between cultivars by subjected them to analysis of variance and by grouping their means by the criterion of Scott-Knott ($p<0.01$ or $p<0.05$), using the System for Statistical Analysis and Genetics (SAEG 9.1). Comparisons within fruit parts and maturation stages were performed by using descriptive statistics.

RESULTS AND DISCUSSION

Four groups were formed regarding the number of clusters per bunch, with the cultivar *Mysore* standing out among the cultivars. The cultivars *Mysore* and *Caipira* stood out with the highest number of fruits per bunch (Table 1), confirming the findings of Silva et al. (2006a), who characterized seven banana cultivars in Selviria, State of Mato Grosso do Sul, Brazil. The cultivar *Caipira* had the highest number of fruits per bunch; result that was also found by Lédo et al. (2008), who assessed 17 banana genotypes in Propria, State of Sergipe, Brazil. The banana bunch weight ranged from 7.5 kg (*Ouro*) to 33.44 kg (*Prata-Graúda*). The banana cluster average weight depended on the number of fruits per bunch and fruit individual weights. Thus, cultivars with more fruits per bunch and highest average fruit weight had higher production per bunch (LÉDO et al., 2008).

Table 1. Number of clusters per bunch (CB), fruits per cluster (FC), fruits per bunch (FB), bunch weight (BW), fruit total length (TL), fruit market length (ML) of unripe fruits and their coefficients of variation (CV%) in 15 banana cultivars.

Cultivars	CB	FC	FB	BW	TL	ML
	---------	---------	---------	---kg---	-----------cm-----------	
Ouro	8.33c	15.20b	125.66c	7.51c	13.02d	10.85c
Nanica	9.00c	14.82b	134.00c	17.98b	20.35b	17.75a
Nanicão	8.00c	14.96b	119.66c	22.84b	22.49b	19.33a
Caru-Verde	6.00d	14.67b	88.00d	14.28c	20.52b	17.69a
Caru-Roxa	6.00d	15.28b	91.66d	18.56b	20.96b	17.59a
Caipira	9.00c	20.21a	181.67a	19.85b	17.83c	14.55b
Prata	9.66c	13.53b	127.00c	10.51c	18.39c	13.98b
Prata-Anã	9.33c	13.53b	139.33c	17.29b	17.48c	13.78b
Maçã	7.33d	14.91b	102.33d	10.30c	16.92c	13.63b
Mysore	15.00a	13.48b	200.67a	12.42c	16.29c	11.97c
Pacovan	9.00c	13.48b	121.66c	16.33b	19.35c	15.22b

Means followed by the same letter in the columns are from the same group by the criterion of Scott-Knott ($p<0.01$).

Table 1. Continuation.

Cultivars	CB	FC	FB	BW	TL	ML
	---------	---------	---------	---kg---	-----------cm-----------	
Terrinha	8.00c	11.38c	91.00d	18.84b	24.58a	17.78a
Marmelo	6.33d	9.96c	66.33d	17.51b	22.34b	17.50a
Prata-Graúda	11.33b	13.59b	152.67b	33.44a	21.72b	17.80a
Caju	7.66c	14.78b	113.33c	14.49c	18.70c	15.00b
Average	8.66	14.25	123.66	16.81	19.39	15.62
CV (%)	10.03	8.65	12.41	17.55	6.81	7.51

Means followed by the same letter in the columns are from the same group by the criterion of Scott-Knott (p<0.01).

The total and market lengths did not vary with fruit ripening, thus, the data presented for these two characteristics were from ripe fruits (Table 1). The fruit total length ranged from 02.13 cm (*Ouro*) to 24.58 cm (*Terrinha*). Seven cultivars were in the group with the highest average market lengths (ML). The variations found in the variables were due to the cultivars used, since AA cultivars, such as *Ouro*, have small, cylindrical fruits and the peel is thin and more adhered to the pulp, unlike triploid and tetraploid cultivars, which have greater fruits, firmer pulp, marked edges and thicker peel, which may influence their larger average diameter and length. Moreover, the cultivar *Terrinha* has more prominent extremities, which contribute to a greater total fruit length, unlike *Nanicão*, which has short tip and pedicel.

The unripe fruit diameters ranged from 29.82 mm (*Ouro*) to 49.96 mm (*Caru-Roxa*) when unripe, and from 28 mm (*Ouro*) to 48.62 mm (*Caru-Roxa*) when ripe. The cultivar *Ouro* had firmer ripe pulp (Table 2).

The fruit ripening caused a decrease of about 5% in fruit average diameter (Table 2), which can be related to the dehydration during the maturation process and consequently reduction in peel thickness. This reduction was also found by Jesus et al. (2004).

Table 2. Diameter, pulp firmness of unripe and ripe fruits and their coefficients of variation (CV%) in 15 banana cultivars.

Cultivars	Diameter (mm)		Pulp firmness (N)	
	Unripe	Ripe	Unripe	Ripe
Ouro	29.82e	28.00d	53.97a	6.17b
Nanica	34.62d	32.05c	39.42c	4.28c
Nanicão	37.62c	34.62b	44.07b	3.92c
Caru-Verde	44.64b	45.30a	33.77d	4.22c
Caru-Roxa	49.96a	48.62a	32.17d	3.77c
Caipira	35.12d	34.14b	40.43c	4.28c
Prata	38.75c	37.72b	39.87c	6.64b
Prata-Anã	37.26c	35.20b	44.41b	6.73b
Maçã	37.52c	35.93b	34.74d	5.62b
Mysore	33.20d	32.15c	38.39c	4.56c
Pacovan	39.03c	36.03b	38.74c	6.44b
Terrinha	40.38c	36.92b	42.67b	12.51a
Marmelo	46.07b	44.13a	33.19d	8.22b
Prata-Graúda	41.61b	38.41b	32.37d	4.10c
Caju	34.34d	32.63c	46.34b	5.16c
Average	38.66	36.79	39.64	5.77
CV (%)	5.85	6.25	10.65	23.20

Means followed by the same letter in the columns are from the same group by the criterion of Scott-Knott (p<0.01).

The pulp firmness reduced with ripening. The cultivar *Terrinha* had the firmest pulp at stage-6 color (Table 2); result also found by Ruiz (2003) for bananas *Terra* compared to *Prata* and *Prata-Graúda*. This results that can be explained by the difference in starch content of these cultivars, since fruits of the cultivar *Terrinha* had high starch content in the pulp (12.6%) even when were ripe, and starch has structural function in banana pulp (AQUINO, 2014). Ruiz (2003) found an abrupt decrease in firmness of the cultivars *Prata* and *Prata -Graúda* from peel stage-3 color, and of cultivar *Terra* from stage-5 related to enzymatic degradation of pectic components of the cell wall and middle lamella, and to conversion of starch into sugars during ripening.

Ruiz (2003) evaluated the pedicel of three banana cultivars and reported high levels of starch in the cultivar *Terra* as one of the factors that contributed to the maintenance of cell firmness and avoid the banana natural falling. Pereira et al. (2004) found that the firmness of the fruit is related to the resistance to falling, i.e., fruits with firm pulp are less susceptible to falling off. Fruits with firm pulp have greater resistance to transport and greater post-harvest durability.

The fruit weight reduced in about 8%, on average, at ripening. However, the ripe pulp fresh weight increased by 5.6%, on average, compared to the unripe pulp. Moreover, all cultivars had a reduction of approximately 5%, on average, in the ripe pulp dry weight percentage compared to the unripe pulp (Table 3). This results are due to the migration of water from the peel to the pulp and the consumption of carbohydrates in respiration with the fruit ripening.

The cultivars *Caru-Roxa* and *Marmelo* stood out with the highest average fresh weight of unripe fruits, while the *Ouro* and *Mysore* had the lowest values compared to the other cultivars (Table 3). The cultivars *Caru-Roxa* and the *Marmelo* had the highest fresh weight of ripe fruits and the *Caru-Roxa* had the greatest pulp weight at both maturation stages, while the *Terrinha* had the highest dry weight percentage at both maturation stages. The cultivars *Nanicão*, *Caru-Verde*, *Caru-Roxa*, *Caipira* (AAA) and *Prata-Graúda* (AAAB) had the lowest pulp dry weight percentage for unripe fruits. The differences in pulp dry weight percentages of cultivars are due to the pulp starch content, since these two variables are directly related. The average percentages of ripe pulp dry weight percentage ranged from 23.63 to 37.38% (Table 3); results that are similar to those found by Jesus et al. (2004) (21.1 to 32.3%) and Bezerra and Dias (2009) (24.09 to 26.32%).

Table 3. Fruit fresh weight (FFW), pulp fresh weight (PFW), pulp dry weight percentage (PDW), pulp-to-peel ratio and their coefficients of variation (CV%) of unripe and ripe fruits in 15 banana cultivars.

Cultivars	FFW		PFW		PDW		Pulp-to-peel ratio	
	Unripe	Ripe	Unripe	Ripe	Unripe	Ripe	Unripe	Ripe
	g				%			
Ouro	60.60d	51.81e	40.57d	41.84e	33.63b	31.88b	2.00a	4.18a
Nanica	133.92c	114.57d	73.22c	76.40d	26.63d	24.75d	1.20c	2.03c
Nanicão	178.20b	155.18c	100.48b	106.77c	29.25c	26.38c	1.29c	2.21c
Caru-Verde	200.55b	192.12b	123.26b	131.76b	26.50d	25.88d	1.60b	2.18c
Caru-Roxa	248.74a	234.56a	156.55a	164.43a	24.63d	23.63d	1.72b	2.59b
Caipira	106.83c	103.11d	68.05c	74.06d	25.75d	24.88d	1.75b	2.60b
Prata	120.27c	117.92d	72.20c	80.46d	32.13b	28.88c	1.50c	2.15c
Prata-Anã	111.71c	103.38d	63.08c	68.20d	32.00b	31.25b	1.30c	1.97c
Maçã	109.19c	107.07d	77.69c	79.32d	29.88c	30.00b	2.26a	2.82b
Mysore	79.85d	75.69e	50.18d	56.73e	29.25c	27.38c	1.67b	2.98b
Pacovan	139.46c	123.53d	74.99c	77.82d	33.38b	31.75b	1.18c	1.72c
Terrinha	153.41c	149.85c	87.19c	97.18d	39.38a	37.38a	1.31c	1.84c
Marmelo	241.26a	221.99a	130.82b	130.47b	33.00b	33.63b	1.18c	1.43c
Prata-Graúda	189.76b	166.79c	108.67b	108.33c	25.88d	24.00d	1.33c	1.86c
Caju	111.05c	104.55d	66.81c	73.14d	29.63c	27.75c	1.50c	2.41c
Average	145.65	134.80	86.25	91.12	30.06	28.62	1.52	2.33
CV (%)	14.40	13.94	17.17	15.63	4.51	6.77	11.43	15.63

Means followed by the same letter in the columns are from the same group by the criterion of Scott-Knott ($p<0.01$).

The pulp-to-peel ratio of unripe fruits ranged from 1.18 to 2.26 (Table 3). The cultivars *Maçã* and *Ouro* had the highest pulp-to-peel ratio and, thus, higher pulp, and the highest pulp yields, despite the reduced diameter and length, since they have fruits with thinner peel, with lower peel weight.

The ripe pulp-to-peel ratio had an average increase of 53% compared to the unripe fruits. This result was due to the migration of water from the peel to the pulp during ripening, from the osmotic pressure gradient caused by the higher concentration of sugars in the pulp compared to the peel. Moreover, the peel loses water to the environment by transpiration process, which reduces its weight. These averages ranged from 1.43 to 4.18 (Table 3), with values similar to those found by Jesus et al. (2004) (1.60 to 4.09) for fruits at stage 6. Pinheiro et al. (2006) also found a significant increase in pulp-to-peel ratio of fruits at stage 7 compared to fruits at stage 3. The cultivar *Ouro* had the highest pulp-to-peel ratio when ripe and, consequently, greater pulp weight.

The pulp yield is an important parameter for both fresh consumption and industry processing. Cultivars whose fruits have high pulp yield had higher processing yields of final products (concentrates), which may represent greater profitability for industries (CHITARRA; CHITARRA, 2005).

Ripe fruits had changes in peel physical aspects compared to unripe fruits, with reduction in the overall average fresh weight and peel thickness and increase in dry weight percentage, due to the loss of water through the peel with fruit ripening (Table 4). The cultivar *Marmelo* had the highest peel fresh weight for both maturation stages; the cultivars *Ouro* and *Mysore* had the lowest average peel fresh weight for both maturation stages and the *Maçã* for the unripe fruits.

Table 4. Peel fresh weight, dry weight percentage, thickness and their coefficients of variation (CV%) in peels of unripe and ripe fruits of 15 banana cultivars.

Cultivars	Peel fresh weight		Peel dry weight		Peel thickness	
	Unripe	Ripe	Unripe	Ripe	Unripe	Ripe
	-------------g-----------		------------%-----------		--------------mm-------------	
Ouro	20.03f	9.97e	12.62b	17.75a	2.84d	1.53c
Nanica	60.70d	38.17d	10.37c	14.13b	4.63b	2.94b
Nanicão	77.72c	48.40c	12.37b	15.25b	4.71b	3.13b
Caru-Verde	77.28c	60.36b	13.87b	15.63b	4.88b	3.52b
Caru-Roxa	91.06b	70.12b	12.75b	15.00b	5.22a	3.68b
Caipira	38.78e	29.05d	11.25c	12.38b	3.74c	2.27c
Prata	48.07e	37.46d	11.65c	13.75b	4.63b	2.98b
Prata-Anã	48.62e	35.18d	12.50b	14.00b	4.23b	3.10b
Maçã	34.12f	27.75d	16.12a	18.13a	3.45c	2.28c
Mysore	29.68f	18.96e	12.37b	16.25b	3.14d	1.63c
Pacovan	64.47d	48.70d	12.50b	14.38b	4.69b	3.43b
Terrinha	66.21d	52.67c	13.22b	14.25b	4.35b	3.29b
Marmelo	110.43a	91.52a	16.75a	20.13a	5.38a	4.59a
Prata-Graúda	81.09c	58.45b	10.75c	12.88b	5.32a	4.09a
Caju	48.24e	31.40d	13.75b	15.88b	3.93c	3.25b
Average	59.76	43.87	12.85	15.31	4.34	3.04
CV (%)	11.36	14.62	7.89	14.16	9.63	17.24

Means followed by the same letter in the columns are from the same group by the criterion of Scott-Knott ($p < 0.01$).

The dry weight percentage in the peel increased by 19% with fruit ripening (Table 4) due to the water loss of ripe peel by transpiration and migration to the pulp. The cultivars *Marmelo* and *Maçã* had the highest dry weight percentage at both maturation stages, and *Ouro* had high percentage at ripening. The cultivars *Maçã* and *Ouro* had reduced fresh weight, but were among the cultivars with the highest average percentage of peel dry weight at both maturation stages.

The cultivars *Marmelo* and *Prata-Graúda* had thicker peel at both maturation stages, as well as the *Caru-Roxa* at unripe stage. Peel thickness reduced with ripening; the smaller thickness variations between stages was presented by the cultivars *Caju* (0.68 mm) and *Marmelo* (0.79 mm), while the cultivar *Nanica* had the greatest variation (1.69 mm) (Table 4).

The cultivars *Caipira*, *Maçã* and *Marmelo* had lower levels of C* coefficient and high rates of Hue* angle in the unripe pulp, showing that these cultivars had the clearer pulps. However, the color parameters indicate that the cultivars *Terrinha* and the *Caru-Roxa*, showed orange pulp color, even at stage-1 color, which were different from the other clear pulp cultivars (Table 5).

The ripe pulp had an increase in color intensity (C*) and a decrease in Hue* angle (Table 5), presenting a yellow-orange color at ripening. The pulp of the cultivar *Marmelo* remained with white color, even when ripe, while ripe fruits of the *Terrinha* had pulp of greater intensity of yellow-orange color. Most cultivars had yellow or cream color. Aquino (2014) reported that cultivars with orange pulp color, regardless the maturation stage, have highest carotenoid content compared to those of cream or white pulp color.

The cultivar *Caru-Roxa* had different color from other cultivars (dark purple peel), presenting the most marked difference between unripe peels (Table 5). The bunches of all cultivars were harvested at the same development stage, thus, the other cultivars had little variations in shades of green color, which were due to particular characteristics of each cultivar evaluated.

The ripe fruits of all cultivars presented peels of intense yellow color, verified by the Hue* angle values, except the *Nanica*, *Nanicão* and *Caru-Roxa*. The cultivars *Nanica* and *Nanicão* had greenish-yellow color, even with ripe pulp. The cultivar *Caru-Roxa* had the lowest color intensity and Hue* values, with red peel in ripe fruits (Table 5).

The peel color change from stage 1 to 6 is characterized by the decrease in chlorophyll content, that cause the appearance of yellow. This color change is due to the enzymatic action on the chlorophyll structure, enabling the expression of carotenoids (NEWILAH et al., 2009), without, however, a measurable synthesis, as found in the pulp.

Table 5. Color parameters of peel and pulp of unripe and ripe fruits (C* and Hue*), ripe pulp color and their coefficients of variation (CV%) in 15 banana cultivars.

Cultivars	Unripe Pulp		Ripe Pulp		Unripe Peel		Ripe Peel		Ripe Pulp Color
	C*	Hue*	C*	Hue*	C*	Hue*	C*[1]	Hue*	
Ouro	30.81b	85.74a	36.96a	82.70c	26.13a	119.59a	40.34a	83.68b	Yellow
Nanica	26.85c	87.09a	34.16a	85.93c	23.12b	119.91a	30.63b	93.37a	Yellow
Nanicão	27.79c	87.00a	34.65a	84.30c	23.77b	121.18a	33.01b	94.87a	Yellow
Caru-Verde	30.42b	80.46b	36.55a	78.25d	23.66b	119.87a	32.60b	84.91b	Orange
Caru-Roxa	30.97b	77.71c	35.76a	75.74d	8.65c	66.42b	21.42c	50.93c	Orange
Caipira	23.20d	88.84a	29.35b	88.36b	23.20b	119.89a	33.12b	86.97b	Cream
Prata	26.48c	85.34a	33.85a	87.02c	27.06a	118.05a	37.97a	87.53b	Cream
Prata-Anã	27.35c	85.85a	33.63a	85.21c	25.95a	118.54a	37.53a	87.63b	Cream
Maçã	24.20d	90.11a	29.84b	89.14b	28.21a	118.36a	39.07a	86.45b	Cream
Mysore	28.67c	82.41b	35.57a	83.08c	25.03a	119.58a	38.46a	85.01b	Yellow
Pacovan	26.28c	86.34a	32.97a	85.66c	23.17b	119.79a	35.59a	87.42b	Cream
Terrinha	35.62a	73.44c	38.87a	72.10e	25.20a	118.17a	33.54b	85.61b	Orange
Marmelo	21.35d	93.29a	23.71c	94.72a	23.20b	116.55a	32.88b	82.85b	White
Prata-Graúda	26.98c	89.25a	31.97a	89.71b	23.53b	119.06a	37.77a	85.59b	Cream
Caju	27.79c	85.71a	36.63a	82.60c	22.04b	122.17a	36.58a	85.07b	Yellow
Average	27.65	85.23	33.63	84.30	23.46	108.60	34.70	84.52	-----------
CV (%)	7.80	3.60	8.27	2.70	7.16	2.01	7.83	2.51	-----------

Means followed by the same letter in the columns are from the same group by the criterion of Scott-Knott ($p<0.01$). [1]Means followed by the same letter in column are from the same group by the criterion Scott-Knott ($p < 0.05$).

Color is related to the attractiveness to the consumer. Bananas that have more intense and bright colors seems to be more attractive, by suggesting that these fruits, with yellow peel are certainly ripe, all the organoleptic characteristics are present, and can be immediately consumed.

Viviani and Leal (2007) evaluate the behavior of 30 tasters regarding the peel color of bananas *Prata-Anã* at the time of purchase and found high preference index for fruits that had color considered ideal to consumption (intense yellow), compared to fruits with peels that were yellow with green parts. The red peel and yellow-orange pulp colors of the *Caru-Roxa* can be an attraction factor for consumers at purchasing the product, when they not associate the purple peel color with cultivars commonly used for cooking or frying, as observed by Matsuura et al. (2004).

The soluble solids were dependent on the cultivar and the maturation stage. The unripe pulp had lower soluble solids content, with average 5-fold less than the ripe pulp. The *Caipira*, *Maçã*, *Mysore*, *Pacovan* and *Terrinha* were grouped as the cultivars of highest average of soluble solids in unripe pulp (Table 6). Ferris et al. (1999) found no differences in soluble solids content in fruit of different banana cultivars at stage 1, in a study conducted in Uganda, however, the differences became more apparent in fruits between stages 3 (more green than yellow peel) and 7 (yellow peel with brown areas). Unripe fruits have high starch content, which is hydrolysed with ripening, resulting in sugar accumulation; and the soluble solids content is an indicative of the sugar content in the fruit (AQUINO, 2014).

The average ºBrix of ripe pulp ranged from 22.01 to 29.53 (Table 6), which were above those reported by Jesus et al. (2004) (19.8 to 27.4 ºBrix), especially in the *Ouro* (AA) and *Prata*, *Prata-Anã*, *Pacovan* and *Terrinha* (AAB).

The ripe pulp had a considerable increase in titratable acidity compared to the unripe pulp (Table 6), which was also observed by Nascimento Junior et al. (2008). However, Pinheiro et al. (2006) found little color variation between stages 3 and 7 for cultivar *Maçã*.

The average titratable acidity of the unripe pulp ranged from 0.14 to 0.28% (Table 6), and were superior to those reported by Ramos et al. (2009) who found 0.08 to 0.18% in fruits of 12 cultivars. The average titratable acidity of the ripe pulp ranged from 0.34 to 0.73%, and were similar to those reported by Gomes et al. (2007) (0.38 to 0.81%), and higher than those found by Jesus et al. (2004) (0.25 to 0.54%), both evaluating ripe pulp of 10 banana genotypes. The B genotype in the ripe pulp of the cultivars is probably a result of an increased acidity (Table 6). The high acidity of *Mysore* (AAB) is easily perceived when consuming the fruit. Similarly, the low acidity can be perceived when consuming the *Nanica* and *Nanicão* (AAA).

Two groups were formed for the peel acidity percentage at both maturation stages, with the *Maçã*, *Mysore*, *Terrinha*, *Marmelo* and *Prata-Graúda* standing out at both stages, and the *Prata-Anã* at ripening (Table 6). According to Bleinroth (1995), bananas at unripe stage have low acidity, which increases with ripening until reaching a maximum, when the peel is completely yellow, and then decreases, indicating the beginning of senescence.

Table 6. Soluble solids (SS) contents, titratable acidity (TA) percentages and their coefficients of variation (CV%) in pulp and peel of unripe and ripe fruits of 15 banana cultivars.

Cultivars	Pulp				Peel	
	Unripe	Ripe	Unripe	Ripe	Unripe	Ripe
	SS (ºBrix)	SS (ºBrix)	TA (%)	TA (%)	TA (%)[1]	TA (%)
Ouro	3.84b	29.04a	0.23a	0.44c	0.15b	0.33b
Nanica	3.95b	24.37c	0.25a	0.35c	0.17b	0.27b
Nanicão	5.06b	25.34b	0.23a	0.37c	0.15b	0.24b
Caru-Verde	4.13b	24.92b	0.22a	0.45c	0.12b	0.31b
Caru-Roxa	4.74b	22.62c	0.24a	0.34c	0.17b	0.29b
Caipira	6.30a	22.01c	0.21a	0.41c	0.13b	0.22b
Prata	3.87b	27.92a	0.17b	0.61b	0.16b	0.35b
Prata-Anã	4.88b	27.54a	0.21a	0.61b	0.15b	0.37a
Maçã	5.88a	25.68b	0.14b	0.56b	0.20a	0.41a
Mysore	5.90a	25.09b	0.28a	0.70a	0.21a	0.47a
Pacovan	5.76a	27.64a	0.17b	0.61b	0.16b	0.29b
Terrinha	6.22a	29.53a	0.18b	0.73a	0.21a	0.45a
Marmelo	4.37b	22.41c	0.16b	0.62b	0.18a	0.30b
Prata-Graúda	3.66b	23.39c	0.20a	0.52b	0.21a	0.37a
Caju	5.02b	25.11b	0.21a	0.59b	0.14b	0.32b
Average	4.90	25.50	0.20	0.52	0.16	0.33
CV (%)	17.59	5.86	14.48	11.99	21.24	19.67

Means followed by the same letter in the columns are from the same group by the criterion of Scott-Knott ($p < 0.01$).
[1]Means followed by the same letter in column are from the same group by the criterion Scott-Knott ($p < 0.05$).

The cultivars had average plant height ranging from 2.25 to 6.15 m. The cultivar *Nanica* was the smallest and the *Prata*, *Pacovan*, *Caru-Roxa* and *Caru-Verde* were tallest plants (Table 7). Moreira (1999) classified banana plant heights in four sizes: up to 2 m (low), 2 to 3.5 m (medium), 3.5 to 6 m (high) and above 6 m (very high). The most widespread cultivars in Brazil (*Nanica*, *Nanicão* and *Prata-Anã*) had the lowest heights, along with the *Terrinha* and the *Ouro*.

Table 7. Plant height (PH), pseudostem diameter (PD), petiole length (PL) leaf blade length (LSL), leaf blade width (LSW), leaf blade length-to-width ratio (LSL-LSW), leaf form (LF) and their coefficients of variation (CV%) in 15 banana cultivars.

Cultivars	PH	PD	PL	LSL	LSW	LSL-LSW	LF
	--m--	---------------------------cm------------------------------					
Ouro	3.73d	23.55c	46.20c	249.80c	65.80b	3.82b	Erect
Nanica	2.25e	28.26b	27.00d	185.80d	84.20a	2.21d	Bent
Nanicão	3.72d	29.63b	40.60c	259.80c	91.20a	2.85c	Bent
Caru-Verde	5.76a	35.26a	55.40b	288.80b	82.60a	3.52b	Bent
Caru-Roxa	6.09a	36.73a	60.40b	288.40b	90.00a	3.21c	Bent
Caipira	4.63b	27.82b	69.20a	305.00b	85.80a	3.55b	Bent
Prata	6.15a	35.34a	65.20a	325.00a	88.60a	3.67b	Bent
Prata-Anã	3.68d	34.69a	45.20c	220.00d	84.40a	2.60d	Bent
Maçã	4.08c	26.99b	73.60a	251.40c	70.40b	3.54b	Curved
Mysore	4.41b	24.70c	50.80c	216.00d	72.20b	2.98c	Bent
Pacovan	6.15a	34.50a	66.60a	351.60a	84.00a	4.21a	Bent
Terrinha	3.69d	22.02c	44.80c	219.20d	81.80a	2.68d	Bent
Marmelo	4.43b	25.02c	49.40c	231.20c	75.80b	3.04c	Curved
Prata-Graúda	4.33b	34.25a	49.80c	234.60c	82.60a	2.84c	Curved
Caju	4.02c	26.47b	58.80b	239.80c	80.00a	3.00c	Bent
Average	4.47	29.68	53.53	257.76	81.29	3.18	-------
CV (%)	5.56	7.78	14.94	8.90	7.49	9.45	-------

Means followed by the same letter in the columns are from the same group by the criterion of Scott-Knott ($p<0.01$).

Banana plant height is important from the phytotechnic and breeding point of view, influencing the planting density, crop management and dumping off of plants, directly interfering in the production (SANTOS et al., 2006). The higher heights of some cultivars may influence the loss of leaf area due to wind, especially in areas with occurrence of strong winds. The cultivars with larger pseudostem diameter were also the highest, except the *Prata-Anã* and *Prata-Graúda*, which stood out in the group with larger diameters (Table 7). According to Borges et al. (2011) high plants are less susceptible to dumping off when the pseudostem are thick. The pseudostem diameter is an important factor in banana breeding, which is related to the vigor and the capacity of the plant to support a bunch (SILVA et al., 2006b).

The cultivars *Prata* and *Pacovan* had the highest total length of plants (pseudostem height plus the petiole length and leaf blade length), exceeding 10 m. Eleven cultivars were grouped with the largest leaf blade widths, including the *Prata* and *Pacovan*, the later had the highest leaf blade length-to-width ratio.

According to Moreira (1999), the total leaf area of plants is an important parameter that for the production of assimilates which results in greater bunch weight; and the relation between bunch weight and leaf area cannot be extrapolated to different cultivars, since these are different in each cultivar. Therefore, it may explain the results of the cultivar *Nanica*, which produced bunches with considerable weight despite its small leaf blade area, and the results of the cultivar *Prata*, which produced small bunches despite its great leaf blade area. The predominant form of the leaves of the cultivars evaluated was bent.

CONCLUSIONS

The cultivar and maturation stage influenced all fruit characteristics evaluated, except the fruit market and total lengths, which did not vary with ripening.

The cultivar *Ouro* (AA) had shorter fruits, fruits with smaller diameter, and firmer fruits when unripe.

The fruit and pulp of cultivar *Caru-Roxa* (AAA) had fresh weights higher than those found in the other cultivars evaluated. However, fruits of the cultivar *Terrinha* (AAB) had higher dry weight percentage and the peels of *Marmelo* (ABB) had higher fresh weight at both maturation stages.

The soluble solids (SS) content in the ripe pulp was 5-fold greater than the unripe pulp contents. The pulp had higher percentage of titratable acidity, compared to the peel, at both maturation stages.

The cultivars with the largest pseudostem diameter were also the highest, except the *Prata-Anã* and *Prata-Graúda*, which had only larger diameters. The cultivars *Prata* and *Pacovan* were the highest cultivars.

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