A Comparative Study of Some Characteristics of Two Plantain Cultivars Which Affect Yields and Product Quality

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INTRODUCTION

The production of plantains in Puerto Rico has been limited to the provision of fruit for the fresh market. Very few studies have been conducted to characterize the varieties planted by farmers and to obtain information on the production patterns, fruit characteristics, and quality, which may be used to select varieties adapted to commercial processing.

González Ríos in 1920 (*1*)[2] made recommendations on the cultivation of plantains, including the preparation of the land, selection of the seed, planting distance, and control of followers and diseases. This author also briefly described the varieties used at that time known as *platano común*, *plátano enano*, and *plátano congo*. López Irizarry (*2*) described a method for the production of plantain flours, but no specific varieties were mentioned. Osuna (*3*) recommended the varieties Enano and Maricongo as the most suitable for commercial production, but these varieties were not described.

Vicente Chandler (*4,5*) studied the effect of planting methods and the use of shade on yields and fruit quality of the Maricongo cultivar grown in the Humid Mountain Region of Puerto Rico. Data on yields, weight of fruit, and number of fruit per bunch were reported. Response to fertilization by this variety was studied by Caro *et al.* (*6*).

The Food Technology Laboratory of the Agricultural Experiment Station has been conducting studies to promote the industrialization of plantains. Cancel *et al.* (*7*) described procedures for the preparation of plantain chips. Rahman (*8*) worked out an improved method for the production of plantain flour. Sánchez and Hernández (*9*) studied a method for the preparation and freezing of ripe plantains in syrup. Sánchez *et al.* (*10*) studied the preharvest changes in the physical and chemical characteristics of Maricongo and Guayamero cultivars.

Two cultivars of plantains have been used for processing studies: the

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[2] Italic numbers in parentheses refer to Literature Cited, pp. 337–8.

Maricongo and the Guayamero. These two cultivars are widely planted by farmers and may have different names in some sections of the Island. The workers engaged in this research were faced with the problem that plantains of apparently the same characteristics are known by different names throughout the Island. Since these two cultivars are used for processing, it was felt convenient to study both to determine production patterns, yields, fruit quality, and processing characteristics. No attempts have been made to characterize the two cultivars on the basis of botanical or agronomical characteristics. This study has been limited to comparison of those characteristics that determine the suitability of a variety for processing, such as length of fruit-bearing period, uniformity of fruit in regard to size, organoleptic properties, chemical composition, yields, and quality of processed products.

MATERIALS AND METHODS

All field experiments were carried out at the Corozal Substation with the Maricongo and Guayamero cultivars. Planting material for the Guayamero plot was obtained from the Seed Farm Division of the Agricultural Experiment Station, and for the Maricongo from a farmer known to produce plantains of fairly uniform characteristics.

The plants were planted at a distance of 5 × 10 feet. Corms ranged in weight from 1 to 4 pounds. Before planting, the corms were treated with a solution of 1.5 liters of Aldrin per 10 gallons of water to control the banana borer, *Cosmopolites sordidus*, G. After tilling the soil, filter-press cake was added. Fertilizer formula 9-10-5 was applied at the rate of 4 pounds per plant in four applications 2 months apart. Six months after planting, the soil was treated with a solution of Aldrin of the same strength used for treating the corms. The plants were sprayed with orchard spray oil every 15 days to control the Sigatoka leaf-spot disease. No followers were allowed to grow.

Bunches were harvested at different ages and taken to the Laboratory for physical measurements and chemical analyses. The bunch was weighed with the stem attached, but with the male bud and stem cut off close to the last hand. Number of hands and fingers were counted. The average weight of fingers was determined by weighing a number of fruits and averaging the weights. Fingers from the third hand were peeled, and the percentage of pulp and peel determined from the weights. Pulp: peel ratios were calculated from average weights of pulp and peel.

To determine the configuration of the cross-sectional area and the angularity of the fruit, a section from the center of fruit from the third hand was cut and photographed. The longer and shorter diameters were measured directly on the fruit with a caliper. Length of the fruit was measured in inches.

Starch, reducing and total sugars, acidity, and pH were determined on the peeled fruit. Starch was determined by the method of Carter and Neubert (*11*). Reducing and total sugars were determined by the Moyer and Holgate method (*12*), inverting with invertase for total sugar determination. Acidity and pH were measured by the A. O. A. C. glass-electrode method (*13*).

Texture was measured with a Lee-Kramer electrical recording and indicating press, with a 5,000-pound proving-ring with the range set for 2,000-pound readings. The plunger was adjusted to move at 1.5 mm. per second. A standard shear-cell was used for all determinations. To make a measurement, the plantains were peeled and cut in halves lengthwise. The slices were cut in length to fit the cell and placed perpendicular to the path of the knives. The cell was packed full, which generally required about 8 ounces of plantain. The time-force curve was recorded and the maximum pressure applied was read directly from the chart.

Plantain chips were prepared by the method described by Cancel (*7*). Ripe plantains cooked in syrup were prepared as described by Sánchez and Hernández (*9*). For the preparation of fried green plantain slices, the fruit was peeled, sliced crosswise into sectors approximately 1 inch thick. The slices were steam-blanched for 2 minutes and cooled with water sprays, packed in Marathon waxed containers, and frozen at −45° F. in a plate freezer. The frozen slices were stored at −10° F. until used. For organoleptic appraisal, the slices were fried without thawing for 8 minutes at 350° F. The fried slices were pressed in a hand-press to about 5/8-inch thickness, and fried a second time for 4 minutes at 375° F.

In all organoleptic tests the hedonic scale (*14*) and Kramer and Ditman's method (*15*) for detecting flavor differences were used.

RESULTS AND DISCUSSION

The plots of the Maricongo and Guayamero cultivars were planted in May 1964 and the first visible inflorescence was observed in April 1965. Temperature and rainfall data for the period, from planting to harvesting, are given in table 1. In figure 1 the periods of vegetative growth, flowering, and harvesting have been indicated, together with the rainfall and temperature curves. Vegetative growth occurred during a period of prolonged drought that affected Puerto Rico, and rainfall at the Corozal Substation was below normal. Flowering coincided with an increase in rainfall.

Table 2 shows that both cultivars exhibited a similar flowering and bunch-development pattern. No appreciable difference in the time of flowering after planting, a span of the flowering period, time from flowering to bunch-shooting, or to the stage at which the bunch finally shot could be observed. However, when the number of plants flowering are plotted against the interval from planting to visible inflorescence (see figs. 2 and 3), it is ob-

TABLE 1.—*Temperature and rainfall data for the Corozal Substation from May 1964 to August 1965 in 15-day intervals*

Year and month	Temperature in °F.		Rainfall (inches)
	Minimum	Maximum	
1964			
May	67.1	89.1	0.12
	67.8	87.8	2.26
June	69.3	90.1	.20
	69.4	85.8	2.56
July	70.3	86.3	2.55
	69.8	86.5	2.08
August	70.3	87.1	1.94
	70.3	86.4	3.85
September	69.4	87.7	2.95
	69.7	87.7	2.15
October	68.7	87.2	2.62
	68.0	86.8	4.35
November	66.3	85.2	2.47
	66.1	82.3	.66
December	64.2	80.7	2.30
1965			
January	—	—	—
	—	—	—
February	62.7	78.0	1.37
	62.8	82.9	.24
March	63.3	86.3	.23
	65.3	83.4	1.39
April	62.5	84.9	.54
	65.2	84.1	3.70
May	66.6	84.3	11.73
	68.8	82.0	6.04
June	68.7	84.5	3.23
	67.7	86.1	1.74
July	70.4	85.5	4.69
	69.9	86.5	2.37
August	69.0	85.3	6.97
	70.3	85.9	3.74
September	69.5	88.2	2.45
	70.1	86.2	4.38
October	69.0	85.8	2.45
	68.6	85.3	2.31
November	68.7	83.7	4.68
	66.3	83.7	3.42

served that 87.9 percent of the plants of the Maricongo cultivar flowered within a period of 49 days after the first inflorescence, while only 59.8 percent of the plants of the Guayamero cultivar flowered during the same interval. According to this flowering behavior, around 90 percent of the crop

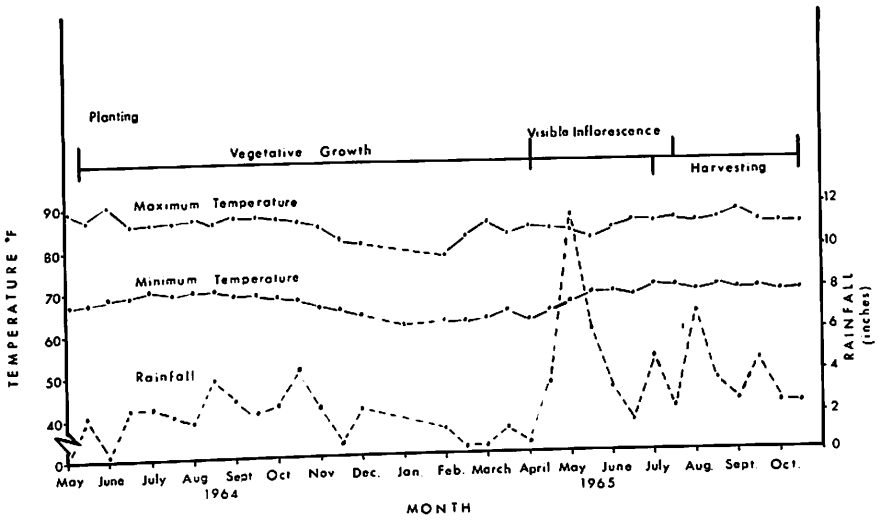

FIG. 1.—Temperature and rainfall data for the period from planting to harvesting.

TABLE 2.—*Flowering and bunch development of Maricongo and Guayamero plantain cultivars*

Item	Visible inflorescence		Bunch shooting		Bunch shot	
	Maricongo	Guayamero	Maricongo	Guayamero	Maricongo	Guayamero
Range from planting.....days	329–420	329–437	332–437	339–420	346–437	349–432
Mean.....days	354.1	369.5	362.5	377.8	373.8	389.4
Standard deviation.....days	21.8	22.1	22.7	22.9	28.8	23.4
Coefficient of variation.....percent	6.1	5.9	6.3	6.0	7.7	6.0

of the Maricongo cultivar could be harvested within a period of 49 days, while it would have taken 71 days to harvest a similar percentage of fruit of the Guayamero cultivar.

With data from one experiment only in which both cultivars were compared, no definite conclusions could be reached on the difference in fruit-production patterns for both cultivars. In figure 4 the flowering pattern of a Guayamero plot harvested at the Corozal Substation a year earlier is

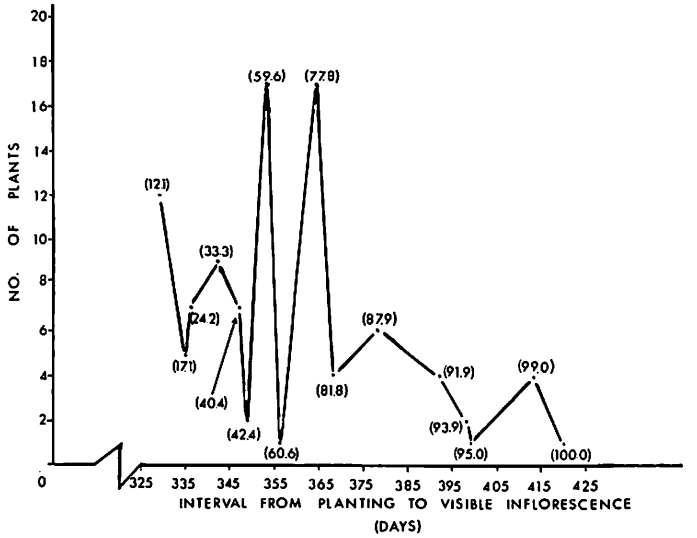

FIG. 2.—Interval from planting to visible inflorescence, Maricongo cultivar. Numbers in parentheses indicate cumulative percentage of plants flowering.

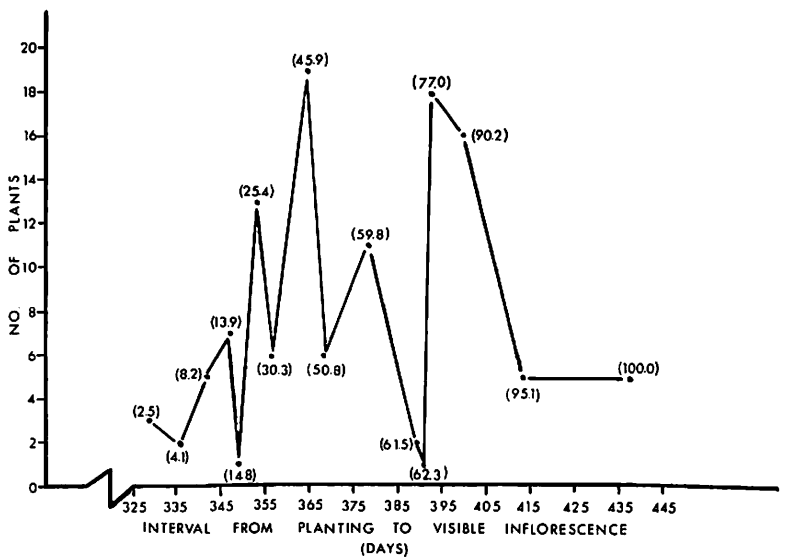

FIG. 3.—Interval from planting to visible inflorescence, Guayamero cultivar. Numbers in parentheses indicate cumulative percentage of plants flowering.

shown. This figure shows that this plantation exhibited a different flowering pattern, with a spread of 137 days from the first to the last inflorescence. About 80 percent of the plants flowered during a period of 85 days after the first inflorescence was noted. This plantation behaved differently than the

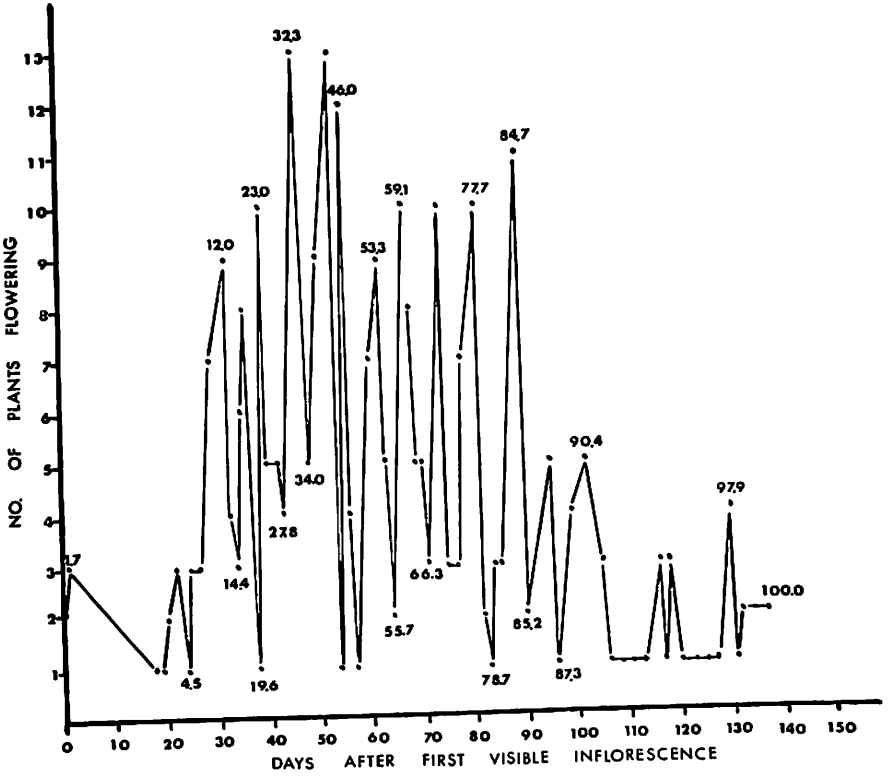

FIG. 4.—Flowering pattern of a plot of plantains of the Guayamero cultivar. Numbers in parentheses indicate cumulative percentage of plants flowering.

Maricongo and Guayamero plots described in this paper, both of which flowered within a period of 91 and 98 days, respectively.

The weight of the bunches, number of hands, and number of fruits per bunch for the Guayamero and Maricongo cultivars harvested at different ages are given in table 3. The weight of the bunches of both cultivars varied within similar limits, the Maricongo had more hands per bunch than the Guayamero, and therefore the number of fruits per bunch was greater. Figure 5 shows the fruit of both cultivars harvested at various ages.

The data in table 3 show a wide variation in the weight of the bunches for

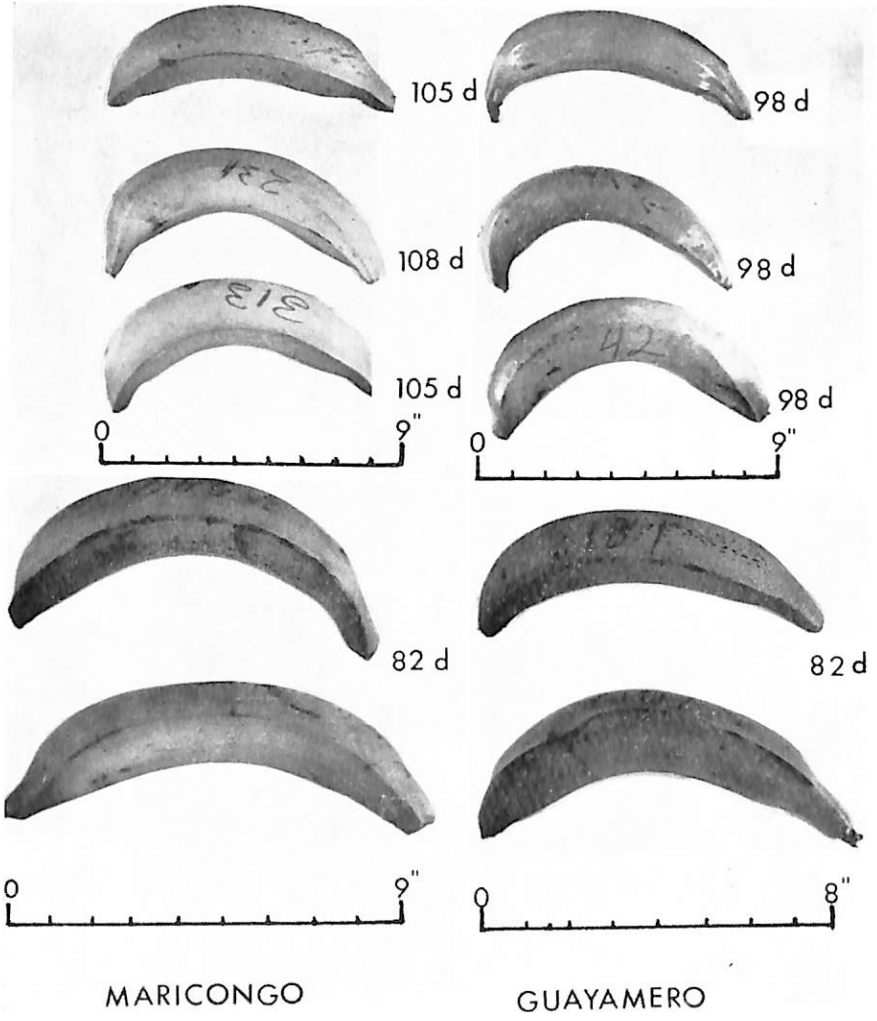

FIG. 5.—Fruit of the Maricongo and Guayamero plantain cultivars harvested at different ages.

each age group. In order to make a better comparison of the cultivars, the bunches were rearranged according to their weights, as shown in table 4. These data show that the Maricongo produced more uniform fruit than the Guayamero. About 80 percent of the bunches of the Maricongo plantains ranged in weight from 16 to 25 pounds, with 5 to 8 hands per bunch of 17 to 60 fruits. In a similar percentage of bunches harvested of the Guayamero

cultivar, the weight ranged from 11 to 25 pounds with 4 to 8 hands and from 12 to 52 fruits.

Although both the Maricongo and Guayamero cultivars were harvested with a wide variation in age, the weight of all bunches harvested, and the total number of fruits produced were averaged to obtain the overall yields.

TABLE 3.—*Characteristic of bunches of the Maricongo and Guayamero plantain cultivars*

Number of observations	Age in days from visible inflorescence		Weight of bunch (pounds)		Number of hands		Number of fruits	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
				Maricongo cultivar				
11	81–85	83	8.5–26.5	17.9	5–8	6.5	11–52	35.2
10	86–90	87	12.7–24.0	18.9	6–8	6.5	27–48	38.0
15	91–95	93.7	13.5–31.0	19.6	6–8	6.5	26–49	38.7
17	96–100	97.0	12.5–25.0	19.2	5–8	6.4	13–45	32.8
10	101–105	102.8	16.0–28.0	20.6	6–8	6.9	24–49	39.9
18	106–110	108.5	19.0–27.5	22.0	5–8	6.7	27–60	40.0
1	116–120	117.0	—	20.0	—	6.0	—	17.0
1	121–125	121.0	—	22.7	—	7.0	—	33.0
1	131–135	131.0	—	31.5	—	8.0	—	32.0
1	141–145	145.0	—	15.7	—	6.0	—	33.0
				Guayamero cultivar				
9	70–75	74.8	9.5–18.0	14.6	4–7	6.0	20–39	27.1
1	76–80	76.0	—	17.8	—	7.0	—	24.0
14	81–85	82.0	8.0–22.0	15.0	4–7	5.9	12–37	26.8
9	86–90	88.0	10.5–29.3	17.7	6–8	6.6	21–45	36.0
5	91–95	95.0	9.0–24.0	16.8	4–7	5.6	13–44	33.0
20	96–100	97.4	11.0–31.0	19.1	5–8	6.2	12–76	36.8
13	101–105	104.2	13.5–29.5	22.5	4–8	6.7	19–55	41.5
5	106–110	109.0	12.5–31.5	21.8	5–7	6.0	13–57	33.6
3	111–115	113.7	11.75–25.0	17.2	4–6	5.0	25–39	31.7

The data in table 5 show that the weight of the bunches of the Maricongo cultivar averaged 2 pounds more than those of the Guayamero. The Maricongo had an average of five more fruits per bunch than the Guayamero. When yields are calculated per *cuerda*[3] with 800 plants in production, it is estimated that the Maricongo would produce 1,500 pounds more per *cvdera* with about 3,000 more fruits.

[3] 0.9712 acre.

The above data show the similarities and differences in the production patterns of the Guayamero and Maricongo cultivars. If the Maricongo would behave in commercial plantations as in the experimental plot, a production peak would be expected with a surplus of fruit available within

TABLE 4.—*Characteristics of bunches of the Maricongo and Guayamero plantain cultivars grouped according to their weights*

Weight range (pounds)	Bunches harvested		Number of hands		Number of fruits	
	Number	Percent	Range	Mean	Range	Mean
Maricongo cultivar						
5-10	1	1.2	—	5.0	—	11.0
11-15	10	1.6	5-7	5.9	13-36	24.0
16-20	43	50.0	5-8	6.5	17-48	36.0
21-25	26	30.2	5-8	7.0	27-60	42.7
26-30	4	4.7	7-7	7.0	41-56	49.5
31-35	2	2.3	6-8	7.0	32-44	38.0
Guayamero cultivar						
5-10	6	7.9	4-6	5.0	12-21	17.0
11-15	26	34.2	4-7	5.6	12-76	27.6
16-20	18	23.7	5-7	6.4	21-50	33.8
21-25	18	23.7	5-8	6.5	32-52	41.6
26-30	6	7.9	7-8	7.5	38-55	45.8
31-35	2	2.6	7-8	7.5	52-57	54.5

TABLE 5.—*Yields obtained from the Maricongo and Guayamero plantain cultivars*

Cultivar	Bunches harvested	Average weight of bunches	Average fruits per bunch	Estimated yield per *cuerda*[1]	
				Weight of bunches	Number of fruits
	Number	*Pounds*	*Number*	*Pounds*	*Number*
Maricongo	86	20.0	37.0	16,016	29,616
Guayamero	76	18.1	33.7	14,504	26,960

[1] *Cuerda* = 0.9712 acre. Estimates are based on 800 plants per *cuerda*.

a period of 2 months. In order to spread production and to have fruit available for a longer period for processing, the Guayamero would be preferable. However, since the Maricongo cultivar produced higher yields of fruit in terms of weight and fruit number and the fruit was more uniform in weight, the use of this cultivar in commerical plantings will be more advantageous to both the grower and the processor.

TABLE 6.—*Characteristics of fruits of the Maricongo and Guayamero plantain cultivars*

Observations (number)	Age (days)		Weight of fruit (grams)		Average pulp content (percent)	Average peel content (percent)	Pulp: peel ratio		Cross-section dimensions			
									Longer diameter (1/16 inch)		Shorter diameter (1/16 inch)	
	Range	Mean	Range	Mean			Range	Mean	Range	Mean	Range	Mean
Maricongo cultivar												
11	80–85	83.0	180.4–309.2	225.0	58.8	41.2	1.25–1.62	1.44	26.0–32.0	28.5	22.0–27.0	25.2
10	86–90	87.0	175.2–245.0	205.9	57.7	42.3	1.21–1.76	1.38	25.0–30.0	26.6	24.0–28.0	25.2
15	91–95	93.7	171.2–281.6	212.4	61.4	38.6	0.67–1.61	1.43	26.0–29.0	27.3	22.0–27.0	25.1
17	96–100	97.0	200.5–368.0	251.9	58.9	41.1	1.20–1.81	1.43	26.0–32.0	28.7	24.0–30.0	26.5
10	101–105	102.8	179.5–332.0	227.6	57.8	42.2	1.16–1.71	1.45	25.0–32.0	28.0	23.0–29.0	25.0
18	106–110	108.5	175.9–366.5	244.3	61.8	38.2	1.06–1.94	1.58	26.0–32.0	28.4	24.0–30.0	26.5
1	116–120	117.0	—	428.1	57.2	42.8	—	1.33	—	32.0	—	29.0
1	121–125	121.0	—	333.6	63.2	36.8	—	1.71	—	34.0	—	32.0
1	131–135	131.0	—	428.6	66.9	33.1	—	2.02	—	35.0	—	33.0
1	141–145	145.0	—	220.5	60.5	39.4	—	1.53	—	28.0	—	25.0
Guayamero cultivar												
9	70–75	74.8	132.2–338.0	212.8	58.8	41.2	1.15–1.69	1.40	25.0–35.0	28.4	22.0–30.0	25.0
1	76–80	76.0	—	184.3	55.9	44.1	—	1.27	—	26.0	—	24.0
14	81–85	82.0	149.7–344.3	255.0	60.2	39.2	1.18–1.77	1.49	24.0–38.0	29.8	22.0–31.0	27.1
9	86–90	88.0	132.1–291.3	200.5	58.5	41.5	1.21–1.61	1.38	26.0–30.0	26.3	21.0–27.0	24.0
5	91–95	95.0	157.7–263.0	204.8	58.2	41.8	1.14–1.59	1.37	24.0–29.0	26.0	24.0–26.0	25.0
20	96–100	97.4	125.7–457.1	259.9	60.8	39.2	0.82–1.99	1.53	24.0–34.0	28.8	21.0–32.0	26.8
13	101–105	104.2	189.4–380.0	226.4	65.2	34.8	1.10–1.70	1.51	27.0–36.0	28.0	25.0–29.0	26.4
5	106–110	109.0	252.3–370.2	303.6	64.4	35.6	1.37–1.86	1.71	28.0–37.0	33.0	23.0–32.0	29.0
3	111–115	113.7	166.5–275.2	220.8	62.0	38.0	1.29–1.89	1.59	28.0–30.0	29.0	23.0–29.0	26.0

From the processor's point of view, the quality of the fruit is of greater importance than the production characteristics. The uniformity in the weight of the fruit, pulp content, variation in fruit size, and flavor are the important characteristics which affect yield and product quality.

Table 6 shows the weight, pulp content, and size of fruits of the Mari-

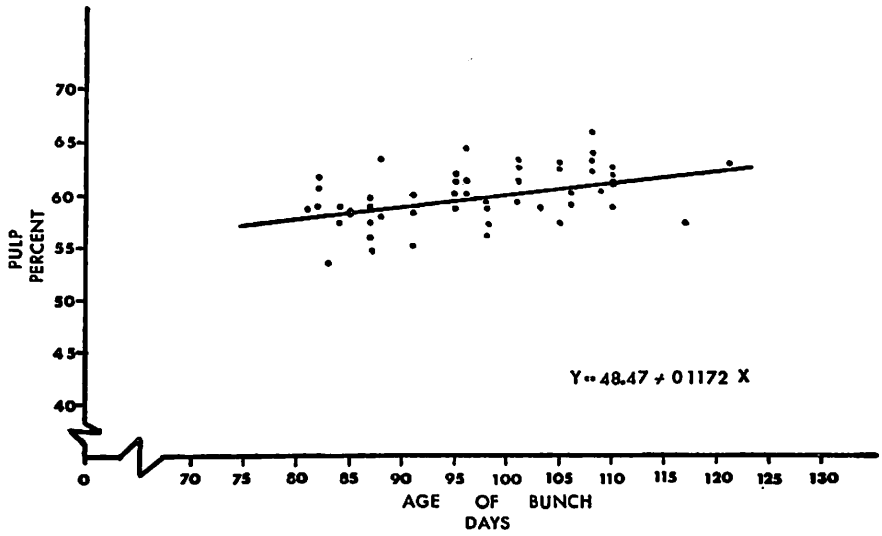

FIG. 6.—Variation of pulp content with the age of plantains, Maricongo cultivar.

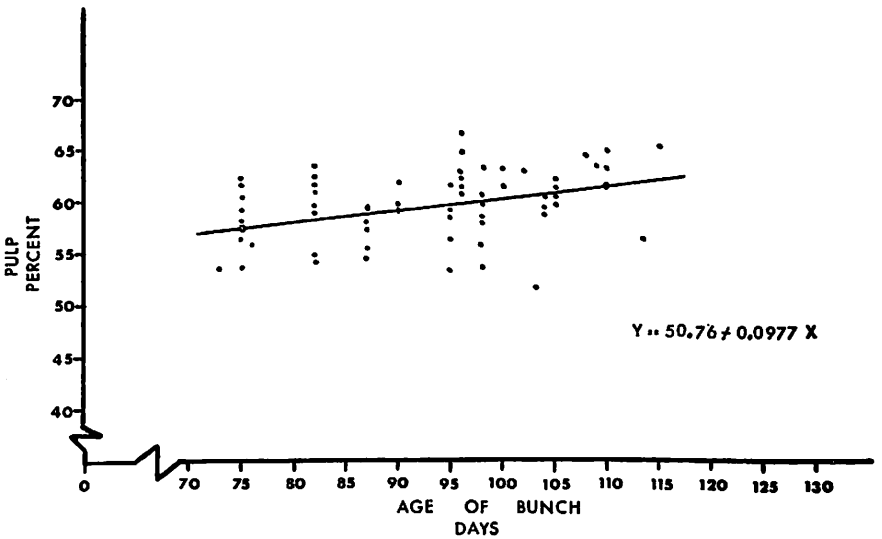

FIG. 7.—Variation of pulp content with the age of plantains, Guayamero cultivar.

congo and Guayamero cultivars harvested at different ages. The wide variation of the values for each characteristic measured makes an exact comparison impossible, but in general the data indicated that both cultivars are quite similar in all the characteristics measured.

Since the pulp content determines the yield of processed products, the variation of pulp content with age for the two cultivars was subjected to statistical analysis. In figures 6 and 7 the values for pulp content for a large number of bunches of both cultivars are plotted together with the regression curves. Both cultivars showed the same change in pulp content

TABLE 7.—*Chemical composition of green plantains of the Maricongo and Guayamero cultivars*

Characteristics	Cultivars	
	Maricongo	Guayamero
Color of peel	Green	Green
Acidity as anhydrous citric acid.....percent	0.09	0.15
pH	6.27	6.06
Moisture.....percent	58.82	60.42
Starch.....Do.	27.29	25.19
Reducing sugars.....Do.	.39	.41
Total sugars (as invert).....Do.	.57	.90

TABLE 8.—*Shear-press values for fruit of the Maricongo and Guayamero plantain cultivars harvested at different ages*

Age[1] in days	Shear-press values	
	Maximum force (pounds)	Area of curve (square inches)
Maricongo		
69–73	1,240	4.40
76	1,320	4.73
81–84	1,350	4.90
88–91	1,240	4.81
95	1,380	5.34
Guayamero		
73	1,300	4.70
83	1,460	5.30
87	1,160	4.52
97	1,040	4.13

[1] Age measured from the date the bunch shot.

with age, and if the two regression curves were plotted on one graph, they would be superimposed. The *t* test also showed no difference in the pulp content of both cultivars.

The chemical composition of green fruit is shown in table 7. Both cultivars at a similar stage of maturity have similar levels of the different constituents indicated.

Shear-press values which were used as a measure of texture are given in table 8. These values are similar in both cultivars at the different ages at which the plantains were harvested.

From the similarity found between the cultivars in pulp content and chemical composition, it is natural to expect little variation in the quality of the processed products. To confirm this assumption plantain chips, frozen

TABLE 9.—*Processing characteristics of plantains of the Maricongo and Guayamero cultivars*

Product prepared	Cultivar	Yields (percent)	Results of organoleptic tests
Plaintain chips	Maricongo	31.25[1]	No significant difference between samples in color and flavor attributes
	Guayamero	31.57	
Fried slices (*tostones*)	Maricongo	47.81[2]	No significant difference between samples in overall quality
	Guayamero	50.35	
Ripe plantains in syrup	Maricongo	59.75[3]	Do.
	Guayamero	59.04	

[1] Percent fried chips on unpeeled green-fruit weight.
[2] Percent trimmed slices on unpeeled green-fruit weight.
[3] Percent trimmed sections on unpeeled green-fruit weight.

green plantain slices, and ripe plantains in syrup were prepared and submitted to organoleptic appraisal. The statistical analysis of the data which is shown in table 9 confirmed that there is no difference in the quality of three types of products prepared from both cultivars. The yields of processed products are also indicated in table 9. Yields of plantain chips and ripe plantains in syrup are similar for both cultivars. Lower yields of slices for freezing and frying were obtained from the Maricongo cultivar. These lower yields may have resulted from excessive trimming, and no evidence was obtained from these experiments to suggest that the lower yields obtained resulted from varietal characteristics.

SUMMARY

Two plantain cultivars grown commercially in Puerto Rico, known as Guayamero and Maricongo, were compared in regard to their suitability

for processing. Both cultivars were found to have a similar flowering and bunch-development pattern. The fruit from both cultivars was similar in pulp composition and texture. The Maricongo cultivar was found to be a higher yielder than the Guayamero, both in terms of number and weight of fruit produced per *cuerda*. No difference in yields or quality was observed when plantain chips, ripe plantains cooked in syrup, and fried green plantain slices were prepared from both cultivars.

RESUMEN

En este estudio se compararon las características de las selecciones de plátano Maricongo y Guayamero que más se prestan para la elaboración. En ambas selecciones fue similar la florecida y la producción del racimo. No se observó diferencia alguna en la composición química ni en la textura de las frutas. El Maricongo superó al Guayamero tanto en el número de plátanos por cuerda como en el peso de la fruta. Al elaborarse tostones, platanutre y plátano maduro en almíbar, no se observó diferencia entre las dos selecciones en los rendimientos ni en la calidad de los productos elaborados.

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