

Studies on the Freezing of Plantains (*Musa paradisiaca*)

III. Effect of Stage of Maturity at Harvest on Quality of Frozen Products¹

*F. Sánchez Nieva, I. Hernández and C. E. Bueso*²

ABSTRACT

The stage of development of the fruit of plantain at harvest was found to affect the quality of fried products prepared from raw and prefried frozen green slices. When harvested from 48 to 125 days after shooting, with a pulp content ranging from 48 to 68 percent, tasters always selected as superior the fried slices prepared from fruit with a pulp content of 60 percent or over. The effect of the stage of development on quality was more pronounced on the attribute of appearance than on flavor. For commercial processing, products of acceptable quality can be prepared from plantains with a pulp content ranging from 55 to 65 percent.

INTRODUCTION

The quality of fried plantain slices was shown by Sánchez et al. (5) to be affected by the stage of maturity at which the fruit was harvested for processing. The quality and appearance rating of fried plantain products prepared from frozen green plantains were affected by the age at which the fruit was harvested. Slices receiving higher rating were those prepared from plantains harvested when 90 days or over after shooting.

From the point of view of the processor, it is of more importance to know the range of maturity at harvest within which the quality of the products can be maintained uniform. In commercial practice it is fairly difficult to obtain plantains for processing at any specific stage of development, as it is a common practice for farmers to harvest the fruit when they judge the fingers by appearance are full enough to command a reasonable price in the market.

The present investigations were conducted to determine in more detail the effect of maturity at harvest on the quality of the two frozen plantain products, raw and pre-fried slices.

¹ Manuscript submitted to Editorial Board October 10, 1974.

² Chemical Engineer, Assistant Chemical Engineer, and Assistant Food Technology Laboratory, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico, Río Piedras, P.R.

MATERIALS AND METHODS

Maricongo cultivar bunches were harvested at different ages measured in days from time of flowering. The bunches were taken to the laboratory immediately and processed the day following harvest. Fingers from the third hand from the stem end were taken to determine pulp content, texture and chemical composition.

Starch of peeled fruit was determined by the method of Carter and Neubert (1). Reducing and total sugars were determined by the Moyer and Holgate method (4). Texture was measured by the procedure described by Sánchez Nieva et al. (6).

The bunches were processed as follows: The fruit was removed from the stems, weighed and peeled in steam over 80 lb/in²g for 30 seconds, followed by cooling with water sprays. The peeled fruit was sliced crosswise into sections about 1 inch thick. The slices were blanched in steam from 3 to 4 minutes and rapidly cooled to about 38° C (100° F) with water sprays. The blanched slices were sulfited in a 0.6 percent K₂S₂O₅ solution for 4 minutes. The sulfited slices were packed in waxed cardboard boxes overwrapped with vapor moisture proof paper and quick frozen at -42.7° C (-45° F) in a plate freezer, then stored at -23.3° C (10° F). When a pre-fried product was to be prepared, the sulfited slices were fried for 4 minutes at 176.6° C (350° F) in a mixture of 60 percent hydrogenated vegetable shortening and 40 percent lard. After frying and drained of fat, the slices were cooled to near room temperature in a stream of cold air and then packed and frozen as indicated above.

For organoleptic tests, the raw frozen slices were fried without thawing in shortening at 176.6° C (350° F) for 8 minutes. The slices were pressed and fried a second time at 190.5° C (375° F) for 5 minutes. The pre-fried slices were fried for only 6 minutes in shortening at 176.6° C (350° F) before serving.

Two methods of organoleptic evaluation were used. For overall quality appraisal, and to determine differences among treatments based on overall quality or on any specific quality factor, a ± 2 scale (2) was used. To determine the relative effect of the different treatments on the different attributes of quality measured, the ranking test of Kramer (3) was employed.

RESULTS AND DISCUSSION

FROZEN RAW PLANTAINS

The characteristics of the fruit used in these experiments are shown in table 1. The age of the fruit at harvest ranged from 48 to 125 days measured from date of shooting. As previously reported by Sánchez et al. (5) the only characteristics measured which varied with age were the texture

TABLE 1.—*Characteristics of plantain harvested at different ages in days after shooting as indicated*

Age at harvest days after shooting	Pulp content	Texture shear press force values	Reducing sugar	Total sugar	Starch
	<i>Percent</i>	<i>Kgs</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
48	46.17	190.5	0.71	3.96	23.83
57	52.70	263.1	0.16	2.05	25.15
68	56.48	362.8	0.22	2.42	33.37
78	54.54	263.1	0.20	2.40	29.34
82	58.10	344.7	0.27	—	31.00
85	60.80	498.8	0.32	1.71	31.17
92	61.10	344.7	0.26	2.82	30.43
99	61.80	313.9	0.28	1.62	31.34
106	63.70	487.1	0.41	1.99	32.70
113	66.81	263.1	0.73	4.14	27.31
125	68.32	235.8	1.30	3.10	27.20

TABLE 2.—*Effect of age at harvest on the quality of fried tostones prepared from raw, frozen green plantain slices*

Age at harvest	Pulp content	Overall sample quality	Order of preference
<i>Days after shooting</i>	<i>Percent</i>	<i>Average score¹</i>	<i>Ranking²</i>
48	46.17	-0.35	11
57	52.70	0.15	10
68	56.48	0.87	9
78	54.54	0.72	8
82	58.10	0.70	6
85	60.80	1.00	7
89	—	0.86	—
92	61.10	0.55	5
99	61.80	0.88	3
106	63.70	0.69	2
113	66.81	0.80	1
125	68.32	0.80	4

¹ ± 2 scale; + 2 best.

² 1 best.

and pulp content. No significant change in starch or carbohydrates was observed among the samples.

Table 2 shows the results of organoleptic tests conducted using a ± 2 scale to rate the overall quality of the samples. The average pulp contents for different ages are also indicated. Statistical analysis of the data for linear correlation of age at harvest and organoleptic rating on a ± 2 scale gives a correlation coefficient of 0.871 significant at the 1 percent level, indicating that the age at which plantains are harvested have an approxi-

mately linear effect on overall quality of tostones prepared from raw frozen fruit.

Similarly, the samples were ranked for appearance, disregarding overall quality or flavor. The results of the ranking tests are given in the following tabulation,

Age at harvest (days)	48	57	68	78	82	85	92	99	106	113	125
Order of preference	11	10	9	8	6	7	5	3	2	1	4

Statistical analysis of the data showed a highly significant correlation ($r = 0.92$) between days after shooting and the order of preference of the tostones prepared from the frozen raw plantains. The results of the ranking test to compare the samples among themselves indicated that the samples prepared from fruit harvested at 48 and 57 days were rejected at the 1-

TABLE 3.—Group comparisons of tostones prepared from fruit of different ages at harvest

Group number	Ages compared	Type of test	Results
	<i>Days</i>		
1	68, 78, 85, 99	\pm Scale	Sample prepared from fruit 68 days old, rejected
2	82, 92, 106, 113	\pm Scale	No significant difference
3	89, 99, 125	\pm Scale	Do.
4	78, 85, 99, 106, 113	Ranking	Do.
5	99, 106, 113, 125	Ranking	Do.

percent level, while those prepared from fruit harvested 106 and 113 days after shooting were found best in the ranking test at the 1 percent level.

To determine the tolerance which could be allowed for age at harvest without affecting quality to a point of rejection, smaller groups of tostones were prepared from plantains harvested at different ages and submitted to taste by the ± 2 scale and by ranking. The results of these tests are summarized in table 3.

The results show that no significant difference in the overall quality of samples prepared from fruit ranging in age from 79 to 125 days at harvest could be determined either when using a ± 2 scale or by ranking. It should be noted that all samples found similar in quality have a pulp content approximating 60 percent, confirming the findings by Sánchez Nieva et al. (6).

PRE-FRIED PLANTAINS

An investigation was conducted on the effect of age at harvest on the quality of tostones prepared from pre-fried slices. The age of the fruit at

TABLE 4.—Characteristic of plantains of the Maricongo cultivar used in the preparation of pre-fried tostones harvested at different ages after shooting

Age at harvest	Average weight of fruit	Pulp content	Pulp to peel ratio	Texture shear press force values
<i>Days after shooting</i>	<i>Grams</i>	<i>Percent</i>		<i>Kgs</i>
49	105.0	48.8	0.96	244.9
61	250.4	62.7	1.69	308.4
64	133.5	50.5	1.02	254.0
72	134.0	55.1	1.22	371.9
78	157.3	52.6	1.15	455.3
85	174.7	57.2	1.33	362.8
92	149.2	54.1	1.18	435.4
98	228.0	63.8	1.67	299.3
100	210.1	60.3	1.52	498.9
106	232.5	61.2	1.58	272.2
113	269.0	64.7	1.87	299.3

TABLE 5.—Effect of age of the fruit at harvest on the appearance attribute of pre-fried tostones

Age after shooting	Pulp content	Rank Sums	Order of Preference	Significance
<i>Days</i>	<i>Percent</i>			
49	48.84	162	11	Rejected**
55	50.62	150	10	Rejected**
68	54.08	128	9	Rejected**
72	55.05	115	8	
78	52.63	60	4	
84	60.34	56	3	Superior**
85	57.18	82	6	
96	62.74	62	5	
98	63.75	49	2	Superior**
106	61.20	110	7	
113	64.79	16	1	Superior**

** Significant at the 1-percent level.

harvest ranged from 49 to 113 days as shown in table 4. The pulp content varied from 48.8 to 64.7 percent.

The results of ranking tests to determine the effect of age at harvest on the appearance of the tostones prepared from pre-fried slices are shown on table 5. Of the 11 samples ranked, those with an age at harvest of 49, 55 and 68 days and a pulp content of 48.84, 50.62 and 54.08 percent respectively, were rejected (at the 1-percent level). Three samples aging 84, 98 and 113 days, all with a pulp content over 60 percent, were found superior. Further analysis of the data showed a significant correlation between age at harvest and order of preference with a correlation coefficient of -0.8040 significant at the 1-percent level. When the samples were ranked for over-

all quality, the results were as shown in the following tabulation, indicating that samples harvested at 49 days with a pulp content of 48.8 percent were rejected at the 1-percent level. Those with an age of 106 days and a pulp content of 61.2 were found to be superior at the 1-percent level.

Age of fruit at harvest	49	68	78	85	98	106	113
Rank sums	60	50	42	41	21	14	24
Rank sums for significant difference: at 1% P				19-53			
				5% P	21-51		

Organoleptic tests using the ± 2 scale with samples stored for 3 months at -10° F confirmed results of previous tests (table 6). Tasters preferred

TABLE 6.—*Organoleptic evaluation of pre-fried tostones using a ± 2 scale for the appraisal of appearance and overall quality*

Sample	Age <i>Days after shooting</i>	Appearance attribute		Overall quality	
		Score	Results	Score	Results
A	49	-1.5		0.0	
B	68	-0.7	Superior to A	0.30	
C	78	0.4	Superior to A and B	0.55	
D	85	0.59	Superior to A and B	0.20	
E	98	1.3	Superior to A, B, C and D	1.2	Superior to A, B and D**
F	106	1.5	Superior to A, B, C and D	1.2	Superior to A, B and D**
G	113	1.3	Superior to A, B, C and D	1.2	Superior to A, B and D**

samples prepared from more mature fruit from both the standpoint of overall quality and appearance, when compared simultaneously with samples of less mature fruit. Tasters in repeated tests could usually detect a difference among samples rated for appearance, preferring samples prepared from the more mature fruit. They failed to detect any difference in quality in samples with a pulp content close to 60 percent.

The results of experiments conducted both with tostones prepared from either raw or pre-fried frozen slices show that age of plantains at time of harvest have a direct effect on product quality. Although found to affect overall quality of the tostones, this age has a more pronounced effect on product appearance.

In numerous tests conducted with frozen plantains, it has been observed that our local tasters do not easily detect quality difference in tostones prepared from fruit subjected to different treatments. They could always

detect differences in appearance, however, due to size, color, or the presence or absence of browning. The quality of fresh plantain purchased by local housewives varies within wide limits. The quality of tostones they prepare may also vary appreciably. Consequently, local people apparently are not too selective in regard to quality attributes they in general expect in tostones.

The processor however must not reach the conclusion that irrespective of the grade of raw material used, the frozen slices he produces will yield tostones of similar quality and equal acceptance. It may be true that for local consumption, because of the wide range of quality acceptability of tostones by consumers, the quality of the product as affected by the stage of development of the fruit at harvest may not be of great importance. For other markets however, where the product stands for itself, and in which acceptance depends on product quality, the product should be prepared controlling all processing variables to obtain the best quality. For this particular market it is very important to process only fruit at the optimum stage of maturity, which corresponds to a pulp content of at least 60 percent, as age affects appearance of fried "tostones", one of the important attributes for product acceptance, particularly so in the pre-fried frozen product.

RESUMEN

Un estudio se llevó a cabo para determinar cómo el estado de desarrollo del plátano (*Musa paradisiaca*) a la época de la cosecha afecta la calidad de rodajas congeladas preparadas del plátano crudo y de las rodajas fritas antes de congelarse.

En ambos tipos de producto, el estado de desarrollo del plátano al cosecharse, medido en términos de los días transcurridos después de la floración y del porcentaje de pulpa, tuvo un efecto significativo sobre la calidad del producto frito conocido en Puerto Rico como "tostón." El producto preparado de plátano cosechado en un estado de desarrollo en el cual el contenido de pulpa era de alrededor de un 60 por ciento, fue siempre seleccionado como superior por los catadores. El estado de desarrollo de la fruta usada en la preparación de las rodajas tuvo un efecto más marcado sobre la apariencia del producto que sobre el sabor. Los datos obtenidos de este estudio tienden a indicar que en la elaboración de las rodajas congeladas en escala comercial, puede obtenerse un producto de buena calidad utilizando plátanos con un contenido de pulpa que fluctúe entre un 55 a un 65 por ciento.

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