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Economical Method for the Production of Flour from Green Plantains

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INTRODUCTION

Plantains are among the most important agricultural products of Puerto Rico and have long been established in the densely populated mountainous area of the Island. This is mostly because of the soil types which are suitable for growing this product, which makes it difficult to find a substitute crop of equivalent nutritional value.

However, farmers have always been harassed by the uncertainty of local market conditions. In order to solve problems dealing with overproduction and consequent low prices for this commodity, an economical method for the processing and development of new products from plantains, suitable for local consumption as well as for export, should be perfected.

The production of flour from the green plantains which could be used as a substitute for part of the imported farinaceous products being locally consumed in great quantities, might contribute to marketing stability and encourage the farmers to increase the production of this product.

Plantain and banana flours are produced in significant quantities in many countries of the world, especially Brazil. These flours have been known and used for centuries in the tropical producing areas of the world.

REVIEW OF LITERATURE

Reported investigations on the dehydration of plantains are not numerous. Methods of dehydration other than the primitive ones, such as sun-drying, are used on a very limited scale. Kulkarni (*1*)[2] stated that it takes 3 to 4 days for the peeled whole plantains to be dried under the sun. He

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[2] Italic numbers in parentheses refer to Literature Cited, p. 10.

added that properly dried plantains keep for 6 months. Some of the farmers in the mountainous areas of the Island dry the plantains by peeling, grating, or slicing in cross-sections, or lengthwise, to about ⅛-inch thick and then spreading the slices on palm leaves or on a piece of cloth placed under the sun for 2 to 3 days. In Brazil, Da Silveira (*2*), studied the discoloration of the ripe banana flour prepared by the drum-drying method, and recommended dipping the fruit in a solution of 1-percent citric acid instead of sulfuring before dehydration. Roudier and Lavollay (*3*) had explained the modern methods used in French Africa in which the fruits were dried in the tunnel dryers operated at temperatures between 140° to 167° F. He recommended sulfuring the fruits to prevent discoloration, using 200 mg. of sulfur dioxide per 100 gm. of fruit.

MATERIALS AND PROCEDURES

EXPLORATORY INVESTIGATIONS

Exploratory investigations were conducted for the development of a successful method of dehydrating green plantains in order to produce a flour of acceptable quality. Peeled as well as unpeeled plantains were used in these investigations which covered the following variables: Slicing at different thicknesses, ranging from ⅛ to ½ inch, peeling by hand, steam, or hot water, chemical pretreatments, such as soaking the slices in different solutions of different concentrations as citric acid, potassium metabisulfite, sodium sulfite, sodium chloride, sugar, ascorbic acid, acerola juice, starch, calcium carbonate, potassium bicarbonate and water, and, finally, the dehydration was carried out at different temperatures ranging between 140° and 200°F. Emphasis was placed upon those procedures which showed promising results that appealed to the author when the experiment was conducted.

PROCESSING

Green plantains of the variety Machete were purchased from the local market. They were divided into five lots weighing 20 pounds each and were prepared for dehydration as follows:

1. Plantains were peeled by hand and then sliced.
2. Plantains were peeled by applying steam under pressure of 70 pounds for 20 seconds, and then sliced.
3. Unpeeled plantains were sliced.
4. Unpeeled plantains were sliced and then soaked in 2-percent citric acid for 24 hours.
5. Unpeeled plantains were sliced and then soaked in a 2-percent solution of potassium metabisulfite for 24 hours, and for 1 hour in water.

All the slices were cut to a thickness of ¼ inch. The slices of each lot

were placed in perforated trays measuring 30 x 20 x 2 inches to a depth of about ¾ inch throughout the entire area of the trays. The trays were then placed in the Proctor and Schwartz cabinet dehydrator. The dry-bulb temperature was set at 200° F., using the cross-circulation airflow and, after 1 hour, it was reduced to 160° F. for the remaining 5 hours of the dehydration period. The wet-bulb temperature varied between 110° F. and 130° F. The dehydrated plantains were weighed and then converted to flour by a mechanical grinder. The flours were placed in polyethylene bags or tin cans for further studies.

CHEMICAL ANALYSIS

The moisture content was determined by drying in the vacuum oven. The protein was determined by the Kjeldahl method. The total sugars, reducing sugars, alcohol-insoluble solids, crude fiber, and starch were determined by the A.O.A.C. (*4*) methods. All the analyses were made in duplicate and then averaged.

PHYSICAL PROPERTIES

The bulk density was obtained by weighing flour into a graduated cylinder and noting the volume before and after the cylinder was rapped 50 times on a wooden table. The color was measured by the Hunter color and color-difference meter. The calories were determined according to the Parr oxygen-bomb combustion method (*5*).

Microscopic slides of the starch grains of the flours were prepared by emulsifying the flour in 80-percent alcohol, then a drop of this slurry was placed on a slide and dried. A cover slide was then mounted using glycerol. These slides were used for the microscopic observations in order to determine the effect of different treatments on the starch grains of the flours.

Separate lots weighing 53 pounds each were used to determine the effect of peeling on the yield of flour as compared with that from unpeeled plantains.

ORGANOLEPTIC APPRAISALS

Samples of each flour were placed separately in small saucers and then presented to a panel of experienced judges for them to indicate their preference as to the color. The color was judged while the saucers were under natural light. The flavor was appraised by preparing meat consomme to which plantain flour of equal amounts from each lot was added separately, thereby forming plantain soup. The judges were seated in air-conditioned taste-booths under red light in order to mask the natural color of the soup while scoring the flavor. The samples were presented in pairs in order to score the difference as well as the preference. The ballots contained the

following questions: 1, Is there any difference? 2, If so, which one do you consider has better flavor, color, or texture?

Other delicacies were prepared from these flours such as "buñuelos" (crullers) and were also appraised by the flavor-acceptance test in which the hedonic scale was used. In this scale 9 points were given to the highest score indicated by "like extremely" to 1 point for the lowest score indicated by "dislike extremely". Soups were also appraised by this method. The data were then analyzed statistically.

TABLE 1.—*Chemical analysis (percent) of different plantain flours as affected by different treatments*

Constituent	Untreated			Treated, not peeled	
	Hand-peeled	Steam-peeled	Not peeled	Potassium metabisulfite	Citric acid
Moisture	10.49	10.17	10.77	11.87	11.05
Total sugars	.49	.53	.65	.18	.25
Alcohol-insoluble solids	88.01	84.43	85.69	86.80	85.08
Starch	71.62	70.09	73.49	70.40	72.68
Crude fiber	.91	—	—	1.08	—
Protein	3.20	3.64	3.92	2.80	2.58

TABLE 2.—*The effect of peeling on the yield of treated and untreated plantain flours*

Determination made	Treated, not peeled		Untreated	
	Potassium metabisulfite used	Citric acid used	Not peeled	Peeled
Weight of green plantains..... pounds	53.00	53.00	53.00	53.00
Weight of treated plantain slices... do.	54.00	53.75	—	—
Weight of dehydrated slices..... do.	17.00	17.00	16.20	13.50
Weight of flour..... do.	16.60	16.50	15.90	13.40
Yield of flour..... percent	31.32	31.13	30.00	25.28

RESULTS AND DISCUSSION

CHEMICAL ANALYSES

The results of the moisture analysis of the different flours as shown in table 1, indicate that the treated flours possessed a relatively higher moisture content than the untreated ones. This was because the plantains gained some weight by absorption during the soaking treatments, as indicated in table 2.

The amounts of alcohol-insoluble solids and starch, as shown in table 1, were about the same in all the flours which indicates that the soaking treatments did not affect them. The same table shows that the treated flours

contained relatively less total sugars and protein than the untreated ones. However, since these losses were very small they did not affect the quality of the flours, as indicated by the results of the organoleptic appraisals

TABLE 3.—*Analysis of variance of the scores of 11 tasters, indicating the degree of acceptance of the color and flavor of soups prepared from different plantain flours*

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F	At 5-percent level
Flavor					
Among treatments	4	126.2	31.55	108.79[1]	2.56
Among scores of tasters	50	14.64	.29		
Total	54	140.84			

Average of the scores of 11 tasters

Flours	Treated with potassium metabisulfite	Treated with citric acid	Hand-peeled	Not peeled	Steam-peeled
Average	6.0	5.7	5.4	6.18	6.9

Color

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F	At 5-percent level
Among treatments	4	65.82	16.45	16.6[2]	2.56
Among scores of tasters	50	49.58	.99		
Total	54	115.40			

Average of the scores of 11 tasters

Flours	Treated with potassium metabisulfite	Treated with citric acid	Hand-peeled	Not peeled	Steam-peeled
Average	7.45	6.5	7.5	4.9	6.45

[1] L.S.D. at 5-percent level = 0.86.
[2] L.S.D. at 5-percent level = 1.61.

shown in tables 3 and 4. Very little difference was shown in the percentage of crude fibers between the peeled and the unpeeled plantains.

OBJECTIVE TESTS FOR COLOR AND BULK DENSITY

The results of the color determinations shown in table 5, indicated that the flour treated with potassium metabisulfite reflected more greenish

color than the other flours. This shade of greenness is caused by the effect of sulfuring upon the chlorophyll pigments present in the plantain skin.

Table 5 also shows that plantains peeled by applying steam at high pressure produced a flour with higher bulk density than the others. This might be because of the effect of heat on the protein as well as on the starch granules. The results of the microscopic studies, as illustrated in

TABLE 4.—*Analysis of variance of the scores of 10 tasters, indicating the degree of acceptance of the color and flavor of "buñuelos"[1] prepared from different plantain flours*

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F	At 5-percent level
Flavor					
Among treatments	4	10.4	2.60	1.71	2.58
Among scores of tasters	45	68.6	1.52		
Total	49	79.0			
Color					
Source of variation	Degrees of freedom	Sum of squares	Mean squares	F	At 5-percent level
Among treatments	4	55.3	13.82	4.78[2]	2.58
Among scores of tasters	45	130.3	2.89		
Total	49	185.6			

Average of the scores of 10 tasters

Item	Treated with potassium metabisulfite	Treated with citric acid	Hand-peeled	Not peeled	Steam-peeled
Average	6.7	5.3	7.1	4.4	6.9

[1] Crullers.

[2] L.S.D. at 5-percent level = 0.90.

figure 1, indicate that the individual starch grains of all the flours, except the steamed one, were observed clearly throughout the entire slide. However, the steamed flour showed only clusters, which is a good indication of the coagulation of starch grains as well as of the protein caused by the application of heat.

Calories produced from the different flours, as shown in table 5, were relatively in the same range, which indicates no substantial effect of the different treatments on the caloric value of the flours.

The results shown in table 2 indicate that the yields of the flours produced from the unpeeled plantains were considerably higher than the

others, especially the one treated with potassium metabisulfite. This increment in yield, as well as the savings in labor involved in peeling might have a favorable effect on the economical outlook for the production of plantain flour on a commercial basis.

ORGANOLEPTIC APPRAISAL

The results shown in table 3 indicate that there is no significant difference in the flavor of the soups prepared from the following flours: Unpeeled plantains treated with potassium metabisulfite, citric acid, not treated, and hand-peeled,

A significant difference was established between the flavor of the soup prepared from the flour of the steam-peeled plantains and the soups pre-

TABLE 5.—*Colorimetric, calorimetric, and bulk-density values of different plantain flours as affected by different treatments*

Value determined	Untreated			Treated (not peeled)	
	Hand-peeled	Steam-peeled	Not peeled	Potassium metabisulfite	Citric acid
Hunter color and color-difference meter values					
Rd	64.2	44.0	49.7	66.6	58.0
a	−1.0	−.9	−.5	−2.5	0
b	+13.9	+20.1	+13.3	+19.4	+17.0
Calories/gm.	5.54	6.06	5.57	5.70	5.82
Bulk density gm./cc.	0.56	0.75	0.60	0.56	0.56

pared from the other flours. However, the steam-peeled plantains are very hard to grind when dehydrated, and produced a flour with higher bulk density than the rest of the flours. The color of the soup prepared from the flour of the unpeeled and untreated plantains was scored the poorest, and a significant difference was established when compared with the rest of the flours.

Table 4 shows that there is no significant difference in the flavor of the "buñuelos" prepared from the different flours. The color of "buñuelos" prepared from the unpeeled and untreated plantains, as well as the ones treated with citric acid, was rated very low by the judges, therefore, a significant difference between them and the rest of the flours was obtained. Although the color of the "buñuelos" prepared from the rest of the flours was rated very high, no significant difference could be established between them.

Fifteen judges were used in determining preference as to color of the

flour obtained from unpeeled plantains treated with potassium metabisulfite as compared with that obtained from unpeeled, untreated plantains. Fourteen judges preferred the former, a significant difference, as only 13

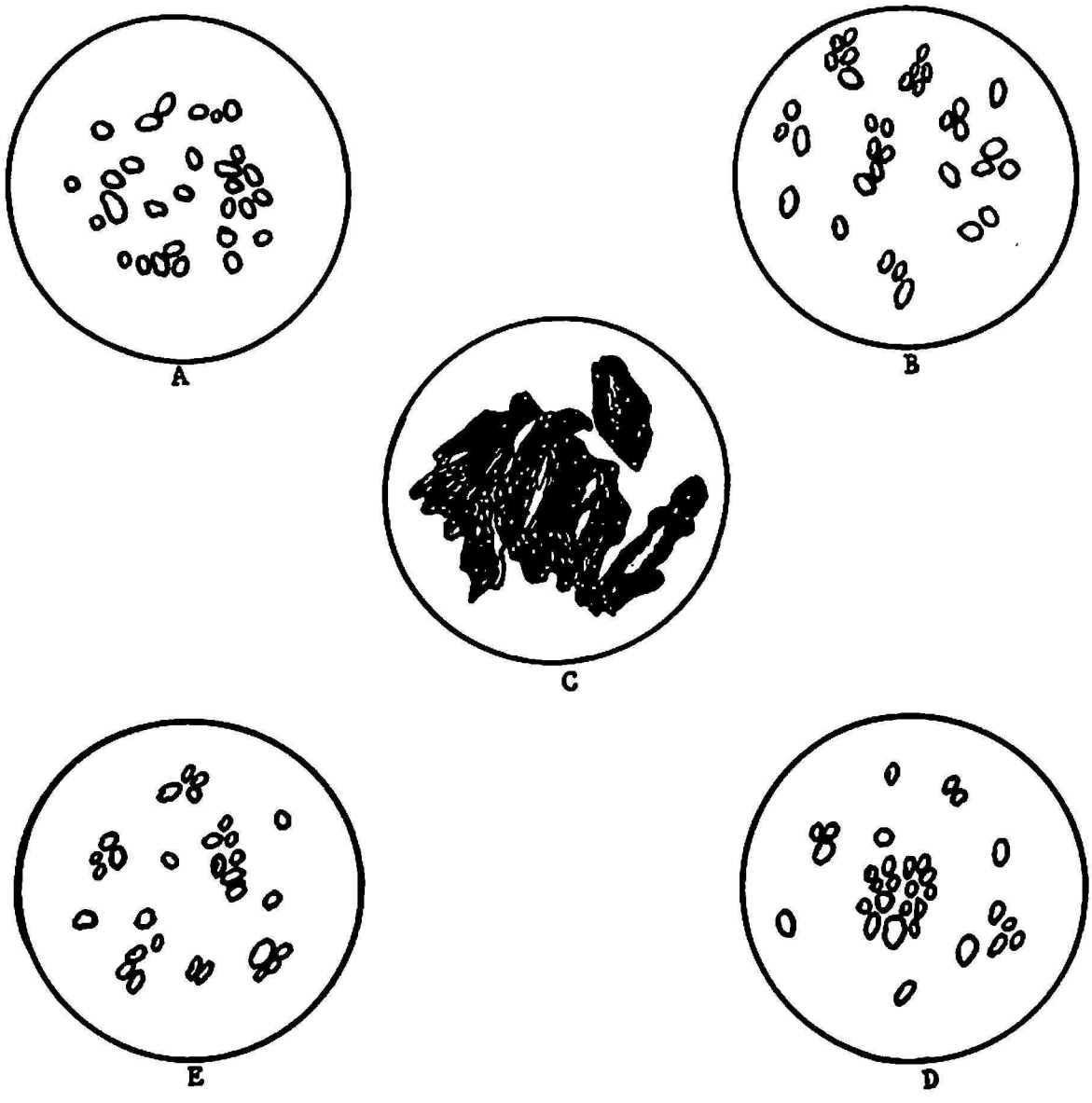

FIG. 1.—Starch grains of different plantain flours as seen under the microscope; Magnification × 80: A, Flour prepared from unpeeled plantains, soaked in 2-percent solution of potassium metabisulfite for 24 hours; B, flour prepared from unpeeled plantains, soaked in 2-percent citric acid for 24 hours; C, flour prepared from steam-peeled plantains; D, flour prepared from peeled, untreated plantains; E, flour prepared from unpeeled, untreated plantains.

would have been required to make the test significant at the 1-percent level.

Ten judges were used in determining the preference as to color of flour obtained from unpeeled plantains treated with 2-percent potassium metabisulfite as compared with those treated with 2-percent citric acid. The

judges were unanimous in preferring the flour from the plantains treated with potassium metabisulfite.

SUMMARY

An economical method was developed for producing a flour of acceptable quality from green plantains. Five lots weighing 20 pounds each were prepared for dehydration as follows: Peeled by hand and sliced, unpeeled and sliced, unpeeled sliced and treated with 2-percent potassium metabisulfite, and unpeeled sliced and treated with 2-percent citric acid.

The results follow:

1. The yield of the flour produced from the plantains which were unpeeled and treated with potassium metabisulfite, 31 to 32 percent, was higher than that produced from the peeled ones, which was 25 to 28 percent. It also showed a trend towards increase in yield compared with the rest of the flours.

2. This flour also possessed better color than the one produced from the unpeeled and untreated plantains, or the flour from plantains treated with citric acid.

3. The flours produced from the treated plantains showed a relatively higher moisture and a trend towards lower total sugars and proteins than the untreated ones.

4. The calories per gram produced from all the flours were almost the same, whereas the bulk density was higher in the flour produced from the steam-peeled plantains than in the rest of the flours which were all about the same.

5. The organoleptic tests established no significant difference between the flavor of soups and "buñuelos" (crullers) prepared from the following flours: Unpeeled not treated, unpeeled but treated with potassium metabisulfite, unpeeled and treated with citric acid, and hand-peeled. However, a significant difference was established in favor of the color of the flour prepared from the unpeeled plantains treated with potassium metabisulfite as compared with flours made from untreated, unpeeled plantains, and from those treated with citric acid.

RESUMEN

Se desarrolló un método económico para producir harinas de calidad aceptable de plátanos verdes. Se prepararon 5 lotes de 20 libras de plátano cada uno, para deshidratarse en la forma siguiente: Cáscaras removidas a mano y rebanados, rebanados con cáscaras, rebanados con cáscara y tratados con metabisulfito de potasio al 2 por ciento y rebanados con cáscara y tratados con ácido cítrico al 2 por ciento.

Los resultados demostraron que:

1. El rendimiento (31–32 por ciento) de harina producida de los plátanos

rebanados con cáscara y tratados con metabisulfito de potasio, fue mayor que el rendimiento (25–28 por ciento) que se obtuvo de los plátanos rebanados sin cáscara. También el rendimiento fue más alto que el de las otras harinas.

2. La harina del plátano verde rebanado con cáscara y tratada con el metabisulfito adquirió mejor color cuando se comparó con las del plátano verde con cáscara sin tratamiento o con la que produjo el plátano tratado con ácido cítrico.

3. Las harinas producidas de los plátanos tratados demostraron un porcentaje de humedad más alto y una tendencia hacia porcentajes de azúcares totales y proteínas más bajos en comparación con las harinas de los plátanos no tratados.

4. No se notó diferencia entre el valor calórico de las harinas producidas bajo los distintos tratamientos, sin embargo, se encontró que la densidad de las harinas producidas de plátanos tratados con vapor para remover las cáscaras, fue mayor que la de las harinas de los otros tratamientos.

5. Las pruebas organolépticas no establecieron diferencia significativa entre los sabores de las diferentes harinas sometidas para evaluación en muestras de sopas y buñuelos. En la preparación de estas muestras se usaron las siguientes harinas de plátano: Con cáscara sin tratamiento, con cáscara y 2 por ciento de metabisulfito, con cáscara y 2 por ciento de ácido cítrico y cáscaras removidas a mano. Sin embargo, pudo establecerse una diferencia significativa a favor del color de la harina de plátano con cáscara tratada con metabisulfito de potasa comparada con las harinas sin tratar derivadas del plátano sin mondar y aquellas tratadas con ácido cítrico.

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