The Freezing of Pigeonpeas[1] for Market

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INTRODUCTION

Fresh pigeonpeas are available in Puerto Rico only during the winter months, from December through March. Although pigeonpeas are canned, the fresh peas are preferred by consumers. Consumer preference for the fresh product can be attributed to changes in color and flavor which take place during canning. Even though the quality of the canned pigeonpeas can be greatly improved by proper processing, as was shown by Sánchez *et al.*, (*1*)[3] the canned product does not resemble the fresh product either in flavor, color, appearance, or texture.

Successful freezing preservation of pigeonpeas would provide the means of preserving the freshness of the product, making it available to consumers throughout the year. Since pigeonpeas are liked so well by Puerto Ricans, marketing of the fresh frozen pigeonpeas offers no major problem. Freezing of this vegetable may provide an additional outlet for the crop, mainly in markets outside Puerto Rico; as a result the acreage of pigeonpeas planted might be increased appreciably.

The present studies were undertaken to determine the feasibility of the commercial freezing of pigeonpeas, to study proper processing techniques, and to estimate the shelf-life of the frozen product and its consumer acceptance.

PROCESSING

Pigeonpeas of the Saragateado variety were grown at the Isabela, Gurabo, and Fortuna experimental farms and harvested as for canning at an average alcohol-insoluble solid content of approximately 26 percent. The pigeonpeas were delivered to the Laboratory the same day they were harvested, and stored in ⅘-bushel crates at 45° F. until they were processed.

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[3] Italic numbers in parentheses refer to Literature Cited, pp. 215-6.

The pigeonpeas were shelled as described by Sánchez *et al.*, (*1*) by steaming the pods to a negative guaiacol-hydrogen peroxide test, unless otherwise indicated, rapidly cooling in running water, and draining in a rod-reel with rods spaced at 5/16 of an inch. The drained peas were transferred to a picking-table for the removal of defective and overmature peas. The peas from the picking-table were delivered into a rotary rod-reel washer and washed with tapwater. The washed peas fell into the hopper of a rotary blancher with a dual heating-control system to maintain uniform temperature throughout, and blanched for the length of time and at the temperature set for the experiment. The blanched peas were cooled in a rotary rod-reel washer provided with water sprays, and were then subjected to a second picking operation for the removal of mashed and broken peas. The processed peas were packed by hand into plastic bags, or in waxed cardboard containers, which were overwrapped with heat-sealable moisture-vaporproof cellophane.

The pigeonpeas were frozen in a blast freezer operating at −45° F., where usually a load of 500 pounds required approximately 2 hours to be completely frozen. The frozen pigeonpeas were stored at −10° F.

To study the effect of maturity on product quality, the shelled pigeonpeas were brine-graded in a small homemade brine-separator from which the floaters and sinkers could be continuously removed. The brine-grader was equipped with a pneumatic density-controller to maintain the brine at a uniform specific gravity throughout the test. Sinkers and floaters were processed separately as already described.

ANALYTICAL METHODS

Starch was determined by the procedure described by Carter and Neubert (*2*) as adapted to pigeonpeas by Sánchez *et al.* Alcohol-insoluble solids, moisture, and reducing and total sugars as invert were determined by the AOAC procedures (*3*, *4*, *5*). Ascorbic acid was determined by the iodometric titration method of Ballantine (*6*). Total acidity was determined by titration with 0.1 N NaOH solution in a tritimeter with calomel and glass electrodes.

A test for peroxidases similar to the one described by Joslyn (*7*) was used to determine enzyme inactivation. A few peas approximating 5 gm. in weight were chosen at random from the lot being processed and crushed under 5 ml. of water in a test tube. One milliliter each of 1-percent guaiacol and 0.5-percent hydrogen peroxide were added, and the test tube was shaken to mix the contents, and allowed to stand for 5 minutes. The test was considered negative if no color development took place after standing at room temperature for 5 minutes.

ORGANOLEPTIC TESTS

Preparation of samples: Fourteen ounces of frozen pigeonpeas were thawed in 2 cups of warm water for 30 minutes. One cup of boiling water was added and the peas boiled for 15 minutes in a covered pot. Three teaspoons of salt were then added and boiling was continued for an additional period of 30 minutes. The pigeonpeas were drained, let cool to room temperature, and served to tasters in white porcelain butter dishes.

For the taste tests in which pureed pigeonpeas were rated, 178 gm. of the peas cooked as indicated were pureed in a Waring blendor by the addition of 150 ml. of distilled water, warmed to 120° F., and served to tasters in small white porcelain dishes.

RESULTS AND DISCUSSION

THE BLANCHING TREATMENT

Proper blanching has been recognized as the most important step in the processing of vegetables for freezing to avoid changes in flavor, color, loss of ascorbic acid, and other undesirable changes. Diehl *et al.* (*8*) showed that unscalded peas develop undesirable odors when cooked. Joslyn *et al.* (*9*) found it necessary to inactivate the peroxidases to prevent undesirable changes in color, flavor, and texture. Each vegetable studied was found to require a critical temperature for enzyme inactivation. Inactivation of the enzyme system was found to be essential for the retention of ascorbic acid in broccoli, green beans, lima beans, peas, spinach, and summer squash (*10*). Lee and Wagenknecht (*11*) traced the development of off-flavor in unblanched frozen peas to the rancidity of the lipid fraction, no rancidity development being observed in properly blanched peas. The effect of the degree of enzyme inactivation on the quality retention of frozen peas was studied by Dietrich and coworkers (*12*). Inactivation of catalase was found effective for retention of chlorophyl and ascorbic acid, but not of flavor. When the peas were heated adequately, as measured by a peroxidase test, they were better protected, so far as flavor, color, and ascorbic acid were concerned, than samples heated for a longer or shorter time.

As a first step in these investigations, the blanching requirements for the inactivation of the enzymes of pigeonpeas were investigated. These studies were limited to water-blanching, which is the only method of blanching pigeonpeas practiced by the local processors. Green peas were blanched in water at 180°, 185°, 190°, 195°, and 200° F., for a length of time ranging from 3 to 15 minutes. The guaiacol-hydrogen peroxidase test described by Joslyn (*7*) was used to determine the adequacy of the blanching treatment from the standpoint of peroxidase inactivation. The test was considered

negative when no color developed in 5 minutes. The results of these tests are given in table 1.

These results show that the usual blanching treatment used in the canning of pigeonpeas, which consists of blanching at 180 to 185° F., is completely inadequate for inactivating the enzyme system. Complete enzyme inactivation was achieved only after a 5-minute blanch at 195° F. Further studies on the time:temperature relationship for blanching pigeonpeas showed that at 180 to 185° F. blanching for 35 minutes was not enough for complete inactivation of the peroxidases. Catalase was inactivated at this temperature in 5 minutes. At temperatures ranging from 195 to 200° F., a 5-minute blanch was always found adequate for complete inactivation of the peroxidase. Samples of pigeonpeas blanched for 5 minutes at 185° F. were found

TABLE 1.—*Inactivation of the peroxidases of pigeonpeas during water-blanching*

Length of blanching in minutes	Results at blanching temperature (°F.) indicated				
	180°	195°	190°	195°	200°
3	+	+	+	+	−
5	+	+	+	−	−
7	+	+	+	−	−
9	+	+	+	−	−
11	+	+	+	−	−
13	+	+	−	−	−
15	+	+	−	−	−

to give a positive peroxidase test even after storage at −10° F. for 21 months.

When pigeonpeas are processed by the method developed by Sánchez (*1*), in which the pods are heated in steam before shelling to inactivate the enzyme system, the shelled peas may require a milder blanching treatment. Samples of pigeonpeas which were steamed before shelling were packed in plastic bags without further treatment and kept in frozen storage at −10° F. for 18 months. Peroxidase tests were made at frequent intervals during the storage period. It was found that some of the samples developed a faint color with the guaiacol-hydrogen peroxide reagent indicating some enzyme activity. Pigeonpeas likewise shelled, but blanched for 5 minutes in water at 180 to 185° F., showed no enzyme activity throughout the storage period. These findings suggest that even when pigeonpeas are shelled by steaming the pods to insure complete enzyme inactivation, they must be blanched. Although blanching for 5 minutes at 185° F. was found adequate in these tests, blanching at 195° F. seems to be safer.

The effects of the blanching treatment on the flavor and other organo-

leptic properties of the frozen pigeonpeas, as well as on their keeping quality were investigated. The frozen pigeonpeas were thawed and cooked as described under Processing. Single samples were served to tasters under red light in air-conditioned booths. Tasters were required to indicate on a

TABLE 2.—*Effect of blanching treatment on the organoleptic properties and keeping quality of pigeonpeas*

Characteristic	Values after number of days indicated	
	7	552
Shelled without steaming the pods, water-blanched at 185° F. for 5 minutes		
Flavor quality	2.50	2.60
Off-flavor intensity	4.12	4.60
Color	3.50	3.40
Texture	3.99	3.40
Shelled by steaming the pods, water-blanched at 185° F. for 5 minutes		
Flavor quality	2.90	3.70
Off-flavor intensity	4.22	4.70
Color	3.47	4.90
Texture	3.63	4.10
Shelled without steaming, unblanched		
Flavor quality	1.60	1.70
Off-flavor intensity	3.00	2.30
Color	2.20	1.80
Texture	3.38	2.10
Shelled by steaming the unblanched pods		
Flavor quality	3.10	3.30
Off-flavor intensity	3.55	4.30
Color	2.75	3.40
Texture	4.16	4.20

5-point scale their opinion about the sample for every characteristic measured. A rating of 5 points indicates excellent quality in flavor, texture, and color. A rating of 5 points also indicates the absence of any off-flavor. Color was rated on a similar sample under daylight. The results of the organoleptic tests for samples which received the four blanching treatments previously discussed are given in table 2. These results show that almost no change in quality took place during storage in the samples which had been blanched,

either by steaming the pods before shelling, by a combined treatment of steaming the pods before shelling and water blanching at 185° F. for 5 minutes, or by a single blanching treatment consisting of heating in water at 185° F. for 5 minutes. Off-flavor development, change in texture, loss of color, and loss in flavor quality, took place in the unblanched samples.

When samples of pigeonpeas from the four blanching treatments were compared for flavor, color, and intensity of off-flavors, using the pair test, no significant difference was found in any of these characteristics among the blanched samples. Significant differences in flavor, color, and intensity of off-flavor were found between the unblanched sample and each of the other samples which received the different blanching treatments.

From the standpoints of flavor retention and off-flavor development, the blanching treatment seems unimportant, provided the enzymes are inac-

TABLE 3.—*Effect of the blanching treatment on the ascorbic acid content of pigeonpeas and on the loss of ascorbic acid during storage*

Treatment	Initial level of ascorbic acid after blanching	Level of ascorbic acid after 240 days of storage at −10°F.	Loss
	Mgs./100 gm.	*Mgs./100 gm.*	*Percent*
Water-blanching at 185° F., 5 minutes	23.0	18.92	17.8
Steaming of the pods and water-blanching at 185° F., 5 minutes	19.6	17.1	14.7
No blanching	14.6	3.9	72.0
Steaming of the pods and no blanching	34.6	26.4	23.5

tivated. No evidence was found in the course of this preliminary work to indicate any advantage in steam-heating the pods before shelling when processing pigeonpeas for freezing, provided the peas have been blanched so as to inactivate the enzyme system completely. No further blanching treatment seems to be required when inactivation of the enzyme system is carried out before shelling by steaming the pods. However, the data available from this preliminary work are insufficient to allow us to advocate the elimination of the water-blanching treatment when the pods are steamed.

Blanching was found to have a direct effect on the ascorbic acid content of pigeonpeas and on the destruction of the vitamin during storage. In table 3 data are presented to show the effect of the blanching treatment on the ascorbic acid content of pigeonpeas and on its destruction during storage.

The ascorbic acid content after blanching was found to depend on the severity of the blanching treatment. It was highest when the pigeonpeas were steam-heated before shelling; it was lower in the sample which was

blanched in water for 5 minutes at 185° F., and still lower in the sample which received the combined treatment of heating in the pods followed by the water-blanching at 185° F. for 5 minutes. The loss of ascorbic acid during storage was found also to depend on the blanching treatment. The unblanched sample lost about 72 percent of its ascorbic acid during storage for 240 days at −10° F., while the loss for the other samples ranged from 14.7 to 23.5 percent. It should be noted that the sample which received the combined blanching treatment of steaming in the pods, followed by water-blanching, retained ascorbic acid better during the period studied. The better retention of the ascorbic acid in the samples during storage can be attributed to the fact that no peroxidase activity could be observed in these

TABLE 4.—*Chemical composition of 3 grades of pigeonpeas obtained by brine-grading*

Characteristic	Results from samples indicated		
	First floaters	Second floaters	Sinkers
Ascorbic acid.....mg./100 gm.	38.85	23.28	14.81
Total activity as anhydrous citric acid..... percent	.11	.14	.15
Total reducing sugars..... do.	0	0	0
Total sugars as invert..... do.	1.32	1.27	1.93
Starch..... do.	9.38	16.95	20.20
Alcohol insoluble solids..... do.	19.28	27.08	30.63
Total moisture..... do.	77.17	70.77	63.31
Hunter *a*	−17.9	−17.6	−6.8
Hunter *b*	20.7	20.4	18.2
Hunter *a/b*	.865	.865	.374

samples after blanching, while some peroxidase activity still remained in the others.

EFFECT OF MATURITY ON THE QUALITY OF FROZEN PIGEONPEAS

To study the effect of maturity on the quality of the frozen product, pigeonpeas of the Saragateado variety were shelled by the method of steaming the pods and brine-grading. The shelled peas were graded in a brine of specific gravity 1.107 and separated into sinkers and floaters. The sinkers were brine-graded a second time in a brine of specific gravity 1.141 and separated into sinkers and floaters. The floaters from both flotations and the sinkers from the last flotation treatment were processed separately, packed in waxed cardboard boxes with heat sealable moisture-vaporproof overwraps, and frozen. In this way pigeonpeas of three different stages of development were obtained. The chemical composition of the three grades of pigeonpeas obtained is given in table 4.

According to the data obtained by Sánchez *et al.* (*13*) in the study of the maturity indices of pigeonpeas the three groups separated by flotation may be classified as follows: First floaters were composed of mature fully developed, predominantly green peas. The group from the second flotation was composed of fully mature pigeonpeas, also predominantly green, but varying in color from green to yellowish green to almost completely devoid of green pigment. The colors of the two groups separated as floaters were more or less alike, as can be seen from the color measurement with the Hunter meter (table 4) while the third group had a more predominant yellow shade.

The acceptance of the frozen pigeonpeas by consumers depends on two main factors: Appearance of the frozen product from the standpoint of uniformity of size, and color and flavor. The pigeonpeas at the three stages of maturity were appraised for quality, taking into consideration separately the appearance of the product in the container and the flavor. Two methods of determining the flavor characteristics were used. In one method the sample was thawed in 3 cups of warm water for 30 minutes, 1 cup of boiling water was added, and the mixture boiled for 15 minutes. Salt was then added and the pigeonpeas cooked for an additional 30 minutes. The peas were drained from the liquor and served to tasters under red light. In the second method 170 gm. of the cooked pigeonpeas were pureed in a Waring blendor after the addition of 150 ml. of distilled water. The puree was served to tasters at a temperature of 120° F. and the tasting was performed under red light.

The appearance of the sample was rated using a 5-point scale in which a rating of 1 indicates a very poor appearance and a rating of 5, excellent appearance. The results from 50 observations evaluated first floaters at 3.02, second floaters at 3.55, and sinkers at 1.40.

The results of these tests show a preference from the standpoint of appearance for both types of floaters, and indicate a trend to preference for the more mature sample. The size of the peas in the second group of floaters was larger than in the first, and the peas were firmer. The number of mashed or broken peas was less in the second group of floaters than in the first, which accounts for the higher appearance rating given to this sample. The lack of color uniformity in the sinkers, in which both green-colored and yellow peas were present, accounts for the very low rating given to this sample.

For flavor evaluation the cooked pigeonpeas were served to tasters in pairs and they were required to indicate their preference for one of the samples. When whole cooked pigeonpeas were served to the tasters, no difference in flavor or preference was found between the two groups of floaters. The second group of floaters was preferred to the sinkers. The

tasters also preferred the floaters to the sinkers when the pureed peas were tasted, and showed a decided preference for the flavor of the second floaters. The results of the taste test indicate that the tasters preferred a fully mature green pea to a more tender or overmature product. The pigeonpeas in this group had an average alcohol-insoluble solid content of around 27 percent. About this same alcohol-insoluble solid content was found by Sánchez *et al.* (*1*) to be the most desirable for canning A-grade pigeonpeas.

KEEPING QUALITY OF FROZEN PIGEONPEAS

Pigeonpeas packed in polyethylene bags and in waxed cardboard containers were stored at −10° F. to study possible changes in appearance, texture, flavor, and intensity of off-flavors during storage. The pigeonpeas

TABLE 5.—*Shelf-life of frozen pigeonpeas stored at −10° F. and packed in polyethylene bags*

Characteristic	Value after—		
	8 days	312 days	512 days
Appearance	2.82	3.72	3.70
Texture	3.50	3.52	4.10
Flavor	2.90	3.38	3.70
Off-flavor	4.22	4.71	4.70

were thawed and cooked as described in Processing for organoleptic evaluation. It was observed that no changes in organoleptic properties took place during storage for 512 days. The data from the organoleptic tests run on the fresh product after 312 and 512 days after storage at 10° F. are given in table 5, for the product packed in polyethylene bags. It should be noted that there is an apparent improvement in flavor during storage. The higher rating given by tasters to the samples after the initial test was due to a change in the cooking procedure in preparing the samples for the taste tests. After the first few tests it was observed that cooking the peas for longer periods improved the flavor, and, consequently, all subsequent tests were run with samples cooked longer.

When the product was packed in waxed cardboard containers with heat-sealable moisture-vaporproof cellophane, no undesirable changes in flavor or other characteristics took place during storage for longer than a year. A few samples were found to be off-flavored, but the changes in flavor were apparently caused by a broken overwrap which failed to protect the product.

PRELIMINARY MARKETING TESTS TO DETERMINE CONSUMER ACCEPTANCE

In order to determine the consumer acceptance for the frozen product, preliminary marketing tests were carried out. Two thousand one hundred and fifteen 14-ounce waxed cardboard containers were sold in four supermarkets; two in the San Juan Metropolitan area, one in the city of Ponce, and one in the city of Mayagüez, under the Food Technology Laboratory label LTA. Before the product was put in the market the public was informed of its availability through press releases and regular supermarket advertisements in newspapers. The test was run during the off-season period from September 22 to October 12.

The frozen pigeonpeas were well accepted by the consumers. The sale of the product proceeded at a much faster rate than had been expected. Some of the supermarkets reported that they exhausted their stock the same day the product was put on display. Favorable comments were received from many consumers in regard to the quality of the product. Although it was not possible to run a controlled marketing test and to determine the sales potential through the repeated-sales technique, the results of this preliminary marketing test show that frozen pigeonpeas would probably be one of the best sellers among the frozen foods sold by supermarkets.

COMMERCIAL PROCESSING

The results of this work show that, for freezing, pigeonpeas may be processed in the same way as for canning, except that the blanching treatment should be 5 minutes at 195° F. to ensure complete enzyme inactivation. Since the quality of the frozen product depends on the maturity of the pigeonpeas it may be necessary to resort to brine-grading to obtain the pigeonpeas at the best stage of development for processing. From the results obtained from other studies on the brine-grading of pigeonpeas the authors believe that it may prove feasible to brine-grade pigeonpeas into two grades, one suitable for freezing and one for canning.

SUMMARY

Studies were conducted to determine the feasibility of freezing pigeonpeas. The results obtained show that pigeonpeas can be successfully frozen for market. If the enzyme system is completely inactivated by proper blanching, no appreciable changes in flavor, texture, appearance, and intensity of off-flavor take place during storage at −10° F. for 2 years. Blanching in water at 195° F. for 5 minutes was found to be the best treatment to inactivate the enzyme system. Fully mature green peas with an alcohol-insoluble solid content of about 27 percent were found to be of better

quality when frozen than more tender or overripe peas. A preliminary marketing test run in four supermarkets: two in the San Juan Metropolitan area, one in the city of Ponce, and one in the city of Mayagüez, indicated that frozen pigeonpeas offered to consumers in the off-season may be one of the best sellers among the frozen products.

RESUMEN

Se llevó a cabo un estudio para ver la posibilidad de congelar el gandur comercialmente. El resultado de este estudio indica que si se inactiva completamente el sistema enzimático del grano, mediante el escaldado adecuado, el producto después de congelado podría conservarse hasta por dos años sin que sufra cambios en su sabor o en sus otras propiedades organolépticas. Para inactivar completamente el sistema enzimático del grano es necesario tratarlo con agua a 195° F. por 5 minutos. La calidad del producto congelado depende del estado de madurez del grano, habiéndose encontrado que el gandur a un estado de madurez en el cual el grano está completamente desarrollado pero aún verde y con un contenido de sólidos insolubles en alcohol de 27 por ciento, tiene una calidad más alta cuando se congela que el gandur más tierno o más maduro. Pruebas limitadas de mercadeo que fueron llevadas a cabo en cuatro supermercados del área metropolitana de San Juan y de las ciudades de Ponce y Mayagüez, han dado indicación de que los gandures congelados han de tener una gran aceptación entre los consumidores puertorriqueños si se ofrecen para la venta fuera de la época de cosecha.

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